Designation: C 33 – 99a$^{\epsilon 1}$

Standard Specification for Concrete Aggregates[1]

This standard is issued under the fixed designation C 33; 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.

ε[1] NOTE—The title of Specification E 11 was editorially corrected December 1999.

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 SI units are to be regarded as the standard. The values given in parentheses are for information only.

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:*

C 29/C 29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate[3]

C 40 Test Method for Organic Impurities in Fine Aggregates for Concrete[3]

C 87 Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar[3]

C 88 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate[3]

C 117 Test Method for Material Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing[3]

C 123 Test Method for Lightweight Particles in Aggregate[3]

C 125 Terminology Relating to Concrete and Concrete Aggregates[3]

C 131 Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine[3]

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates[3]

C 142 Test Method for Clay Lumps and Friable Particles in Aggregates[3]

C 227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)[3]

C 289 Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)[3]

C 295 Guide for Petrographic Examination of Aggregates for Concrete[3]

C 330 Specification for Lightweight Aggregates for Structural Concrete[3]

C 331 Specification for Lightweight Aggregates for Concrete Masonry Units[3]

C 332 Specification for Lightweight Aggregates for Insulating Concrete[3]

C 342 Test Method for Potential Volume Change of Cement-Aggregate Combinations[3]

C 535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine[3]

C 586 Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)[3]

C 637 Specification for Aggregates for Radiation-Shielding Concrete[3]

C 638 Descriptive Nomenclature of Constituents of Aggregates for Radiation-Shielding Concrete[3]

[1] This specification is under the jurisdiction of ASTM Committee C-9 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 C 331, C 332, and C 330; for heavyweight aggregates see Specification C 637 and Descriptive Nomenclature C 638.

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

C 666 Test Method for Resistance of Concrete to Rapid Freezing and Thawing[3]
D 75 Practice for Sampling Aggregates[4]
D 3665 Practice for Random Sampling of Construction Materials[4]
E 11 Specification for Wire Cloth and Sieves for Testing Purposes[5]

3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology C 125.

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 C 33____,

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 (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 (Table 1). If not stated, the 3.0 % limit shall apply,

4.2.4.4 The appropriate limit for coal and lignite (Table 1). 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) (11.1 and Table 2), or alternate grading as agreed between the purchaser and aggregate supplier.

4.2.5.2 The class designation (11.1 and Table 3),

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 (Table 3), which salt is to be used. If none is stated, either sodium sulfate or magnesium sufate 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 C 33____.

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,

4.3.2.2 In the case of the sulfate soundness test (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 (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 1). If not stated, the 1.0 % limit shall apply.

4.3.3 When the aggregate being described is coarse aggregate:

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 (10.1 and Table 2). 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 (11.1 and Table 3),

4.3.3.3 Whether the restriction on reactive materials in 10.2 applies,

4.3.3.4 In the case of the sulfate soundness test (Table 3), which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used, and

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

4.3.4 Any exceptions or additions to this specification (See Note 1).

[4] *Annual Book of ASTM Standards,* Vol 04.03.
[5] *Annual Book of ASTM Standards,* Vol 14.02.

TABLE 1 Limits for Deleterious Substances in Fine Aggregate for Concrete

Item	Mass Percent of Total Sample, max
Clay lumps and friable particles	3.0
Material finer than 75-µm (No. 200) sieve:	
Concrete subject to abrasion	3.0[A]
All other concrete	5.0[A]
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0

[A] In the case of manufactured sand, if the material finer than the 75-µm (No. 200) sieve consists of the dust of fracture, essentially free of clay or shale, these limits are permitted to be increased to 5 and 7 %, respectively.

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 following limits:

TABLE 2 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 ½in.)	...	...	...	...	...	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 (⅜in. 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] Although size 9 aggregate is defined in Terminology C 125 as a fine aggregate, it is included as a coarse aggregate when it is combined with a size 8 material to create a size 89, which is a coarse aggregate as defined by Terminology C 125.

TABLE 3 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 9 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 waterront 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 waterront 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 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 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.)

