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StandardSpecification for Concrete Aggregates[1]

This standard is issued under the fixed designation C33/C33M; 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 defines the requirements for grading and quality of fine and coarse aggregate (other than lightweight or heavyweight aggregate) for use in concrete.[2]

1.2 This specification is for use by a contractor, concrete supplier, or other purchaser as part of the purchase document describing the material to be furnished.

NOTE 1—This specification is regarded as adequate to ensure satisfactory materials for most concrete. It is recognized that, for certain work or in certain regions, it may be either more or less restrictive than needed. For example, where aesthetics are important, more restrictive limits may be considered regarding impurities that would stain the concrete surface. The specifier should ascertain that aggregates specified are or can be made available in the area of the work, with regard to grading, physical, or chemical properties, or combination thereof.

1.3 This specification is also for use in project specifications to define the quality of aggregate, the nominal maximum size of the aggregate, and other specific grading requirements. Those responsible for selecting the proportions for the concrete mixture shall have the responsibility of determining the proportions of fine and coarse aggregate and the addition of blending aggregate sizes if required or approved.

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

1.5 The text of this standard 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 this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C40 Test Method for Organic Impurities in Fine Aggregates for Concrete

C87 Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar

C88 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

C117 Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

C123 Test Method for Lightweight Particles in Aggregate

C125 Terminology Relating to Concrete and Concrete Aggregates

C131 Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C142 Test Method for Clay Lumps and Friable Particles in Aggregates

C150 Specification for Portland Cement

C227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)

C289 Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)

C294 Descriptive Nomenclature for Constituents of Concrete Aggregates

C295 Guide for Petrographic Examination of Aggregates for Concrete

C311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete

C330 Specification for Lightweight Aggregates for Structural Concrete

C331 Specification for Lightweight Aggregates for Concrete Masonry Units

[1] This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.20 on Normal Weight Aggregates.

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[2] For lightweight aggregates, see Specifications C330, C331, and C332; for heavyweight aggregates see Specification C637 and Descriptive Nomenclature C638.

[3] 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**

C332 Specification for Lightweight Aggregates for Insulating Concrete
C342 Test Method for Potential Volume Change of Cement-Aggregate Combinations (Withdrawn 2001)[4]
C441 Test Method for Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction
C535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C586 Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method)
C595 Specification for Blended Hydraulic Cements
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C637 Specification for Aggregates for Radiation-Shielding Concrete
C638 Descriptive Nomenclature of Constituents of Aggregates for Radiation-Shielding Concrete
C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing
C989 Specification for Slag Cement for Use in Concrete and Mortars
C1105 Test Method for Length Change of Concrete Due to Alkali-Carbonate Rock Reaction
C1157 Performance Specification for Hydraulic Cement
C1240 Specification for Silica Fume Used in Cementitious Mixtures
C1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
C1293 Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
C1567 Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
D75 Practice for Sampling Aggregates
D422 Test Method for Particle-Size Analysis of Soils
D2419 Test Method for Sand Equivalent Value of Soils and Fine Aggregate
D3665 Practice for Random Sampling of Construction Materials
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *Other Standards:*

AASHTO T 330 Method of Test for the Qualitative Detection of Harmful Clays of the Smectite Group in Aggregates Using Methylene Blue[5]

3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology C125.

4. Ordering and Specifying Information

4.1 The direct purchaser of aggregates shall include the information in 4.2 in the purchase order as applicable. A project specifier shall include in the project documents information to describe the aggregate to be used in the project from the applicable items in 4.3.

