CRD-C 55-92

Test Method for Within-Batch Uniformity of Freshly Mixed Concrete

1. Scope

1.1 This standard gives procedures for estimating the uniformity of distribution of constituents within a batch of freshly mixed hydraulic-cement concrete. These data, together with limits based on their use, may provide requirements for uniformity as this should be achieved when a satisfactory mixer mixes a batch of concrete for an appropriate length of time.

1.2 The procedures given in this standard are similar to but different from those given in CRD-C 31. The primary difference is that this standard requires estimation of uniformity based on three samples rather than two samples from a single batch of mixed concrete.

2. Applicable Documents

2.1 Corps of Engineers Standards

CRD-C 4 Method of Sampling Freshly Mixed Concrete (ASTM C 172)

CRD-C 5 Test Method for Slump of Portland Cement Concrete (ASTM C 143)

CRD-C 7 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete (ASTM C 138)

CRD-C 8 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method (ASTM C 173)

CRD-C 10 Practice for Making and Curing Concrete Test Specimens in the Laboratory (ASTM C 192)

CRD-C 11 Practice for Making and Curing Concrete Test Specimens in the Field (ASTM C 31)

CRD-C 14 Test Method for Compressive Strength of Cylindrical Concrete Specimens (ASTM C 39)

CRD-C 31 Specification for Ready-Mixed Concrete (ASTM C 94)

CRD-C 41 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method (ASTM C 231)

CRD-C 75 Test Method for Unit Weight of Structural Lightweight Concrete (ASTM C 567)

CRD-C 97 Method of Making, Accelerated Curing, and Testing of Concrete Compression Test Specimens (ASTM C 684)

CRD-C 102 Specification for Wire-Cloth Sieves for Testing Purposes (ASTM E 11)

CRD-C 113 Test Method for Total Moisture Content of Aggregate by Drying (ASTM C 566)

3. Significance and Use

3.1 This test method is used primarily to provide a basis for establishing the minimum time of mixing required to produce a batch of concrete from given materials and proportions in a given concrete mixer with adequate uniformity of distribution of constituents in the batch. The performance of a given concrete mixer as used for mixing a given batch of concrete for a given mixing time may be evaluated from the information calculated from the results of tests made using this method. Requirements for satisfactory performance of a mixer with respect to uniformity should be given in the applicable specification.

3.2 Since the sequence of method of charging the mixer will have an important effect on the uniformity of the concrete, it follows that the results obtained by the use of this standard not only measure effects of the mixer itself and the mixing time, but also those of the manner in which the mixer was charged.

4. Apparatus and Materials

4.1 The apparatus and materials shall consist of the following:

4.1.1 Scales or Balances. - Scales and balances having capacities of 1000 lb (453.59 kg). 2 kg, and 500 g with an accuracy of 0.1 percent of the test load at any point within the range of use for this test, and meeting the requirements for sensitivity and tolerances prescribed in CRD-C 10.

4.1.2 Drying Apparatus. - A hot plate capable of heating to at least 110 C, a drying pan, and a spatula; or a suitable microwave oven with oven glass containers. A suitable microwave oven is one that is capable of drying six 500-g samples of mortar of 0.6 water-cement ratio (by mass) to constant mass in a time period of not more than 48 min. Constant mass is achieved when the mass of a sample does not change by more than 0.2 percent of the original mass on

successive determinations of mass. The apparatus described in CRD-C 113 is satisfactory.

4.1.3 Sieving Apparatus. - A mechanical sieve shaker and sieves for sieving the concrete. The apparatus described in CRD-C 4 has been found satisfactory. The sieves shall conform to the requirements of CRD-C 102.

4.2 In addition, the apparatus and materials required to perform such of the tests listed under applicable documents as may be specified for the particular testing to be done, shall be provided.

