

**1102- AGGREGATES FOR CONCRETE**

**SECTION 1102**

**AGGREGATES FOR CONCRETE**

**1102.1 DESCRIPTION**

This specification is for coarse aggregates, intermediate aggregates, fine aggregates, mixed aggregates (both coarse and fine material) and miscellaneous aggregates for use in all types of concrete construction.

**1102.2 REQUIREMENTS**

**a. Coarse Aggregates for Concrete.**

(1) Composition. Provide coarse aggregate that is crushed or uncrushed gravel, chat, or crushed stone. (Consider limestone, calcite cemented sandstone, rhyolite, quartzite, basalt and granite as crushed stone). When using quartzite, include supplementary cementitious materials to prevent ASR. Mixtures utilizing quartzite must comply with **Subsection 401.3 j or k**.

(2) Quality.

(a) Provide coarse aggregates for structures (SCA) and coarse aggregates for applications "not placed on-grade" that comply with **TABLE 1102-1**:

<b>TABLE 1102-1: QUALITY REQUIREMENTS FOR COARSE AGGREGATES FOR STRUCTURAL CONCRETE AND COARSE AGGREGATES FOR APPLICATIONS NOT PLACED ON-GRADE</b>				
<b>Concrete Classification</b>	<b>Soundness (min.)</b>	<b>Wear (max.)</b>	<b>Absorption (max.)</b>	<b>Acid Insol. (min.)</b>
Grade xx (AE)(SW) <sup>1</sup>	0.90	40	-	-
Grade xx (AE)(SA) <sup>2</sup>	0.90	40	2.0	-
Grade xx (AE)(AI) <sup>3</sup>	0.90	40	-	55
Grade xx (AE)(PB) <sup>4</sup>	0.90	40	3.0	-
BDWS <sup>5</sup>	0.95	40	-	55
All Other Grades	0.90	50	-	-

<sup>1</sup>Grade xx (AE)(SW) - Structural concrete with select coarse aggregate for wear.

<sup>2</sup>Grade xx (AE)(SA) - Structural concrete with select coarse aggregate for wear and absorption.

<sup>3</sup>Grade xx (AE)(AI) - Structural concrete with select coarse aggregate for wear and acid insolubility.

<sup>4</sup>Grade xx (AE)(PB) - Structural concrete with select aggregate for use in prestressed concrete beams.

<sup>5</sup>BDWS - Bridge Deck Wearing Surface.

(b) The quality requirements for coarse aggregates for applications "placed on-grade" (CPA) are:

- All Aggregates:
  - Soundness, minimum (KTMR-21) ..... 0.90\*
  - Wear, maximum (KTMR-25) ..... 50%

\*Soundness will be waived for limestone and dolomite complying with all requirements for Class I aggregate.

(3) Additional Requirements for Limestone or Dolomite for Concrete on-grade.

- Class I Aggregate
  - Modified Soundness, minimum (KTMR-21) ..... 0.85
  - Durability Factor, minimum (KTMR-22) ..... 95
  - Expansion, maximum (KTMR-22) ..... 0.025%
- Limestone or dolomite used in CPA-4 with >5 percent retained on ¾ inch sieve (Class 2 aggregate):
  - Modified Soundness, minimum (KTMR-21) ..... 0.85
  - Durability Factor, minimum (KTMR-22) ..... 97
  - Expansion, maximum (KTMR-22) ..... 0.015%

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(4) Product Control.

(a) Provide Structural Coarse Aggregates that comply with **TABLE 1102-2**.

<b>TABLE 1102-2: GRADING REQUIREMENTS FOR COARSE AGGREGATES FOR STRUCTURAL CONCRETE</b>									
<b>Type</b>	<b>Composition</b>	<b>Percent Retained - Square Mesh Sieves</b>							
		<b>1½"</b>	<b>1"</b>	<b>¾"</b>	<b>½"</b>	<b>⅜"</b>	<b>No. 4</b>	<b>No. 8</b>	<b>No. 30</b>
SCA-1	Chat	0	0-5				55-75	87-97	95-100
SCA-2	Siliceous Gravel or Crushed Stone			0	0-35	30-70	75-100	95-100	
SCA-3	Siliceous Gravel or Crushed Stone		0	0-20		40-70		95-100	
SCA-4*	Siliceous Gravel, Chat or Crushed Stone		0	0-20				95-100	
SCA-5	Crushed Siliceous Gravel, Chat and Crushed Stone			0	0-10	15-50	85-100		

\*Use with Basic Aggregate to produce Mixed Aggregate

(b) Provide Coarse Paving Aggregates that comply with **TABLE 1102-3**.

