Designation: C 823 – ~~95~~00

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

This standard is issued under the fixed designation C 823; 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. ~~Note 1—The procedures are not applicable directly to concrete in place that does not harden in a normal manner or that fails to develop strength sufficient to allow removal of forms or temporary supports or to sustain required loads. Under such circumstances, the actions to be taken are dictated by considerations for safety and requirements for continuation of construction operations.~~

1.2 *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:*

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[1] This practice is under the jurisdiction of ASTM Committee ~~C-9~~ C09 on Concrete and Concrete Aggregates , and is the direct responsibility of Subcommittee C09.65 on Petrography.

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

C 42/C 42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete[2]
C 125 Terminology Relating to Concrete and Concrete Aggregates[2]
C 215 Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens[2]
C 295 Guide for Petrographic Examination of Aggregates for Concrete[2]
C 457 Practice 457 Test Method for Microscopical Determination of Air-Void Content and Parameters of the Air-Void System in Hardened Concrete[2]
C 597 Test Method for Pulse Velocity Through Concrete[2]
C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]
C 856 Practice for Petrographic Examination of Hardened Concrete[2]
E 105 Practice for Probability Sampling of Materials[3]
E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process[3]
E 141 Practice for Acceptance of Evidence Based on the Results of Probability Sampling[3]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology C 125.
3.2 *Definitions of Terms Specific to This Standard:* ~~*Definitions:*~~
~~3.1.1~~
3.2.1 *concrete constructions*, *n*—any object, unit, or structure that has been built of hydraulic cement concrete.
3.~~1~~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).

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 C 856, 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

[2] *Annual Book of ASTM Standards*, Vol 04.02.
[3] *Annual Book of ASTM Standards*, Vol 14.02.

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 ~~verify~~ 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 C 856, 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 C 597). Selected critical portions of structures may be probed and sampled by drilling (Method C 42/C 42M). The cores may be tested in accordance with Test Method C 215. Borehole cameras and viewing devices have been found to be helpful in specific instances **(1, 2, 3).**[4]

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

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

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 C 295. 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,

9.3.3.2 Differences in exposure to moisture, which may arise by orientation of the construction with respect to prevailing winds during times of rainfall or snowfall, and which will be affected by the diurnal thermal cycles,

9.3.3.3 Differences in the mineral composition of the subgrade so that part of the construction is located on a foundation containing swelling clay or containing unstable sulfides or sulfates, or

9.3.3.4 Differences of the moisture content of the subgrade during or after construction.

9.3.4 The foundation and subgrade materials and conditions should also be carefully examined if there is a possibility of their involvement in serviceability of the concrete.

9.3.5 The observations made, together with relevant information developed as described under Assembly of Records, and the results of the preliminary investigations as described in Preliminary Investigations, shall be assembled as may be appropriate into a report which shall either be submitted to those for whom the study was conducted or prepared for incorporation in a more comprehensive document covering other phases of an investigation of broader scope.

SAMPLING CONCRETE IN CONSTRUCTIONS

10. Requirements

10.1 Sampling each category of concrete should be done objectively so that the suite of samples taken is not weighted with unusually poor or unusually sound concrete. Samples may be taken to exemplify unusual or extreme conditions or features to aid in the identification of causes of distress or failure of concrete, but these samples should be kept apart from samples that are taken to exemplify statistically the properties of the concrete in place. Thus, the samples may be of two types, namely, (*a*) those that, together, are intended to be representative of the variability of the concrete in place, and (*b*) those that display specific features of interest but are not intended, individually or collectively, to be representative of any substantial proportion of the concrete in place. In order to be suitable for sampling, the concrete must have developed sufficient strength to allow removal of forms or temporary supports or to sustain required loads.

10.2 The samples should include portions of both near-surface concrete and concrete at depth, because the concrete may vary substantially with depth in the development of cracking, deterioration of the cement paste, progress of cement-aggregate reactions, and other features.

10.3 The samples should be sufficient in size and number to permit application of all necessary laboratory procedures upon different samples or portions of samples than those used for other tests except as noted under the section on Sampling for Compliance with Construction Specifications. Therefore, the sampling program should be arranged with foreknowledge of the laboratory testing program to be covered by the plan of the investigation.

10.4 The samples secured for each test procedure should be sufficient in number to provide an estimate that is of acceptable reliability as described in the Sampling Plan Section.

