

SECTION 706

AGGREGATES FOR PORTLAND CEMENT PRODUCTS

SCOPE

706.01.01 MATERIALS COVERED

- A. This specification covers the quality and size of aggregates used in Portland cement products.

REQUIREMENTS

706.02.01 GENERAL

- A. The mineral aggregate shall be the product of approved deposits. The Engineer reserves the right to prohibit the use of aggregates from any source when:
1. The character of the material is such, in the opinion of the Engineer, as to make improbable the furnishing of aggregates conforming to the requirements of these specifications.
 2. The character of the material is such that, in the opinion of the Engineer, undue additional costs may be accrued by the Contracting Agency.
- B. For mix design approval, the proposed proportions of coarse, intermediate, and fine aggregate, combined mathematically by volume or mass, shall produce a mixture within the grading limits for combined aggregates as shown in Table 1 (not applicable to lightweight concrete):

Table 1 - Grading Limits of Combined Aggregates

Sieve Size	Percentage Passing				
	1-1/2-inch Max.	1-inch Max	3/4-inch Max.	1/2-inch Max	3/8-inch Max.
2-inch	100	--	--	-	-
1-1/2-inch	87-100	100	--	-	-
1-inch	65-90	97-100	100	-	-
3/4-inch	48-82	70-100	80-100	100	-
1/2-inch	--	--	--	90-100	100
3/8-inch	39-57	43-70	46-70	70-90	70-100
No. 4	30-45	32-48	34-50	45-60	47-70
No. 8	23-38	23-42	24-42	38-56	34-55
No. 16	15-33	15-34	17-34	24-38	23-43
No. 30	8-24	8-25	10-25	13-27	15-33
No. 50	4-13	4-15	5-15	7-17	7-20
No. 100	1-5	2-7	2-7	0-6	2-8
No. 200	0-5	0-5	0-5	0-5	0-5

- C. If the Contractor prefers a finer gradation for the purpose of slip-form operations, the following gradation is permitted with approval of the Engineer.

Table 2 - Gradation for Slip-Form Operations

Sieve Size	Percentage Passing	
	1-1/2-inch Max.	3/4-inch Max.
2-inch	100	--
1 1/2-inch	87-100	--
1-inch	65-97	100
3/4-inch	48-91	80-100
1/2-inch	--	--
3/8-inch	39-70	46-74
No. 4	30-54	34-54
No. 8	23-38	24-50
No. 16	15-33	17-38
No. 30	8-24	10-29
No. 50	4-13	5-19
No. 100	1-5	2-9
No. 200	0-5	0-5

- D. If the Contractor proposes to use an admixture other than an air-entraining agent, Contractor shall state the complete brand name and the quantity proposed to be used per sack of cement.
- E. Should the Contractor change Contractor's source of supply, Contractor shall submit in writing to the Engineer the new gradation before their intended use.
- F. In addition to the coarse, intermediate, and fine aggregates meeting the individual source requirements, the combined gradation shall meet the following source requirement:

Table 3 - Alkali-Silica Reaction

Source Requirement Test, Combined Aggregates	Test Method	Requirement
Accelerated Detection of Potentially Deleterious Expansion of Mortar Bars Due to Alkali-Silica Reaction	AASHTO T303	0.10% Max. Expansion ¹

- G. Previous AASHTO T303 qualified aggregates for concrete mix designs will not automatically qualify for approval. Submit new AASHTO T303 test results with concrete mix design.
- H. Perform this test on the coarse, intermediate, and fine aggregates together, combined in the same proportions as the proposed mix design.
1. The test may be performed on each size separately and the results combined mathematically.
 2. Perform the test using the proposed sources together with proposed job cement and job pozzolan or other admixture, if used.
 3. The pozzolan and silica fume quantities will be considered as cement in meeting the requirements of cement in Table 2 of Subsection [501.03.04](#), "Classification and Proportions."

¹ This requirement applies to all aggregate used in the concrete bridge structures, including approach slabs, reinforced concrete boxes, walkways, or sidewalks on the bridge structure itself, and all concrete bridge rail.