Sieve (Specification E 11)	Percent Passing
9.5-mm (⅜-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

NOTE 2—Concrete with fine aggregate gradations 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 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—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 4—Relevant properties are those properties of the concrete which are important to the particular application being considered. STP 169C[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 5—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.

7. Deleterious Substances

7.1 The amount of deleterious substances in fine aggregate shall not exceed the limits prescribed in Table 1.

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 C 87, 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 ($Na_2O + 0.658K_2O$) or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction. (See Appendix X1.)

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 C 666).

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, or a combination thereof, conforming to the requirements of this specification.

NOTE 6—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 2 for the size number specified.

NOTE 7—The ranges shown in Table 2 are by necessity very wide in order to accommodate nationwide conditions. For quality control of any specific operation, a producer should develop an average gradation for the particular source and production facilities, and control the gradation within reasonable tolerances from this average. Where coarse aggregate sizes 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 3 shall apply for the class of coarse aggregate designated in the purchase order or other document (Note 8 and Note 9). 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 3 and Fig. 1).

NOTE 8—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 3 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

[6] *Significance of Tests and Properties of Concrete and Concrete Making Materials, STP 169C*, ASTM, 1994.

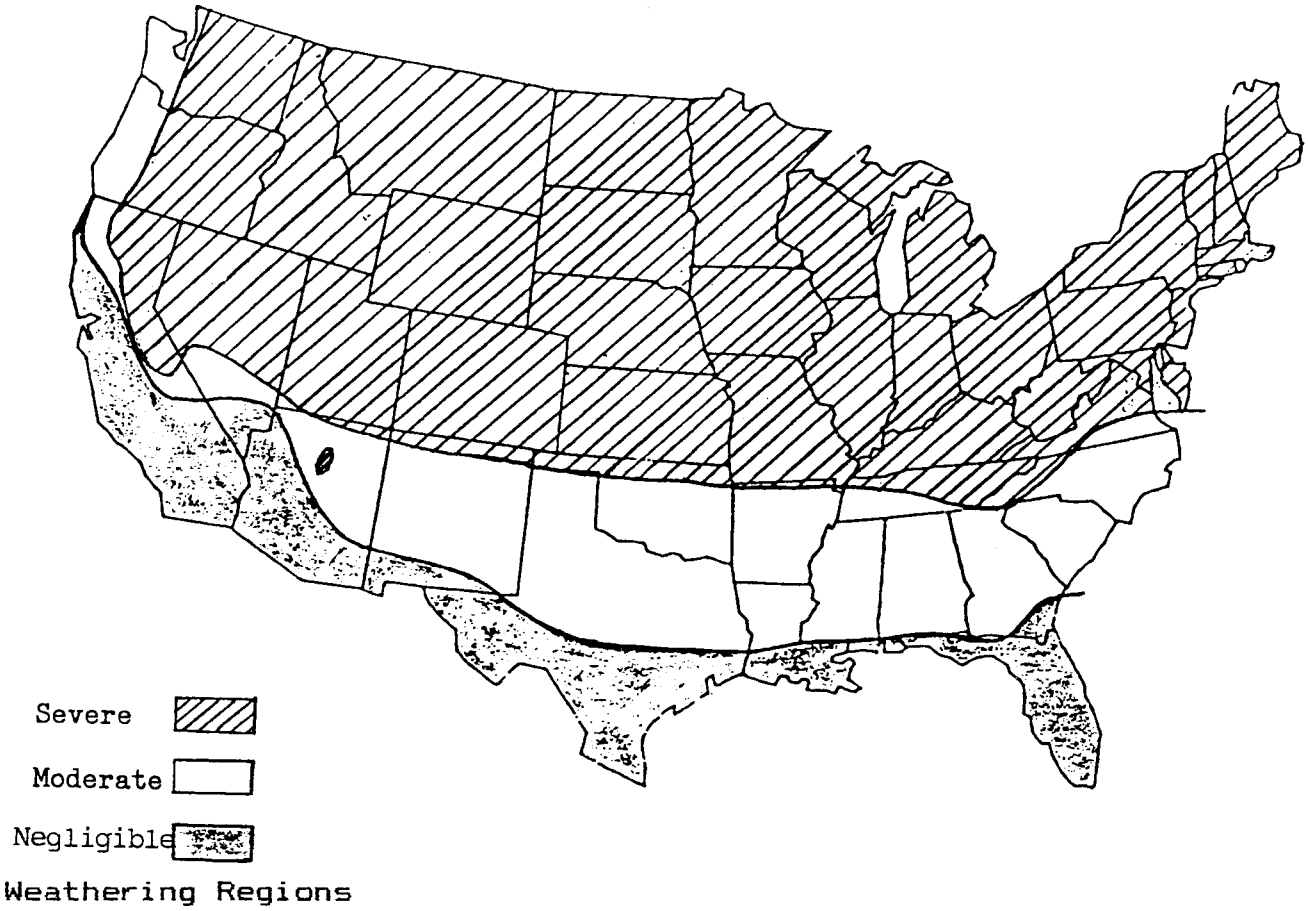

FIG. 1 Location of Weathering Regions

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 9—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 3 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 ($Na_2O + 0.658K_2O$) or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction. (See Appendix X1.)

11.3 Coarse aggregate having test results exceeding the limits specified in Table 3 shall be regarded as meeting the requirements of this section provided the supplier demonstrates to the purchaser or specifier that concrete made with similar aggregate from the same source has given satisfactory service when exposed in a similar manner to that to be encountered; or, in the absence of a demonstrable service record, provided that the aggregate produces concrete having satisfactory relevant properties (see Note 4).

METHODS OF SAMPLING AND TESTING

12. Methods of Sampling and Testing

