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Standard Practice for Examination and Sampling of Hardened Concrete in Constructions[1]

This standard is issued under the fixed designation C823/C823M; 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 Department of Defense.

1. Scope *

1.1 This practice outlines procedures for visual examination and sampling of hardened concrete in constructions. Reference is made to the examination and sampling of concrete in prefabricated building units, precast products, and laboratory specimens.

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

1.3 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C125 Terminology Relating to Concrete and Concrete Aggregates
C215 Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens
C295 Guide for Petrographic Examination of Aggregates for Concrete
C457 Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete
C597 Test Method for Pulse Velocity Through Concrete
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C856 Practice for Petrographic Examination of Hardened Concrete
E105 Practice for Probability Sampling of Materials
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E141 Practice for Acceptance of Evidence Based on the Results of Probability Sampling

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology C125.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *concrete constructions*, *n*—any object, unit, or structure that has been built of hydraulic cement concrete.

3.2.2 *category of concrete*, *n*—a specified level of quality in concrete that is observed to be in a definable range of condition as a result of service or test exposure, as distinguished from concrete in the same or related constructions that is either of differing specified quality or of the same specified quality but in observably different condition at the time of examination. It is also used to refer to concrete having a certain attribute or attributes. (see the Sampling Plan Section).

[1] This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates , and is the direct responsibility of Subcommittee C09.65 on Petrography.

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[2] 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. Significance and Use

4.1 The examination may provide a basis for laying out in situ testing of the concrete.

4.2 The sampling can provide materials for petrographic examination, in accordance with Practice C856, chemical or physical analytical procedures, or any of a wide variety of destructive or nondestructive tests to determine physical, mechanical, or structural properties of the concrete.

4.3 The results of examination and sampling carried out in accordance with this practice may be used for a variety of purposes and to serve a variety of objectives, some of which are discussed in the Procedural Plan Section.

5. Qualifications and Instruction of Personnel

5.1 *Qualifications*—The examination, formulation of sampling plan, and the sampling procedures shall be performed by persons qualified by education and experience to carry out such work, to operate equipment employed, to record and interpret observations, and to report upon the sampling plan and its execution. Technicians and workmen may be required to assist in the operations but appropriate training and supervision are mandatory.

5.2 *Instruction of Personnel*—This practice may be used by personnel employed directly by those for whom the examination and sampling program are conducted. The employer should tell the personnel in as much detail as necessary, the purposes and objectives of the examination, the kind of information sought, and the extent of examination and sampling desired. Pertinent background information should be made available. If the person to perform the work is highly experienced, the employer should seek his or her advice in delineating the investigation. The nature, extent, and objectives of the examination and sampling plan should be recorded, and the record may appropriately include the items under Agreements with Consultants.

5.3 *Agreements with Consultants*—This practice may be the basis for establishing arrangements between a purchaser of a consulting service and the consultant. The purchaser and consultant should jointly determine the nature, extent, and objectives of the examination and sampling program to be made, and should record their agreement in writing. The agreement may stipulate specific determinations to be made, observations to be reported, numbers and kinds of samples to be taken, level of reliability required for results of tests, portions of the constructions to be sampled, funds to be obligated, a time schedule for the investigation, or a combination of these and other conditions.

EXAMINATION OF CONCRETE IN CONSTRUCTIONS

6. Procedural Plan

6.1 *Objective*—The objective of the examination of concrete is to provide information that can be used to evaluate the condition of the concrete and the constructions, and to corroborate observed satisfactory performance, or to document and explain distress or failure. The examination of concrete in service or under test should be undertaken in accordance with a scope, an objective, and systematic procedures, all agreed upon between the responsible parties. The extent of the investigation and the procedures that are most appropriate for the examination depend upon a decision as to the objectives of the investigation and the level of reliability required of resulting test data. This decision may stipulate an authorized budget and a time schedule for completion of various stages of the investigation. The budget and time schedule can be modified following preliminary investigations and adjusted periodically as information accumulates.

6.2 *Purpose*—Investigations of the condition of concrete in service are usually undertaken for the following reasons: (*a*) to determine the ability of the concrete to perform satisfactorily under anticipated conditions of future service; (*b*) to identify the processes or materials causing distress or failure; (*c*) to discover conditions in the concrete that caused or contributed to satisfactory performance or to failure; (*d*) to establish methods for repair or replacement without hazard of recurrence of the distress; *(e)* to determine conformance with construction specification requirements; (*f*) to develop data to aid in fixing financial and legal responsibility for cases involving failure or unsatisfactory service; and (*g*) to evaluate the performance of the components used in the concrete. It is assumed that the manager of the investigation will begin with one or more working hypotheses, derived from information received or gathered, that are intended to explain the reasons for the condition or conditions of the concrete, and that will be continuously revised and refined as more information is received. It is intended that at the end of the investigation, an explanation will have been produced which is the best obtainable from the investigation of the available evidence concerning the mechanisms that operated to produce the condition or conditions of the constructions.

6.3 *Scope of Investigation*—The scope of an investigation of concrete in service may be limited to only isolated areas displaying deterioration. Or the investigation may be concerned with general distress, such as excessive deflection or collapse of structural members. It may involve study of the dislocation of entire structures or large portions of structures. The investigation may be confined chiefly to the study of the concrete, or it may require substantial research into other circumstances, such as foundation conditions, conditions of service, construction practices, and comparisons with other structures.

