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APPENDIX A8—PROPOSED STANDARD SPECIFICATION FOR COMBINED AGGREGATES FOR HYDRAULIC CEMENT CONCRETE

The following is a proposed standard specification for combined aggregates for hydraulic cement concrete to be included in the *AASHTO Standard Specifications for Transportation Materials and Methods of Sampling, Part 1: Specifications.*

It is suggested that the proposed standard for combined aggregates for hydraulic cement concrete be grouped with M 6-02, Fine Aggregates for Portland Cement Concrete, and M 80-87 (1999), Coarse Aggregate for Portland Cement Concrete, in the table of contents under Aggregates with a heading of “Combined Aggregates for Hydraulic Cement Concrete.”

Present specifications are AASHTO M 6 and AASHTO M 80.

[Referenced in Article 8.3.5, “Combined Aggregates.”]

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APPENDIX A8

AASHTO Designation: M XXI
Standard Specification for Combined Aggregates for Hydraulic Cement Concrete

1. SCOPE

1.1. This specification covers the requirements for combined aggregates for hydraulic cement concrete having a nominal maximum aggregate size of 50 mm (2.0 in.) or less. Fine and coarse aggregate shall be blended to achieve the desired properties. Two approaches are given. One is based on performance and the other on method type.

1.2. The values stated in SI units are to be regarded as standard.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
M 6 Fine Aggregate for Portland Cement Concrete
M 43 Sizes of Aggregate for Road and Bridge Construction
M 80 Coarse Aggregate for Portland Cement Concrete
M 195 Lightweight Aggregates for Structural Concrete
T 22 Compressive Strength of Cylindrical Concrete Specimens
T 23 Making and Curing Concrete Test Specimens in the Field
T 97 Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
T 119 Slump of Hydraulic Cement Concrete
T 141 Sampling Freshly Mixed Concrete
T 160 Length Change of Hardened Hydraulic Cement Mortar and Concrete
T 198 Splitting Tensile Strength of Cylindrical Concrete Specimens
T 259 Resistance of Concrete to Chloride Ion Penetration
T 277 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
PP 34 Estimating the Cracking Tendency of Concrete

2.2. *American Concrete Institute Standards*:
211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
221.2 Standard Practice for Selecting Proportions for Structural Lightweight Concrete

3. SIGNIFICANCE AND USE

3.1. The goal of a combined aggregate grading is to improve the workability of concrete at given water and paste contents or to improve the hardened properties by minimizing the amount of the water and paste for a given workability or to improve both the workability and hardened properties of concrete.

3.2. The shape and texture of the aggregate also have a large influence on the water and paste demand. Trial batches shall be made to ensure that desired concrete properties are achieved.

4. GENERAL REQUIREMENTS

4.1. Fine and coarse aggregates used shall comply with the relevant provisions of AASHTO M 6, M 43, M 80, and M 195 for ordering information, grading (M 43 shall be used unless otherwise permitted) based on a nominal maximum size, uniformity of grading, deleterious substances, and, if specified, reactive aggregates. Tests for performance characteristics of the concrete shall comply with the relevant specifications and specified AASHTO Test Methods for sampling (T 141), making test specimens (T 23), slump (T 119), crack tendency (PP 34), or other test methods as specified.

Proportions of fine and coarse aggregate shall be selected using the performance-based approach of Section 5 or the method-type approach of Section 6.

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5. PERFORMANCE-BASED APPROACH

5.1. Contractor shall select the combined aggregate grading and demonstrate with trial batches that the specified properties are achieved (Note 1). It shall be the Contractor's responsibility to ensure that the combined grading provides the specified properties for the project.

Note 1—For proportioning hydraulic cement concrete, the *AASHTO LRFD Bridge Construction Specifications*, Article 8.4.1.1 specify the use of the absolute volume method for normal-density (normal-weight) concrete such as described in ACI publication 211.1 and the use of trial mixes for structural low-density (lightweight) concrete using methods such as described in ACI publication 211.2.

