TECHNICIAN WORKBOOK

ACI Certification Program for Concrete Field Testing Technician—Grade I

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PREFACE

The ACI Certification Program for Concrete Field Testing Technician—Grade I has been developed for the purpose of certifying concrete technicians who have demonstrated the knowledge and ability to properly perform the basic field tests on freshly mixed concrete.

The increasing demand for certification by many governmental agencies has made it desirable for ACI to accept leadership in creating and maintaining a certification program to improve the accuracy and reliability of the field testing of freshly mixed concrete. In addition to upgrading the quality of concrete construction, this program is intended to prepare the industry for the possibility of future mandatory certification, and to form the basis for higher level certification programs. Technicians who upgrade their skills and credentials through ACI certification will increase their own opportunities as well as contribute to the advancement of the industry.

This Technician Workbook (CP-1) describes the operation of the ACI Certification Program and provides technical materials and directions necessary to prepare for the examinations.

Check the ACI website for updated information and/or errata/addendums:
www.concrete.org/publications/documenterrata.aspx

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Concrete Primer ACI Publication SP-1

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PROGRAM INFORMATION

Purpose and Importance of Certification

ACI Concrete Field Testing Technician—Grade I Certification provides international recognition by an independent group of acknowledged concrete experts. This recognition may improve your potential for advancement and employment opportunities.

Construction projects benefit from using certified technicians to perform test procedures on freshly mixed concrete, such as preparing specimens for standard or field curing, and recording temperature of fresh concrete when preparing specimens for strength tests. Proper performance of test procedures improves the reliability of test results and aids in the quality control of the concrete. Most importantly, proper testing assures accurate and timely verification of concrete that meets design specifications and identifies concrete that is substandard, which can minimize job site problems and costly delays. In the event of a dispute, the certified technician's complete and accurate test records become essential.

Increasingly, specifications for construction projects are requiring certified testing personnel. Some federal, state, and local agencies specify the use of certified field testing technicians. The National Voluntary Laboratory Accreditation Program (NVLAP), sponsored by the Department of Commerce, requires an annual assessment of a technician's competence and will accept ACI certification as fulfillment of this requirement.

Overview of the ACI Program

In order to attain ACI Certification as a Concrete Field Testing Technician—Grade I, you must successfully complete both the ACI written and performance examinations (see Figure 1). While there are no prerequisites in either training or experience, the examinations are designed so that only knowledgeable technicians will pass.

Administration

The American Concrete Institute, through its Certification Programs Committee, administers the certification program. This includes the development and maintenance of all program policies and procedures, instructional materials, and examinations.

The ACI certification program is conducted by a sponsoring group, such as an ACI chapter, a state or local concrete industry association, a college or university, or other organization committed to upgrading the quality of concrete. This group is responsible for scheduling and conducting all sessions; arrangement of facilities, material, equipment, and personnel; payment of all bills; and establishment and collection of all registration fees.

The ACI Certification Department assists the sponsoring groups in setting up the program and manages the daily operation of the program. This includes the publication and dissemination of all instructional materials and examinations, grading examinations, maintenance of certification records, and issuance of certification to successful candidates.

Definitions

ACI—The American Concrete Institute (38800 Country Club Drive, Farmington Hills, MI 48331), which developed and published instructional materials and examinations used in this program, and which certifies individuals who satisfy all requirements of this program.

ACI Certification—A formal recognition, valid for a specified period of time, which shows that a person has satisfactorily completed the certification requirements.

ACI Certification Department—The department within ACI that manages the certification programs.

ACI Concrete Field Testing Technician—Grade I—A person who has demonstrated knowledge and ability to properly perform and record the results of seven specified field tests on freshly mixed concrete by passing the ACI certification examinations.

ASTM—ASTM International (100 Barr Harbor Drive, West Conshohocken, PA 19428-2959), which developed and published technical standards used in this program.

Examiner—A person authorized by ACI to be in responsible charge of an examination session.

JTA—Job Task Analysis; a detailed list of items of knowledge and skills that can be used as a study guide for the examination.

Recertification—A process to renew expired certification by successfully completing the then-current requirements.

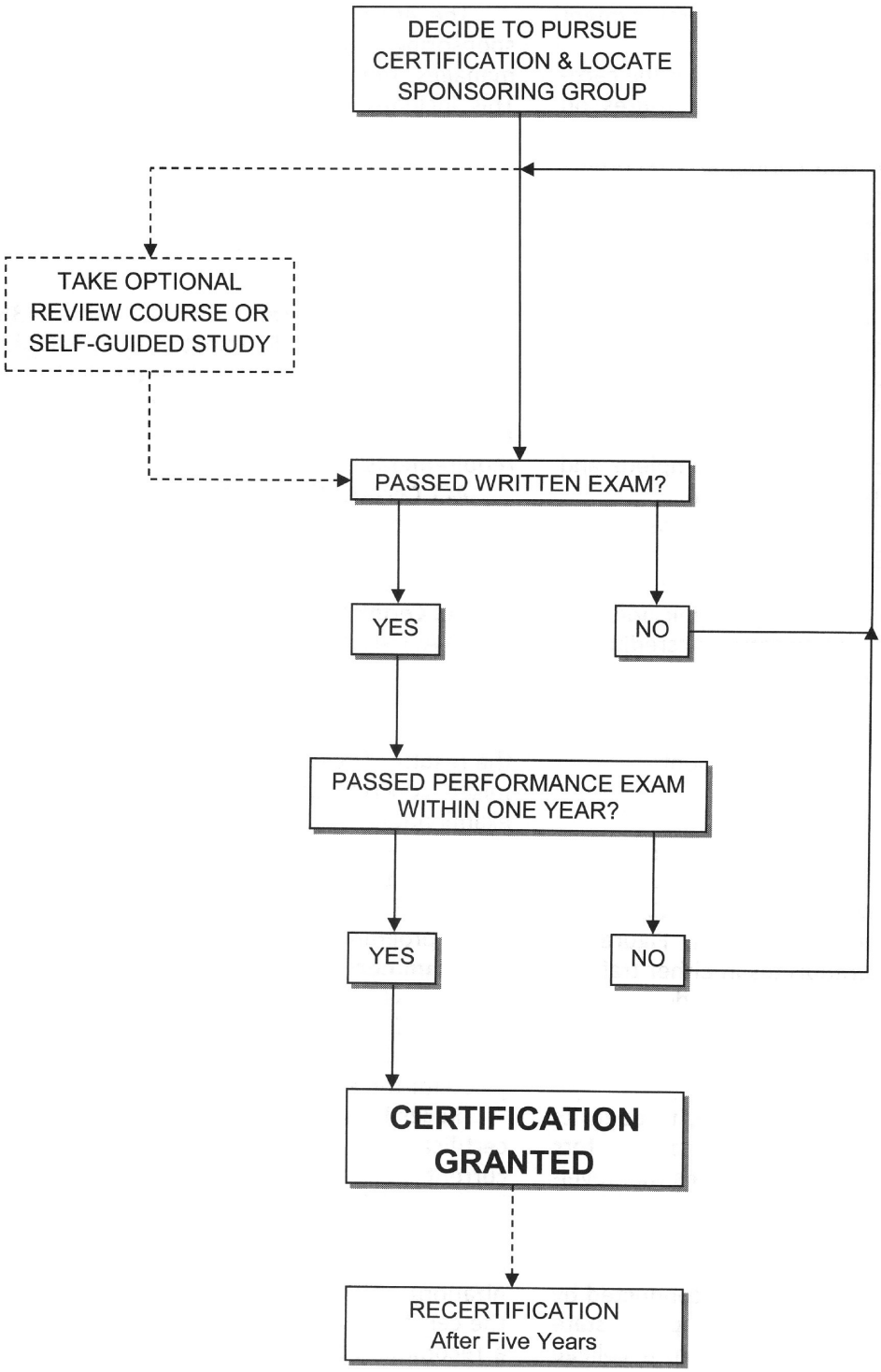
Sponsoring Group—The local organization (such as an ACI chapter, trade association, public agency, private testing laboratory, or other organization) which takes responsibility for conducting the certification examination in its locality and, as a recommended option, for conducting a review course.

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ACI CONCRETE FIELD TESTING TECHNICIAN CERTIFICATION PROCESS

Figure 1



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Supplemental Examiner—A person who assists the Examiner by administering the performance examination.

Trial—In the performance examination, one of two attempts allowed for the examinee to successfully perform each step of the procedure.

Proctor—A person authorized to assist the Examiner in conducting the written examination.

Resource Materials

This technician workbook is the primary resource for Concrete Field Testing Technician—Grade I and contains the essential resource material you need to prepare for the examinations.

Program Information contains general information about this ACI certification program and describes all policies, procedures, and requirements.

Technical Sections is divided into seven parts, each containing a brief outline, introduction, reprint of the ASTM standard, study questions, and performance examination checklist(s).

The ASTM standards covered in this program are:

- C1064/C1064M Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
- C172/C172M Standard Practice for Sampling Freshly Mixed Concrete
- C143/C143M Standard Test Method for Slump of Hydraulic-Cement Concrete
- C138/C138M Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- C231/C231M Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- C173/C173M Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- C31/C31M Standard Practice for Making and Curing Concrete Test Specimens in the Field

Study Materials contains the Job Task Analysis (JTA), a sample exam, and answers to the study questions and sample exam, to aid your individual study.

Appendix A and **B** contain supplemental reference material for further study, but are not covered on the examinations.

This workbook and ACI CCS-0, *Concrete Fundamentals*, a supplemental reference on concrete and concrete construction, make up ACI's Technician Study Package, CP-1 PACK.

Job Task Analysis (JTA)

The JTA is a detailed list of fundamental job elements, including the items of knowledge and skills required to successfully perform a job's functions. These elements are further distinguished in the JTA between general knowledge (understanding concepts), working knowledge (knowing facts or values), and physical proficiency (performing a physical task).

The written and performance examinations for Concrete Field Testing Technician—Grade I are designed to assess these fundamental elements. Therefore, the JTA may also serve as a guide when studying/preparing for certification; it outlines the expected knowledge and skill base of a Concrete Field Testing Technician—Grade I and governs the areas of competency assessed by the written and performance examinations for this program.

The JTA for this certification program can be found in **Study Materials.**

Preparation for the Examinations

ACI recommends that you attend a review course prior to the examinations, if offered by the sponsoring group. Sponsoring groups typically have access to resources (laboratory equipment and time, video training materials, etc.) that an individual does not. Course content and instructional time varies between sponsoring groups depending upon local needs.

Examinees are not required to participate in a review course, but preparing for the examinations without the benefit of the review course is not recommended. If a review course is not offered, or if you choose not to enroll in the course when offered, you should prepare a course of self-study.

Remember that your individual study, with or without the review course, can mean the difference between passing and failing the examinations.

Examinations

To achieve Concrete Field Testing Technician—Grade I certification, both a written and performance examination must be passed. You may be required to show photo identification to gain admittance to the examinations.

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Written Examination

The Concrete Field Testing Technician—Grade I written examination covers all seven ASTM standards listed under **Resource Materials**. Questions are derived directly from the text as well as special applications which you may or may not encounter on a construction project. There are no questions on general concrete technology on the examination.

The examination is **closed-book**; access to technical materials or notes during the examination is not allowed.

The examination consists of 55 multiple-choice questions, divided into 7 sections, each covering an individual standard. Each section consists of 5 to 10 questions. A maximum of 1 hour (60 minutes) is allowed to complete the entire examination.

To pass the examination, **both** of the following criteria must be met:

1. At least 60% of the questions in each of the seven sections must be answered correctly (e.g., 5 correct out of 8 equals 63%).

2. At least 70% of all questions on the examination must be answered correctly (e.g., 39 correct out of 55 equals 71%).

Calculations may be required for some questions; you may bring a simple-function pocket calculator to the examination. You may not share a calculator with another examinee during the examination.

ACI uses an optical reader to scan all personal data and written examination answer sheets. Two No. 2 pencils and a clean eraser are recommended for the written examination.

