**Designation: D 5106 – 9903**

# Standard Specification for Steel Slag Aggregates for Bituminous Paving Mixtures[1]

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## 1. Scope

1.1 This specification covers crushed steel slag coarse and fine aggregates suitable for use in bituminous paving mixtures.

1.2 Steel slag coarse and fine aggregates shall be used entirely (Note 1) or combined with other mineral aggregates covered in Specification D 692 or D 1073, to produce paving mixtures as described in Specification D 3515 or D 4215.

NOTE 1—When 100 % of the coarse aggregate in a bituminous mixture is steel slag, the amount of steel slag fines in that mixture may be limited to prevent bulking.

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

1.4 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.

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[1] The specification is under the jurisdiction of ASTM Committee ~~D-4~~ D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.50 on Aggregate Specifications.

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## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 88 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C 117 Test Method for Material Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
C 125 Terminology Relating to Concrete and Concrete Aggregates
C 131 Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion, and Impact in the Los Angles Machine
C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
C 142 Test Method for Clay Lumps and Friable Particles in Aggregates
D 8 Terminology Relating to Materials for Roads and Pavements
D 75 Practice for Sampling Aggregates
D 448 Classification for Sizes of Aggregate for Road and Bridge Construction
D 692 Specification for Coarse Aggregate for Bituminous Paving Mixtures
D 1073 Specification for Fine Aggregates for Bituminous Paving Mixtures
D 3319 Test Method for Accelerated Polishing of Aggregates Using the British Wheel
D 3515 Specification for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
D 3665 Practice for Random Sampling of Construction Materials
D 4215 Specification for Cold-Mixed, Cold-Laid Bituminous Paving Mixtures
D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D 4792 Test Method for Potential Expansion of Aggregates from Hydration Reactions
D 4867/D 4867M Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures
D 5711 Test Method for Determining the Adherent ~~Fines~~[3] Coating on Course Aggregates
D 5821 Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

2.2 *Federal Registrar:*[3]

SW846 1311 EPA Test Method, Toxicity Characteristic Leaching Procedure

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *steel slag*, *n*—the nonmetallic product, consisting essentially of calcium silicates and ferrites combined with fused and mineralogically combined oxides of iron, aluminum, manganese, calcium, and magnesium, that is developed simultaneously with steel in basic oxygen, electric, or open hearth furnaces.

3.1.2 Other terms used in this specification are defined in Terminologies C 125 and D 8.

## 4. Ordering Information

4.1 Orders for the material under this specification shall include the following information:

4.1.1 The name of material (steel slag coarse aggregate and/or steel slag fine aggregate).

4.1.2 The specification designation and year of issue.

4.1.3 The grading of the aggregate to be furnished, by reference to a size number in Classification D 448 for coarse aggregate, grading number in Specification D 1073 for fine aggregate, or other grading as specified by the purchaser.

4.1.4 The quantity required.

4.1.5 For coarse aggregate, whether the intended use is for conventional mixtures or open-graded friction course mixtures (see 6.1.2), and whether for surface courses or base courses (see 6.1.3).

4.1.6 For sulfate soundness tests, which salt is to be used in Test Method C 88 and whether soundness requirements are applicable for the fine aggregate.

4.1.7 Any special requirements.

## 5. General Characteristics

5.1 The coarse and fine aggregates shall consist of hard, tough, durable pieces of steel slag as defined in 3.1.1. The aggregates shall be processed, as necessary to meet the requirements of this specification, by crushing ~~and~~ or screening, or both, and magnetic separation for the removal of metallics. At the time of delivery, the aggregates shall be free of injurious amounts of foreign materials such as clay, loam, wood, tramp metal, unhydrated lime and other mill wastes.

## 6. Physical Requirements

6.1 *Coarse Aggregate*:

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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*, ~~Vol 04.02.~~ volume information, refer to the standard's Document Summary page on the ASTM website.
~~*Annual Book*~~

[3] Available from the Department of ~~ASTM Standards, Vol 04.03.~~ Commerce, National Technical Information Center, 5285 Port Royal Road, Springfield, VA 22151. Order Number: EPAW-846.3.3.

6.1.1 *Grading*—The coarse aggregate grading shall conform to the requirements of Classification D 448 for the size number designated, or to another grading as stated in the order (Note 2).

NOTE 2—The coarse aggregate grading to be furnished is dependent upon the desired composition of the paving mixture, and whether the grading to be used in the mixture is achieved with or without blending. Other coarse aggregate gradings may be used provided that the combined aggregates and filler, when used, will produce a paving mixture that provides the desired characteristics.

6.1.1.1 The size to be used is dependent upon the desired composition of the paving mixture, and the required size or sizes either before or after blending as specified.

6.1.2 *Crushed Pieces in Aggregate* —Orders for material under this specification shall state the appropriate requirements for percentage of crushed pieces (Test Method D 5821).

6.1.2.1 Conventional mixtures, not less than 40 % by mass, of the pieces retained on the 4.75-mm (No. 4) sieve shall have at least one fractured face (Notes 3 and 4).

6.1.2.2 Open graded friction course mixtures, of the aggregate pieces retained on the 4.75-mm (No. 4) sieve, not less than 90 % by mass, shall have one or more fractured faces and 75 % by mass, two or more fractured faces.

NOTE 3—Attention is called to the distinction between conventional (dense mixtures or open mixtures) and open-graded friction course mixtures in Specification D 3515.

NOTE 4—Some sources of aggregate contain angular particles that will perform similarly to a mechanically crushed particle. Where laboratory tests or service records indicate this to be true, such angular particles may be considered as crushed.