- I. Prior to mix design approval, the Contracting Agency reserves the right to verify the AASHTO T303 test results, using the sources and proportions of materials as indicated by the mix design.
- J. Conduct another test upon changes in source of cementitious materials, including fly ash, or changes in cement type or mitigating admixture suppliers.

PHYSICAL PROPERTIES AND TESTS

706.03.01 COARSE AGGREGATE

- A. The aggregate shall conform to the following table requirements:

Table 4 - Percentage by Weight Passing Sieve

Sieve Size	Size No. 3 2-inch to 1-inch	Size No. 4 1-1/2-inch to 3/4-inch	Size No. 7 1/2-inch to No. 4	Size No. 57 1-inch to No. 4	Size No. 67 3/4-inch to No. 4	Size No. 357 2-inch to No. 4	Size No. 467 1-1/2-inch to No. 4
2-1/2-inch	100	--	--	--	--	100	--
2-inch	95-100	100	--	--	--	95-100	100
1-1/2-inch	35-70	90-100	--	100	--	--	95-100
1-inch	0-15	20-55	--	95-100	100	35-70	--
3/4-inch	--	0-15	100	--	90-100	--	35-70
1/2-inch	0-5	--	90-100	25-60	--	10-30	--
3/8-inch	--	0-5	40-70	--	20-55	--	10-30
No. 4	--	--	0-15*	0-10*	0-10*	0-5	0-5

*Not more than 5 percent shall pass No. 8 Sieve.

NOTE: Sizes No. 357 and No. 467 shall each be split into 2 sizes. Size No. 357 shall be furnished in stockpile or bunker in Sizes No. 3 (2-inch to 1-inch) and Size No. 57 (1-inch to No. 4.) Size No. 467 shall be furnished in stockpile or bunker in Size No. 4 (1-1/2-inch to 3/4-inch) and Size No. 67 (3/4-inch to No. 4). The two sizes shall be uniformly combined at the mixing plant to comply with the grading requirements of Sizes No. 357 and No. 467 respectively.

Table 5 - Coarse Aggregate Properties

Tests	Test Method	Requirements
Sieve Analysis	AASHTO T27	Above
Sampling Aggregate	ASTM D75	--
Material Passing 200 Sieve	AASHTO T27	1% Maximum
Percentage of Wear (100 Rev.)	ASTM C131	10% Maximum
Percentage of Wear (500 Rev.)	ASTM C131	50% Maximum
Soundness (5 Alternations) (sodium sulfate)	AASHTO T104	9% Maximum Loss
Cleanness Value min.	CALIF 227	71 706.03.01.B.1
Clay Lumps	AASHTO T112	1% Maximum
Potential Reactivity	AASHTO T303	Innocuous 706.03.01.B.2

- B. Thin or elongated pieces (length greater than 5 times maximum thickness) shall not exceed 15 percent by weight.

1. When 2 or more stockpiles are to be combined, each stockpile shall have a cleanness value of at least 65 with a minimum combined cleanness value of 71 calculated by the percent of material used from each stockpile.
 2. If the material from a proposed source fails this test requirement, the material may still be used for concrete aggregate provided that it is incorporated in an approved mix design with an approved Type F or Type N Pozzolan, or with a Type IP cement.
- C. If a pozzolan is used for this purpose, use 1 part pozzolan to 4 parts of cement by mass. The pozzolan quantity shall be considered as cement in meeting the required minimum cement content. If a Type IP cement is used for this purpose, the use of pozzolan is not required.