4.2 Include in the purchase order for aggregates the following information, as applicable:

4.2.1 Reference to this specification, as C33____,

4.2.2 Whether the order is for fine aggregate or for coarse aggregate,

4.2.3 Quantity, in metric tons or tons,

4.2.4 When the order is for fine aggregate:

4.2.4.1 Whether the restriction on reactive materials in 7.3 applies,

4.2.4.2 In the case of the sulfate soundness test (see 8.1) which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used,

4.2.4.3 The appropriate limit for material finer than 75-µm (No. 200) sieve (see Table 1). If not stated, the 3.0 % limit shall apply,

4.2.4.4 The appropriate limit for coal and lignite (see Table 2). If not stated, the 1.0 % limit shall apply,

4.2.5 When the order is for coarse aggregate:

4.2.5.1 The grading (size number) (see 10.1 and Table 3), or alternate grading as agreed between the purchaser and aggregate supplier.

4.2.5.2 The class designation (see 11.1 and Table 4),

4.2.5.3 Whether the restriction on reactive materials in 11.2 applies,

4.2.5.4 In the case of the sulfate soundness test (see Table 4), which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used, and

4.2.6 Any exceptions or additions to this specification (see Note 1).

4.3 Include in project specifications for aggregates the following information, as applicable:

4.3.1 Reference to this specification, as C33____.

4.3.2 When the aggregate being described is fine aggregate:

4.3.2.1 Whether the restriction on reactive materials in 7.3 applies,

TABLE 1 Grading Requirements for Fine Aggregate

Sieve (Specification E11)	Percent Passing
9.5-mm (3⁄8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3.0[A,B]

[A] For concrete not subject to abrasion, the limit for material finer than the 75-µm (No. 200) sieve shall be 5.0 % maximum.
[B] For manufactured fine aggregate, if the material finer than the 75-µm (No. 200) sieve consists of dust of fracture, essentially free of clay or shale, this limit shall be 5.0 % maximum for concrete subject to abrasion, and 7.0 % maximum for concrete not subject to abrasion.

[4] The last approved version of this historical standard is referenced on www.astm.org.
[5] *AASHTO Standard Specifications, Part 2B: Tests.* Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

TABLE 2 Limits for Deleterious Substances in Fine Aggregate for Concrete

Item	Mass Percent of Total Sample, max
Clay lumps and friable particles	3.0
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0

4.3.2.2 In the case of the sulfate soundness test (see 8.1) which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used.

4.3.2.3 The appropriate limit for material finer than the 75-µm (No. 200) sieve (see Table 1). If not stated, the 3.0 % limit shall apply, and

4.3.2.4 The limit that applies with regard to coal and lignite (Table 2). If not stated, the 1.0 % limit shall apply.

4.3.3 When the aggregate being described is coarse aggregate, include:

4.3.3.1 The nominal maximum size or sizes permitted, based on thickness of section or spacing of reinforcing bars or other criteria. In lieu of stating the nominal maximum size, the specifier shall designate an appropriate size number or numbers (see 10.1 and Table 3). Designation of a size number to indicate a nominal size shall not restrict the person responsible for selecting proportions from combining two or more gradings of aggregate to obtain a desired grading, provided that the gradings are not otherwise restricted by the project specifier and the nominal maximum size indicated by the size number is not exceeded,

4.3.3.2 The class designation (see 11.1 and Table 4),

4.3.3.3 Whether the restriction on reactive materials in 11.2 applies,

4.3.3.4 In the case of the sulfate soundness test (see Table 4), which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used, and

4.3.4 The person responsible for selecting the concrete proportions if other than the concrete producer.

4.3.5 Any exceptions or additions to this specification (see Note 1).

FINE AGGREGATE

5. General Characteristics

5.1 Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof.

6. Grading

6.1 *Sieve Analysis*—Fine aggregate, except as provided in 6.2 and 6.3 shall be graded within the limits in Table 1.

NOTE 2—Concrete with fine aggregate gradings near the minimums for percent passing the 300 µm (No.50) and 150 µm (No.100) sometimes have difficulties with workability, pumping or excessive bleeding. The addition of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

6.2 The fine aggregate shall have not more than 45 % passing any sieve and retained on the next consecutive sieve of those shown in 6.1, and its fineness modulus shall be not less than 2.3 nor more than 3.1.

