Designation: C 1451 – 99

# Standard Practice for Determining Uniformity of Ingredients of Concrete From a Single Source[1]

This standard is issued under the fixed designation C 1451; 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 a procedure for determining the uniformity of properties of concrete materials from a single source. It includes recommendations on sampling, testing, analysis of data, and reporting.

1.2 The values stated in SI units are to be regarded as 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:*

C 125 Terminology Relating to Concrete and Aggregates[2]

C 219 Terminology Relating to Hydraulic Cement[3]

C 294 Descriptive Nomenclature of Constituents of Natural Mineral Aggregates[2]

C 494 Specification for Chemical Admixtures for Concrete[2]

C 638 Descriptive Nomenclature of Constituents of Aggregates for Radiation Shielding of Concrete[2]

C 917 Test Method for Evaluation of Cement Strength Uniformity from a Single Source[3]

D 75 Practice for Sampling Aggregates[4]

D 3665 Practice for Random Sampling of Construction Materials[4]

## 3. Terminology

3.1 *Definitions*—For definitions of terms relating to this practice refer to Terminology C 125, Terminology C 219, Descriptive Nomenclature C 294, and Descriptive Nomenclature C 638.

## 4. Significance and Use

4.1 This practice provides a systematic procedure for sampling and calculating uniformity of concrete materials. It will measure variability of a property of an ingredient from a single source, over a period of time. The calculation corrects for the effects of testing error. It is applicable to any property of any concrete ingredient. Control of uniformity of concrete relates to controlling or adapting to variability of the ingredients, but this practice does not purport to identify the relative importance of these properties.

## 5. Sampling

5.1 All sampling is to be performed by Quality Control or testing personnel specifically trained for this purpose.

5.2 Take random grab samples from a point in the storage and handling regime of the material that will accurately reflect the uniformity of the material as it will be used in concrete. Practice D 3665 provides general guidance. Additional guidance for specific materials is listed in 5.2.1-5.2.4. The lot size from which a sample is taken shall be determined prior to initiation of this procedure (Note 1). Identify samples by the date on which the material was shipped or received, its source, and designated type and applicable specifications.

NOTE 1—A lot is defined as the quantity in a typical delivery unit, for example, a 25-ton truck of aggregate or a 100-ton railroad car.

5.2.1 Sample cement in accordance with Test Method C 917.

5.2.2 Sample fine and coarse aggregates in accordance with Practice D 75.

5.2.3 Sample chemical admixtures in accordance with Specification C 494.

5.2.4 Sample mineral admixtures in accordance with Practice C 917.

5.3 The required sampling frequency depends on how the data are being used. A producer might reasonably sample relatively frequently, for example, every production lot or day's production. A user might be interested in uniformity of a material over a longer time frame, for example, approximately

[1] This practice is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.94 on Evaluation of Data.

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

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 04.03.

representing the frequency of purchase for a particular application. These two sampling frequencies might indicate different levels of uniformity, therefore, it is important that the sampling program used be described in the report (Section 8).

## 6. Procedure

6.1 *General*—Test all samples in accordance with the appropriate ASTM Test Method for the particular property being measured. Variation within a single source is estimated by first calculating total variation from test data on grab samples, and then correcting this by subtracting variation inherent in the test method (testing error). Best results are obtained if all tests are conducted in the same laboratory, but guidance is provided if it is necessary to use data from more than one laboratory.

6.2 *Total Variation*—Test all samples in accordance with the appropriate ASTM Standard Test Method for the particular test property being measured. Calculate the total variation among the samples, as directed in 7.1.2.

6.3 *Testing Error*—Testing error is comprised of components due to within-laboratory variation and between-laboratory variation. If results are obtained from only one laboratory, then between-laboratory variation makes no contribution. If data are obtained from more than one laboratory, it is preferable to keep data from each one separate during data analysis, pooling estimates of parameters at the end of the analysis.

6.3.1 If no within-laboratory testing standard deviation history has been established, duplicate tests made from a single sample are required to determine this parameter. Samples must be tested in duplicate on different days until at least ten samples have been tested in duplicate. Calculate the standard deviation and the coefficient of variation, as outlined in 7.1.3 and 7.1.4. If the testing error exceeds the level of error reported in the precision statement for the applicable test method, but is less than 1.5 times this value, continue duplicate tests at this same rate. When the testing error is equal to or below the testing error reported in the precision statement, reduce the frequency of duplicate testing. If the testing error exceeds 1.5 times the testing error reported in the precision statement, the data is of unacceptable precision, and the laboratory procedure and equipment should be thoroughly examined. Use the results of duplicate tests, indicating acceptable precision to estimate the single laboratory testing variation for all other types of similar materials tested in that laboratory during the same period of time, provided that duplicate tests have been made on a least one sample per month.

6.3.2 When two or more laboratories are used to evaluate the uniformity of a source, then additional tests of a standard sample or exchanged portions of the same sample may be necessary to determine differences in testing that are likely to be obtained in the different laboratories. When two laboratories exchange portions of the sample and run single tests, results from the laboratories shall not differ by more than the multi-laboratory precision (D2S value) of the average of the two laboratories. If a larger number of samples are exchanged, then the difference between laboratories exceed the D2S no more than 5 % of the time.

6.4 *Single-Source Variation*—Calculate single-source variation according to 7.1.5.

## 7. Calculation

7.1 The calculations shall include the following (Note 2):

NOTE 2—Values for averages and standard deviations can be calculated by other methods that are available in MNL 7 (STP 150).[5] Electronic calculators are available for obtaining these statistics directly.

7.1.1 *Average Measurement*:

$$\bar{x} = \frac{x_1 + x_2 + ... + x_n}{n} \quad (1)$$

where:

$\bar{x}$ = average measurement,
$x_1, x_2, ... x_n$ = individual measurements, and
$n$ = number of individual tests.

7.1.2 *Standard Deviation*:

$$s = \sqrt{\left[\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + ... + (x_n - \bar{x})^2}{(n-1)}\right]} \quad (2)$$

where:

$s_t$ = standard deviation in units of measurement.

7.1.3 *Testing Error:* The standard deviation in testing is calculated as follows:

$$s_e = \sqrt{\frac{\sum d^2}{2k}} \quad (3)$$

where:

$s_e$ = standard deviation estimated from tests of duplicate measurements made in a single laboratory from the sample,
$d$ = difference between duplicate determinations, and
$k$ = number of sets of duplicate determinations.

7.1.4 *Coefficient of Variation:* The coefficient of variation for testing is calculated as follows,

$$CV(\%) = \frac{s_e}{\bar{x}} \cdot 100 \quad (4)$$

7.1.5 *Single-Source Standard Deviation*:

Standard deviation of material from a single source, corrected for testing error is calculated as follows:

$$s_c = \sqrt{s^2 - s_e^2} \quad (5)$$

where:

$s_c$ = standard deviation corrected for testing error,
$s$ = standard deviation for all tests included in the calculation, and
$s_e$ = standard deviation of duplicate tests run on split samples to evaluate testing error.

## 8. Report

8.1 Sufficient information shall be provided to identify the material sampled including the following:

8.1.1 Name of manufacturer and location,
8.1.2 Classification or type of material,
8.1.3 Location of sampling,
8.1.4 Laboratory designation,
8.1.5 Period of time represented by the report, and

[5] *Manual on Presentation of Data and Control Chart Analysis, MNL7 (STP 150)*, 6th edition, ASTM.