12.1 Sample and test the aggregates in accordance with the following methods, except as otherwise provided in this specification. Make the required tests on test specimens that comply with requirements of the designated test methods. It is not prohibited to use the same test specimen for sieve analysis and for determination of material finer than the 75-μm (No. 200) sieve. It is not intended to prohibit use of separated sizes from the sieve analysis for preparation of samples for soundness or abrasion tests. For determination of all other tests and for evaluation of potential alkali reactivity where required, use independent test specimens.

12.1.1 *Sampling*—Practice D 75 and Practice D 3665.

12.1.2 *Grading and Fineness Modulus*—Test Method C 136.

12.1.3 *Amount of Material Finer than 75-μm (No. 200) Sieve*—Test Method C 117.

12.1.4 *Organic Impurities*—Test Method C 40.

12.1.5 *Effect of Organic Impurities on Strength*—Test Method C 87.

12.1.6 *Soundness*—Test Method C 88.

12.1.7 *Clay Lumps and Friable Particles*— Test Method C 142.

12.1.8 *Coal and Lignite*—Test Method C 123, using a liquid of 2.0 specific gravity to remove the particles of coal and lignite. Only material that is brownish-black, or black, shall be considered coal or lignite. Coke shall not be classed as coal or lignite.

12.1.9 *Weight of Slag*—Test Method C 29/C 29M.

12.1.10 *Abrasion of Coarse Aggregate*—Test Method C 131 or Test Method C 535.

12.1.11 *Reactive Aggregates*—See Appendix X1.

12.1.12 *Freezing and Thawing*—Procedures for making freezing and thawing tests of concrete are described in Test Method C 666.

12.1.13 *Chert*—Test Method C 123 is used to identify particles in a sample of coarse aggregate lighter than 2.40 specific gravity, and Guide C 295 to identify which of the particles in the light fraction are chert.

13. Keywords

13.1 aggregates; coarse aggregate; concrete aggregates; fine aggregate

APPENDIX

(Nonmandatory Information)

X1. METHODS FOR EVALUATING POTENTIAL REACTIVITY OF AN AGGREGATE

X1.1 A number of methods for detecting potential reactivity have been proposed. However, they do not provide quantitative information on the degree of reactivity to be expected or tolerated in service. Therefore, evaluation of potential reactivity of an aggregate should be based upon judgment and on the interpretation of test data and examination of concrete structures containing a combination of fine and coarse aggregates and cements for use in the new work. Results of the following tests may assist in making the evaluation:

X1.1.1 *Guide C 295*—Certain materials are known to be reactive with the alkalies in cements. These include the following forms of silica: opal, chalcedony, tridymite, and cristobalite; intermediate to acid (silica-rich) volcanic glass such as is likely to occur in rhyolite, andesite, or dacite; certain zeolites such as heulandite; and certain constituents of some phyllites. Determination of the presence and quantities of these materials by petrographic examination is helpful in evaluating potential alkali reactivity. Some of these materials render an aggregate deleteriously reactive when present in quantities as little as 1.0 % or even less.