6.3 Fine aggregate failing to meet these grading requirements shall meet the requirements of this section provided that the supplier can demonstrate to the purchaser or specifier that concrete of the class specified, made with fine aggregate under consideration, will have relevant properties (see Note 5) at least equal to those of concrete made with the same ingredients, with the exception that the reference fine aggregate shall be selected from a source having an acceptable performance record in similar concrete construction.

NOTE 3—Manufactured fine aggregate having elevated proportions of material passing the 75-µm (No. 200) sieve may need further evaluation to ensure that material passing the 75-µm (No. 200) sieve is essentially composed of dust of fracture derived from the parent rock in the crushing operation, and does not contain an appreciable level of clay minerals or other deleterious constituents as described in Descriptive Nomenclature C294. Because some of the dust of fracture may occur in the clay size range, defined here as material finer than 2 µm, care must be taken to properly differentiate these clay-sized materials from clay minerals. Natural fine aggregate with elevated proportions of material passing the 75-µm (No. 200) sieve may have higher potential for clay mineral content.

Various means are available for characterizing these fines, such as petrographic analysis (Guide C295), sand equivalent determination (Test Method D2419), hydrometer analysis (Test Method D422), methylene blue adsorption determination (AASHTO T 330) and X-ray diffraction analysis. While these techniques are useful for investigative purposes, no specific limits have been established for prediction of performance of these materials in concrete under various intended service conditions. Methylene blue adsorption and hydrometer analyses are believed to be two relatively quick and reliable tests for characterization of material passing the 75-µm (No. 200) sieve to determine suitability for use in concrete. Research (**6,7**) has indicated that manufactured fine aggregate with less than 4 % by mass finer than 2 µm, and with methylene blue adsorption values less than 5 mg/g generally is suitable for use in concrete. Fine aggregate that exceeds these values also may be suitable for use provided that fresh and hardened concrete properties are shown to be acceptable.

NOTE 4—Fine aggregate that conforms to the grading requirements of a specification, prepared by another organization such as a state transportation agency, which is in general use in the area, should be considered as having a satisfactory service record with regard to those concrete properties affected by grading.

NOTE 5—Relevant properties are those properties of the concrete that are important to the particular application being considered. STP 169D[6] provides a discussion of important concrete properties.

6.4 For continuing shipments of fine aggregate from a given source, the fineness modulus shall not vary more than 0.20 from the base fineness modulus. The base fineness modulus shall be that value that is typical of the source. The purchaser or specifier has the authority to approve a change in the base fineness modulus.

NOTE 6—The base fineness modulus should be determined from previous tests, or if no previous tests exist, from the average of the fineness modulus values for the first ten samples (or all preceding samples if less than ten) on the order. The proportioning of a concrete mixture may be dependent on the base fineness modulus of the fine aggregate to be used. Therefore, when it appears that the base fineness modulus is considerably different from the value used in the concrete mixture, a suitable adjustment in the mixture may be necessary.

[6] *Significance of Tests and Properties of Concrete and Concrete Making Materials, STP 169D*, ASTM, 2006.