This examination may be conducted verbally if requested; please make arrangements with the sponsoring group prior to the examination date.

Question Challenges

If you encounter a test question that appears to be unclear, incorrect, or unfair, please describe your complaint on the Question Challenge Form included with your examination.

You must mark a response on your answer sheet that best answers the question. All questions have been formulated from the ASTM standards; any challenge based on a reference from an outside document will not be considered unless the reference agrees with the ASTM standard. If your explanation is found to be valid, scores will be adjusted accordingly.

All questions for the written examination are developed by the Field Technician Certification Committee and maintained at ACI Headquarters by the ACI Certification Department. Neither the examiner nor the sponsoring group have any jurisdiction over the content or the scoring of the written examination.

Performance Examination

The Concrete Field Testing Technician—Grade I performance examination covers all seven ASTM standards listed under **Resource Materials**. You will be judged on your ability to correctly perform all required steps for each procedure based on the criteria in the Performance Examination Checklists. In instances where performance is not feasible, you will be prompted to verbally describe the step(s). Checklists are provided in **Study Materials** to aid your study, but are revised periodically and may not be inclusive of the current examination.

Omission or incorrect performance on one or more steps of a procedure will constitute failure of that trial. You are allowed up to two trials on the day of the examination for each procedure. Failure of any procedure after two trials will constitute failure of the performance examination. All seven procedures must be passed at the same time to pass the performance examination.

You are required to perform the correct steps for each procedure in the direct presence of the examiner or a supplemental examiner. You may not refer to notes or any other written material during the trial. Talking is not prohibited, however the examiner is not allowed to respond to any questions, or offer coaching of any kind.

Immediately following completion of each trial, the examiner will tell you whether you passed or failed that trial. If a failure has occurred, the examiner will tell you which steps were performed or described (for verbal steps only) incorrectly. The examiner will not stop the trial at the point an error is made, or express approval or disapproval (verbal or nonverbal).

If, during a trial, you feel that you have made an error, you may request to suspend that trial and immediately begin the procedure over. If a trial is suspended voluntarily, it will not be counted as a failure of the trial. You may voluntarily suspend one trial per procedure.

The performance examination is physically demanding. If you feel you are risking personal injury in performing, or are unable to perform the procedures in the performance examination due to diminished physical capacity or physical disability, please inform the sponsoring group in advance of the examination date so alternative arrangements may be made.

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Appeals

All ACI certification policies, procedures, requirements, and examination materials have been developed through the voluntary consensus process and carefully reviewed for accuracy and fairness. However, an appeal process is available in the event that you feel that some aspect of the examination administration is unclear, incorrect, or unfair (see **Challenges** for examination content disputes). If a complaint is found to be valid, ACI will adjust grades accordingly.

The first level of appeal rests with the examiner. This person is a registered professional engineer with sufficient education and experience in concrete testing and inspection to be approved by ACI as their local representative for this program.

If the examiner cannot satisfy your complaint, appeals are handled in order by the following people or groups:

1. Sponsoring Group
2. Director of Certification
3. Certification Appeals Committee
4. Committee C610—Field Technician Certification
5. Certification Programs Committee

Note: Members of the Certification Appeals Committee include the Director of Certification, the Chair of the Certification Programs Committee, and the Chair of Committee C610.

Appeals submitted directly to ACI must be received, in writing, within 60 days of the receipt of the examination at ACI Headquarters. Appeals that are not made during the examination session will not be considered.

Re-Examination

Failure of the written examination by either the subtest or overall score criteria will require re-examination on the entire written examination, not just on the failed subtest(s). All subtests must be passed at the same time.

Failure of a performance examination on one or more procedure will require re-examination on the entire performance examination, not just on the failed procedure(s). All procedures must be passed at the same time.

A re-examination on either exam may be taken at any time, together or independently of one another; however, both exams must be passed within one year to be considered for certification.

It is your responsibility to request re-examination. To do so, contact the examiner and/or sponsoring group to arrange a convenient time, location, and appropriate fee. If you require further assistance, contact the ACI Certification Department.

Recertification

Your ACI certification as a Concrete Field Testing Technician—Grade I expires five years from the date that you complete the certification requirements. Your original certification and subsequent recertification periods run concurrently, not consecutively.

Recertification is granted by successfully completing the then-current written and performance examinations.

Americans with Disabilities Act (ADA)

If you have a disability and are qualified to do a job, the ADA protects you from job discrimination on the basis of your disability. To be protected under the ADA, you must have a substantial—as opposed to a minor—impairment. (A "substantial" impairment is one that significantly limits or restricts a major life activity such as hearing, seeing, speaking, walking, breathing, performing manual tasks, caring for oneself, learning or working.) If you have a disability, you must also be qualified to perform the essential functions or duties of a job, with or without reasonable accommodation, in order to be protected from job discrimination by the ADA.

ACI Certification programs are ADA-compliant. Individuals who are seeking certification and require reasonable accommodations must provide ACI Certification with a letter from their physician that outlines the recommended accommodations. ACI will review the request and formulate a recommended course of action for the Sponsoring Group (Testing Center) to follow. All requests are handled on a case-by-case basis and must be made allowing enough time for evaluation and appropriate action by ACI.

To contact ACI Certification, call (248) 848-3790 or email aci.certification@concrete.org.

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TECHNICAL SECTIONS

Each section consists of:

- Introduction
- Reprint of ASTM Standard
- Study Questions
- Performance Checklist

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SECTION 1

ASTM C1064/C1064M
Standard Test Method for
Temperature of Freshly Mixed Hydraulic-Cement Concrete

Introduction

Concrete temperature is one of the most important factors influencing the quality, time of set, and strength of the concrete. Without control of the concrete temperature, predicting the concrete's performance is very difficult, if not impossible.

A concrete with a high initial temperature will probably have higher than normal early strength and lower than normal later strength. The ultimate overall quality of the concrete will also probably be lowered. Conversely, concrete placed and cured at low temperatures will develop strength at a slower rate but ultimately will have higher strength and be of a higher quality. The temperature of concrete is used to indicate the type of curing and protection that will be needed, as well as the length of time the curing and protection should be maintained. By controlling the concrete temperature within acceptable limits, immediate and future problems may be avoided. When different types of concrete are to be evaluated, the mixing temperature of each concrete should be as identical as possible. Concrete temperature affects the performance of chemical admixtures, air entraining admixtures, pozzolanic materials and other additives and admixtures.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: C1064/C1064M – 17

Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete[1]

This standard is issued under the fixed designation C1064/C1064M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of temperature of freshly mixed hydraulic-cement concrete.

1.2 The values stated in either SI or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 The text of this standard references notes and footnotes that provide explanatory information. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C125 Terminology Relating to Concrete and Concrete Aggregates

C172/C172M Practice for Sampling Freshly Mixed Concrete

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

3. Terminology

3.1 For definitions of the terms used in this test method, refer to Terminology C125.

4. Significance and Use

4.1 This test method provides a means for measuring the temperature of freshly mixed concrete. The measured temperature represents the temperature at the time of testing and may not be an indication of the temperature of the freshly mixed concrete at a later time. It may be used to verify conformance to a specified requirement for temperature of concrete.

4.2 Concrete containing aggregate of a nominal maximum size greater than 75 mm [3 in.] may require up to 20 min for the transfer of heat from aggregate to mortar. (See ACI Committee 207.1R Report.[4])

5. Apparatus

5.1 *Container,* shall be large enough to provide at least 75 mm [3 in.] of concrete in all directions around the sensor of the temperature measuring device; concrete cover must also be at least three times the nominal maximum size of the coarse aggregate.

5.2 *Temperature Measuring Device,* shall be capable of accurately measuring the temperature of the freshly mixed concrete to ± 0.5 °C [±1 °F] throughout a range of 0° to 50 °C [30° to 120 °F]. The design of the temperature measuring device shall be such that it allows 75 mm [3 in.] or more immersion during operation.

5.3 Partial immersion liquid-in-glass thermometers (and possibly other types) shall have a permanent mark to which the device must be immersed without applying a correction factor.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.60 on Testing Fresh Concrete.

Current edition approved Oct. 1, 2017. Published October 2017. Originally approved in 1986. Last previous edition approved in 2012 as C1064/C1064M–12. DOI: 10.1520/C1064_C1064M-17.

[2] Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol 04.02.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org.

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5.4 *Reference Temperature Measuring Device,* shall be readable and accurate to ± 0.2 °C [0.5 °F] at the verification points in 6.1. A certificate or report that verifies the accuracy shall be available in the laboratory for review. Accuracy of liquid-in-glass reference temperature measuring devices shall be verified once. Verification of direct-reading resistance reference temperature measuring devices shall be performed at least every twelve months. The certificate or report shall provide documentation that the reference standard used in the verification is traceable to the National Institute of Standards and Technology (NIST).

6. Verification of the Accuracy of Temperature Measuring Devices

6.1 The accuracy of each temperature measuring device used for determining the temperature of freshly mixed concrete shall be verified at least annually, or whenever there is a question of accuracy. Verify the accuracy of the temperature measuring device by comparing the readings of the reference temperature measuring device to the temperature measuring device at two temperatures at least 15 °C [30 °F] apart.

6.2 Verification of the accuracy of the temperature measuring devices may be made in oil or other suitable bath liquids having uniform density if provision is made to:

6.2.1 Maintain the bath temperature constant within 0.2 °C [0.5 °F] during the verification process.

6.2.2 Continuously circulate the bath liquid to provide a uniform temperature throughout the bath.

6.2.3 Suspend the temperature measuring devices in such a manner that the devices are not contacting the sides or bottom of the bath container during verification.

6.3 Place both the temperature and reference temperature measuring devices in the bath for at least 5 min before reading temperatures at the test points specified in 6.1.

6.4 Prior to reading the temperature measuring devices, if the temperature in the bath has been reduced, slightly tap thermometers containing liquid to avoid adhesion of the liquid to the glass.

6.5 Read and record the temperature of both the reference temperature measuring device and the temperature measuring device. Reject the temperature measuring device if the difference in readings exceeds 0.5 °C [1 °F] at either test point. If the indicator of the rejected temperature measuring device is adjustable, reverification is permitted after adjustment. In addition to the temperature readings, record the identification numbers of both devices used, the date verified, and the name of individual performing the verification.

7. Sampling Concrete

7.1 It is acceptable to measure the temperature of freshly mixed concrete in either the transporting equipment or the forms after discharge provided the sensor of the temperature measuring device has at least 75 mm [3 in.] of concrete cover in all directions.

7.2 If the transporting equipment or placement forms are not used as the container, a sample shall be prepared as follows:

7.2.1 Immediately, prior to sampling the freshly mixed concrete, dampen (with water) the sample container.

7.2.2 Sample the freshly mixed concrete in accordance with Practice C172/C172M, except that composite samples are not required if the only purpose for obtaining the sample is to determine temperature.

7.2.3 Place the freshly mixed concrete into the container.

8. Procedure

8.1 Position the temperature measuring device so that the end of the temperature sensing portion is submerged a minimum of 75 mm [3 in.] into the freshly mixed concrete. Close the void left by the placement by gently pressing the concrete around the temperature measuring device at the surface of the concrete to prevent ambient air temperature from affecting the reading.

8.2 Leave the temperature measuring device in the freshly mixed concrete for at least 2 min but not more than 5 min, then read and record the temperature to the nearest 0.5 °C [1 °F]. Do not remove the device from the concrete when reading the temperature.

9. Report

9.1 Report the measured temperature of the freshly mixed concrete to the nearest 0.5 °C [1 °F].

10. Precision and Bias

10.1 The data used to develop the precision statement were obtained using the inch-pound version of this test method. The precision indices shown in SI units are conversions of the values in brackets.