5. Samples

5.1 Any quantity of concrete, such as a batch that has been mixed in a given mixer for a given length of time, shall be sampled in accordance with the applicable provisions of CRD-C 4, in such a manner as to obtain three samples which represent separately each of the three thirds of the quantity being investigated. In the case of a batch that has been mixed, these three samples shall represent the first, middle, and last third of the batch as it is discharged from the mixer. If the batch is sampled as it is discharged, the mixer shall be discharged using normal procedures (not in increments). If the device used for sampling concrete for other tests is not adaptable for obtaining three samples as described above, during discharge of the mixer, samples may be obtained as the concrete is discharged from the wet-batch hopper, or especially in the case of turbine mixers, they may be taken from the mixer drum at third points in the batch. In the event that the samples are taken from the wet-batch hopper, care should be taken to insure that the hopper is empty when the batch is discharged into the hopper and that no concrete is added to the hopper until the sampling is complete.

5.2 The very first and very last concrete to be discharged should not be sampled; specifically, the three samples shall be taken as nearly as possible from within volumes making up each of three different fifths of the batch as visualized from beginning to end of discharge as illustrated in Fig. 1.

5.3 The sample size shall be as follows:

Maximum Nominal Size of Concrete Aggregate		Approximate Size of Each of Three Samples	
mm	in.	cu ft	m^3
19.0	3/4	2.00	0.057
37.5	1-1/2	2.25	0.064
75	3	3.50	0.099
150	6	5.00	0.142

6. Sample Preparation

6.1 *Preliminary Sieving.* For concrete mixtures containing aggregate larger than 37.5 mm (1-1/2 in.), perform a preliminary mechanical sieving with enough materials of each sample in order to obtain approximately 180 lb (82 kg) of material passing the 37.5-mm (1-1/2 in.) sieve for use in determining the slump, unit weight of air-free mortar, water content, and molding specimens for compressive strength test. Discard those materials retaining on the 37.5-mm (1-1/2 in.) sieve. The remaining materials in each sample shall be used

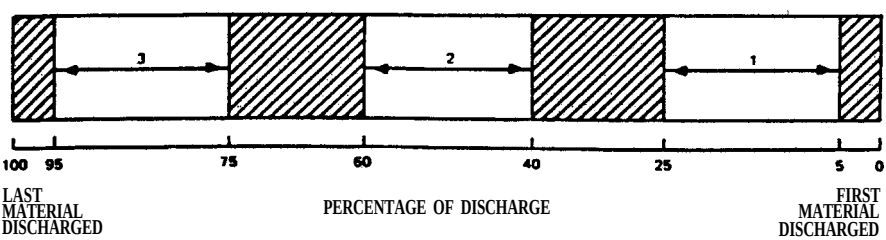

Fig. 1. Hypothetical distribution linearly of a batch or other volume of concrete to be sampled for uniformity, indicating (by cross hatching) zones to be avoided and (by numerals) zones within which the three samples are to be taken.

for the determination of percentage of coarse aggregate in accordance with paragraph 12.1. Do not include any portions that have been removed during the preliminary mechanical sieving. For concrete mixtures containing no aggregate particles that would be retained on the 37.5-mm (1-1/2 in.) sieve, preliminary mechanical sieving is not needed.

6.2 Take approximately 25 lb (or 11 kg) of the concrete containing no aggregate particles that would be retained on the 37.5-mm (1-1/2-in.) sieve, representing each of the three samples of the mixture, and mechanically sieve each over a dampened 4.75-mm (No. 4) sieve for 5 min. Use the material passing the 4.75-mm (No. 4) sieve for water content test.

6.3 In both of the sieving operations, use coarser sieves above the test sieve to prevent overloading. Conduct the sampling and testing of the three samples in as short a time as possible, since the results are significantly affected by the time of testing.

7. Regular Testing

7.1 Regular testing will include slump, air content, compressive strength, unit weight of air-free mortar, water content, and percentage of coarse aggregate.