<b>TABLE 1102-3: GRADING REQUIREMENTS FOR COARSE AGGREGATES FOR CONCRETE PAVEMENT AND ON-GRADE CONCRETE</b>									
<b>Type</b>	<b>Composition</b>	<b>Percent Retained - Square Mesh Sieves</b>							
		<b>1½"</b>	<b>1"</b>	<b>¾"</b>	<b>½"</b>	<b>⅜"</b>	<b>No. 4</b>	<b>No. 8</b>	<b>No. 30</b>
CPA-1	Siliceous Gravel or Crushed stone except limestone or dolomite	0	0-10	14-35		50-75		95-100	
CPA-2	Chat	0	0-5				55-75	87-97	95-100
CPA-3	Siliceous Gravel or Crushed Stone			0	0-35	30-70	75-100	95-100	
CPA-4*	Siliceous Gravel, Chat or Crushed Stone		0	0-10**				95-100	

\* Use with Basic Aggregate to produce Mixed Aggregate

\*\*If limestone or dolomite aggregates do not comply with Class 2 in **subsection 1102.2a.(3)**, the maximum percent retained is 5.

(c) Deleterious Substances. Maximum allowed deleterious substances by weight are:

- Material passing the No. 200 sieve (KT-2) ..... 2.5%
- Shale or Shale-like material (KT-8) ..... 0.5%
- Clay lumps and friable particles (KT-7) ..... 1.0%
- Sticks (wet) (KT-35) ..... 0.1%
- Coal (AASHTO T 113) ..... 0.5%

(d) Uniformity of Supply. Designate or determine the fineness modulus (grading factor) according to the procedure listed in the Construction Manual Part V, Section 17 before delivery, or from the first 10 samples tested and accepted. Provide aggregate that is within ±0.20 of the average fineness modulus.

(e) Proportioning of Coarse and Fine Aggregate. Combine fine and coarse aggregates in a 50%-50% ratio by weight. Adjustments to improve workability may be made when approved by the Engineer. Use of a proven optimization method such as the ACI 302.1 method can provide adequate justification.

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(5) Do not combine siliceous fine aggregate with siliceous coarse aggregate if neither comply with **subsection 1102.2c.(2)(a)**. Consider such material, regardless of proportioning, as a Mixed Aggregate that must comply with **subsection 1102.2d**.

(6) Handling Coarse Aggregates.

(a) Segregation. Before acceptance testing, remix all aggregate segregated by transportation or stockpiling operations.

(b) Stockpiling.

- Stockpile accepted aggregates in layers 3 to 5 feet thick. Berm each layer so that aggregates do not "cone" down into lower layers.
- Keep aggregates from different sources, with different grading, or with a significantly different specific gravity separated.
- Transport aggregate in a manner that insures uniform gradation.
- Do not use aggregates that have become mixed with earth or foreign material.
- Stockpile or bin all washed aggregate produced or handled by hydraulic methods for 12 hours (minimum) before batching. Rail shipment exceeding 12 hours is acceptable for binning provided the car bodies permit free drainage.
- Provide additional stockpiling or binning in cases of high or non-uniform moisture.

### **b. Intermediate Aggregate for Mixed Aggregate.**

(1) Composition. Provide intermediate aggregate for mixed aggregates (IMA) that is crushed or uncrushed gravel, chat, crushed stone, natural occurring sand, or manufactured sand.

(2) Quality. Provide IMA complying with **subsection 1102.2a.(2), 1102.2c.(2) or 1102.2d.(2)**.