10.2 The single operator standard deviation for measurement of concrete temperature has been found to be 0.3 °C [0.5 °F]. [5] Therefore, results of two properly conducted tests by the same operator on the same sample of material should not differ by more than 0.7 °C [1.3 °F]. [5]

10.3 The multi-operator standard deviation for the measurement of concrete temperature on the same sample has been found to be 0.4 °C [0.7 °F]. [5] Therefore, two tests properly conducted by different operators but on the same material should not differ by more than 1.1 °C [1.9 °F]. [5]

10.4 The precision values given were derived from an inter-laboratory study using 11 operators on two concrete batches at around 24 °C [75 °F]. [6]

10.5 Since there is no accepted reference material suitable for determining the bias of this test method, no statement on bias is being made.

11. Keywords

11.1 freshly mixed concrete; temperature; temperature measuring device

[5] These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C670.

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1028.

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SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this specification since the last issue, C1064/C1064M–12, that may impact the use of this specification. (Approved October 1, 2017)

(1) Added Terminology (Section 3).
(2) Revised 5.4 to add the wording "at least."
(3) Revised 6.1 to add the wording "at least."

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STUDY QUESTIONS

Test Method C1064/C1064M – 17
Temperature of Freshly Mixed Hydraulic-Cement Concrete

1. The end of the temperature sensing portion of the temperature measuring device is submerged a minimum of _____ into the freshly mixed concrete.
2. The temperature measuring device shall be capable of accurately measuring the temperature of freshly mixed concrete to _____ throughout a range of _____.
3. The temperature measuring device shall be verified _____, or whenever there is a question of _____.
4. The temperature of concrete may be measured in a wheelbarrow. *True or False?*
5. The temperature of concrete may be measured in a wall form. *True or False?*
6. A composite sample of concrete is required even if the only purpose for obtaining the sample is to determine temperature. *True or False?*
7. What must be done to the sample container prior to sampling the concrete? _____
8. What must be done to the concrete surrounding the temperature measuring device after the device is submerged in the fresh concrete? _____
   _____
9. How long must the temperature measuring device remain in the freshly mixed concrete? _____
   _____
10. After the temperature of the concrete is read, what is then required? _____
11. The temperature of the concrete is reported to the nearest _____.
12. According to Test Method C1064/C1064M, what is one reason to take the temperature of concrete?
    _____
13. A maximum temperature of freshly mixed concrete is specified in Test Method C1064/C1064M. *True or False?*
14. The sample of concrete used for temperature determination must be rodded 25 times. *True or False?*

Answers to study questions are included in Study Materials.

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PERFORMANCE CHECKLIST

Test Method C1064/C1064M – 17
Temperature of Freshly Mixed Hydraulic-Cement Concrete

The following is a summary of the key steps involved in measuring the temperature of freshly mixed concrete. This summary is derived from the actual checklist used in the ACI performance examination. It can be used to familiarize yourself with the basic procedures of this method before proceeding with your study of the ASTM Standard itself. **However, this summary is not intended to take the place of your complete study of the ASTM Standard.**

1. Place the temperature measuring device (TMD) in the concrete so that the sensing portion is submerged a minimum of 75 mm [3 in.]. (Para. 8.1)

2. Gently press concrete around the TMD so that ambient (outside) air temperature does not influence the measured temperature. (Para. 8.1)

3. Leave the TMD in the concrete for at least 2 min but not more than 5 min. (Para. 8.2)

4. Read and record the fresh concrete temperature to the nearest 0.5°C [1°F]. Do not remove the TMD from the concrete when reading the temperature. (Para. 8.2)

5. Report the measured temperature of the freshly mixed concrete to the nearest 0.5°C [1°F]. (Para. 9.1)

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SECTION 2

ASTM C172/C172M
Standard Practice for
Sampling Freshly Mixed Concrete

Introduction

The process of testing fresh concrete in the field begins with the procedures for obtaining and preparing the sample of concrete to be tested. ASTM C172/C172M gives the standard procedures for obtaining a representative sample of a batch of concrete, from various types of mixing and/or agitating equipment. In addition, ASTM C172/C172M gives specific time limits regarding when tests for slump and air content must be started and for beginning the molding of test specimens.

All too often, it has been the bad habit of technicians to obtain the sample of concrete as quickly as possible upon its arrival at the job site, resulting in sampling the first portion of the batch discharge. This practice is in violation of the specifications under which the concrete is being supplied (i.e., ACI 301, ACI 318, and ASTM C94/C94M), and it may result in a nonrepresentative sample of concrete. When you consider that the specifications may only require strength tests to be made once every 100 cubic yards (ACI 301) or every 150 cubic yards (ACI 318), the need for a truly representative sample becomes readily apparent. The minimum 1 cubic foot (28 liter) sample of concrete, from which the compressive strength test specimens will be made, represents only 0.025 to 0.037 percent of the total amount of concrete placed.

To assure accuracy in testing of fresh concrete, every precaution should be taken to obtain a sample of concrete which is truly representative of the entire batch and then to protect that sample from the damaging effects of evaporation and contamination.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: C172/C172M – 17

Standard Practice for Sampling Freshly Mixed Concrete[1]

This standard is issued under the fixed designation C172/C172M; 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.

1. Scope*

1.1 This practice covers procedures for obtaining representative samples of fresh concrete as delivered to the project site on which tests are to be performed to determine compliance with quality requirements of the specifications under which the concrete is furnished (Note 1). The practice includes sampling from stationary, paving and truck mixers, and from agitating and nonagitating equipment used to transport central-mixed concrete and from continuous mixing equipment as described in Specification C685/C685M.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

NOTE 1—Composite samples are required by this practice, unless specifically excepted by procedures governing the tests to be performed such as tests to determine uniformity of consistency and mixer efficiency. Procedures used to select the specific test batches are not described in this practice, but it is recommended that random sampling be used to determine overall specification compliance.

1.3 This practice also covers the procedures to be used for preparing a sample of concrete for further testing where it is desirable or necessary to remove the aggregate larger than a designated size. This removal of larger aggregate particles is preferably accomplished by wet-sieving.

1.4 The text of this standard references notes and footnotes which provide explanatory material and shall not be considered as requirements of the practice.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C685/C685M Specification for Concrete Made by Volumetric Batching and Continuous Mixing

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Significance and Use

3.1 This practice is intended to provide standard requirements and procedures for sampling freshly mixed concrete from different containers used in the production or transportation of concrete. The detailed requirements as to materials, mixtures, air content, temperature, number of specimens, slump, interpretation of results, and precision and bias are in specific test methods.

4. Sampling

4.1 The elapsed time shall not exceed 15 min. between obtaining the first and final portions of the composite sample.

4.1.1 Transport the individual samples to the place where fresh concrete tests are to be performed or where test specimens are to be molded. They shall be combined and remixed with a shovel the minimum amount necessary to ensure uniformity and compliance with the maximum time limits specified in 4.1.2.

4.1.2 Start tests for slump, temperature, and air content within 5 min after obtaining the final portion of the composite sample. Complete these tests expeditiously. Start molding

[1] This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.60 on Testing Fresh Concrete.

Current edition approved Oct. 1, 2017. Published October 2017. Originally approved in 1942. Last previous edition approved in 2014 as C172/C172M–14a. DOI: 10.1520/C0172_C0172M-17.

[2] Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol 04.02.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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specimens for strength tests within 15 min after fabricating the composite sample. Expeditiously obtain and use the sample and protect the sample from the sun, wind, and other sources of rapid evaporation, and from contamination.

5. Procedure

5.1 *Size of Sample*—Make the samples to be used for strength tests a minimum of 28 L [1 ft^3]. Smaller samples are not prohibited for routine air content, temperature, and slump tests. The size of the samples shall be dictated by the maximum aggregate size.

5.2 The procedures used in sampling shall include the use of every precaution that will assist in obtaining samples that are truly representative of the nature and condition of concrete sampled as follows:

NOTE 2—Sampling should normally be performed as the concrete is delivered from the mixer to the conveying vehicle used to transport the concrete to the forms; however, specifications may require other points of sampling, such as the discharge of a concrete pump.

5.2.1 *Sampling from Stationary Mixers, Except Paving Mixers*—Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch. Obtain these portions within the time limit specified in Section 4. Combine into one composite sample for testing purposes. Do not obtain portions of the composite sample from the very first or last part of the batch discharge (Note 3). Perform sampling by passing a receptacle completely through the discharge stream, or by completely diverting the discharge into a sample container. If discharge of the concrete is too rapid to divert the complete discharge stream, discharge the concrete into a container or transportation unit sufficiently large to accommodate the entire batch and then accomplish the sampling in the same manner as given above. Take care not to restrict the flow of concrete from the mixer, container, or transportation unit so as to cause segregation. These requirements apply to both tilting and nontilting mixers.

NOTE 3—No samples should be taken before 10 % or after 90 % of the batch has been discharged. Due to the difficulty of determining the actual quantity of concrete discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and the end of the load.

5.2.2 *Sampling from Paving Mixers*—Sample the concrete after the contents of the paving mixer have been discharged. Obtain samples from at least five different portions of the pile and combine them into one composite sample for test purposes. Avoid contamination with subgrade material or prolonged contact with and absorptive subgrade.

NOTE 4—Discharging concrete across shallow containers placed on the subgrade, or supported above the subgrade, may be effective in precluding contamination or absorption by the subgrade. If used, the concrete from the shallow containers should provide a composite sample that is in agreement with the maximum aggregate size.

5.2.3 *Sampling from Revolving Drum Truck Mixers or Agitators*—Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch. Take the samples so obtained within the time limit specified in Section 4 and combine them into one composite sample for test purposes. In any case do not obtain samples until after all of the water and any admixtures have been added to the mixer; also do not obtain samples from the very first or last portions of the batch discharge (Note 3). Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of discharge of the batch by the rate of revolution of the drum and not by the size of the gate opening.

5.2.4 *Sampling from Continuous Mixers*—Sample the concrete after the discharge of at least 140 L [5 ft^3] of concrete, following all mixture proportioning adjustments. Sample the concrete at the frequency specified by collecting two or more portions taken at regularly spaced intervals during discharge of the concrete. Take the portions so obtained within the time limit specified in Section 4, and combine them into one composite sample for test purposes. Do not obtain samples from the very first or last portions of a mixer's continuous discharge (Note 3). Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. After obtaining the composite sample, wait a minimum of 2 minutes and a maximum of 5 minutes before beginning tests (Note 5).

NOTE 5—The waiting period prior to commencing the testing is needed because the mix water is input only seconds before discharge from the continuous mixer.

5.2.5 *Sampling from Open-Top Truck Mixers, Agitators, Nonagitating Equipment, or Other Types of Open-Top Containers*—Take samples by whichever of the procedures described in 5.2.1, 5.2.2, or 5.2.3 is most applicable under the given conditions.

6. Additional Procedure for Large Maximum Size Aggregate Concrete

6.1 When the concrete contains aggregate larger than that appropriate for the size of the molds or equipment to be used, wet-sieve the sample as described below except perform density (unit weight) tests for use in yield computations on the full mix.

NOTE 6—The effect of wet-sieving on the test results should be considered. For example, wet-sieving concrete causes the loss of a small amount of air due to additional handling. The air content of the wet-sieved fraction of concrete is greater than that of the total concrete because the larger size aggregate which is removed does not contain air. The apparent strength of wet-sieved concrete in smaller specimens is usually greater than that of the total concrete in larger appropriate size specimens. The effect of these differences may need to be considered or determined by supplementary testing for quality control or test result evaluation purposes.

6.2 *Definition:*

6.2.1 *wet-sieving concrete*—the process of removing aggregate larger than a designated size from the fresh concrete by sieving it on a sieve of the designated size.

6.3 *Apparatus:*

6.3.1 *Sieves,* as designated, conforming to Specification E11.

6.3.2 *Receptacle*—A container of suitable size having a nonabsorbent surface.

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6.3.3 *Wet-Sieving Equipment*—Equipment for wet-sieving concrete shall be a sieve as noted in 6.3.1 of suitable size and conveniently arranged and supported so that one can shake it rapidly by either hand or mechanical means. Generally, a horizontal back and forth motion is preferred. The equipment shall be capable of rapidly and effectively removing the designated size of aggregate.