X1.1.2 *Test Method C 289*—In this test method, aggregates represented by points lying to the right of the solid line of Fig. 2 of Test Method C 289 usually should be considered potentially reactive.

X1.1.2.1 If R_c exceeds 70, the aggregate is considered potentially reactive if S_c is greater than R_c.

X1.1.2.2 If R_c is less than 70, the aggregate is considered potentially reactive if S_c is greater than $35 + (R_c/2)$.

X1.1.2.3 These criteria conform to the solid line curve given in Fig. 2 of Test Method C 289. The test can be made quickly and, while not completely reliable in all cases, provides helpful information, especially where results of the more time-consuming tests are not available.

X1.1.3 *Test Method C 227*—The results of this test method when made with a high-alkali cement, furnish information on the likelihood of harmful reactions occurring. The alkali content of the cement should be substantially above 0.6 %, and preferably above 0.8 %, expressed as sodium oxide. Combinations of aggregate and cement that have produced excessive expansions in this test usually should be considered potentially reactive. While the line of demarcation between nonreactive and reactive combinations is not clearly defined, expansion is generally considered to be excessive if it exceeds 0.05 % at 3 months or 0.10 % at 6 months. Expansions greater than 0.05 % at 3 months should not be considered excessive where the 6-month expansion remains below 0.10 %. Data for the 3-month tests should be considered only when 6-month results are not available.

X1.1.4 *Test Method C 342*—This test method is intended primarily for research concerning the potential expansion of cement-aggregate combinations subjected to variations of temperature and water saturation during storage under prescribed conditions of test. Its use is mainly by those interested in research on aggregates that are found in parts of Kansas, Nebraska, Iowa and possibly other adjoining areas.

X1.1.4.1 In addition to its usefulness in research, this test method has been found useful in the selection of aggregates of the so-called“ sand-gravel” type found mainly in some parts of Kansas, Nebraska and Iowa, which contain very little coarse material; generally 5 to 15 % retained on the No. 4 (4.75-mm) sieve. Much work has been done on the problems of using these aggregates successfully in concrete and is reported in summary in the “Final Report of Cooperative Tests of Proposed Tentative Method of Test for Potential Volume Change of Cement-Aggregate Combinations.”[7] It indicates that cement-aggregate combinations tested by this procedure in which expansion equals or exceeds 0.200 % at an age of 1 year

[7] Appendix to Committee C-9 Report, Proceedings, ASTM, Volume 54, 1954, p. 356.

may be considered unsatisfactory for use in concrete exposed to wide variations of temperature and degree of saturation with water. In that geographical region, the problem has been reduced through the use of partial replacement of the "sand-gravel" with limestone coarse aggregate.

X1.1.5 *Potential Reactivity of Carbonate Aggregates*—The reaction of the dolomite in certain carbonate rocks with alkalies in portland cement paste has been found to be associated with deleterious expansion of concrete containing such rocks as coarse aggregate. Carbonate rocks capable of such reaction possess a characteristic texture and composition. The characteristic texture is that in which relatively large crystals of dolomite are scattered in a finer-grained matrix of calcite and clay. The characteristic composition is that in which the carbonate portion consists of substantial amounts of both dolomite and calcite, and the acid-insoluble residue contains a significant amount of clay. Except in certain areas, such rocks are of relatively infrequent occurrence and seldom make up a significant proportion of the material present in a deposit of rock being considered for use in making aggregate for concrete. Test Method C 586 has been successfully used in (*1*) research and (*2*) preliminary screening of aggregate sources to indicate the presence of material with a potential for deleterious expansions when used in concrete.