Designation: C 331 – 05

Standard Specification for Lightweight Aggregates for Concrete Masonry Units[1]

This standard is issued under the fixed designation C 331; 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 specification covers lightweight aggregates intended for use in concrete masonry units when a prime consideration is to reduce the density of the units.

1.2 The values stated in SI units are to be regarded as the standard. The values shown in parentheses are for information purposes only.

1.3 The text of this specification 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.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 29/C 29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C 40 Test Method for Organic Impurities in Fine Aggregates for Concrete

C 114 Test Methods for Chemical Analysis of Hydraulic Cement

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C 142 Test Method for Clay Lumps and Friable Particles in Aggregates

C 151 Test Method for Autoclave Expansion of Hydraulic Cement

C 157/C 157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

C 641 Test Method for Iron Staining Materials in Lightweight Concrete Aggregates

C 702 Practice for Reducing Samples of Aggregate to Testing Size

C 1262 Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units

D 75 Practice for Sampling Aggregates

3. Aggregate Types

3.1 Three general types of lightweight aggregates are covered by this specification, as follows:

3.1.1 Aggregates prepared by expanding, pelletizing, or sintering products such as blast-furnace slag, clay, diatomite, fly ash, shale, or slate, and

3.1.2 Aggregates prepared by processing natural materials, such as pumice, scoria, or tuff, and

3.1.3 Aggregates consisting of end products of coal or coke combustion.

3.2 The aggregates shall be composed predominately of lightweight-cellular and granular inorganic material.

4. Chemical Composition

4.1 Lightweight aggregates shall not contain excessive amounts of deleterious substances, as determined by the following limits:

4.1.1 *Organic Impurities (Test Method C 40)*—Lightweight aggregates subjected to the test for organic impurities that produce a color darker than the standard shall be rejected, unless it is demonstrated that the discoloration is due to small quantities of materials not harmful to the concrete.

4.1.2 *Staining (Test Method C 641)*—An aggregate producing a stain index of 60 or higher shall be rejected when the deposited stain is found upon chemical analysis to contain an iron content, expressed as Fe_2O_3 equal to or greater than 1.5 mg/200 g of sample.

4.1.3 *Loss on Ignition (Test Methods C 114)*—Loss on ignition of aggregates, consisting of end products of coal or coke combustion, shall not exceed 12 %. Loss on ignition of other aggregates shall not exceed 5 %.

NOTE 1—Some aggregates may contain carbonates or water of hydration that contribute to loss on ignition but may not affect the quality of the product. Therefore, when evaluating an aggregate, consideration should be given to the material characteristics that cause the ignition loss.

[1] This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.21 on Lightweight Aggregates and Concrete.

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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.

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

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5. Physical Properties

5.1 Lightweight aggregate under test shall meet the following requirements:

5.1.1 *Clay Lumps and Friable Particles*— The amount of clay lumps and friable particles shall not exceed 2 % by dry mass.

5.1.2 *Grading*—Aggregate grading shall be by mutual agreement between interested parties. See Appendix X1 for aggregate grading guidance.

5.1.3 *Uniformity of Grading*—To ensure reasonable uniformity in the gradation of successive shipments of lightweight aggregate, fineness modulus shall be determined on samples taken from shipments at intervals stipulated by the purchaser. If the fineness modulus of the aggregate in any shipment differs by more than 7 % from that of the sample submitted for acceptance tests, the aggregate in the shipment shall be rejected, unless the supplier demonstrated that it will produce concrete of the required characteristics.

5.1.4 *Loose Bulk Density (Test Method C 29/C 29M)*—The loose bulk density of lightweight aggregates shall conform to the requirements in Table 1 using a 14 L (½ cubic foot) measure.

5.1.5 *Uniformity of Loose Bulk Density*— The dry loose bulk density of lightweight aggregate shipments sampled and tested shall not differ by more than ±50 kg/m^3 (3 lb/ft^3) or 7 %, whichever is greater, from that of the sample submitted for acceptance tests, and shall not exceed the limits in Table 1.

5.2 Concrete specimens containing lightweight aggregate under test shall meet the following requirements:

5.2.1 *Popouts*—Concrete specimens prepared and tested in accordance with 8.1 shall show no surface popouts.

5.2.2 *Resistance to Freezing and Thawing*— When required, the aggregate supplier shall demonstrate by test or proven field performance that the lightweight aggregate when used in manufactured concrete masonry units and related concrete units has the necessary resistance to freezing and thawing to perform satisfactorily in its intended use.