6.3.4 *Hand Tools*—Shovels, hand scoops, plastering trowels, and rubber gloves as required.

6.4 *Procedure:*

6.4.1 *Wet-Sieving*—After sampling the concrete, pass the concrete over the designated sieve and remove and discard the aggregate retained. This shall be done before remixing. Shake or vibrate the sieve by hand or mechanical means until no undersize material remains on the sieve. Mortar adhering to the aggregate retained on the sieve shall not be wiped from it before it is discarded. Place only enough concrete on the sieve at any one time so that after sieving, the thickness of the layer of retained aggregate is not more than one particle thick. The concrete which passes the sieve shall fall into a batch pan of suitable size which has been dampened before use or onto a clean, moist, nonabsorbent surface. Scrape any mortar adhering to the sides of the wet-sieving equipment into the batch. After removing the larger aggregate particles by wet-sieving remix the batch with a shovel the minimum amount necessary to ensure uniformity and proceed testing immediately.

7. Keywords

7.1 air content; batch; composite sample; concrete; slump; temperature; wet-sieving

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this practice since the last issue, C172/C172M–14a, that may impact the use of this practice. (Approved October 1, 2017)

(1) Revised 5.2.2.

(2) Revised Note 4.

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STUDY QUESTIONS

Practice C172/C172M – 17
Sampling Freshly Mixed Concrete

1. Sampling by this practice covers procedures for obtaining representative samples, on which tests are to be performed to determine _____ with quality requirements of the specifications under which the concrete is furnished.

2. This practice covers sampling from five types of equipment, which are _____, _____, _____, _____, and _____.

3. The elapsed time between obtaining the first and final portions of a composite sample shall not exceed _____.

4. Portions of a composite sample shall be thoroughly remixed before beginning tests on the sample. *True or False?*

5. Start tests for slump, temperature, and air content within _____ after obtaining the final portion of the composite sample.

6. Start molding specimens for strength tests within _____ after fabricating the composite sample.

7. The concrete sample must be protected from contamination and _____.

8. The minimum size sample for making strength test specimens is _____.

9. When sampling from a stationary mixer, the batch must be sampled at _____ or more regularly spaced intervals during discharge of the middle portion of the batch.

10. When sampling from a paving mixer, obtain samples from at least _____ different portions of the pile and combine them into one composite sample for test purposes.

11. When sampling from a revolving drum truck mixer, sample the concrete by collecting _____ or more portions take at regularly spaced intervals during discharge of the middle portion of the batch.

12. Concrete samples from a truck mixer must be obtained before any water or admixtures are added to the mixer at the job site. *True or False?*

13. The composite sample from a truck mixer must be obtained from the _____ portion of the batch.

14. When the concrete contains aggregate larger than that permitted for a particular test method, the sample of concrete must be _____ before making the test.

Answers to study questions are included in Study Materials.

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PERFORMANCE CHECKLIST

Practice C172/C172M – 17
Sampling Freshly Mixed Concrete

The following is a summary of the key steps involved in sampling freshly mixed concrete. This summary is derived from the actual checklist used in the ACI performance examination. It can be used to familiarize yourself with the basic procedures of this method before proceeding with your study of the ASTM Standard itself. **However, this summary is not intended to take the place of your complete study of the ASTM Standard.**

One or more procedures on this checklist are in the form of a verbal question. You will be expected to verbally provide all information in the response(s) indicated by boldface type.

1. What must occur before a sample of concrete can be taken from a revolving drum mixer? (Para. 5.2.3)
   - ***All water and admixtures must be added to the mixer***

2. When sampling from a stationary or revolving drum mixer, what is collected and when is it taken during discharge? (Para. 5.2.1 and 5.2.3)
   - ***In two or more portions of concrete***
   - ***At regularly spaced intervals***
   - ***From the middle of the batch***

3. How are the sample portions obtained from the discharge stream of a stationary or revolving drum mixer? (Para. 5.2.1 and 5.2.3)
   - ***Repeatedly pass a receptacle through the entire discharge stream***
   - ***Completely divert the discharge stream into a sample container***

4. Describe the procedure for collecting a sample from a paving mixer. (Para. 5.2.2)
   - ***Discharge the contents of the paving mixer***
   - ***Obtain samples from at least five different portions of the pile***

5. What is the minimum size for a sample when strength test specimens are to be molded? (Para. 5.1)
   - ***28 L [1 ft^3]***

6. What is the maximum allowable time between obtaining the first and final portions of the composite sample? (Para. 4.1)
   - ***15 min***

7. What action is required after the individual concrete samples have been transported to the place where tests are to be performed? (Para. 4.1.1)
   - ***Combine and remix the samples with a shovel***

8. What should be done if the concrete contains aggregate larger than is appropriate for the size of the molds or equipment being used? (Para. 6.1)
   - ***Wet sieving***

9. Start the tests for slump, temperature, and air content within how many minutes after obtaining the final portion of the composite sample? (Para. 4.1.2)
   - ***5 min***

10. Start molding specimens for strength tests within how many minutes after fabricating the composite sample? (Para. 4.1.2)
    - ***15 min***

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11. From what must the concrete sample be protected? (Para. 4.1.2)
    - ***Sun, wind, and rapid evaporation***
    - ***Contamination***

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PERFORMANCE CHECKLIST

Practice C172/C172M – 17
Sampling Freshly Mixed Concrete
Alternate Performance-Only

The following is a summary of the key steps involved in sampling freshly mixed concrete. This summary is derived from the actual checklist used in the ACI performance examination. It can be used to familiarize yourself with the basic procedures of this method before proceeding with your study of the ASTM Standard itself. **However, this summary is not intended to take the place of your complete study of the ASTM Standard.**

1. Obtain a representative sample source (i.e. revolving drum truck mixer):

   A. Ensure that all water has been added. (Para. 5.2.3)

   B. Sample the concrete at two or more regularly-spaced intervals during discharge of the middle portion of the batch. (Para. 5.2.1 and 5.2.3)

   C. Repeatedly pass receptacle through entire discharge stream or completely divert discharge stream into sampling container. (Para. 5.2.1 and 5.2.3)

   D. Transport samples to place of testing. Combine and remix to form composite sample. (Para. 4.1.1 and 5.2.3)

   E. Obtain composite sample within 15 min from the start of sampling. (Para. 4.1)

   F. Minimum size of sample used for strength tests shall be 28 L [1 ft^3]. (Para. 5.1)

2. Start tests for slump, temperature, and air content within 5 min after obtaining final portion of composite sample. (Para. 4.1.2)

3. Start molding specimens within 15 min after fabricating the composite sample. (Para. 4.1.2)

4. Protect sample against rapid evaporation and contamination. (Para. 4.1.2)

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SECTION 3

ASTM C143/C143M
Standard Test Method for
Slump of Hydraulic-Cement Concrete

Introduction

The purpose of the slump test is to determine the consistency of the concrete. This is a measure of the relative fluidity or mobility of the concrete mixture. Slump does not measure the water content or workability of the concrete. It is true that an increase or decrease in the water content will cause a corresponding increase or decrease in the slump of the concrete, provided that all of the other materials and conditions are constant. However, many factors can cause the slump of the concrete to change without any change in the water content.

Also, the water content may increase or decrease without any apparent change in the slump of the concrete. Factors such as a change in the aggregate properties or grading, mix proportions, air content, concrete temperature, or the use of special admixtures can influence the slump of the concrete, or conversely, can result in a change in the water content requirement for maintaining a given slump. For example, an over-sanded mix may require more mixing water than the original design mix proportions call for, but the slump may remain the same. Therefore, you cannot assume that the water/cement ratio is being maintained simply because the slump is within the specification limits.

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Designation: C143/C143M – 15a

Standard Test Method for Slump of Hydraulic-Cement Concrete[1]

This standard is issued under the fixed designation C143/C143M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers determination of slump of hydraulic-cement concrete, both in the laboratory and in the field.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

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.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

C172 Practice for Sampling Freshly Mixed Concrete

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D638 Test Method for Tensile Properties of Plastics

3. Summary of Test Method

3.1 A sample of freshly mixed concrete is placed and compacted by rodding in a mold shaped as the frustum of a cone. The mold is raised, and the concrete allowed to subside. The vertical distance between the original and displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete.

4. Significance and Use

4.1 This test method is intended to provide the user with a procedure to determine slump of plastic hydraulic-cement concretes.

NOTE 1—This test method was originally developed to provide a technique to monitor the consistency of unhardened concrete. Under laboratory conditions, with strict control of all concrete materials, the slump is generally found to increase proportionally with the water content of a given concrete mixture, and thus to be inversely related to concrete strength. Under field conditions, however, such a strength relationship is not clearly and consistently shown. Care should therefore be taken in relating slump results obtained under field conditions to strength.

4.2 This test method is considered applicable to plastic concrete having coarse aggregate up to 1½ in. [37.5 mm] in size. If the coarse aggregate is larger than 1½ in. [37.5 mm] in size, the test method is applicable when it is performed on the fraction of concrete passing a 1½-in. [37.5-mm] sieve, with the larger aggregate being removed in accordance with the section titled "Additional Procedure for Large Maximum Size Aggregate Concrete" in Practice C172.

4.3 This test method is not considered applicable to non-plastic and non-cohesive concrete.

NOTE 2—Concretes having slumps less than ½ in. [15 mm] may not be adequately plastic and concretes having slumps greater than about 9 in. [230 mm] may not be adequately cohesive for this test to have significance. Caution should be exercised in interpreting such results.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.60 on Testing Fresh Concrete.

Current edition approved Dec. 15, 2015. Published February 2016. Originally approved in 1922. Last previous edition approved in 2015 as C143/C143M – 15. DOI: 10.1520/C0143_C0143M-15A

[2] Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol. 04.02.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

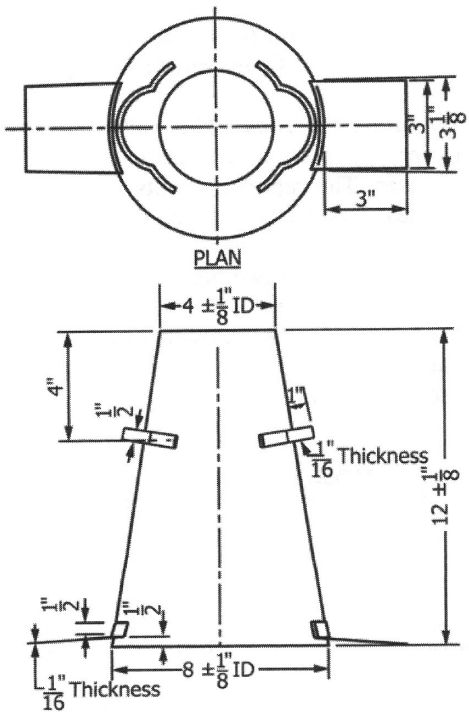
***A Summary of Changes section appears at the end of this standard**

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5. Apparatus

5.1 *Mold*—The test specimen shall be formed in a mold made of metal or plastic not readily attacked by the cement paste. The mold shall be sufficiently rigid to maintain the specified dimensions and tolerances during use, resistant to impact forces, and shall be non-absorbent. Metal molds shall have an average thickness of not less than 0.060 in. [1.5 mm] with no individual thickness measurement less than 0.045 in. [1.15 mm]. Plastic molds shall be ABS plastic or equivalent (Note 3) with a minimum average wall thickness of 0.125 in. [3 mm], with no individual thickness measurement less than 0.100 in. [2.5 mm]. The manufacturer or supplier shall certify the materials used in mold construction are in compliance with the requirements of this test method. The mold shall be in the form of the lateral surface of the frustum of a cone with the base 8 in. [200 mm] in diameter, the top 4 in. [100 mm] in diameter, and the height 12 in. [300 mm]. Individual diameters and heights shall be within ±⅛ in. [3 mm] of the prescribed dimensions. The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mold shall be provided with foot pieces and handles similar to those shown in Fig. 1. The mold shall be constructed without a seam. The interior of the mold shall be relatively smooth and free from projections. The mold shall be free from dents, deformation, or adhered mortar. A mold which clamps to a nonabsorbent base plate is acceptable instead of the one illustrated, provided the clamping arrangement is such that it can be fully released without movement of the mold and the base is large enough to contain all of the slumped concrete in an acceptable test.



