Section 902. AGGREGATES

902.01 General Requirements. Approval of aggregates at the producing plant does not constitute a waiver of the Department's right to inspect and test at the point of actual use. Equipment or the means necessary to allow safe access to the material will be furnished by the supplier or Contractor for sampling from haul units or stockpiles.

Aggregate must be transported and placed without material loss or contamination when it is loaded and measured. Foundry sand which has been used for metal castings will not be permitted on Department projects in any form.

902.02 Testing. Testing will be accomplished by the methods specified throughout this section and by the following general methods

Wire Cloth and Sieves	ASTM E 11
Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing	ASTM C 117
Specific Gravity and Absorption of Coarse Aggregate	ASTM C 127
Specific Gravity and Absorption of Fine Aggregate	ASTM C 128
Sieve Analysis of Fine and Coarse Aggregates	ASTM C 136
Sampling and Testing Fly Ash	ASTM C 311
Sand Equivalent of Fine Aggregate	ASTM D 2419
Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate	ASTM D 4791
Organic Impurities in Fine Aggregate	AASHTO T 21
Sieve Analysis of Mineral Filler	AASHTO T 37
Mortar Strength	AASHTO T 71
Particle Size Analysis	AASHTO T 88
Water Asphalt Preferential Test	MTM 101
L.A. Abrasion Resistance of Aggregate	MTM 102
Insoluble Residue in Carbonate Aggregate	MTM 103
Sampling Aggregates	MTM 107
Loss by Washing	MTM 108
Sieve Analysis of Aggregate	MTM 109
Deleterious and Objectionable Particles	MTM 110
Aggregate Wear Index	MTM 112
Selection and Preparation of Coarse Aggregate Samples for Freeze-Thaw Testing	MTM 113
Making Concrete Specimens for Freeze-Thaw Testing on Concrete Coarse Aggregate	MTM 114
Freeze-Thaw Testing of Coarse Aggregate	MTM 115
Crushed Particles in Aggregates	MTM 117
Angularity Index of Fine Aggregate	MTM 118
Dry Unit Weight (LM) of Coarse Aggregate	MTM 123

A. **Terminology.** The following terminology is used in the testing and acceptance of aggregates:

1. **Natural Aggregates.** Natural aggregates originate geologically from stone quarries, gravel, sand or igneous/metamorphic rock deposits.

2. **Slag Aggregates.** Slag aggregates are by-products formed in the production of iron, copper, and steel.

   a. Iron blast furnace slag is a synthetic nonmetallic by-product produced simultaneously with pig iron in a blast furnace. The slag consists principally of a fused mixture of oxides of silica, alumina, calcium, and magnesia.

   b. Reverberatory furnace slag is a nonmetallic by-product resulting from refining copper ore.

   c. Steel furnace slag is a synthetic by-product of basic oxygen, electric, or open hearth steel furnaces and consists principally of a fused mixture of oxides of calcium, silica, iron, alumina, and magnesia.

3. **Crushed Concrete Aggregate.** Crushed concrete aggregate is produced by crushing Portland cement concrete.

4. **Salvaged Aggregate.** Salvaged aggregate is any dense-graded aggregate saved or manufactured from department project sources. The material may consist of natural aggregate, blast furnace slag, crushed concrete, or reclaimed asphalt pavement with a maximum two inch particle size and no visible organic or foreign matter, including steel reinforcement.

5. **Manufactured Fine Aggregate.** Manufactured fine aggregate is produced by totally crushing rock, gravel, iron blast furnace slag, reverberatory furnace slag, steel furnace slag, or Portland cement concrete.

6. **Natural Sand 2NS and 2MS.** These fine aggregates, used in concrete mixtures, mortar mixtures, and intrusion grout for pre-placed aggregate concrete, are the fine granular material resulting from the natural disintegration of rock. The material must be clean, hard, durable, uncoated particles of sand, free from clay lumps and soft or flaky material.

7. **Stone Sand 2SS.** Stone sand is manufactured from stone meeting all the physical requirements of Coarse Aggregate 6A. Stone sand will be permitted only in concrete base course or in structural concrete not exposed to vehicular traffic.

8. **Soft Particles.** Soft particles are non-durable particles that are structurally weak or experience environmental deterioration in service and include shale, siltstone, friable sandstone, ochre, coal, and clay-ironstone.

9. **Crushed Particles**. A crushed particle is one which has one or more fractured faces. The number of fractured faces is determined by its use.

10. **Base Fineness Modulus.** The base fineness modulus is the average fineness modulus typical of the source for a specific fine aggregate.

11. **Cobblestones.** Cobblestones or cobbles are rock fragments, usually rounded or semi-rounded, with an average dimension between 3 and 10 inches.