6. METHOD-TYPE APPROACH

6.1. *One of the following procedures shall be used to determine combined aggregate grading*:

Combined fineness modulus
Coarse factor chart
Power chart
Percent retained on each sieve

Note 2—Details of the procedures are given in the Appendix.

6.2. The specific combined grading to which the aggregate is to be blended, along with the tolerances for quality control, shall be submitted for approval. Concrete characteristics shall be verified by trial batches to ensure that the specified properties are achieved.

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APPENDIX

(Nonmandatory Information)

X.1. METHOD-TYPE APPROACH

X1.1. *Fineness Modulus*:

X1.1.1. The combined fineness modulus (FM) is obtained by adding the total percentages of material in the sample that are coarser than each of a set of sieves (cumulative percentages retained) and dividing the sum by 100 (see ACI 116). [1] FM is an index of the fineness of the material. A higher FM means that the aggregate is coarser. Trial batches are necessary to establish target values.

X1.2. *Coarseness Factor*:

X1.2.1. Workability factor and coarseness factor are determined for the combined aggregate. The factors are plotted on the chart shown in Figure X1.1. Zone II is the desired location. [2]

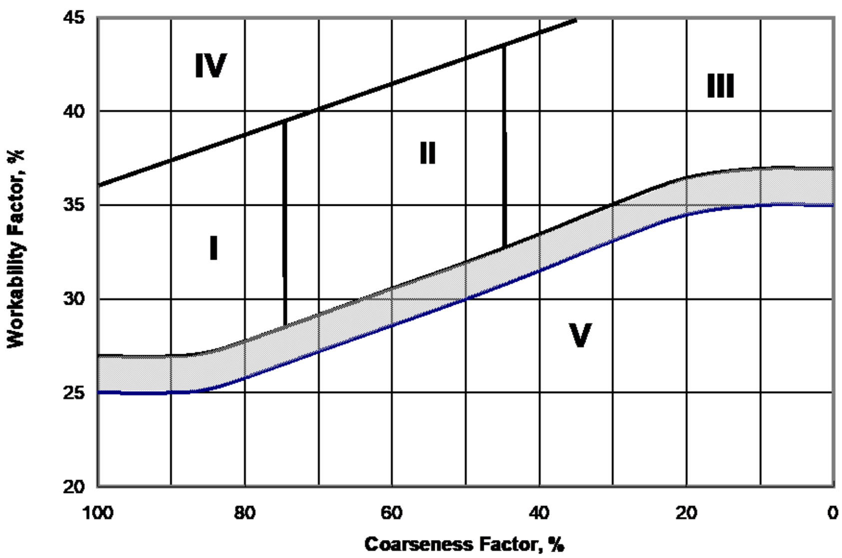

Figure X1.1—Coarseness Factor Chart

X1.2.2. The workability factor is the percent passing the 2.36-mm (No. 8) sieve adjusted for cementitious materials content of the proposed concrete mix. The measured percent passing the 2.36-mm (No. 8) sieve is increased or decreased by one percentage point for each 22 kg/m^3 (37 lb/cu yd) that the cementitious materials content is above or below 334 kg/m^3 (563 lb/cu yd), respectively.

X1.2.3. The coarseness factor is the cumulative percent retained on the 9.5-mm ($^3/_8$-in.) sieve divided by the cumulative percent retained on the 2.36-mm (No. 8) sieve.

X1.2.4. The five zones in the chart represent the following types of concretes:

I “Gap-graded” and tends to segregate
II Well graded 37.5 to 12.5 mm ($1^1/_2$ to $^1/_2$ in.)
III 12.5 mm ($^1/_2$ in.) and finer
IV Sticky
V Rocky

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X1.2.5. Example

Cement Content		362	kg/m^3
Aggregate Data: As shown in Table X1.1			
Aggregate ID	Size 57		Sand
SSD Weight, kg	856		503
Specific Gravity	2.77		2.61
Aggregate, % by weight	63		37