Dimensional Units									
in.	1/16	⅛	½	1	3	3⅛	4	8	12
mm	[2]	[3]	[15]	[25]	[75]	[80]	[100]	[200]	[300]

FIG. 1 Mold for Slump Test

NOTE 3—ABS (Acrylonitrile Butadiene Styrene) plastic exhibits the following minimum mechanical properties:

Tensile modulus of elasticity, at 73 °F [23 °C]	320 000 psi	[2206 MPa]
Tensile strength (Test Method D638)	5670 psi	[39 MPa]
Percent Elongation at Break, at 73 °F [23 °C]	40%	

5.1.1 Check and record conformance to the mold's specified dimensions when it is purchased or first placed in service and at least annually thereafter. To measure the top diameter, bottom diameter, and height, perform two measurements for each, approximately 90° apart, and record the results of each measurement. To verify mold thickness, perform two measurements approximately 180° apart at 1 ± ½ in. [25 ± 10 mm] from the top of the mold, two measurements approximately 180° apart at 1 ± ½ in. [25 ± 10 mm] from the bottom of the mold, and calculate the average of the four measurements.

5.2 *Tamping Rod*—A round, smooth, straight steel rod, with a ⅝ in. [16 mm] ± 1/16 in. [2 mm] diameter. The length of the tamping rod shall be at least 4 in. [100 mm] greater than the depth of the mold in which rodding is being performed, but not greater than 24 in. [600 mm] in overall length (Note 4). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 4—A rod length of 16 in. [400 mm] to 24 in. [600 mm] meets the requirements of the following: Practice C31/C31M, Test Method C138/C138M, Test Method C143/C143M, Test Method C173/C173M, and Test Method C231.

5.3 *Measuring Device*—A ruler, metal roll-up measuring tape, or similar rigid or semi-rigid length measuring instrument marked in increments of ¼ in. [5 mm] or smaller. The instrument length shall be at least 12 in. [300 mm].

5.4 *Scoop*—of a size large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so it is not spilled during placement in the mold.

6. Sample

6.1 The sample of concrete from which test specimens are made shall be representative of the entire batch. It shall be obtained in accordance with Practice C172.

7. Procedure

7.1 Dampen the mold and place it on a rigid, flat, level, moist, nonabsorbent surface, free of vibration, and that is large enough to contain all of the slumped concrete. It shall be held firmly in place during filling and perimeter cleaning by the operator standing on the two foot pieces or by a clamping arrangement to a base plate as described in 5.1. From the sample of concrete obtained in accordance with Section 6, immediately fill the mold in three layers, each approximately one third the volume of the mold (See Note 5). Place the concrete in the mold using the scoop described in 5.4.

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the scoop around the perimeter of the mold opening to ensure an even distribution of the concrete with minimal segregation.

NOTE 5—One third of the volume of the slump mold fills it to a depth of 2⅝ in. [70 mm]; two thirds of the volume fills it to a depth of 6⅛ in. [160 mm].

7.2 Rod each layer 25 times uniformly over the cross section with the rounded end of the rod. For the bottom layer, this will necessitate inclining the rod slightly and making approximately half of the strokes near the perimeter, and then progressing with vertical strokes spirally toward the center. Rod the bottom layer throughout its depth. For each upper layer, allow the rod to penetrate through the layer being rodded and into the layer below approximately 1 in. [25 mm].

7.3 In filling and rodding the top layer, heap the concrete above the mold before rodding is started. If the rodding operation results in subsidence of the concrete below the top edge of the mold, add additional concrete to keep an excess of concrete above the top of the mold at all times. After the top layer has been rodded, strike off the surface of the concrete by means of a screeding and rolling motion of the tamping rod. Continue to hold the mold down firmly and remove concrete from the area surrounding the base of the mold to preclude interference with the movement of slumping concrete. Remove the mold immediately from the concrete by raising it carefully in a vertical direction. Raise the mold a distance of 12 in. [300 mm] in 5 ± 2 s by a steady upward lift with no lateral or torsional motion. Complete the entire test from the start of the filling through removal of the mold without interruption and complete it within an elapsed time of 2½ min.

7.4 Immediately measure the slump by determining the vertical difference between the top of the mold and the displaced original center of the top surface of the specimen. If a decided falling away or shearing off of concrete from one side or portion of the mass occurs (Note 6), disregard the test and make a new test on another portion of the sample.

NOTE 6—If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of the concrete from the mass of the specimen, the concrete probably lacks necessary plasticity and cohesiveness for the slump test to be applicable.

8. Report

8.1 Report the slump in terms of inches [millimetres] to the nearest ¼ in. [5 mm] of subsidence of the specimen during the test.

9. Precision and Bias[4]

9.1 *Precision*—The estimates of precision for this test method are based upon results from tests conducted in Fayetteville, Arkansas by 15 technicians from 14 laboratories representing 3 states. All tests at 3 different slump ranges, from 1.0 in. [25 mm] to 6.5 in. [160 mm], were performed using one load of truck-mixed concrete. The concrete was delivered and tested at a low slump, with water then being added and mixed into the remaining concrete to independently produce moderate and finally high-slump concrete. The concrete mixture that used a No. 67 crushed limestone aggregate and a washed river sand, contained 500 lb of cementitious materials per cubic yard [297 kg of cementitious material per cubic metre]. The 500 lb [227 kg] were equally divided between a C150, Type I/II cement and a Class C fly ash. A double dosage of a chemical retarder was used in an attempt to minimize slump losses and maintain workability of the concrete. Concrete temperatures ranged from 86 to 93 °F [30 to 34 °C]. Slump losses averaged 0.68 in. [17 mm] during the 20 min required to perform a series of 6 tests at 1 slump range. Testing was performed alternately using metal and plastic molds, which were determined to produce comparable results. Precision data thus applies to both metal and plastic molds. A total of 270 slump tests were performed.

9.1.1 *Inch-Pound [SI]*—The data used to develop the precision statement were obtained using metric units (millimetres). The precision values shown in inch-pound units are conversions from the millimetre measurements, which were recorded to the nearest 1 mm.

9.1.2 *Measure of Variability*—The standard deviation was determined to be the most consistent measure of variability and was found to vary with the slump value.

9.1.3 *Single-Operator Precision*—The single-operator standard deviation represented by (1s) is shown in Table 1 by average slump values. The reported results for the replicate readings apply to tests conducted by the same operator performing successive tests, one immediately following the other. Acceptable results of two properly conducted tests by the same operator on the same material (Note 7) will not differ from each other by more than the (d2s) value of the last column of Table 1 for the appropriate slump value and single-operator precision.

9.1.4 *Multilaboratory Precision*—The multilaboratory standard deviation represented by (1s) is shown in Table 1 by average slump values. The reported results for the replicate readings apply to tests conducted by different operators from different laboratories performing tests less than 4 min apart. Therefore, acceptable results of two properly conducted slump tests on the same material (Note 7) by two different laboratories will not differ from each other by more than the (d2s) value of the last column of Table 1 for the appropriate slump value and multilaboratory precision.

TABLE 1 Precision

Slump and Type Index	Standard Deviation (1s)[A]		Acceptable Range of Two Results (d2s)[A]	
Single-Operator Precision:	in.	[mm]	in.	[mm]
Slump 1.2 in. [30 mm]	0.23	[6]	0.65	[17]
Slump 3.4 in. [85 mm]	0.38	[9]	1.07	[25]
Slump 6.5 in. [160 mm]	0.40	[10]	1.13	[28]
Multilaboratory Precision:				
Slump 1.2 in. [30 mm]	0.29	[7]	0.82	[20]
Slump 3.4 in. [85 mm]	0.39	[10]	1.10	[28]
Slump 6.5 in. [160 mm]	0.53	[13]	1.50	[37]

[A] These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C670.

[4] The test data used to develop this precision statement were based on tests performed in September 1997. Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1022.

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NOTE 7—"Same materials," is used to mean freshly mixed concrete from one batch.

9.2 *Bias*—This test method has no bias since slump is defined only in terms of this test method.

10. Keywords

10.1 concrete; concrete slump; cone; consistency; plasticity; slump; workability

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this standard since the last issue (C143/C143M – 15) that may impact the use of this standard. (Approved Dec. 15, 2015.)

(1) Revised 5.1.1.

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STUDY QUESTIONS

Test Method C143/C143M – 15a
Slump of Hydraulic-Cement Concrete

1. The slump test is applicable to plastic concrete with a maximum size aggregate of _____.
2. When the concrete contains aggregate larger than allowed for the slump test, the large aggregate must be _____.
3. The mold for making the slump test is in the shape of _____.
4. The height of the slump mold is _____.
5. The interior surface of the slump mold is allowed to have minor irregularities. *True or False?*
6. For use in the slump test, the tamping end or both ends of the tamping rod must be _____ _____.
7. The sample of concrete for use in making the slump test must be obtained in accordance with Practice _____.
8. The slump mold should be in a dry condition before beginning the test. *True or False?*
9. The surface on which the slump mold will be placed must be _____ _____.
10. The slump mold is filled in _____ layers.
11. Each layer should fill approximately _____ the volume of the mold.
12. The approximate concrete depth (in vertical distance) after placing the first layer is _____, and the second layer is _____.
13. Rod each layer _____ times uniformly over the cross section with the rounded end of the rod.
14. How deep should the tamping rod penetrate into each layer? _____ _____ _____
15. When rodding the bottom layer, the tamping rod must be _____ to uniformly distribute the strokes.
16. What must be done if the concrete drops below the top of the slump mold while the top layer is being rodded? _____ _____
17. Prior to lifting the mold, concrete must be removed from _____ _____.
18. After the final rodding, the sides of the slump mold should be tapped lightly with the tamping rod. *True or False?*
19. When raising the slump mold, it should not be rotated or twisted. *True or False?*

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STUDY QUESTIONS

20. How much time is allowed for lifting the slump mold? _____

21. The measurement for slump is made from the top of the mold to what point of the concrete specimen? _____

_____

22. The slump of the concrete is measured and reported to the nearest _____.

23. How much time is allowed to conduct the slump test from beginning to completion? _____

Answers to study questions are included in Study Materials.