TABLE 3 Grading Requirements for Coarse Aggregates

Size Number	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square-Openings), Mass Percent													
		100 mm (4 in.)	90 mm (3½ in.)	75 mm (3 in.)	63 mm (2½ in.)	50 mm (2 in.)	37.5 mm (1½ in.)	25.0 mm (1 in.)	19.0 mm (¾ in.)	12.5 mm (½ in.)	9.5 mm (⅜ in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	1.18 mm (No. 16)	300 µm (No.50)
1	90 to 37.5 mm (3½ to 1½ in.)	100	90 to 100	...	25 to 60	...	0 to 15	...	0 to 5	...	...	...	...	...	...
2	63 to 37.5 mm (2½ to 1½ in.)	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...	...
3	50 to 25.0 mm (2 to 1 in.)	...	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...
357	50 to 4.75 mm (2 in. to No. 4)	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	...	0 to 5	...	...	...
4	37.5 to 19.0 mm (1½ to ¾ in.)	...	...	...	...	100	90 to 100	20 to 55	0 to 15	...	0 to 5	...	...	...	...
467	37.5 to 4.75 mm (1½ in. to No. 4)	...	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	0 to 5	...	...	...
5	25.0 to 12.5 mm (1 to ½ in.)	...	...	...	...	...	100	90 to 100	20 to 55	0 to 10	0 to 5	...	...	...	...
56	25.0 to 9.5 mm (1 to ⅜ in.)	...	...	...	...	...	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	...	...	...
57	25.0 to 4.75 mm (1 in. to No. 4)	...	...	...	...	...	100	95 to 100	...	25 to 60	...	0 to 10	0 to 5	...	...
6	19.0 to 9.5 mm (¾ to ⅜ in.)	...	...	...	...	...	...	100	90 to 100	20 to 55	0 to 15	0 to 5	...	...	...
67	19.0 to 4.75 mm (¾ in. to No. 4)	...	...	...	...	...	...	100	90 to 100	...	20 to 55	0 to 10	0 to 5	...	...
7	12.5 to 4.75 mm (½ in. to No. 4)	...	...	...	...	...	...	...	100	90 to 100	40 to 70	0 to 15	0 to 5	...	...
8	9.5 to 2.36 mm (⅜ in. to No. 8)	...	...	...	...	...	...	...	...	100	85 to 100	10 to 30	0 to 10	0 to 5	...
89	9.5 to 1.18 mm (⅜ in. to No. 16)	...	...	...	...	...	...	...	...	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5
9[A]	4.75 to 1.18 mm (No. 4 to No. 16)	...	...	...	...	...	...	...	...	...	100	85 to 100	10 to 40	0 to 10	0 to 5

[A] Size number 9 aggregate is defined in Terminology C125 as a fine aggregate. It is included as a coarse aggregate when it is combined with a size number 8 material to create a size number 89, which is a coarse aggregate as defined by Terminology C125.

TABLE 4 Limits for Deleterious Substances and Physical Property Requirements of Coarse Aggregate for Concrete

NOTE 1—See Fig. 1 for the location of the weathering regions and Note 10 for guidance in using the map. The weathering regions are defined as follows:
(S) Severe Weathering Region—A cold climate where concrete is exposed to deicing chemicals or other aggressive agents, or where concrete may become saturated by continued contact with moisture or free water prior to repeated freezing and thawing.
(M) Moderate Weathering Region—A climate where occasional freezing is expected, but where concrete in outdoor service will not be continually exposed to freezing and thawing in the presence of moisture or to deicing chemicals.
(N) Negligible Weathering Region—A climate where concrete is rarely exposed to freezing in the presence of moisture.

Class Designation	Type or Location of Concrete Construction	Maximum Allowable, %						
		Clay Lumps and Friable Particles	Chert (Less Than 2.40 sp gr SSD)	Sum of Clay Lumps, Friable Particles, and Chert (Less Than 2.40 sp gr SSD)	Material Finer Than 75-μm (No. 200) Sieve	Coal and Lignite	Abrasion[A]	Magnesium Sulfate Soundness (5 cycles)[B]
		Severe Weathering Regions						
1S	Footings, foundations, columns and beams not exposed to the weather, interior floor slabs to be given coverings	10.0	...	...	1.0[C]	1.0	50	...
2S	Interior floors without coverings	5.0	...	...	1.0[C]	0.5	50	...
3S	Foundation walls above grade, retaining walls, abutments, piers, girders, and beams exposed to the weather	5.0	5.0	7.0	1.0[C]	0.5	50	18
4S	Pavements, bridge decks, driveways and curbs, walks, patios, garage floors, exposed floors and porches, or waterfront structures, subject to frequent wetting	3.0	5.0	5.0	1.0[C]	0.5	50	18
5S	Exposed architectural concrete	2.0	3.0	3.0	1.0[C]	0.5	50	18
		Moderate Weathering Regions						
1M	Footings, foundations, columns, and beams not exposed to the weather, interior floor slabs to be given coverings	10.0	...	...	1.0[C]	1.0	50	...
2M	Interior floors without coverings	5.0	...	...	1.0[C]	0.5	50	...
3M	Foundation walls above grade, retaining walls, abutments, piers, girders, and beams exposed to the weather	5.0	8.0	10.0	1.0[C]	0.5	50	18
4M	Pavements, bridge decks, driveways and curbs, walks, patios, garage floors, exposed floors and porches, or waterfront structures subject to frequent wetting	5.0	5.0	7.0	1.0[C]	0.5	50	18
5M	Exposed architectural concrete	3.0	3.0	5.0	1.0[C]	0.5	50	18
		Negligible Weathering Regions						
1N	Slabs subject to traffic abrasion, bridge decks, floors, sidewalks, pavements	5.0	...	...	1.0[C]	0.5	50	...
2N	All other classes of concrete	10.0	...	...	1.0[C]	1.0	50	...