Cement Content		611	lb/yd^3
Aggregate Data: As shown in Table X1.1			
Aggregate ID	Size 57		Sand
SSD Weight, lb	1887		1108
Specific Gravity	2.77		2.61
Aggregate, % by weight	63		37

Table X1.1—Sieve Analysis and Combined Grading

Sieve Size		Size 57		Sand		Combined		
		% Passing	% Mix	% Passing	% Mix	% Passing	Cum. % Retained	% Retained
50 mm	(2.0 in.)	100.0	63.0	100.0	37.0	100.0	0.0	0.0
37.5 mm	(1.5 in.)	100.0	63.0	100.0	37.0	100.0	0.0	0.0
25.0 mm	(1.0 in.)	100.0	63.0	100.0	37.0	100.0	0.0	0.0
19.0 mm	(0.75 in.)	85.0	53.6	100.0	37.0	90.6	9.4	9.4
12.5 mm	(0.5 in.)	60.0	37.8	100.0	37.0	74.8	25.2	15.8
9.5 mm	(0.375 in.)	35.0	22.1	100.0	37.0	59.1	40.9	15.7
4.75 mm	(No. 4)	10.0	6.3	99.7	36.9	43.2	56.8	15.9
2.36 mm	(No. 8)	0.0	0.0	87.8	32.5	32.5	67.5	10.7
1.18 mm	(No. 16)	0.0	0.0	65.7	24.3	24.3	75.7	8.2
600 µm	(No. 30)	0.0	0.0	33.6	12.4	12.4	87.6	11.9
300 µm	(No. 50)	0.0	0.0	12.7	4.7	4.7	95.3	7.7
150 µm	(No. 100)	0.0	0.0	3.4	1.3	1.3	98.7	3.4
75 µm	(No. 200)	0.0	0.0	0.0	0.0	0.0	100.0	1.3

Q = Cumulative percent retained on 9.5 mm (0.375 in.) sieve = 40.9
R = Cumulative percent retained on 2.36 mm (No. 8) sieve = 67.5
W = Percent passing 2.36 mm (No. 8) sieve = 32.5
C = Cementitious materials content = 362 kg/m^3 (611 lb/yd^3)

Workability Factor (WF) = SI $W + (C - 335)/22 = 32.5 + (362 - 335)/22 = 33.7\%$
= (USC) $W + (C - 564)/38 = 32.5 + (611 - 564)/38 = 33.7\%$

Coarseness Factor (CF) $= 100\,(Q/R) = 100\,(40.9/67.5) = 60.6\%$

When the values of *CF* and *WF* are plotted on the Coarseness Factor Chart of Figure X1.1, they fall in Zone II.

X1.3. *Power Chart*:

X1.3.1. In this method, the percent passing each sieve size is plotted against the sieve size in microns raised to power of 0.45 on semilog paper. A best fit straight line is then drawn through data points as shown by the broken line in Figure X1.2. The combined grading should follow the straight broken line within plus or minus seven percentage points deviation for percent passing. The dash lines in Figure X1.2 are seven percentage points below and above the broken line indicating the acceptable variability. For aggregates passing the 600 µm (No. 30) sieve, the grading curve may fall below the power chart line to compensate for the presence of fine cementitious materials. [3]