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PERFORMANCE CHECKLIST

Test Method C143/C143M – 15a
Slump of Hydraulic-Cement Concrete

Following is a summary of the key steps involved in determining the slump of hydraulic-cement concrete. This summary is derived from the actual checklist used in the ACI performance examination. It can be used to familiarize yourself with the basic procedures of this method before proceeding with your study of the ASTM Standard itself. **However, this summary is not intended to take the place of your complete study of the ASTM Standard.**

1. Dampen the mold. (Para. 7.1)

2. Place the mold on a rigid, flat, level, moist, nonabsorbent surface, free of vibration, that is large enough to contain all of the slumped concrete. (Para. 7.1)

3. Hold the mold firmly in place during filling and cleaning by standing on the two foot pieces on either side of the mold. A base plate with clamps is also acceptable. (Para. 7.1)

4. Using a scoop, fill the mold in three layers, moving the scoop around the perimeter of the mold opening to ensure an even distribution of the concrete. For the first layer:

   A. Fill the mold to approximately 1/3 of its volume (2-5/8 in. [70 mm]). (Para. 7.1 and Note 5)

   B. Rod the layer 25 times throughout its depth with the rounded end of the tamping rod. Uniformly distribute the strokes over the cross section of the layer. Incline the rod slightly, starting near the perimeter, and progress with vertical strokes spirally toward the center. (Para. 7.2)

5. For the second layer:

   A. Fill the mold to approximately 2/3 of its volume (6-1/8 in. [160 mm]). (Para. 7.1 and Note 5)

   B. Rod the layer 25 times uniformly over the cross section, with the rounded end of the rod. Rod through the layer and into the layer below approximately 1 in. [25 mm]. Uniformly distribute the strokes over the cross section of the layer. (Para. 7.2)

6. For the third layer:

   A. Heap concrete above the top of the mold. (Para. 7.3)

   B. Rod the layer 25 times uniformly over the cross section, with the rounded end of the rod. Rod through the layer and into the layer below approximately 1 in. [25 mm]. Uniformly distribute the strokes over the cross section of the layer. (Para. 7.2)

   C. Should rodding the layer result in the concrete falling below the top of the mold, add concrete to keep an excess above the mold. Continue the rodding count from the value reached before concrete was added to the mold. (Para. 7.3)

7. Strike off the top surface of concrete with the tamping rod in a screeding and rolling motion. (Para. 7.3)

8. While maintaining downward pressure, remove any concrete which collected around the base of the mold during strike off. (Para. 7.3)

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9. Immediately remove the mold by raising it in a steady, vertical direction. There should be no lateral or torsional motion of the mold while lifting. Lift the mold off the concrete, a distance of 12 in. [300 mm], in 5 ± 2 s. (Para. 7.3)

10. Complete the slump test, from the start of filling the mold through the removal of the mold, in 2-1/2 min. (Para. 7.3)

11. If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample. (Para. 7.4)

12. Immediately measure the slump. This is the vertical distance between the top of the mold and the displaced original center of the top surface of the specimen. (Para. 7.4)

13. Report the slump to the nearest 1/4 in. [5 mm]. (Para. 8.1)

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SECTION 4

ASTM C138/C138M
Standard Test Method for
Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

Introduction

The density test is a very important tool used to control the quality of freshly-mixed concrete. After a concrete mixture proportion has been established, a change in the concrete's density will indicate a change in one or more of the other concrete performance requirements. A lower density may indicate 1) that the materials have changed [lower specific gravity], 2) a higher air content, 3) a higher water content, 4) a change in the proportions of ingredients, and/or 5) a lower cement content. Conversely, the higher density would indicate the reverse of the above-mentioned concrete characteristics.

A lower density from the established concrete mix proportion will generally indicate an over-yield. This means that the required cement content for a cubic meter or cubic yard is now diluted to produce a greater volume of concrete. Therefore, lower strengths are to be expected as well as a reduction of the other desirable qualities of the concrete. If the reduction of the density of the concrete was due to an increase in air content, possibly the concrete will be more durable in its resistance to cycles of freezing and thawing, but the strength, abrasion resistance, resistance to chemical attack, shrinkage, and cracking qualities of concrete will be adversely affected.

The density test must be used to control lightweight and heavyweight concretes. A change in density could adversely affect the pumpability, placeability, finishability, and strength of all types of concrete.

Because the density test is so important to regulate the quality of concrete, it is very important that the test be conducted in accordance with the specified standard procedures. The exact volume of the container must be known and after the sample of concrete is struck off level, any concrete adhering to the outside of the container must be removed before weighing the sample.

The density test can also be used to determine the air content (percentage of voids) of concrete, as long as the theoretical weight of the concrete computed on an air-free basis (kg/m^3 or lb/ft^3) is known.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: C138/C138M – 17a

American Association State
Highway and Transportation Officials Standard
AASHTO No.: T121

Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete[1]

This standard is issued under the fixed designation C138/C138M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers determination of the density (see Note 1) of freshly mixed concrete and gives formulas for calculating the yield, cement content, and air content of the concrete. Yield is defined as the volume of concrete produced from a mixture of known quantities of the component materials.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

NOTE 1—Unit weight was the previous terminology used to describe the property determined by this test method, which is mass per unit volume.

1.3 The text of this test method references notes and footnotes that provide explanatory information. These notes and footnotes (excluding those in tables) shall not be considered as requirements of this test method.

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.* (**Warning—**Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C143/C143M Test Method for Slump of Hydraulic-Cement Concrete

C150/C150M Specification for Portland Cement

C172/C172M Practice for Sampling Freshly Mixed Concrete

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

C188 Test Method for Density of Hydraulic Cement

C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C1758/C1758M Practice for Fabricating Test Specimens with Self-Consolidating Concrete

3. Terminology

3.1 *Symbols:*

A = air content (percentage of voids) in the concrete
C = actual cement content, kg/m^3 [lb/yd^3]
C_b = mass of cement in the batch, kg [lb]
D = density (unit weight) of concrete, kg/m^3 [lb/ft^3]
M = total mass of all materials batched, kg [lb] (see Note 3)
M_c = mass of the measure filled with concrete, kg [lb] or
M_m = mass of the measure, kg [lb]
R_y = relative yield
T = theoretical density of the concrete computed on an airfree basis, kg/m^3 [lb/ft^3] (see Note 2)

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.60 on Testing Fresh Concrete.

Current edition approved March 15, 2017. Published May 2017. Originally approved in 1938. Last previous edition approved in 2017 as C138/C138M – 17. DOI: 10.1520/C0138_C0138M-17A.

[2] See section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol 04.02.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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Y = yield, volume of concrete produced per batch, m^3 [yd^3]
Y_d = volume of concrete which the batch was designed to produce, m^3 [yd^3]
Y_f = volume of concrete produced per batch, m^3 [ft^3]
V = total absolute volume of the component ingredients in the batch, m^3 [ft^3]
V_m = volume of the measure, m^3 [ft^3]

NOTE 2—The theoretical density is, customarily, a laboratory determination, the value for which is assumed to remain constant for all batches made using identical component ingredients and proportions.

NOTE 3—The total mass of all materials batched is the sum of the masses of the cement, the fine aggregate in the condition used, the coarse aggregate in the condition used, the mixing water added to the batch, and any other solid or liquid materials used.

4. Apparatus

4.1 *Balance*—A balance or scale accurate to 45 g [0.1 lb] or to within 0.3 % of the test load, whichever is greater, at any point within the range of use. The range of use shall be considered to extend from the mass of the measure empty to the mass of the measure plus its contents at 2600 kg/m^3 [160 lb/ft^3].

4.2 *Tamping Rod*—A round, smooth, straight steel rod, with a 16 mm [⅝ in.] ± 2 mm [1⁄16 in.] diameter. The length of the tamping rod shall be at least 100 mm [4 in.] greater than the depth of the measure in which rodding is being performed, but not greater than 600 mm [24 in.] in overall length (see Note 4). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 4—A rod length of 400 mm [16 in.] to 600 mm [24 in.] meets the requirements of the following: Practice C31/C31M, Test Method C138/C138M, Test Method C143/C143M, Test Method C173/C173M and Test Method C231/C231M.

4.3 *Internal Vibrator*—The vibrator frequency shall be at least 9000 vibrations per minute [150 Hz] while the vibrator is operating in the concrete. The outside diameter or the side dimension of the vibrating element shall be at least 19 mm [0.75 in.] and not greater than 38 mm [1.50 in.]. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 75 mm [3 in.]. The vibrator frequency shall be checked with a vibrating reed tachometer at an interval not to exceed two years. If the vibrator manufacturer recommends a shorter verification interval, a verification procedure, or other verification device, the manufacturer's recommendation shall be followed.

4.4 *Measure*—A cylindrical container made of steel or other suitable metal (see Note 5). The minimum capacity of the measure shall conform to the requirements of Table 1 based on the nominal size of aggregate in the concrete to be tested. All measures, except for measuring bowls of air meters which are also used for Test Method C138/C138M tests, shall conform to the requirements of Test Method C29/C29M. When measuring bowls of air meters are used, they shall conform to the requirements of Test Method C231/C231M, and shall be calibrated for volume as described in Test Method C29/C29M. The top rim of the air meter bowls shall be smooth and plane within 0.01 in. [0.3 mm] (see Note 6).

NOTE 5—The metal should not be readily subject to attack by cement paste. However, reactive materials such as aluminum alloys may be used in instances where as a consequence of an initial reaction, a surface film is rapidly formed which protects the metal against further corrosion.

TABLE 1 Capacity of Measures

Nominal Maximum Size of Coarse Aggregate		Capacity of Measure[A]	
mm	[in.]	L	[ft^3]
25.0	[1]	6	[0.2]
37.5	[1½]	11	[0.4]
50	[2]	14	[0.5]
75	[3]	28	[1.0]
112	[4½]	70	[2.5]
150	[6]	100	[3.5]

[A] The indicated size of measure shall be used to test concrete containing aggregates of a nominal maximum size equal to or smaller than that listed. The actual volume of the measure shall be at least 95 % of the nominal volume listed.

NOTE 6—The top rim is satisfactorily plane if a 0.3-mm [0.01-in.] feeler gage cannot be inserted between the rim and a piece of 6-mm [¼-in.] or thicker plate glass laid over the top of the measure.

4.5 *Strike-Off Plate*—A flat rectangular metal plate at least 6 mm [¼ in.] thick or a glass or acrylic plate at least 12 mm [½ in.] thick with a length and width at least 50 mm [2 in.] greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of 2 mm [1⁄16 in.].

4.6 *Mallet*—A mallet (with a rubber or rawhide head) having a mass of 600 ± 200 g [1.25 ± 0.50 lb] for use with measures of 14 L [0.5 ft^3] or smaller, and a mallet having a mass of 1000 ± 200 g [2.25 ± 0.50 lb] for use with measures larger than 14 L [0.5 ft^3].

4.7 *Scoop*—of a size large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so it is not spilled during placement in the measure.

5. Sample

5.1 Obtain the sample of freshly mixed concrete in accordance with Practice C172/C172M.

6. Procedure

6.1 Base the selection of the method of consolidation on the slump, unless the method is stated in the specifications under which the work is being performed. The methods of consolidation are rodding and internal vibration. Rod concretes with a slump greater than 75 mm [3 in.]. Rod or vibrate concrete with a slump of 25 to 75 mm [1 to 3 in.]. Consolidate concretes with a slump less than 25 mm [1 in.] by vibration.

NOTE 7—Nonplastic concrete, such as is commonly used in the manufacture of pipe and unit masonry, is not covered by this test method.

6.2 Dampen the interior of the measure and remove any standing water from the bottom. Determine the mass of the empty measure to an accuracy consistent with the requirements of 4.1. Place the measure on a flat, level, firm surface. Place the concrete in the measure using the scoop described in 4.7. Move the scoop around the perimeter of the measure opening to ensure an even distribution of the concrete with minimal segregation. Fill the measure in the number of layers required by the consolidation method (6.3 or 6.4).

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6.2.1 Follow the procedures in Practice C1758/C1758M for filling the measure, if self-consolidating concrete is being tested. Upon completion of the filling process, proceed to 6.6.

6.3 *Rodding*—Place the concrete in the measure in three layers of approximately equal volume. Rod each layer with 25 strokes of the tamping rod when nominal 14-L [0.5-ft^3] or smaller measures are used, 50 strokes when nominal 28-L [1-ft^3] measures are used, and one stroke per 20 cm^2 [3 in.^{2}] of surface for larger measures. Rod each layer uniformly over the cross section with the rounded end of the rod using the required number of strokes. Rod the bottom layer throughout its depth. In rodding this layer, use care not to damage the bottom of the measure. For each upper layer, allow the rod to penetrate through the layer being rodded and into the layer below approximately 25 mm [1 in.]. After each layer is rodded, tap the sides of the measure 10 to 15 times with the appropriate mallet (see 4.6) using such force so as to close any voids left by the tamping rod and to release any large bubbles of air that may have been trapped. Add the final layer so as to avoid overfilling.

6.4 *Internal Vibration*—Fill and vibrate the measure in two approximately equal layers. Place all of the concrete for each layer in the measure before starting vibration of that layer. Insert the vibrator at three different points for each layer. In compacting the bottom layer, do not allow the vibrator to rest on or touch the bottom or sides of the measure. In compacting the final layer, the vibrator shall penetrate into the underlying layer approximately 25 mm [1 in.] . Take care that the vibrator is withdrawn in such a manner that no air pockets are left in the specimen. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator (see Note 8). Continue vibration only long enough to achieve proper consolidation of the concrete (see Note 9). Observe a constant duration of vibration for the particular kind of concrete, vibrator, and measure involved.