(3) Product Control. Provide IMA grading as necessary to obtain specified MA grading and any coarseness factor and workability requirements.

### **c. Fine Aggregates for Concrete.**

(1) Composition.

(a) Type FA-A. Provide either singly or in combination natural occurring sand resulting from the disintegration of siliceous or calcareous rock, or manufactured sand produced by crushing predominately siliceous materials.

(b) Type FA-B. Provide fine granular particles resulting from the crushing of zinc and lead ores (Chat).

(c) Type FA-C. Provide a singly crushed siliceous gravel or chat that is free of dirt, clay, and foreign or organic material.

(2) Quality.

(a) Mortar strength and Organic Impurities. If the DME determines it is necessary, because of unknown characteristics of new sources or changes in existing sources, provide fine aggregates that comply with the following:

- Mortar Strength (Mortar Strength Test, KTMR-26). Compressive strength when combined with Type III (high early strength) cement:

- At age 24 hours, minimum ..... 100%\*

- At age 72 hours, minimum ..... 100%\*

\*Compared to strengths of specimens of the same proportions, consistency, cement and standard 20-30 Ottawa sand.

- Organic Impurities (Organic Impurities in Fine Aggregate for Concrete Test, AASHTO T 21). The color of the supernatant liquid is equal to or lighter than the reference standard solution.

(b) Hardening characteristics. Specimens made of a mixture of 3 parts FA-B and 1 part cement with sufficient water for molding will harden within 24 hours. There is no hardening requirement for FA-A or FA-C.

(c) Provide FA-C for Multi-Layer Polymer Concrete Overlay complying with **TABLE 1102-4**.

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<b>TABLE 1102-4: QUALITY REQUIREMENTS FOR MULTI-LAYER POLYMER CONCRETE OVERLAY</b>		
<b>Property</b>	<b>Requirement</b>	<b>Test Method</b>
Soundness, minimum	0.92	KTMR-21
Wear, maximum	30%	KTMR-25
Acid Insoluble Residue, minimum	55%	KTMR-28
Fine Aggregate Angularity, minimum	45	KT-50
Moisture Content, maximum	0.2%	KT-11

(3) Product Control.

(a) Size Requirements. Provide fine aggregates that comply with **TABLE 1102-5**.

<b>TABLE 1102-5: GRADING REQUIREMENTS FOR FINE AGGREGATES FOR CONCRETE</b>							
<b>Type</b>	<b>Percent Retained-Square Mesh Sieves</b>						
	<b>3/8"</b>	<b>No. 4</b>	<b>No. 8</b>	<b>No. 16</b>	<b>No. 30</b>	<b>No. 50</b>	<b>No. 100</b>
FA-A	0	0-10	0-27	15-55	40-77	70-93	90-100
FA-B	0	0-5	0-24	15-50	40-75	70-90	90-100
FA-C	0	0	25-70	95-100	100	100	100

(b) Deleterious Substances.

- Type FA-A: Maximum allowed deleterious substances by weight are:
  - Material passing the No. 200 sieve (KT-2)..... 2.0%
  - Clay lumps and friable particles (KT-7)..... 1.0%
  - Sticks (wet) (KT-35)..... 0.1%
  
- Type FA-B: Provide materials that are free of organic impurities, sulfates, carbonates, or alkali. Maximum allowed deleterious substances by weight are:
  - Material passing the No. 200 sieve (KT-2)..... 2.0%
  - Clay lumps & friable particles (KT-7)..... 0.25%

(c) Uniformity of Supply. Designate or determine the fineness modulus (grading factor) according to the procedure listed in Part V, Section 17 before delivery, or from the first 10 samples tested and accepted. Provide aggregate that is within ±0.20 of the average fineness modulus.

(4) Proportioning of Coarse and Fine Aggregate. Combine Fine and Coarse aggregates in a 50%-50% ratio by weight. Adjustments to improve workability may be made when approved by the Engineer. Use of a proven optimization method such as the ACI 302.1 method can provide adequate justification.