7. Preliminary Investigations

7.1 *Purpose*—The purpose of preliminary investigations is to establish the general condition of the concrete and the existence of any unsatisfactory condition, to describe its nature, and to estimate its extent and possible effect upon the performance, service life, and safety of the structure. An investigation of failure or inadequate performance of concrete in constructions is predicated upon a conclusion, usually by the owner or his representatives, that an unsatisfactory condition exists or is imminent. Such a

conclusion may be in error, either because the observed condition is insignificant, or because the full extent of the actual distress or inadequacy has not been detected.

7.2 *Test Methods*—The preliminary investigation may include, as appropriate, visual inspection of the structure, review of plans and specifications for the work, and examination of available reports of project engineers and inspectors, compilation of available data on service conditions, petrographic examination in accordance with Practice C856, and testing of a few selected samples of concrete and secondary chemical deposits in or on the concrete or both. Deflection or expansion (or shrinkage) of typical portions of the structure might appropriately be measured. The condition of the concrete in place can be estimated using nondestructive testing procedures, such as impact devices and ultrasonic methods (see Test Method C597). Selected critical portions of structures may be probed and sampled by drilling (Method C42/C42M). The cores may be tested in accordance with Test Method C215. Borehole cameras and viewing devices have been found to be helpful in specific instances **(1, 2, 3).**[3]

7.3 *Conclusions*—The findings of the preliminary investigation may allay all concern with respect to the condition of the concrete. In certain cases, the findings are adequate for a final conclusion on the significance of observed distress. Otherwise, care should be taken to assure that the preliminary investigation provides the information necessary to delineate a plan for the further investigations covered in Sections 8-14.

8. Assembly of Records

8.1 *Reports and Legal Documents*—The investigation of concrete performance should be preceded or accompanied by the assembly and critical review of records pertaining to the project specifications, construction contract, construction operations, concrete-making materials, weather conditions during and after construction, and the actual conditions of service. Such records should establish the specified requirements for the materials and the completed work, and may reveal circumstances or conditions that caused or contributed to the distress of the concrete. Records of operation and maintenance may describe the beginning and progress of unsatisfactory performance.

8.2 *Interviews*—Interviews with contractors, engineers, inspectors, tradesmen, and suppliers should be conducted to obtain pertinent information that is not included in the written record. Owners, occupants, and users of the constructions should be queried concerning the onset and progress of evident distress, especially with respect to possible relationship to any change of the conditions of use and service.

9. Detailed Investigations of Concrete in Constructions

9.1 *Procedures*—A detailed investigation of concrete in constructions should include all procedures that are required to achieve the approved scope and objectives within the authorized budget and time schedule. After the preliminary investigation to establish the general condition of the concrete and the extent of any unsatisfactory performance, the detailed investigation may comprise: (*a*) thorough examination of the concrete constructions; (*b*) surveys and field tests to define and evaluate the condition of the concrete in place and the safety of the constructions; and (*c*) taking samples to be examined and tested by laboratory procedures.

9.2 *Scope of Field Examination*—A detailed visual examination should be made by personnel familiar with concrete and concrete constructions. This examination should locate and describe all of the categories of concrete. All affected constructions or portions thereof should be identified and the external aspects of failure should be described as quantitatively as possible. The examination may be extended to aggregate sources in accordance with the procedures described in Practice C295. Photographs of pertinent features of the constructions, their environs, and the manifestations of failure are valuable and should be obtained.

9.3 *Observations*—Features of the concrete to be noted especially include: (*a*) the nature and extent of cracking and fractures; (*b*) evidences of volume change, deflection, or dislocation of the constructions or portions thereof, which may include the closing or opening of joints, tilting, shearing, or misalignment of structural elements and shifting or misalignment of machinery; (*c*) the condition of exposed surfaces, especially such features as spalling, popouts, unusual weakness, disintegration, excessive wear, and discoloration; (*d*) evidences of cement-aggregate reactions; (*e*) secondary deposits on surfaces, in cracks, and in voids; and (*f*) the presence and extent of repair work and the quality of its bond to the original concrete.

9.3.1 Some of the features listed in this section can be detected more readily in laboratory examination.

9.3.2 Some of the other properties of the concrete requiring observation include: the thoroughness of consolidation; whether the concrete is air-entrained; evidences of segregation and bleeding; indications of extremely high, low, or normal water content; in the case of reinforced concrete, the condition of the steel and its location in the section; and the nature and condition of other embedded items.

9.3.3 Any phenomena indicating distress of the concrete should be studied in relation to possible causative or contributory factors, such as varying conditions of exposure over the area of the constructions; the sequence of placing operations; conditions prevailing during construction; sources of supply of concrete and concrete-making materials; identifiable problems of handling, placing, and finishing; conditions of curing and early protection; and the adequacy of the structural design and conformance to the plans. Varying conditions of exposure over the area of the constructions during and after construction may include the following:

9.3.3.1 Differences in thermal exposure to solar heating. Shaded portions probably are subjected to the lowest range of diurnal thermal cycles,

[3] The boldface numbers in parentheses refer to the list of references at the end of this practice.