NOTE 8—Usually, sufficient vibration has been applied as soon as the surface of the concrete becomes relatively smooth.

NOTE 9—Overvibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

6.5 On completion of consolidation the measure must not contain a substantial excess or deficiency of concrete. An excess of concrete protruding approximately 3 mm [⅛ in.] above the top of the mold is optimum. A small quantity of concrete may be added to correct a deficiency. If the measure contains a great excess of concrete at completion of consolidation, remove a representative portion of the excess concrete with a trowel or scoop immediately following completion of consolidation and before the measure is struck-off.

6.6 *Strike-Off*—After consolidation, strike-off the top surface of the concrete and finish it smoothly using the flat strike-off plate so that the measure is level full. Strike-off the measure by pressing the strike-off plate on the top surface of the measure to cover about two thirds of the surface and withdraw the plate with a sawing motion to finish only the area originally covered. Then place the plate on the top of the measure to cover the original two thirds of the surface and advance it with a vertical pressure and a sawing motion to cover the whole surface of the measure and continue to advance it until it slides completely off the measure. Incline the plate and perform final strokes with the edge of the plate to produce a smooth surface.

6.7 *Cleaning and Weighing*—After strike-off, clean all excess concrete from the exterior of the measure and determine the mass of the concrete and measure to an accuracy consistent with the requirements of 4.1.

7. Calculation

7.1 *Density (Unit Weight)*—Calculate the net mass of the concrete in pounds or kilograms by subtracting the mass of the measure, M_m, from the mass of the measure filled with concrete, M_c. Calculate the density, D, kg/m^3 [lb/ft^3] , by dividing the net mass of concrete by the volume of the measure, V_m as follows:

$$D = (M_c - M_m) / V_m \quad (1)$$

7.2 *Theoretical Density*—Calculate the theoretical density as follows:

$$T = M / V \quad (2)$$

7.2.1 The absolute volume of each ingredient in cubic meters is equal to the mass of the ingredient in kilograms divided by 1000 times its relative density (specific gravity). The absolute volume of each ingredient in cubic feet is equal to the quotient of the mass of that ingredient divided by the product of its relative density times 62.4 lb/ft^3. For the aggregate components, base the relative density and mass on the saturated, surface-dry condition. For cement, determine the actual relative density using Test Method C188. It is permitted to use a value of 3.15 for the relative density of portland cements that conform to Specification C150/C150M. The relative density used for other cements and supplementary cementitous material shall be as determined by testing or as supplied by the material's manufacturer.

7.3 *Yield*—Calculate the yield as follows:

$$Y(\text{yd}^3) = M / (D \times 27) \quad (3)$$

or

$$Y(\text{m}^3) = M / D \quad (4)$$

7.4 *Relative Yield*—Relative yield is the ratio of the actual volume of concrete obtained to the volume as designed for the batch (see Note 10) calculated as follows:

$$R_y = Y / Y_d \quad (5)$$

NOTE 10—A value for R_y greater than 1.00 indicates an excess of concrete being produced whereas a value less than 1.00 indicates the batch to be "short" of its designed volume. In the inch-pound system, a ratio of yield in cubic feet per cubic yard of design concrete mixture is frequently used, for example, 27.3 ft^3/yd^3.

7.5 *Cement Content*—Calculate the actual cement content as follows:

$$C = C_b / Y \quad (6)$$

7.6 *Air Content*—Calculate the air content as follows:

$$A = [(T - D) / T] \times 100 \quad (7)$$

or

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$$A = [(Y - V) / Y] \times 100 \text{ (SI units)} \quad (8)$$

or

$$A = [(Y_f - V) / Y_f] \times 100 \text{ [inch – pound units]} \quad (9)$$

8. Report

8.1 Report the following information:

8.1.1 Identification of concrete represented by the sample.

8.1.2 Date of test.

8.1.3 Volume of density measure to the nearest 0.01 L [0.001 ft^3].

8.1.4 Density (unit weight) to the nearest 1.0 kg/m^3 [0.1 lb/ft^3].

8.1.5 Theoretical density, when requested, to the nearest 1.0 kg/m^3 [0.1 lb/ft^3].

8.1.6 Yield, when requested, to the nearest 0.1 m^3 [0.1 yd^3].

8.1.7 Relative yield, when requested, to the nearest 0.01.

8.1.8 Cement content, when requested, to the nearest 0.5 kg [1.0 lb].

8.1.9 Air content, when requested, to the nearest 0.1 percent.

9. Precision and Bias

9.1 The following estimates of precision for this test method are based on a collection of data from various locations by the National Ready Mixed Concrete Association.[4] The data represent concrete mixtures with slump ranging from 75 to 150 mm [3 to 6 in.] and density ranging from 1842 to 2483 kg/m^3 [115 to 155 lb/ft^3] and included air-entrained and non air-entrained concrete. The study was conducted using 7-L [0.25 ft^3] and 14-L [0.5 ft^3] measures.

9.1.1 *Single-Operator Precision*—The single operator standard deviation of density of freshly mixed concrete has been found to be 0.65 lb/ft^3 [10.4 kg/m^3] (1s). Therefore, results of two properly conducted by the same operator on the same sample of concrete should not differ by more than 1.85 lb/ft^3 [29.6 kg/m^3] (d2s).

9.1.2 *Multi-Operator Precision*—The multi-operator standard deviation of density of freshly mixed concrete has been found to be 13.1 kg/m^3 [0.82 lb/ft^3] (1s). Therefore, results of two properly conducted tests by the two operators on the same sample of concrete should not differ by more than 37.0 kg/m^3 [2.31 lb/ft^3] (d2s).

9.2 *Bias*—This test method has no bias since the density is defined only in terms of this test method.

10. Keywords

10.1 air content; cement content; concrete; relative yield; unit weight; yield

[4] Mullings, G. M., NRMCA/NAA Joint Research Lab Study "Series D324 Accuracy of Concrete Density Test," Feb. 17, 2000.

APPENDIXES

(Nonmandatory Information)

X1. SAMPLE CALCULATIONS (SI UNITS)

X1.1 Concrete Mix Data:

X1.1.1 The following quantities are batched for a designed 10 m^3 load:

Cement	3560 kg
Coarse Aggregate	10 975 kg
Fine Aggregate	8070 kg
Added Water	1216 kg
Total Mass of Materials Batched (*M*)	23 821 kg

X1.1.2 The following are the properties of the aggregates:

Coarse Aggregate	(Moisture content = 2.0%; Absorption = 0.8%; Relative Density (Specific Gravity) SSD = 2.72)
Fine Aggregate	(Moisture content = 4.0%; Absorption = 1.1%; Relative Density (Specific Gravity) SSD = 2.63)

X1.1.3 The following fresh concrete properties were measured at the job site:

Slump	=	115 mm
Air content	=	5.0 %
Density (unit weight)	=	2335 kg/m^3

X1.2 Calculate the Yield (*Y*):

$$Y = M / D = (\text{Total Mass of Materials Batched}) / (\text{Density of Concrete})$$

$$Y = 23821 / 2355 = 10.2 m^3 \quad (X1.1)$$

X1.3 Calculate the Relative Yield (R_Y):

$$R_y = Y / Y_d = (\text{Yield}) / (\text{Design Yield})$$

$$R_y = 10.2 / 10.0 = 1.02 \quad (X1.2)$$

X1.4 Convert the batch mixture proportions of the fine and coarse aggregates to a saturated-surface-dry (SSD) basis, by first dividing the batch quantity of the aggregate by [1 + the moisture content (expressed as a decimal)] to determine the mass of the dry aggregate. Then multiply the mass of the dry aggregate by [1 + the absorption (expressed as a decimal)] to calculate the mass of the SSD aggregate.

Mass of dry coarse aggregate	=	10 975 / 1.02 = 10 760 kg
Mass of coarse aggregate (SSD)	=	10 760 × 1.008 = 10 846 kg
Mixing water contributed by coarse aggregate	=	(2.0 % – 0.8 %) = 1.2 % × 10 760 = 129 kg
Mass of dry fine aggregate	=	8070 / 1.04 = 7760 kg
Mass of fine aggregate (SSD)	=	7760 × 1.011 = 7845 kg
Mixing water contributed by fine aggregate	=	(4.0 % – 1.1%) = 2.9 % × 7760 = 225 kg
Total mixing water	=	batch water + water contributed by aggregates
Total mixing water	=	1216 + 225 + 129 = 1570 kg

X1.5 To obtain the calculated batch quantities per cubic meter, divide the mixture proportions by the actual Yield (*Y*) (10.2 m^3, in this case). Use the SSD basis for the aggregates.

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and the total mixing water. The absolute volume of each ingredient in cubic meters is equal to the mass of the ingredient in kilograms divided by 1000 times its relative density (specific gravity).

	Mass, kg	Absolute Volume, m^3	Calculated Batch Quantity, kg/m^3
Cement	3560	1.13	349
Coarse Agg. (SSD)	10 846	3.99	1063
Fine Agg. (SSD)	7,845	2.983	769
Mixing Water	1570	1.57	154
Total	23 821	9.673	

X1.6 Calculate the Theoretical Density (T) on an air-free basis:

$$T = M / V = \frac{\text{(Total Mass of Materials Batched)}}{\text{(Absolute Volume of Mix Components)}}$$

$$T = 23821 / 9.673 = 2463 \text{ kg/m}^3 \quad \text{(X1.3)}$$

X1.7 The Air Content (A) can be calculated using one of two methods:

$$A = \left[\frac{(T - D)}{T}\right] \times 100 = \left[\frac{\text{(Theoretical Density} - \text{Density)}}{\text{Theoretical Density}}\right] \times 100$$

$$A = [(2463 - 2335) / 2463] \times 100 = 5.2\ \% \quad \text{(X1.4)}$$

or

$$A = \frac{(Y_f - V)}{Y_f} \times 100 = \left[\frac{\text{(Actual Yield} - \text{Sum of Abs. Vols.)}}{\text{Actual Yield}}\right] \times 100$$

$$A = [(10.2 - 9.673) / 10.2] \times 100 = 5.2\ \% \quad \text{(X1.5)}$$

X2. SAMPLE CALCULATIONS (IN-LB UNITS)

X2.1 Concrete Mix Data:

X2.1.1 The following quantities are batched for a designed 10 yd^3 load:

Cement	6000 lb
Coarse Aggregate	18 500 lb
Fine Aggregate	13 600 lb
Added Water	2050 lb (246 gal)
Total Mass of Materials Batched (M)	40 150 lb

X2.1.2 The following are the properties of the aggregates:

Coarse Aggregate	(Moisture content = 2.0%; Absorption = 0.8%; Relative Density (Specific Gravity) SSD = 2.72)
Fine Aggregate	(Moisture content = 4.0%; Absorption = 1.1%; Relative Density (Specific Gravity) SSD = 2.63)

X2.1.3 The following fresh concrete properties were measured at the job site:

Slump	=	4.5 in.
Air content	=	5.0% (by pressure method)
Density (unit weight)	=	145.8 lb/ft^3

X2.2 Calculate the Yield (Y):

$$Y = M / D = \frac{\text{(Total Mass of Materials Batched)}}{\text{(Density of Concrete)}}$$

$$Y = 40150 / 145.8 = 275.4 \text{ ft}^3$$

$$Y = 275.4 / 27 = 10.2 \text{ yd}^3 \quad \text{(X2.1)}$$

X2.3 Calculate the Relative Yield (R_Y).

$$R_Y = Y / Y_d = \text{(Yield)} / \text{(Design Yield)}$$

$$R_Y = 10.2 / 10.0 = 1.02 \quad \text{(X2.2)}$$

X2.4 Convert the batch mixture proportions of the fine and coarse aggregates to a saturated-surface-dry (SSD) basis, by first dividing the batch quantity of the aggregate by [1 + the moisture content (expressed as a decimal)] to determine the mass of the dry aggregate. Then multiply the mass of the dry aggregate by [1 + the absorption (expressed as a decimal)] to calculate the mass of the SSD aggregate.