NOTE 2—Methods are available to evaluate the performance of manufactured concrete masonry products made with lightweight aggregates. For example, Test Method C 1262 includes procedures for evaluating manufactured concrete masonry units and related concrete units, but does not include criteria for determining compliance. Care should be used in evaluating the results of Test Method C 1262 or any other method since the results are affected by other characteristics of the concrete mixture in addition to the characteristics of the lightweight aggregate, including, but not limited to the following: cement content, cement type, admixtures, and water content.

TABLE 1 Maximum Bulk Density (Dry Loose) Requirements of Lightweight Aggregates for Concrete Masonry Units

Nominal Size Designation	Maximum Dry Loose Bulk Density kg/m^3(lb/ft^3)
Fine aggregate 4.75 mm (No. 4) to 0	1120 (70)
Coarse aggregate 9.5 to 2.36 mm (⅜ in. to No. 8)	880 (55)
Combined fine and coarse aggregate	1040 (65)

5.2.3 *Drying Shrinkage*—Drying shrinkage of concrete specimens prepared and tested in accordance with 8.6 shall not exceed 0.10 %.

6. Sampling

6.1 Sample lightweight aggregates in accordance with Practice D 75.

6.2 Reduce sample to test sizes in accordance with Practice C 702.

7. Number of Tests

7.1 *Tests on Aggregate*—One representative sample is required for each test for organic impurities, staining, clay lumps, loss on ignition, grading, and bulk density.

7.2 *Tests on Concrete Masonry Units*— Three specimens are required for the test for popout materials.

8. Test Methods

8.1 *Test for Popout Materials*—Obtain test specimens by one of the following methods: (*1*) Whole concrete masonry units, free of visible cracks or other structural defects; (*2*) Portions of concrete masonry units cut from whole units and having a surface area of at least 580 cm^2(90 in. ^{2}); (*3*) Specimens prepared as described in 8.6. Autoclave test specimens in accordance with Test Method C 151. Visually inspect the autoclaved specimens for the number of popouts that have developed on the surface and report the average number of popouts per specimen.

8.2 *Test for Resistance to Freezing and Thawing*—Make tests for resistance to freezing and thawing of manufactured concrete masonry units and related concrete units in accordance with Test Method C 1262.

8.3 *Grading*—Follow the procedures of Test Method C 136 except that the mass of the test sample for fine aggregate shall be in accordance with Table 2. The test sample for coarse aggregate shall consist of 2830 cm^3 (0.1 ft^3) or more of the material used for determination of bulk density. Mechanical sieving of aggregate shall be for 5 min.

8.4 *Bulk Density (Loose)* (Test Method C 29/C 29M)—The aggregate shall be tested in an oven-dry condition utilizing the shoveling procedure.

8.5 *Clay Lumps and Friable Particles in Aggregates*, shall be in accordance with Test Method C 142.

8.6 *Shrinkage of Concrete*, shall be in accordance with Test Method C 157/C 157M, with the following exceptions:

TABLE 2 Mass of Sieve Test Sample for Fine Lightweight Aggregates

Nominal Bulk Density (Loose) of Aggregate		Mass of Test Sample, g
kg/m^3	lb/ft^3	
80–240	5–15	50
240–400	15–25	100
400–560	25–35	150
560–720	35–45	200
720–880	45–55	250
880–1040	55–65	300
1040–1120	65–70	350

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8.6.1 Prepare a concrete mix in the proportions of one part portland cement to six parts combined aggregates, measured by dry loose volume. Adjust the water content so as to produce a slump of 50 to 75 mm (2 to 3 in.) and thoroughly consolidate the concrete in steel molds 50 by 50 by 285 mm (2 by 2 by 11¼ in.). The surface of the concrete shall be steel-troweled.

8.6.2 Cure the test specimens in a moist condition for 7 days at a temperature of 23 ± 2 °C (73.5 ± 3.5 °F) and a relative humidity of not less than 95 %. Make the initial length measurements immediately after removal of specimens from moist storage. Store the specimens in an atmosphere of 23 ± 2 °C (73.5 ± 3.5 °F) and a relative humidity of 50 ± 5 % for the duration of the test. Make subsequent measurements at 28 and 100 days.