Do not combine siliceous fine aggregate with siliceous coarse aggregate if neither comply with **subsection 1102.2c.(2)(a)**. Consider such fine material, regardless of proportioning, as a Basic Aggregate and must comply to **subsection 1102.2d**.

(5) Handling and Stockpiling Fine Aggregates.

- Maintain separation between aggregates from different sources, with different gradings or with a significantly different specific gravity.
- Transport aggregate in a manner that promotes uniform grading.
- Do not use aggregates that have become mixed with earth or foreign material.
- Stockpile or bin all washed aggregate produced or handled by hydraulic methods for 12 hours (minimum) before batching. Rail shipment exceeding 12 hours is acceptable for binning provided the car bodies permit free drainage.
- Provide additional stockpiling or binning in cases of high or non-uniform moisture.

**d. Mixed Aggregates for Concrete.**

(1) Composition.

(a) Total Mixed Aggregate (TMA). A natural occurring, predominately siliceous aggregate from a single source that complies with the Wetting & Drying Test and grading requirements.

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(b) Mixed Aggregate.

- Basic Aggregate (BA). Singly or in combination, a natural occurring, predominately siliceous aggregate that does not comply with either the Wetting & Drying Test or grading requirements of the Total Mixed Aggregate. For MA-1 or MA-2 mixes, sweetened basic aggregate must contain at least 50% basic aggregate. For Contractor optimized mixes (MA-3), sweetened basic aggregate must contain at least 30% basic aggregate.
- Coarse Aggregate Sweetener. Types and proportions of aggregate sweeteners to be used with BA are listed in **TABLE 1102-6**.

<b>TABLE 1102-6: COARSE AGGREGATE SWEETENER FOR BASIC AGGREGATE</b>	
<b>Type of Coarse Aggregate Sweetener</b>	<b>Proportion Required by Percent Weight</b>
Crushed Sandstone*	30 (minimum)
Chat*	25 (minimum)
Crushed Limestone or Dolomite*	30 (minimum)
Gravel Approved under <b>1102.2d.(2)</b> *	30 (minimum)
Gravel not Approved under <b>1102.2d.(2)</b> **	30 (maximum)

\*Waive the minimum portion of Coarse Aggregate Sweetener for all BA that comply with the wetting and drying requirements for TMA. In this case, combine the BA and coarse aggregate sweetener in proportions required complying with the grading listed in **TABLE 1102-6**.

\*\*To be used only with BA that complies with the wetting and drying requirements of TMA.

(2) Quality.

(a) Total Mixed Aggregate.

- Soundness, minimum (KTMR-21) ..... 0.90
- Wear, maximum (KTMR-25) ..... 50%
- Wetting & Drying Test of Sand-Gravel Aggregate for Concrete (KTMR-23)

Concrete Modulus of Rupture:

- At 60 days, minimum..... 550 psi
- At 365 days, minimum..... 550 psi

Expansion:

- At 180 days, maximum..... 0.050%
- At 365 days, maximum..... 0.070%

Aggregates produced from the following general areas are exempt from the Wetting and Drying Test:

- Blue River Drainage Area.
- The Arkansas River from Sterling, west to the Colorado state line.
- The Neosho River from Emporia to the Oklahoma state line.

(b) Basic Aggregate.

- Retain 10% or more of the BA on the No. 8 sieve before adding the Coarse Aggregate Sweetener. Aggregate with less than 10% retained on the No. 8 sieve is to be considered a Fine Aggregate described in **subsection 1102.2c**. Provide material with less than 5% calcareous material retained on the 3/8 inch sieve.
- Soundness, minimum (KTMR-21) ..... 0.90
- Wear, maximum (KTMR-25) ..... 50%
- Mortar strength and Organic Impurities. If the DME determines it is necessary, because of unknown characteristics of new sources or changes in existing sources, provide mixed aggregates that comply with the following:
  - Mortar Strength (Mortar Strength Test, KTMR-26). Compressive strength when combined with Type III (high early strength) cement:
  - At age 24 hours, minimum ..... 100%\*

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- At age 72 hours, minimum ..... 100%\*  
\*Compared to strengths of specimens of the same proportions, consistency, cement and standard 20-30 Ottawa sand.