6.1.3 *Polishing Characteristics*—The coarse aggregates, or the coarsest fraction of the aggregate for use in surface course mixtures, shall be of a type known to possess adequate resistance to polishing action of the anticipated traffic (Note 5).

NOTE 5—No ASTM standard has been recognized to be capable of defining adequate resistance to the polishing action of specific traffic conditions. Test Method D 3319 has been found useful in evaluating the relative polish resistance between samples of different aggregates or mixtures containing different aggregates.

6.1.4 *Soundness*—The coarse aggregate, when subjected to five cycles of the soundness test (see Test Method C 88), shall have a mass loss not greater than 12 % when sodium sulfate is used or 18 % when magnesium sulfate is ~~used (Note 6).~~ used. If the salt is not designated by the purchaser, the aggregate shall be acceptable if it meets the indicated limit for either salt used.

6.1.5 *Degradation*— Aggregate subjected to testing in accordance with Test Method C 131 shall have a loss not greater than 40 % for surface courses or 50 % for base ~~courses (Note 6).~~

~~NOTE 6—Coarse aggregate failing to meet the requirements of 6.1.4 or 6.1.5 may be considered for use provided that (a) similar aggregates from the same source have been shown by experience to result in satisfactory pavement and (b) the results of other tests indicate that the desired performance can be obtained. Aggregate from a new source that fails the requirements of 6.1.4 or 6.1.5, and for which no experience exists, may be considered acceptable provided the results of the other relevant laboratory tests indicate, to the satisfaction of the purchaser, that the desired performance can be obtained.~~ courses.

6.2 *Fine Aggregate*:

6.2.1 The fine aggregate grading shall conform to the requirements of Specification D 1073 for the size number designated, or to another grading as designated in the order (Note ~~7).~~ 6).

NOTE ~~7~~6—The fine aggregate grading to be furnished is dependent upon the desired composition of the paving mixture, and whether the grading to be used in the mixture is achieved with or without blending. Other fine aggregate gradings may be used provided that the combined aggregates and filler, when used, will produce a paving mixture that provides the desired characteristics.

6.2.2 The size to be used is dependent upon the desired composition of the paving mixture, and the required size or sizes either before or after blending as specified.

6.2.3 *Grading Variability*—For continuing shipments of fine aggregate from a given source, the fineness modulus shall not vary more than 0.25 from the base fineness modulus (Note ~~8).~~ 7). The base fineness modulus shall be that value that is typical of the source. The base fineness modulus shall not be changed except when approved by the purchaser.

6.2.3.1 The base fineness modulus shall 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.

NOTE ~~8~~7—Base fineness modulus of the fine aggregate has a great influence on proportioning of bituminous mixtures; therefore, large changes in its value may make adjustments in the mixture necessary.

6.2.4 Plasticity index of the fine aggregate fraction smaller than the 425–μm (No. 40) sieve shall not exceed 4.0 (Test Method D 4318).

6.3 *General Requirements*:

6.3.1 *Expansion*—Aggregates that contain components subject to hydration shall be obtained from sources approved by the purchaser on the basis of either satisfactory performance record, aging, or other treatment known to reduce potential expansion to a satisfactory level (Note ~~9).~~ 8).

NOTE ~~9~~8—Test Method D 4792 has been used to evaluate the potential for expansion of dense graded materials only.

6.3.2 *Environmental Stability*—Aggregates shall be evaluated for environmental considerations (air quality, water quality, and storage) using the required local, state, and federal test methods in effect at the time of use.

6.3.2.1 The aggregate shall meet all applicable local, state, and federal environmental requirements in effect at the time of use.

6.3.2.2 Aggregates that exhibit a potential for producing leachates shall be tested using the Toxicity Characteristic Leaching Procedure (EPA Method SW846 1311) or appropriate test method as approved by the purchaser. Results shall indicate that all areas tested (metals, volatiles, semi-volatiles, and organics) are below regulatory limits.

6.3.3 *Special Requirements*—Evaluation will be required for the following items (but not exclusive of) when specified by the purchaser: the potential for stripping (Test Method D 4867/D 4867M) and friable particles (Test Method C 142).

## 7. Sampling

7.1 Sample the aggregates and determine the properties enumerated in this specification in accordance with the following standards:

7.1.1 Random Sampling—Practice D 3665,
7.1.2 Sampling—Practice D 75,
7.1.3 Grading and Fineness Modulus—Test Methods C 136 and C 117, Procedure A,
7.1.4 Soundness—Test Method C 88,
7.1.5 Degradation—Test Method C 131,
7.1.6 Expansion—Test Method D 4792,
7.1.7 Friable Particles—Test Method C 142,
7.1.8 Stripping—Test Method D 4867/D 4867M,
7.1.9 Adherent Coatings—Test Method D 5711,
7.1.10 Crushed Count—Test Method D 5821,
7.1.11 Plasticity Index—Test Method D 4318, and
7.1.12 Leaching—EPA Test Method SW846 1311.

## 8. Keywords

8.1 bituminous paving; coarse aggregate; fine aggregate; paving mixtures; steel slag aggregate

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified by the purchaser in the contract or order.

S1. *Sulfate Soundness*—The fine aggregate, when subjected to five cycles of the soundness test in accordance with Test Method C 88, shall have a weighted loss of not greater than 15 % when sodium sulfate is used or 20 % when magnesium sulfate is used. If the salt used is not stated by the purchaser, the fine aggregate shall be acceptable if it meets the requirement when tested with either salt.