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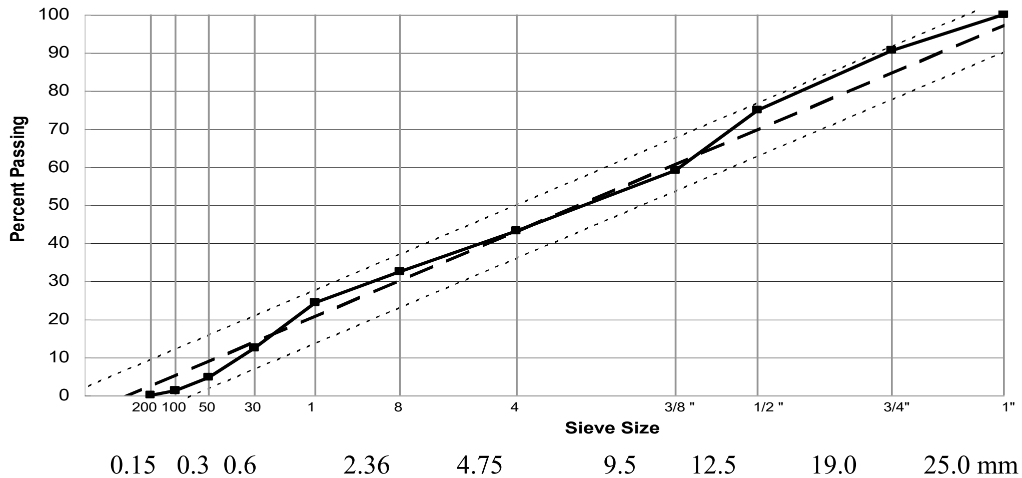

Figure X1.2—Power Chart

X1.4. *Percent Retained on Each Sieve*:

X1.4.1. In this method, the percent retained on each sieve size is kept to a limited range and the difference between percent retained on consecutive sieve sizes should be less than ten percentage points.

X1.4.2. ACI 302 suggests limits for the material retained on each sieve for satisfactory reduction in water demand while providing good workability.[4] If the largest size aggregate is 37.5 mm (1.5 in.), the percentage of material retained on each sieve size below the top size and above the 500 µm (No. 100) sieve shall be between 8 and 18. If the largest size aggregate is 25 mm or 19 mm (1.0 in. or 0.75 in.), the range shall be 8 to 22 percent. The ideal range for 600 µm (No. 30) and 300 µm (No. 50) sieves is eight percent to 15 percent retained on each. These ranges are illustrated in Figure X1.3 together with the data from Table X1.1.

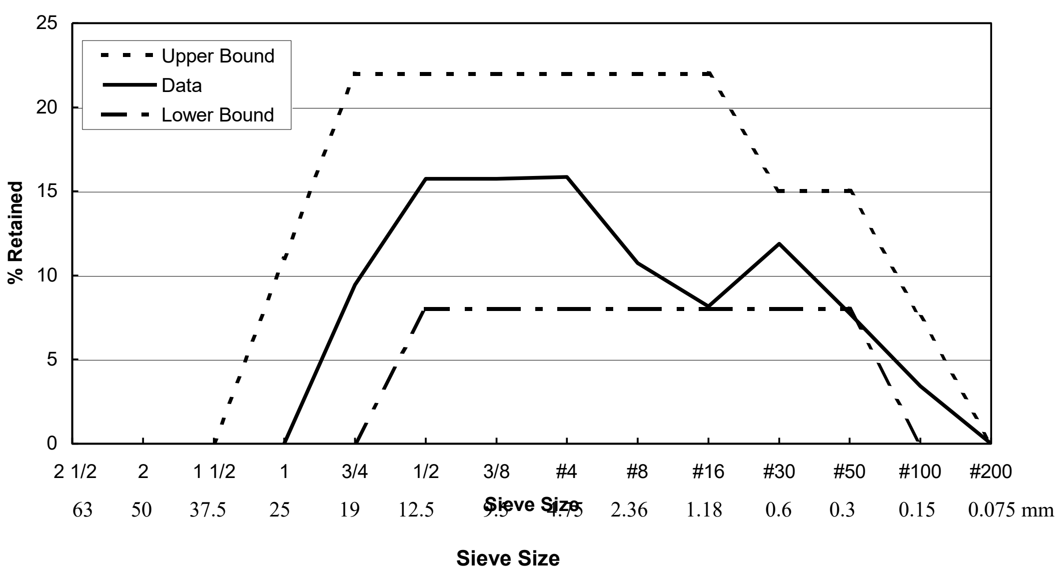

Figure X1.3—Percent Retained on Each Sieve

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1 *Cement and Concrete Technology*, ACI 116-R, ACI Committee 116. 2000.