8. Slump

8.1 Material from each of the three samples shall be tested for slump using CRD-C 5.

9. Compressive Strength

9.1 Material from each of the three samples shall be used to make three compressive strength specimens according to the applicable portions of CRD-C 11 or CRD-C 10 depending on whether the work is being done in the field or in the laboratory. The specimens shall be tested for compressive strength at the age of 7 days according to CRD-C 14. They may be cured according to the warm water method in CRD-C 97, if results are needed quickly.

9.2 The compressive strength of each specimen and the average strength of the three specimens from each sample shall be calculated.

10. Unit Weight of Air-Free Mortar

10.1 The unit weight of air-free mortar is determined on the portion of each of the three samples passing the 37.5-mm (1-1/2-in.) sieve. First, consolidate the concrete in the air-content test container and obtain the mass for that volume according to CRD-C 7. Then determine the air content on the same sample using the procedure given in CRD-C 41. Wash the entire air-content test sample over a 4.75-mm (No. 4) sieve, and obtain the saturated surface-dry mass of the retained aggregate.

10.2 The unit weight of air-free mortar is calculated as follows:

$$M = \frac{b - c}{V - \left(\frac{V \times A}{100} + \frac{c}{G \times W}\right)}$$

where

M = unit weight of air-free mortar, lb/cu ft (kg/m^3).

b = mass of concrete sample, lb (kg),

c = saturated surface-dry mass of aggregate retained on the 4.75-mm (No. 4) sieve, lb (kg),

V = volume of air-content test container, cu ft (m^3),

A = air content of sample test, %,

G = specific gravity of the coarse aggregate, and

W = unit weight of water, 62.3 lb/ft^3 (998 kg/m^3).

10.3 If the concrete is structural lightweight concrete, unit weight shall be determined by CRD-C 75 and air content by CRD-C 8.

11. Water Content

11.1 Using that portion of the mixture passing the 4.75-mm (No. 4) sieve for each of the three samples, weigh out two 500-g fractions into pans and dry on the hot plate for at least 15 min until constant mass is achieved, being careful to prevent any loss of solid material from the pans during drying; or weigh out two 500-g fractions into oven glass containers and dry in the microwave oven until constant mass is achieved.

11.2 Upon completion of the drying, again weigh the samples to the nearest 0.1 g and determine the water contents by the following formula:

$$P = \frac{500 - W}{500} \times 100$$

where:

P = water content of sample, %, and

W = mass of dried sample, g.

11.3 The average water content of the two determinations for each of the three samples shall be calculated.

12. Percentage of Coarse Aggregate in Sample

12.1 Weigh each of the three samples remaining for determining the percentage of coarse aggregate and wash the materials over a 4.75-mm (No. 4) sieve to obtain the total saturated surface-dry weight of the material retained on the 4.75-mm (No. 4) sieve.

12.2 For concrete containing large aggregate it may be desirable, after the total mass retained on the 4.75-mm (No. 4) sieve has been obtained, to sieve the retained material over the 37.5-mm (1-1/2-in.) and 75-mm (3-in.) sieves to obtain further information concerning the distribution of the coarse aggregate for each of the three samples.

12.3 The percentage of coarse aggregate retained on each of these sieves is obtained by dividing the saturated surface-dry mass of the material retained on each sieve by the mass of the original sample of the freshly mixed concrete as obtained from the mixer discharge, as follows:

$$P = (c/b) \times 100$$

where

P = mass % of coarse aggregate in concrete,

c = saturated surface-dry-mass in lb (kg) of aggregate retained on the 4.75-mm (No. 4) sieve, resulting from washing all material finer than this sieve from the fresh concrete, and

b = mass of sample of fresh concrete, lb (kg)

13. Abbreviated Testing

13.1 Abbreviated testing consists of the determination of coarse-aggregate content, compressive strength, and unit weight of air-free mortar as described above.

14. Report

14.1 In preparing the report on evaluation of the performance of the mixer under test, the results for each of the three samples for each batch and mixing time should be reported and the difference between the highest and lowest of the values for each determination (Fig. 2) reported. These values for the three batches mixed at the designated or selected mixing time shall also be reported (Fig. 3).