11. Sampling Plan

11.1 Representative samples should be taken in accordance with a prearranged plan that will meet the stipulations given under Sampling Concrete in Constructions. The plan should also conform with the recommendations of the Sections on Characteristics of a Probability Sampling Plan and Minimum Standards for a Probability Sampling Plan in ~~Recommended~~ Practice E 105. For guides in application of statistical methods to small numbers of samples, see Ref **(4)**. Two sampling situations may arise, namely:

11.1.1 *Situation 1*—The preliminary examination and other information indicate that all of the concrete is in a similar condition and is of similar quality, or that it is infeasible without taking and testing samples, to determine whether or not the concrete is essentially uniform; and

11.1.2 *Situation 2*—The preliminary examination and other information indicate that the concrete is in two or more categories or comprises two or more portions that are or are likely to be of differing composition or quality.

11.2 Under Situation 1, sampling locations should be spread randomly or systematically over the area of interest. For large structures and substantial areas of pavement, the sampling sequence should be repeated at some predetermined frequency, such as for each 500, 1000, or 5000 ft^2 (50, 100, 500 m^2) of exposed concrete, as may be appropriate. Any method for determining sampling locations may be employed provided the locations are established without bias.

11.3 In Situation 2, samples may be taken for comparison with respect to several categories of performance by using the Chi-Square test **(5)**.

11.4 *Recommended Sampling Method*—Prepare to scale an outline sketch or sketches or obtain scaled large photographs of the surface or surfaces from which representative samples are to be extracted, and subdivide the entire area, comprising all of the separate surfaces, into equal or approximately equal sections, at least ten in number and not less than the number of separate areas that are included in the investigation. Designate each section by a number or letter. Choose sections to be sampled by drawing numbered or lettered slips of paper at random from a container, or by using a list of random numbers or letters. Take samples, as by drilling, in accordance with the provisions of the section on Sampling Procedures at locations that are marked at random on the sketch of each of the indicated sections (Note ~~2).~~ 1).

11.4.1 In an investigation of test specimens or concrete products, the units to be examined and tested should be selected randomly by similar means from the lot or lots.

11.4.2 Prefabricated products of large dimension, such as building units, pipe, and piling, can be sampled by the recommended method as it is applied to structures and pavements.

11.4.3 The procedure should be modified as appropriate to provide for sampling concrete members or elements that have been removed from constructions that are under investigation.

NOTE ~~2~~1—If it is necessary to avoid critical reinforcement, embedded hardware, or other construction features, shift the sampling location a minimum necessary distance to the north (or up on vertical surfaces). If such a move is not feasible, shift to the east, south, or west (or right, down, or left), alternatively considered, in that order.

11.5 *Sample Size*—For samples to be subjected to tests yielding a numeric value, the number of samples should be determined in accordance with the recommendations of ~~Recommended~~ Practice E 122, based upon the degree of confidence desired to be placed in the result. The quantity of concrete and the dimensions of pieces secured in the sampling operation should conform with the stipulations of the applicable method of test.

11.6 *Evaluation of Test Results*—Test results from samples obtained in accordance with Situation 1 are evaluated on the basis of the following statistics, average or mean values, $\bar{X}$; standard deviation of individual values, s. These statistics are computed as follows:

$$\bar{X} = \frac{\Sigma X_i}{n} \quad (1)$$

~~where X_i is an individual test result, and n is the number of test results averaged.~~

$$s = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n - 1}} \quad (2)$$

where:

X_i = an individual test result, and

n = the number of test results averaged.

11.6.1 *Evaluation of Test Results on the Basis of Variability*—Variability of test results within a group is indicated by s. Whether or not these statistics are excessively large can only be determined by comparing them with some prior knowledge about what the variability ought to be. The best information on what the variability should be is contained in the precision statement in the test method by which the results were obtained. Directions for obtaining an acceptable range for n individual results and an acceptable difference between the averages of two groups of tests from the same category of concrete are given in Practice C 670.

11.6.2 *Evaluation of the Quality of Concrete*—Quality of the concrete in question can be assessed by comparing the average of test measurements from a group within the category of questionable quality with one obtained from a category of good quality. A Student's t test may be applied to the difference between the two averages to make a decision whether the difference is significant or not **(6)**. Before conducting the t test, other considerations must be borne in mind. These include the nature and intent of the

constructions, the kinds of properties relevant to successful concrete in the constructions, the nature of any distress, the economics of maintenance, the need for repair, if any, and the desired service life of the structure.