706.03.02 LIGHTWEIGHT AGGREGATES

- A. These aggregates shall conform to the following requirements:

Table 6 - Lightweight Aggregate Gradation

Sieve Size	Percentage of Weight Passing Sieve			
	Fine Natural	Fine Lightweight	1-inch Size Coarse	3/4-inch Size Coarse
1-inch	--	--	95-100	100
3/4-inch	--	--	--	90-100
1/2-inch	--	--	25-60	--
3/8-inch	100	100	--	20-60
No. 4	95-100	85-100	0-10	0-10
No. 16	45-80	40-80	--	--
No. 50	10-35	10-35	--	--
No. 100	2-12	5-25	--	--
No. 200	0-5	--	--	--

Table 7 - Lightweight Aggregate Properties

Tests	Test Method	Requirements
Sieve Analysis	AASHTO T27	Above 706.03.02.A.1 below
Sampling	ASTM D75	--
Unit Weight (loose oven dry) Fine Aggregate 70 lb/ft ³	Nev. T487	Maximum 706.03.02.A.2 below
Unit Weight (loose oven dry) Coarse Aggregate 55 lb/ft ³		
Unit Weight (loose oven dry) Combined Fine and Coarse Aggregate 65 lb/ft ³		
Organic Impurities	ASTM C40	Satisfactory 706.03.02.A.3 below
Clay Lumps	AASHTO T112	2.0% Maximum
Test for Staining Materials	ASTM D330	Satisfactory 706.03.02.A.4 below
Mortar Making Properties of Sand	ASTM C87	95% Minimum 706.03.02.A.5 below

1. With the following exceptions: The weight of the test sample for the fine lightweight aggregate shall be in accordance with Table 8, and the aggregate when mechanically

sieved shall be sieved for only 5 minutes. The test sample for coarse aggregate shall consist of no less than 0.1 cubic foot of the material used for the determination of unit weight.

Table 8 - Weight of Sieve Test Sample for Fine Lightweight Aggregates

Nominal Weight of Aggregate		Weight of Test Sample	
(lbs/ft ³)	kg/m ³	Grams	Oz.
25-35	401-561	150	5.3
35-45	561-721	200	7.0
45-55	721-881	250	8.8
55-65	881-1042	300	10.6
65-70	1042-1122	350	12.3

2. The unit weight of successive shipments of lightweight aggregate shall not differ by more than 10 percent from that of the sample submitted for acceptance tests.
3. Aggregates tested and showing color darker than the standard shall be rejected unless it can be demonstrated that the discoloration is due to small quantities of materials not harmful to the concrete.
4. Aggregates tested and showing stain darker than "heavy stain" (stain index of 80) shall be tested by chemical procedure, and aggregates that contain 1.5 mg or more of ferric oxide (Fe₂O₃) per 200 gram sample shall be rejected for use.
5. Fine Aggregate failing in the test for organic impurities (ASTM C40) may be used provided that when tested for effect of organic impurities on strength of mortar, the relative strength at 7 and 28 days calculated in accordance with ASTM C87 is not less than 95 percent.

706.03.03 FINE AGGREGATE

A. This aggregate shall conform to the following requirements:

Table 9 - Fine Aggregate Gradation

Sieve Sizes	Percentage by Weight Passing Sieve
3/8-inch	100
No. 4	95-100
No. 16	45-80
No. 50	10-35
No. 100	2-12
No. 200	0-5

Table 10 - Fine Aggregate Properties

Tests	Test Method	Requirements
Sieve Analysis	AASHTO T27	Above
Sampling Aggregate	ASTM D75	--
Soundness (5 alternations) (sodium sulfate)	AASHTO T104	10% Maximum Loss
Clay Lumps	AASHTO T112	1.0% Maximum
Lightweight Pieces in Aggregate (less than 2.0 sp. gr.)	AASHTO T113	1.0% Maximum

Table 10 - Fine Aggregate Properties

Tests	Test Method	Requirements
Organic Impurities	ASTM C40	Satisfactory 706.03.03.A.2 below
Mortar Making Properties	ASTM C87	95% Minimum 706.03.03.A.1 below