14.2 The report shall include the following (except that a report of abbreviated testing will not include results of tests not part of such testing).

14.2.1 Name of manufacturer of mixer.

14.2.2 Type and capacity of mixer.

14.2.3 Mixing time for each batch of concrete tested.

14.2.4 Complete data concerning the mixture proportions, including materials used and mass of each ingredient in the batch: slump, air content, and unit weight results for each of the three samples.

14.2.5 Mass of each of the three concrete test samples from each batch tested.

14.2.6 Water content of each mortar specimen and average water content of two specimens to the nearest 0.1 percent by mass for each of the three test samples.

14.2.7 The unit weight of air-free mortar to the nearest 0.1 lb/ft^3 (1.6 kg/m^3) for each of the three test samples.

14.2.8 Total amount of coarse aggregate to the nearest 0.1 percent by mass for each of the three test samples.

14.2.9 Compressive strength of each specimen and the average compressive strength of three specimens from each of the three test samples.

14.2.10 The range of the three values for the three samples for each batch. Range is the numerical difference between the highest value and the lowest value obtained from the different portions of a batch of concrete being evaluated for uniformity.

Corps of Engineers U.S. Army	Concrete Uniformity Batch Report			
Project: Reservoir		Date: 23 May		
Name, Mfg. of Mixer: Koehring-Johnson				
Type, Cap. of Mixer: Tilt Model 168-S, 6.2 cu yd		Slump, in.: 2-1/4*		
Mixing time: 3 min.		Batch size: 6.0 cu yd		
Mix: Exterior	Batch: #1		Max. size aggregate: 3 in.	

Test Results						
		Front Sample	Middle Sample	Rear Sample	Ave. (3 Samples)	Range
Total Mass, lb		301.5	245.0	266.0		
Water, %	1st Specimen	10.9	10.0	10.5		
	2nd Specimen	10.7	10.4	10.7		
	Ave. (2 Spec.)	10.8	10.2	10.6		0.6
Unit Weight of Mortar, lb/ft^3		139.5	140.0	141.2		1.7
Coarse Aggregate, %		54.7	52.0	53.0		2.7
Air Content, %*		5.6	4.8	4.3		1.3
Slump, in.		3.0	2-1/2	3-1/4		3/4
7-Day Comp. Strength, psi	1st Specimen	3100	3350	3200		
	2nd Specimen	3070	3150	3150		
	3rd Specimen	3070	3370	3220		
	Ave. (3 Spec.)	3080	3290	3190	3187	210

*On the portion passing the 37.5-mm (1-1/2-in.) sieve.

Remarks:

Fig. 2. Test results for one batch.

Corps of Engineers U.S. Army			Concrete Uniformity Summary Report			
Project: Reservoir			Date: 24 May			
Name, Mfg. of Mixer: Koehring-Johnson						
Type, Cap. of Mixer: Tilt Model 168-S, 6.2 cu yd						
Mixing time: 3 min.			Batch size: 6.0 cu yd			
Mix: Exterior			Nom. Max. size aggregate: 3 in.			
Portion	Cement	Water	Admixture	Fine Aggregate	Coarse Aggregate	Total
Mass, lb	1,692	1,098	450	6,600	14,280	24,120
Volume, cu ft	8.6	17.6	2.9	40.4	85.8	155.4
Type	II	--	Fly Ash	Natural Sand	Crushed Limestone	--

Results, Range

Batch No.	Slump, in. (a)	Water, % (b)	Unit Wt of Mortar lb/ft^3 (c)	Coarse Aggregate, % (d)	7d Comp. Strength			Air Content, %
					Ave. of 3 Samples, psi (e)	Range, psi (f)	% Range (g) = (f)/(e) × 100%	
1	3/4	0.6	1.7	2.7	3187	210	6.6	1.3
2								
3								
Ave. (3 Batches)								

Remarks:

Fig. 3. Test results for three batches.