[A] Crushed air-cooled blast-furnace slag is excluded from the abrasion requirements. The rodded or jigged bulk density (unit weight) of crushed air-cooled blast-furnace slag shall be not less than 1120 kg/m^3 [70 lb/ft^3]. The grading of slag used in the bulk density (unit weight) test shall conform to the grading to be used in the concrete. Abrasion loss of gravel, crushed gravel, or crushed stone shall be determined on the test size or sizes most nearly corresponding to the grading or gradings to be used in the concrete. When more than one grading is to be used, the limit on abrasion loss shall apply to each.
[B] The allowable limits for soundness shall be 12 % if sodium sulfate is used.
[C] This percentage under either of the following conditions: (*1*) is permitted to be increased to 1.5 if the material is essentially free of clay or shale; or (*2*) if the source of the fine aggregate to be used in the concrete is known to contain less than the specified maximum amount passing the 75-μm (No. 200) sieve Table 1 the percentage limit *(L)* on the amount in the coarse aggregate is permitted to be increased to $L = 1 + [(P)/(100 - P)](T - A)$, where P = percentage of sand in the concrete as a percent of total aggregate, T = the Table 1 limit for the amount permitted in the fine aggregate, and A = the actual amount in the fine aggregate. (This provides a weighted calculation designed to limit the maximum mass of material passing the 75-μm (No. 200) sieve in the concrete to that which would be obtained if both the fine and coarse aggregate were supplied at the maximum tabulated percentage for each of these ingredients.)

7. Deleterious Substances

7.1 The amount of deleterious substances in fine aggregate shall not exceed the limits prescribed in Table 2.

7.2 *Organic Impurities:*

7.2.1 Fine aggregate shall be free of injurious amounts of organic impurities. Except as herein provided, aggregates subjected to the test for organic impurities and producing a color darker than the standard shall be rejected.

7.2.2 Use of a fine aggregate failing in the test is not prohibited, provided that the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.

7.2.3 Use of a fine aggregate failing in the test is not prohibited, provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at 7 days, calculated in accordance with Test Method C87, is not less than 95 %.

7.3 Fine aggregate for use in concrete that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any materials that are deleteriously reactive with the alkalies in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, use of the fine aggregate is not prohibited when used with a cement containing less than 0.60 % alkalies calculated as sodium oxide equivalent ($Na_2O + 0.658K_2O$), if there is a satisfactory service record evaluation, or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction. (See Appendix X1, X1.1.2, X1.1.3)

8. Soundness

8.1 Except as provided in 8.2 and 8.3, fine aggregate subjected to five cycles of the soundness test shall have a weighted average loss not greater than 10 % when sodium sulfate is used or 15 % when magnesium sulfate is used.