- Organic Impurities (Organic Impurities in Fine Aggregate for Concrete Test, AASHTO T 21). The color of the supernatant liquid is equal to or lighter than the reference standard solution.

(c) Coarse Aggregate Sweetener. Comply with SCA-3 or CPA-4 in **subsection 1102.2a**.

(3) Product Control.

(a) Size Requirement. Provide mixed aggregates that comply with **TABLE 1102-7**.

<b>TABLE 1102-7: GRADING REQUIREMENTS FOR MIXED AGGREGATES FOR CONCRETE</b>											
<b>Type</b>	<b>Usage</b>	<b>Percent Retained - Square Mesh Sieves</b>									
		<b>1"</b>	<b>¾"</b>	<b>½"</b>	<b>⅜"</b>	<b>No. 4</b>	<b>No. 8</b>	<b>No.16</b>	<b>No. 30</b>	<b>No. 50</b>	<b>No. 100</b>
MA-1	All concrete except mainline pavement <sup>1</sup>	0	0-5			20-60			76-84	90-96	
MA-2	All Concrete		0	3-15	15-30	33-50	45-66	64-80	78-90	87-96	95-100
MA-3	Optimized for PCCP concrete	0	0-6 <sup>2</sup>	Note <sup>3,4</sup>	Note <sup>3,4</sup>	Note <sup>3,4</sup>	Note <sup>3,4</sup>	Note <sup>5</sup>	Note <sup>5</sup>	Note <sup>5</sup>	95-100
MA-5	Drilled Shafts <sup>6</sup>	0	0-12	8 min	22-34		55-65		75 min		95-100

<sup>1</sup>MA-1 can be used in concrete for mainline patching.

<sup>2</sup>If aggregate qualities fail to comply with Class 2 aggregate requirements, **subsection 1102.2a**, the maximum retained gradation is restricted to 3%.

<sup>3</sup>Retain a maximum of 24% and a minimum of 6% of the material on each individual sieve.

<sup>4</sup>When Class 2 aggregate is used, retain a maximum of 20% on each individual sieve.

<sup>5</sup>Retain a maximum of 15% and a minimum of 6% of the material on each individual sieve.

<sup>6</sup>It is recommended that the aggregate gradation combine a SCA-3 or CPA-4 and an FA-A or Basic Aggregate for MA.

(b) Deleterious Substances. Maximum allowed deleterious substances by weight are:

- Material passing the No. 200 sieve (KT-2) ..... 2.5%
- Shale or Shale-like material (KT-8) ..... 0.5%
- Clay lumps and friable particles (KT-7) ..... 1.0%
- Sticks (wet) (KT-35) ..... 0.1%
- Coal (AASHTO T 113) ..... 0.5%

(c) Uniformity of Supply. Designate or determine the fineness modulus (grading factor) according to the procedure listed in Part V, Section 17 before delivery, or from the first 10 samples tested and accepted. Provide aggregate that is within ±0.20 of the average fineness modulus.

(4) Handling Mixed Aggregates.

(a) Segregation. Before acceptance testing, remix all aggregate segregated by transit or stockpiling.

(b) Stockpiling.

- Maintain separation between aggregates from different sources, with different gradings or with a significantly different specific gravity.
- Transport aggregate in a manner that promotes uniform grading.
- Do not use aggregates that have become mixed with earth or foreign material.
- Stockpile or bin all washed aggregate produced or handled by hydraulic methods for 12 hours (minimum) before batching. Rail shipment exceeding 12 hours is acceptable for binning provided the car bodies permit free drainage.
- Provide additional stockpiling or binning in cases of high or non-uniform moisture.

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**e. Miscellaneous Aggregates for Concrete.**

(1) Aggregates for Mortar Sand, Type FA-M.

(a) Composition. Provide aggregates for mortar sand, Type FA-M that is natural occurring sand.

(b) Quality.