11.7 Under Situation 2, each separate category of exposed surface of the concrete constructions, or each category of test specimens or concrete products should be treated individually as under Situation 1 to establish sampling locations and number of samples and to select particular specimens or product units for examination. For example, completely scaled, partially scaled, and unscaled areas of pavement concrete of a specified level of quality should be sampled separately in accordance with the recommended method so that three suites of samples are secured, each suite comprising concrete of a specific category and each conforming with the recommendations of ~~Recommended~~ Practices E 105 and E 122. Any number of suites of samples may be required for proper investigation of concrete that is within the scope of an approved plan so as to adequately evaluate concrete of differing specified levels of quality and concrete in differing condition following the service exposure.

11.8 For purposes of engineering surveys and research programs, the number of samples and their characteristics may be established by responsible personnel in accordance with the scope and objectives of the investigation.

12. Sampling for Compliance with Construction Specifications

12.1 To determine compliance of hardened concrete with requirements of codes or contract specifications, each sample of concrete should be sufficient in quantity and dimensions to permit performance of the applicable test procedure in accordance with the stipulations of the method of test.

12.2 The number of samples to be taken from each category of concrete should be established in accordance with recommendations of ~~Recommended~~ Practices E 105 and E 122 so as to provide a reliable estimate of the standard deviation and average value of the test results. The level of reliability required and the criteria for acceptance of the results as set forth in ~~Recommended~~ Practice E 141 should be established as a part of construction specifications or, if not, as a part of the sampling plan. In the event that no such stipulation has been established beforehand, not less than five samples shall be taken from each category of concrete for each test procedure stipulated in the Procedural Plan, except as provided in 12.3 and 12.4.

12.3 In some instances, two or more tests may be performed on the sample or samples, provided the tests performed initially do not modify the properties of the concrete to be evaluated by subsequent tests. Any such reuse or successive use of samples shall be stipulated in detail beforehand in the sampling plan so as to specify the kinds of tests that may be performed successively, the sequence of testing, and precautions to be taken in performance of the tests and handling of the sample during the course of the testing. Examples of permissible successive testing are unit weight followed by a compression test, air void content in accordance with ~~Practice~~ Test Method C 457 followed by petrographic examination, and compression test followed by chemical test for cement content (provided care is taken to avoid loss of fragments of the specimen).

~~12.4 For purposes of engineering surveys and research programs, the number of samples and their characteristics may be established by responsible personnel in accordance with the scope and objectives of the investigation.~~

13. Sampling Procedures

13.1 In general, samples of hardened concrete from constructions, concrete products of large size, or large test specimens should be secured in accordance with the applicable sections of Test Method C 42/C 42M. Specimens of hardened concrete may be obtained by coring, sawing, or otherwise removing portions of the concrete (Note ~~3~~ 2). Sawing or coring by rotary drilling (Note ~~4~~ 3) is preferred for samples to be subjected to tests of physical properties or to petrographic examination. Caution should be used to avoid or to minimize fracturing the concrete or contamination of the sample with foreign substances. Use of sledges, chisels, and similar tools should be avoided. Their possible effects on the integrity of the sample must be considered during examination and testing of the samples.

NOTE ~~3~~2—Care should be taken to avoid cutting critical sections of reinforcement, conduit, and duct-work.

NOTE ~~4~~3—Diamond-drilled cores are preferred to shot-drilled cores, because the outer surfaces are smoother and reveal the composition and fabric of the concrete more clearly than shot-drilled cores.

13.2 Samples for examination may be secured from small beam or slab specimens or from small prism-shaped or columnar concrete products by sawing across the entire width and depth, for example at the third-points and the middle of the length. Samples from vertically cast concrete cylinders should be secured from top and bottom halves or top, middle, and bottom portions or by sawing the specimen longitudinally. These samples will represent any variability arising as a consequence of placing and compaction procedures, segregation, or bleeding. Similar procedures and precautions should be employed in securing samples from other types of test specimens and concrete products. Methods for obtaining portions of samples for testing purposes are outlined in 13.1, 13.2, and in Table 1.

13.3 If feasible, samples should be taken perpendicular to the layers in which the concrete was deposited. The sample should include the exposed surface, near-surface concrete, any concrete in contact with aggressive waters or other aggressive substances, and concrete at depth. Samples of isolated spalls or popouts should include representative examples of the spalls and popouts and the underlying and adjacent concrete. For sampling, various common types of concrete constructions, recommended minimum depths or thicknesses across which samples should be taken, are shown in Table 1. Deeper drilling may be required to determine the extent of cracking, condition of construction joints, extent of any cement-aggregate reactions, condition of concrete in contact with subgrade material, and variability of the concrete.