8.6.3 Calculate the difference in length of the specimens, when removed from moist storage at an age of 7 days and at the final measurement at the age of 100 days, to the nearest 0.01 % of the effective gage length, and report as the drying shrinkage of the specimen. Report the average drying shrinkage of the specimens tested as the drying shrinkage of the concrete.

9. Rejection

9.1 Material that fails to conform to the requirements of this specification shall be subject to rejection. The reason for rejection shall be reported to the producer or supplier promptly and in writing.

10. Certification

10.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser that the material was sampled and tested in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

APPENDIX

(Nonmandatory Information)

X1. AGGREGATE GRADING GUIDE FOR CONCRETE MASONRY UNITS WITH LOWER DENSITIES

X1.1 Concrete masonry units with lower densities are manufactured with lightweight aggregate, with a blend of lightweight aggregates, or a blend of lightweight and normal-weight aggregates. Because the aggregates being blended may come from several different sources, the proper combined aggregate grading (see Fig. X1.1 and Table X1.1) is important, and is one of the essential ingredients in producing quality concrete masonry units. The combined aggregate grading range shown optimizes the particle size distribution which, in turn, optimizes the quality of the CMU in the following ways:

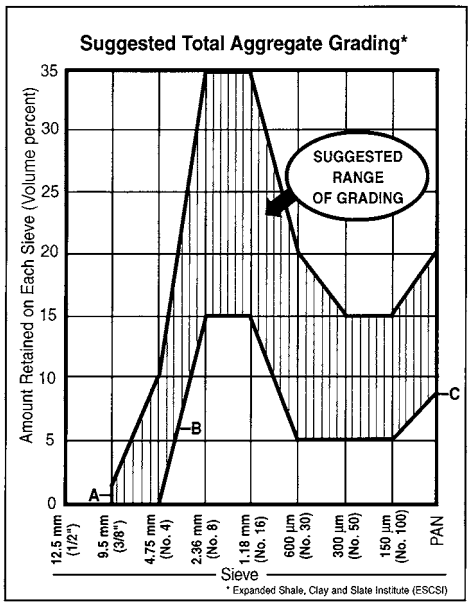

FIG. X1.1 Suggested Total Aggregate Grading

TABLE X1.1 Suggested Total Aggregate Grading

Sieve Size	Amount Retained On Each Sieve (Volume %) (see Fig. X1.1 and [A])
9.5 mm (⅜ in.)	0-2
4.75 mm (No. 4)	0-10
2.36 mm (No. 8)	15-35
1.18 mm (No. 16)	15-35
600 µm (No. 30)	5-20
300 µm (No. 50)	5-15
150 µm (No. 100)	5-15
Pan	8-20

[A] Volume % and mass % retained on each sieve are essentially equal when the particle density of the retained fractions are approximately the same. Volumetric analysis of particle sizes of blended aggregates composed of aggregates of different densities is accomplished by considering the proportions of each aggregate.

X1.1.1 Compactibility and high strengths are obtained without excessive amounts of cementitious materials.

X1.1.2 Shrinkage is reduced by maximizing aggregate packing.

X1.1.3 Water absorption and penetration are reduced because of improved compaction.

X1.1.4 Resistance to freezing and thawing is improved because better compaction results in fewer interconnected voids.

X1.2 Comments

X1.2.1 Keep particles retained on the 9.5 mm (⅜ in.) sieve to a minimum. ("0" is optimum.) (Refer to Letter "A" in Fig. X1.1.)

X1.2.2 A uniform, fine textured surface is controlled by limiting the material on 4.75 mm (No. 4) and 2.36 mm (No. 8) sieves. (Refer to Letter "B" in Fig. X1.1.)

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X1.2.3 A minimum of 8 % passing the 150 μm (No. 100) sieve is desirable for green strength, moldability and compaction. Less than 8 % is acceptable when using mixtures with high cementitious material content. (Refer to Letter "C" in Fig. X1.1.)

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this specification since the last issue, C 331–04, which may impact the use of this specification. (Approved December 15, 2005)

(*1*) Revised 5.1.4.

Committee C09 has identified the location of selected changes to this specification since the last issue, C 331–03a, which may impact the use of this specification. (Approved January 1, 2004)

(*1*) Revised X1.1.
(*2*) Changed "Mass %" to "Volume %" in Fig. X1.1 and Table X1.1.
(*3*) Added footnote to Table X1.1.

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