- Mortar strength and Organic Impurities. If the DME determines it is necessary, because of unknown characteristics of new sources or changes in existing sources, provide aggregates for mortar sand, Type FA-M that comply with the following:
  - Mortar Strength (Mortar Strength Test, KTMR-26). Compressive strength when combined with Type III (high early strength) cement:
    - At age 24 hours, minimum ..... 100%\*
    - At age 72 hours, minimum ..... 100%\*
  - \* Compared to strengths of specimens of the same proportions, consistency, cement and standard 20-30 Ottawa sand.
  - Organic Impurities (Organic Impurities in Fine Aggregate for Concrete Test, AASHTO T 21). The color of the supernatant liquid is equal to or lighter than the reference standard solution.

(c) Product Control.

- Size Requirements. Provide aggregates for mortar sand, Type FA-M that comply with **TABLE 1102-8**.

<b>TABLE 1102-8: GRADING REQUIREMENTS FOR MORTAR SAND</b>							
Type	Percent Retained - Square Mesh Sieves						Gradation Factor
	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	
FA-M	0	0-2	0-30	20-50	50-75	90-100	1.70-2.50

- Deleterious Substances. Maximum allowed deleterious substances by weight are:
  - Material passing the No. 200 sieve (KT-2) ..... 2.0%
  - Clay lumps and friable material (KT-7) ..... 0.5%
  - Sticks (wet) (KT-35) ..... 0.1%
  - Coal (AASHTO T 113) ..... 0.5%

(2) Modified Lightweight Aggregates.

(a) Composition. Provide an expanded shale lightweight aggregate produced from a uniform deposit of raw material combined with FA-A **subsection 1102.2c**.

(b) Quality.

- Soundness, minimum (KTMR-21) ..... 0.90
- Loss on Ignition ..... 5%

(c) Product Control.

- Size Requirements. Provide modified lightweight aggregates that comply with **TABLE 1102-9**.

<b>TABLE 1102-9: GRADING REQUIREMENTS FOR MODIFIED LIGHTWEIGHT AGGREGATES</b>						
Type	Percent Retained - Square Mesh Sieves					
	¾"	½"	⅜"	No. 4	No. 8	No. 16
Grade 1	0	0-10	30-60	85-100	95-100	
Grade 2		0-2	0-30	20-50	50-75	90-100

- Deleterious Substances.
  - Organic Impurities (Organic Impurities in Fine Aggregate for Concrete Test, AASHTO T 21). The color of the supernatant liquid is equal to or lighter than the reference standard solution.

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- Expanded Shale Unit Weight (dry, loose weight) (max.) ..... 1890 lbs/cu yd

(d) Concrete Making Properties. Drying shrinkage of concrete specimens prepared with expanded shale and FA-A proportioned as shown in the Contract Documents can not exceed 0.07%.

(e) Uniformity of Supply. Designate or determine the fineness modulus (grading factor) according to procedure listed in Part V, Section 17 before delivery, or from the first 10 samples tested and accepted. Provide aggregate that is within  $\pm 0.20$  of the average fineness modulus.

(f) Proportioning Materials. Combine separately batched FA-A and expanded shale aggregate in proportions as shown in the Contract Documents.

(g) Stockpiling

- Stockpile accepted aggregates in layers 3 to 5 feet thick. Berm each layer so that aggregates do not "cone" down into lower layers.
- Keep aggregates from different sources, with different gradings or with a significantly different specific gravity separated.
- Transport aggregate in a manner that promotes uniform gradation.
- Do not use aggregates that have become mixed with earth or foreign material.
- Stockpile or bin all washed aggregate produced or handled by hydraulic methods for 12 hours (minimum) before batching. Rail shipment exceeding 12 hours is acceptable for binning provided the car bodies permit free drainage.
- Provide additional stockpiling or binning in cases of high or non-uniform moisture.

### 1102.3 TEST METHODS

Test aggregates according to the applicable provisions of **SECTION 1115**.

### 1102.4 PREQUALIFICATION

Aggregates for concrete must be prequalified according to **subsection 1101.02**.

### 1102.5 BASIS OF ACCEPTANCE

The Engineer will accept aggregates for concrete base on the prequalification required by this specification and **subsection 1101.03**.