TABLE 1 Minimum Depth of Sampling of Concrete for Testing Purposes[A]

Types of Construction	Thickness of Section, ft (m)	Minimum Depth to Be Sampled, ft (m)
Slabs, pavements, walls, linings, foundations, structural	1.0 (0.3) or less	entire depth
elements accessible from one side only	1.0 (0.3) or greater	1.0 (0.3)
Suspended slabs,[B] walls, conduits, foundations, structural	0.5 (0.15) or less	entire depth
elements exposed to the atmosphere at two or more sides; concrete products	0.5–2.0 (0.15–0.3)	one half the thickness or 0.5 (0.15) whichever is greater
Massive sections	2.0 (0.6) or greater	2.0 (0.6)

[A] The requirements of Table 1 may not provide the quantities or dimensions of samples that are required by the stipulations of Sections 11 and 12. In that case, the necessary additional quantity of concrete in pieces of appropriate minimum size should be taken at each sampling location in accordance with the requirements of Section 13.

[B] When suspended slabs are cored, it is desirable to leave the lower 1 in. or 25 mm uncored, so as not to lose the core by its falling from the barrel and to make it easier to patch the core hole.

13.4 Samples should be identified and oriented by painted or inked markings on the material itself, if feasible. The concrete should be wrapped and sealed as may be appropriate to preserve the moisture content representative of the structure at the time of sampling, and should be packed so as to be properly protected from freezing or damage in transit or storage, especially if the concrete is very weak.

14. Information to Accompany Samples

14.1 The personnel who will supervise the laboratory tests, analyses, or examinations of the samples should receive complete information on the identity and sources of the samples and on the problem that is being investigated. In particular, they should be advised of and, preferably, consulted about the specific questions that are to comprise the objectives of the investigation.

14.2 Specific items of information that should be available to the supervisor or consultant are:

14.2.1 Location of the source of each sample, orientation of the sample, depth from which the sample was taken, and sampling procedures. Photographs of samples and of the sampling locations should be provided, if possible.

14.2.2 Report of both the preliminary and detailed field investigations, including a description of the performance of concrete in service and the results of the examination of the concrete in the field. The surveys, field tests, and other pertinent information on the constructions and sources of the concrete and concrete-making materials should be included.

14.2.3 Results of any tests or analyses that were performed on the concrete or concrete-making materials.

15. Keywords

15.1 construction; coring; deterioration; exposure condition; field inspection; hardened concrete; performance; petrographic examination; photograph; representative sample

REFERENCES

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(**2**) Burwell, E. B., Jr., and Nesbitt, R. H., “The NX Borehole Camera,’’ *Mining Engineering,* MIENA Vol 6, No. 8, 1954, pp. 805–808; or *Journal of Metals,* American Institute of Mining, Metallurgical and Petroleum Engineers, JOMTA, Vol 6, No. 11, Section 1, Nov 1954, pp. 1197–1198.

(**3**) Burwell, E. B., Jr., and Nesbitt, R. H., “The NX Borehole Camera,’’ *Systems,* Vol 18, No. 3, 1954, pp. 12–13.

(**4**) Simpson, G. G., Roe, Anne, and Lewontin, R. C., *Quantitative Zoology,* Revised Ed., Harcourt Brace and Co., New York, N. Y., 1960.

(**5**) Natrella, M. G., *Experimental Statistics, NBS Handbook 91,* National Bureau of Standards, NBSHA, Chapter 9, August 1963; Crow, E. L., Davis, F. A., and Maxfield, M. W., *Statistics Manual,* Dover Publications, New York, N.Y., Chapter 8, 1960, p. 209ff; MIL-STD-105 D, 29 April 1963, Military Standard Sampling Procedures and Tables for Inspection by Attributes.

(**6**) Natrella, M. G., *Experimental Statistics,* Chapter 3, 1963.

SUMMARY OF CHANGES

This section identifies the location of changes to this practice that have been incorporated since the last issue. Committee C-9 has highlighted those changes that affect the technical interpretation or use of this practice.

(*1*) Note 1 was reworded and moved to the end of 10.1.
(*2*) C 125 was added to Section 2.
(*3*) Title correction for C 457 in Section 2.
(*4*) Footnotes for Practices E 122 and E 141 were corrected in Section 2.
(*5*) Section 3 was rewritten to comply with Blue Book.
(*6*) First sentence of 7.1 was rewritten.
(*7*) Paragraph 11.6 was edited for clarity, and equations numbered.
(*8*) Paragraph 12.4 was moved to Section 11 as 11.8.