Mass of dry coarse aggregate	=	18 500 / 1.02 = 18 137 lb
Mass of coarse aggregate (SSD)	=	18 137 x 1.008 = 18 282 lb
Mixing water contributed by coarse aggregate	=	(2.0 % – 0.8 %) = 1.2 % x 18 137 = 218 lb
Mass of dry fine aggregate	=	13 600 / 1.04 = 13 077 lb
Mass of fine aggregate (SSD)	=	13 077 x 1.011 = 13 221 lb
Mixing water contributed by fine aggregate	=	(4.0 % - 1.1 %) = 2.9% x 13 077 = 379 lb
Total mixing water	=	batch water + water contributed by aggregates
Total mixing water	=	2 050 + 218 + 379 = 2 647 lb

X2.5 To obtain the calculated batch quantities per cubic yard, divide the mixture proportions by the actual Yield (Y) (10.2 yd^3, in this case). Use the SSD basis for the aggregates and the total mixing water. The absolute volume of each ingredient in cubic feet is equal to the mass of the ingredient in pounds (lb) divided by 62.4 times its relative density (specific gravity).

	Mass, lb	Absolute Volume,ft^3	Calculated Batch Quantity, lb/yd^3
Cement	6000	30.53	588
Coarse Agg. (SSD)	18 282	107.71	1792
Fine Agg. (SSD)	13 221	80.56	1296
Mixing Water	2647	42.42	260
Total	40 150	261.22	

X2.6 Calculate the Theoretical Density (T) on an air-free basis:

$$T = M / V = \frac{\text{(Total Mass of Materials Batched)}}{\text{(Absolute Volume of Mix Components)}}$$

$$T = 40150 / 261.22 = 153.7 \text{ lb/ft}^3 \quad \text{(X2.3)}$$

X2.7 The Air Content (A) can be calculated using one of two methods:

$$A = (T - D) / T \times 100 = \left[\frac{\text{(Theoretical Density} - \text{Density)}}{\text{Theoretical Density}}\right] \times 100$$

$$A = [(153.7 - 145.8) / 153.7] \times 100 = 5.1\ \% \quad \text{(X2.4)}$$

or

$$A = [(Y_f - V) / Y_f] \times 100$$

$$A = \left[\frac{\text{(Vol. of Concrete Prod. per Batch} - \text{Sum of Abs. Vols.)}}{\text{Vol. of Concrete Prod. per Batch}}\right] \times 100$$

$$A = [(275.38 - 261.22) / 275.38] \times 100 = 5.1\ \% \quad \text{(X2.5)}$$

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$Y = 23821 / 2355 = 10.2 m^3$ (X1.1)

X1.5 To obtain the calculated batch quantities per cubic meter, divide the mixture proportions by the actual Yield (*Y*)

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this standard since the last issue (C138/C138M – 17) that may impact the use of this standard. (Approved March 15, 2017.)

(1) Added Practice C1758/C1758M to 2.1. *(2)* Added 6.2.1.

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STUDY QUESTIONS

Test Method C138/C138M – 17a
Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

1. The diameter of the tamping rod used in this test method is _____.
2. What is the required shape of the tamping end of the rod? _____
3. What is the required minimum frequency of the vibrator used in this test method? _____
   _____
4. The outside diameter or side dimension of the vibrating element must be at least _____ but not greater than _____.
5. A plastic container can be used for the measure in this test method. *True or False?*
6. What is the minimum thickness of a metal strike-off plate? _____
7. What is the minimum thickness for a glass or acrylic strike-off plate? _____
8. What is the specified weight of the mallet used on measures that are 14 L [0.5 ft^3] or smaller?
   _____
9. Measures other than air meter bowls used for this test must conform to Test Method _____.
10. Air meter bowls used for this test must conform to Test Method _____ and be calibrated for volume according to Test Method _____.
11. The concrete sample must be obtained in accordance with what ASTM Practice? _____
12. What method of consolidation must be used when the slump is greater than 75 mm [3 in.]?
    _____
13. What method of consolidation must be used when the slump is less than 25 mm [1 in.]?
    _____
14. If rodding is the method of consolidation being used, the measure must be filled in how many layers? _____
15. For a measure of 14 L [0.5 ft^3], what is the required number of strokes of the tamping rod for consolidation of each layer? _____
16. When rodding the middle and the top layers, the tamping rod should penetrate into the layer below approximately _____.
17. If vibration is the method of consolidation, the measure must be filled in _____ approximately equal layers.
18. If, after consolidation of the final layer, the concrete level is 13 mm [1/2 in.] above the top of the measure, what should be done? _____
    _____
19. After consolidation of the final layer, an excess of concrete _____ above the top of the measure is considered optimum.

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STUDY QUESTIONS

20. After completing the strike-off procedure, what must be done before weighing the measure and sample? _____

21. Density (Unit Weight) Calculation Known:

    Volume of measure = 14.27 L or 0.01427 m^3 [0.504 ft^3]
    Mass of empty measure = 8.89 kg [19.6 lb]

    The procedures of Test Method C138/C138M are followed, and the mass of the measure plus the concrete is found to be 41.78 kg [92.1 lb].

    Calculate the density of the concrete in kg/m^3 [lb/ft^3].

22. Yield calculations for a design batch of 5.4 m^3 [7.0 yd^3], the total mass of all materials batched was 12,383 kg [27,300 lb]. Using the density of the concrete as determined in Question 21, calculate:

    A. The yield per batch in ft^3
    B. The yield per batch in yd^3
    C. The yield in m^3
    D. The yield per cubic yard in ft^3/yd^3

23. Relative Yield Calculation: Using the information given and calculated in Question 22, calculate the relative yield for the batch of concrete.

24. Air Content Calculation: Your air meter has been damaged in transit to the job site. You do, however, possess the theoretical density that was determined in the lab; it is 2426 kg/m^3 [151.4 lb/ft^3].

    Using the density calculated in Question 21, calculate the air content of the batch (in percentage).

Answers to study questions are included in Study Materials.

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Test Method C138/C138M – 17a
Density (Unit Weight), Yield and Air Content (Gravimetric) of Concrete

The following is a summary of the key steps involved in determining the unit weight of concrete. This summary is derived from the actual checklist used in the ACI performance examination. It can be used to familiarize yourself with the basic procedures of this method before proceeding with your study of the ASTM Standard itself. **However, this summary is not intended to take the place of your complete study of the ASTM Standard.**

1. Dampen the interior of the measure and remove any standing water from the bottom of the measure. (Para 6.2)

2. Determine the mass (kg or lb) of the empty measure to be used and place it on a flat, level, firm surface. (Para 6.2)

3. Using a scoop, place the concrete in the measure in three layers of approximately equal volume, moving the scoop around the perimeter of the measure opening to ensure an even distribution of the concrete. For the first layer:

   A. Fill the measure to approximately 1/3 of its volume. (Para. 6.3)

   B. Rod the layer 25 times, uniformly over the cross section, with the rounded end of the rod. Rod the layer throughout its depth using care not to damage the bottom of the measure. (Para. 6.3)

   C. Tap the sides of the measure 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air. (Para. 6.3)

4. For the second layer:

   A. Fill the measure to approximately 2/3 of its volume. (Para. 6.3)

   B. Rod the layer 25 times, uniformly over the cross section, with the rounded end of the rod. Rod through the layer and into the layer below approximately 25 mm [1 in.]. (Para. 6.3)

   C. Tap the sides of the measure 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air. (Para. 6.3)

5. For the third layer:

   A. Add material so as to avoid overfilling. (Para. 6.3)

   B. Rod the layer 25 times, uniformly over the cross section, with the rounded end of the rod. Rod through the layer and into the layer below approximately 25 mm [1 in.]. (Para. 6.3)

   C. Tap the sides of the measure 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air. (Para. 6.3)

6. After consolidating the third layer, an approximate 3 mm [1/8 in.] of excess concrete above the top of the measure is considered optimal. Representative material can be added or removed as needed prior to strike-off. (Para. 6.5)

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7. Strike-off the top surface of the concrete and finish it smoothly with the flat strike-off plate, leaving the measure just level full:

   A. Press the strike-off plate on the top surface of the measure to cover 2/3 of the surface. Withdraw the plate with a sawing motion to finish only the area originally covered. (Para. 6.6)

   B. Place the plate on top of the measure to cover the original 2/3 of the surface. Advance it with a vertical pressure and a sawing motion to cover the whole surface of the measure. Continue to advance the plate until it slides completely off the measure. (Para. 6.6)

   C. Incline the plate and perform several strokes with the edge of the plate to produce a smooth finish. (Para. 6.6)

8. Completely clean the exterior of the measure and determine the mass of the measure filled with concrete. (Para. 6.7)

9. Report the density (unit weight) of the concrete to the nearest 1.0 kg/m^3 [0.1 lb/ft^3]. (Para. 7.1 and 8.1.4)

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SECTION 5

ASTM C231/C231M
Test Method for
Air Content of Freshly Mixed Concrete by the Pressure Method

Introduction

This test method can be used to determine the air content of normal and heavyweight concretes. However, it cannot be used with highly porous aggregates, such as found in lightweight concrete. This test method will determine the amount of both the entrained and entrapped air voids in the concrete.

Air entrainment is necessary in concrete that will be exposed to cycles of freezing and thawing, and to deicing chemicals. The microscopic entrained air voids provide a source of internal pressure relief within the concrete to accommodate the pressures that develop as ice crystals form in the pores and capillaries of the concrete. Without the proper air content in the mortar fraction of the concrete, normal concrete that is exposed to cycles of freezing and thawing will scale and/or spall, resulting in a durability failure of the concrete.

However, care must be taken not to have too much entrained air in the concrete. In concretes designed to produce 20 to 35 MPa (3000 to 5000 psi), as the air content increases (say, above 5%) there will be a corresponding reduction in the strength of the concrete. Typically, this strength reduction will be on the order of 3 to 5% for each one percent of air content above the design value. For example, a concrete proportioned for 5% air will be approximately 15 to 25% lower in strength if the air content rises to 10%.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: C231/C231M – 17a

Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[1]

This standard is issued under the fixed designation C231/C231M; 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.

1. Scope*

1.1 This test method covers determination of the air content of freshly mixed concrete from observation of the change in volume of concrete with a change in pressure.

1.2 This test method is intended for use with concretes and mortars made with relatively dense aggregates for which the aggregate correction factor can be satisfactorily determined by the technique described in Section 6. It is not applicable to concretes made with lightweight aggregates, air-cooled blast-furnace slag, or aggregates of high porosity. In these cases, Test Method C173/C173M should be used. This test method is also not applicable to nonplastic concrete such as is commonly used in the manufacture of pipe and concrete masonry units.

1.3 The text of this test method references notes and footnotes that provide explanatory information. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

C143/C143M Test Method for Slump of Hydraulic-Cement Concrete

C172/C172M Practice for Sampling Freshly Mixed Concrete

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

3. Significance and Use

3.1 This test method covers the determination of the air content of freshly mixed concrete. The test determines the air content of freshly mixed concrete exclusive of any air that may exist inside voids within aggregate particles. For this reason, it is applicable to concrete made with relatively dense aggregate particles and requires determination of the aggregate correction factor (see 6.1 and 9.1).

3.2 This test method and Test Method C138/C138M and C173/C173M provide pressure, gravimetric, and volumetric procedures, respectively, for determining the air content of freshly mixed concrete. The pressure procedure of this test method gives substantially the same air contents as the other two test methods for concretes made with dense aggregates.

3.3 The air content of hardened concrete may be either higher or lower than that determined by this test method. This

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.60 on Testing Fresh Concrete.

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[2] Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol 04.02.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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