2 "Concrete Mixture Optimization," *Concrete International*, Vol. 12, No. 6, June 1990, pp. 33–39.

3 *Properties of Concrete*, 4th Edition, A. M. Neville, 1996.

4 *Guide for Concrete Floor and Slab Construction*, ACI 302.1R, ACI Committee 302. 1996.

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SECTION 9: REINFORCING STEEL

TABLE OF CONTENTS

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SECTION 9

REINFORCING STEEL

9.1—DESCRIPTION

This work shall consist of furnishing and placing reinforcing steel in accordance with these Specifications and in conformity with the contract documents.

9.2—MATERIAL

All reinforcing bars shall be deformed except that plain bars may be used for spirals and ties.

Reinforcing steel shall conform to the requirements herein.

9.2.1—Uncoated Reinforcing

Uncoated reinforcing steel shall conform to one of the following specifications:

- Deformed and Plain Billet-Steel Bars for Concrete Reinforcement—AASHTO M 31M/M 31 (ASTM A615/A615M). Grade 60 (Grade 420) shall be used unless otherwise specified in the contract documents.
- Rail-Steel and Axle-Steel Plain Bars for Concrete Reinforcement—AASHTO M 322M/M 322 (ASTM A996/A996M). Grade 60 (Grade 420) steel shall be used unless otherwise specified in the contract documents.
- Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement—ASTM A706/A706M.
- Deformed Steel Wire for Concrete Reinforcement—AASHTO M 225M/M 225 (ASTM A496).
- Welded Plain Steel Wire Fabric for Concrete Reinforcement—AASHTO M 55M/M 55 (ASTM A185).
- Plain Steel Wire for Concrete Reinforcement—AASHTO M 32M/M 32 (ASTM A82).
- Steel Welded Wire Reinforcement, Deformed, for Concrete—AASHTO M 221M/M 221 (ASTM A497).

C9.2.1

Grade 60 (Grade 420) in ASTM A615/A615M.

Grade 60 (Grade 420) in ASTM A615/A615M.

9.2.2—Epoxy-coated Reinforcing

The reinforcing steel to be epoxy-coated shall conform to Article 9.2.1.

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When epoxy coating of reinforcing bars is required, the coating materials and process, the fabrication, handling, identification of the bars, and the repair of damaged coating that occurs during fabrication and handling, to the point of shipment to the job site, shall conform to the requirements of AASHTO M 284M/M 284 (ASTM D3963/D3963M) or to ASTM A934/A934M, as specified in the contract documents.

Epoxy-coated reinforcing bars shall be coated in a certified epoxy coating applicator plant in accordance with the Concrete Reinforcing Steel Institute Voluntary Certification Program for Fusion-Bonded Epoxy Coating Applicator Plants, or equivalent.

Epoxy-coated wire and welded wire fabric shall conform to the requirements of ASTM A884/A884M, Class A.

Each shipment of epoxy-coated reinforcing steel shall be accompanied with a Certificate of Compliance signed by the applicator of the coating certifying that the epoxy-coated reinforcing bars conform to the requirements of AASHTO M 317M/M 317 (ASTM D3963/D3963M) and AASHTO M 284M/M 284 (ASTM A775/A775M) or ASTM A934/A934M, or that epoxy-coated wire or welded wire fabric conforms to ASTM A884/A884M, Class A.

9.2.3—Stainless Steel Reinforcing Bars

When specified in the contract document, deformed or plain stainless steel reinforcing bars shall conform to the requirements of ASTM A955/A955M.

9.2.4—Low Carbon, Chromium, Steel Reinforcing Bars

Where specified in the contract documents, deformed, low carbon, chromium, steel reinforcing bars shall conform to the requirements of ASTM A1035/A1035M.

9.2.5—Mill Test Reports

When steel reinforcing bars, other than bars conforming to ASTM A706/A706M, are to be spliced by welding or when otherwise requested, a certified copy of the mill test report showing physical and chemical analysis for each heat or lot of reinforcing bars delivered shall be provided to the Engineer.

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