8.2 Fine aggregate failing to meet the requirements of 8.1 shall be regarded as meeting the requirements of this section provided that the supplier demonstrates to the purchaser or specifier that concrete of comparable properties, made from similar aggregate from the same source, has given satisfactory service when exposed to weathering similar to that to be encountered.

8.3 Fine aggregate not having a demonstrable service record and failing to meet the requirements of 8.1 shall be regarded as meeting the requirements of this section provided that the supplier demonstrates to the purchaser or specifier it gives satisfactory results in concrete subjected to freezing and thawing tests (see Test Method C666/C666M).

COARSE AGGREGATE

9. General Characteristics

9.1 Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, air-cooled blast furnace slag, or crushed hydraulic-cement concrete (see Note 7), or a combination thereof, conforming to the requirements of this specification.

NOTE 7—Although crushed hydraulic-cement concrete has been used as an aggregate with reported satisfactory results, its use may require some additional precautions. Mixing water requirements may be increased because of the harshness of the aggregate. Partially deteriorated concrete, used as aggregate, may reduce freeze-thaw resistance, affect air void properties or degrade during handling, mixing, or placing. Crushed concrete may have constituents that would be susceptible to alkali-aggregate reactivity or sulfate attack in the new concrete or may bring sulfates, chlorides, or organic material to the new concrete in its pore structure.

10. Grading

10.1 Coarse aggregates shall conform to the requirements prescribed in Table 3 for the size number specified.

NOTE 8—The ranges shown in Table 3 are by necessity very wide in order to accommodate nationwide conditions. For quality control of any specific operation, a producer should develop an average grading for the particular source and production facilities, and should control the production gradings within reasonable tolerances from this average. Where coarse aggregate size numbers 357 or 467 are used, the aggregate should be furnished in at least two separate sizes.

11. Deleterious Substances

11.1 Except for the provisions of 11.3, the limits given in Table 4 shall apply for the class of coarse aggregate designated in the purchase order or other document (see Note 9 and Note 10). If the class is not specified, the requirements for Class 3S, 3M, or 1N shall apply in the severe, moderate, and negligible weathering regions, respectively (see Table 4 and Fig. 1).

NOTE 9—The specifier of the aggregate should designate the class of coarse aggregate to be used in the work, based on weathering severity, abrasion, and other factors of exposure (see Table 4 and Fig. 1) . The limits for coarse aggregate corresponding to each class designation are expected to ensure satisfactory performance in concrete for the respective type and location of construction. Selecting a class with unduly restrictive limits may result in unnecessary cost if materials meeting those requirements are not locally available. Selecting a class with lenient limits may result in unsatisfactory performance and premature deterioration of the concrete. While concrete in different parts of a single structure may be adequately made with different classes of coarse aggregate, the specifier may wish to require the coarse aggregate for all concrete to conform to the same more restrictive class to reduce the chance of furnishing concrete with the wrong class of aggregate, especially on smaller projects.

NOTE 10—For coarse aggregate in concrete exposed to weathering, the map with the weathering regions shown in Fig. 1 is intended to serve only as a guide to probable weathering severity. Those undertaking construction, especially near the boundaries of weathering regions, should consult local weather bureau records for amount of winter precipitation and number of freeze-thaw cycles to be expected, for determining the weathering severity for establishing test requirements of the coarse aggregate. For construction at altitudes exceeding 1520 m [5000 ft] above sea level, the likelihood of more severe weathering than indicated by the map should be considered. In arid areas, severity of weathering may be less than that indicated. In either case, the definitions of weathering severity in Table 4 would govern. If there is doubt in choosing between two regions, select the more severe weathering region.

11.2 Coarse aggregate for use in concrete that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any materials that are deleteriously reactive with the alkalies in the cement in an amount sufficient to cause excessive expansion of mortar or concrete except that if such materials are present in injurious amounts, the coarse aggregate is not prohibited when used with a cement containing less than 0.60 % alkalies calculated as sodium oxide equivalent ($Na_2O + 0.658K_2O$), if there is a