1. Aggregates tested and showing color darker than the standard shall be rejected unless they pass the mortar making properties test in accordance with ASTM C87.
2. Fine aggregate failing in the test for organic impurities (ASTM C40) may be used provided that when tested for effect of organic impurities on strength of mortar, the relative strength of 7 and 28 days calculated in accordance with ASTM C87 is not less than 95 percent.
3. If the material from a proposed source fails this test requirement, the material may still be used for concrete aggregate provided that it is incorporated in an approved mix design with an approved Type F or Type N Pozzolan, or with a Type IP cement.
 - a. If a pozzolan is used for this purpose, use 1 part pozzolan to 4 parts of cement by mass.
 - b. The pozzolan quantity shall be considered as cement in meeting the required minimum cement content.
 - c. The limitation on replacement of cement with pozzolans at a minimum of 20 percent in Subsection [501.02.03](#), "Admixtures," is hereby waived to meet this requirement.
 - d. If a Type IP cement is used for this purpose, the use of pozzolan is not required.

706.03.04 GROUT AND MORTAR SAND

- A. This aggregate shall conform to the following requirements:
- B. Sand for grout and mortar shall conform to the size requirements of Subsection [706.03.03](#), "Fine Aggregate," except if the Contractor elects, Contractor may screen the sand over a No. 8 screen to produce the following:

Table 11 - Grout Aggregate Gradation

Sieve Sizes	Percentage by Weight Passing Sieve
No. 8	100
No. 50	15-40
No. 100	0-10
No. 200	0-5

Table 12 - Grout Aggregate Properties

Tests	Test Method	Requirements
Sieve Analysis	AASHTO T27	Above
Sampling Aggregate	ASTM D75	-----
Organic Impurities	ASTM C40	Satisfactory 706.03.04.B.2
Mortar Making Properties	ASTM C87	95% Minimum 706.03.04.B.1

1. Aggregates tested and showing color darker than the standard shall be rejected unless they pass the mortar making properties test in accordance with ASTM C87.

2. Fine aggregate failing in the test for organic impurities (ASTM C40) may be used provided that when tested for effect of organic impurities on strength of mortar, the relative strength at 7 and 28 days calculated in accordance with ASTM C87 is not less than 95 percent.

706.03.05 RIPRAP GROUT

- A. The mix design for the placing requirements addresses 2 placement methods:
 1. Direct discharge from the transit mixer.
 2. Placement by small diameter line pumping methods.
- B. Two typical mixtures that would meet the above minimum requirements are as follows:

Table 13 - Proportions for 1.0 Cubic Yard of Grout

	Pump Method Approx. Volume (Cu. Ft.)	Transit Mixer Discharge Approx. Volume (Cu. Ft.)
Pea Gravel	3.5	7.6
Washed Concrete Sand	10.6	7.6
Water	6.5	5.9
Type V cement	3.5	3.1
Fly Ash class F	1.6	1.4
Balance Air	1.3	1.4

- C. Factors which shall be considered for a given grout mix are:
 1. Fine and coarse aggregates.
 2. Consistency.
 3. Elapse time between placement and initial set.
 4. Length of time between batching and placement during which continuous or intermittent mixing is required.
- D. Materials used in the production of riprap grout shall meet the minimum following material standards:
 1. Fine and Coarse Aggregate: ASTM C33; Section [206](#), "Structure Excavation."
 2. Portland Cement: ASTM C150, Type V; Section [701](#), "Hydraulic Cement."
 3. Fly Ash: ASTM C618; Section [729](#), "Fly Ash."
 4. Water: Section [722](#), "Water."
 5. Air Entraining Admixture: ASTM C260; Section [702](#), "Aggregates for Portland Cement Products."
- E. A trial batch shall be placed for review by the Engineer for final approval for the project.
- F. The Engineer shall be provided with a legible ticket with each load of grout delivered to the project site which shall contain the following information:
 1. Name of Vendor.
 2. Name of Contractor.

3. Number of Cubic Yards in the Load.
4. Actual Weights of Cement and of each Size of Aggregate.
5. Amount of Water Added at the Plant.
6. Amount of Water in the Aggregate.
7. Brand and Type of Cement.
8. Brand and Amount of Admixture.
9. Time and Date of Batching.