902.03 Coarse Aggregates for Portland Cement Concrete. Michigan Class 4AA, 6AAA, 6AA, 6A, 17A, and 26A coarse aggregate will be produced from natural aggregate, iron blast furnace slag, or reverberatory furnace slag sources. Michigan Class 6A, 17A and 26A can be produced by crushing Portland cement concrete, but for only uses stipulated within this specification. The bulk dry specific gravity will be within the limits established by freeze-thaw testing. Aggregates will conform to the grading requirements in Table 902-1, the physical requirements in Table 902-2, and the following:

A. **Slag Coarse Aggregate.** Iron blast furnace slag or reverberatory furnace slag conforming to the grading specified for the concrete mixture will have a dry (loose measure) unit weight of not less than 70 pounds per cubic foot as determined by MTM 123.

B. **Crushed Concrete Coarse Aggregate.** Crushed concrete coarse aggregate will originate only from concrete sources owned by the Department as part of the contracted project. Crushed concrete coarse aggregate may be used in concrete mixtures for curb and gutter, valley gutter, sidewalk, concrete barriers, driveways, temporary pavement, interchange ramps with commercial ADT below 250, and concrete shoulders. Crushed concrete coarse aggregate will not be used in mainline pavements or ramps with commercial ADT equal to or greater than 250, concrete base course, bridges, box or slab culverts, head walls, retaining walls, prestressed concrete, or other heavily reinforced concrete.

   Crushed concrete coarse aggregate will be processed in a manner that avoids contamination with any non-concrete materials including joint sealants, bituminous patching, and base layer aggregate or soil. Contamination particles retained on the ⅜- inch sieve are limited to 3.0 percent maximum by particle count of the total aggregate particles. The aggregate stockpile will be rejected totally when there is any evidence of contamination from non-Department sources, such as building brick, wood, or plaster. Pieces of steel reinforcement are allowable in the stockpile provided they pass the maximum grading sieve size without hand manipulation. The fine aggregate portion of the gradation will not exceed a liquid limit of 25.0 percent or a plasticity index of 4.0.

   Crushed concrete coarse aggregate will be tested for freeze-thaw durability for each project. This testing requires a minimum of three months after samples of the produced aggregate are received in the laboratory.

   The equipment and methods used to crush concrete will maintain uniformity in aggregate properties: specific gravity ± 0.05 and absorption ± 0.40, with no apparent segregation. This requirement includes separating crushed concrete aggregate according to its original coarse aggregate type, except for the following situations:

   1. Different aggregate types may exist in the same stockpile, if the quantities by weight of each aggregate type retained on the Number 4 sieve do not differ by more than ± 10 percent from the average quantity obtained from at least three representative samples.

2. When aggregate is produced from concrete pavement with only one aggregate type that has been repaired with concrete patches with a different aggregate type.

902.04 Coarse Aggregates for HMA Mixtures. These aggregate will be natural aggregate, iron blast furnace slag, reverberatory furnace slag, steel furnace slag, or crushed concrete meeting the grading and physical requirements in the contract documents.

902.05 Coarse Aggregates for Chip Seals. Chip seal 25A coarse aggregate will meet both the grading and physical requirements in Table 902-1 and 902-2 and the following; have a minimum

AWI of 260, a maximum moisture content of 4 percent at the time of placement and meet any special requirements stated in section 508. There is no AWI requirement for shoulder chip seal aggregates**.**

902.06 Dense-Graded Aggregates for Base Course, Surface Course, Shoulders, Approaches and Patching. Michigan Class 21AA, 21A, 22A, and 23A dense-graded aggregates will consist of natural aggregate, iron blast furnace slag, reverberatory furnace slag, or crushed concrete, in combination with fine aggregate as necessary to meet the gradation requirements in Table 902-1, the physical requirements in Table 902-2, and the following:

A. Dense-graded aggregate produced by crushing Portland cement concrete will not contain building rubble as evidenced by the presence of more than 5.0 percent, by particle count, building brick, wood, plaster, or similar materials. Sporadic pieces of steel reinforcement may be present provided they pass the maximum grading sieve size without hand manipulation.

B. Class 21AA, 21A and 22A dense-graded aggregate produced from crushing Portland cement concrete will not be used to construct either an aggregate base or aggregate separation layer when either of the following conditions apply:

   1. When there is a geotextile liner or membrane present with permeability requirements.

   2. In a pavement structure with an underdrain, unless there is a filter material between the crushed concrete and the underdrain. This filter material will be either a minimum of 12 inches (300 mm) of granular material or a geotextile liner or blocking membrane that will be a barrier to leachate.

C. Class 23A dense-graded aggregate may be produced from steel furnace slag, but only for use as an unbound aggregate surface course or as an unbound aggregate shoulder.

902.07 Open-Graded Aggregates for Earthwork, Open-Graded Drainage Courses and Underdrains. Michigan Class 2G, 3G, 4G, 34G, and 34R open-graded aggregates will be obtained from natural aggregate, iron blast furnace slag, or reverberatory furnace slag. These aggregates will conform to the grading requirements in Table 902-1, and the physical requirements in Table 902-2.

902.08 Granular Materials for Fill and Subbase. Granular materials for use as fill, trench backfill, and subbase must consist of sand, gravel, crushed stone, iron blast furnace slag, reverberatory

furnace slag or a blend of aggregates conforming to the grading requirements of Table 902-3 and this subsection can be used.

When Class II material is specified, Class I material may be substituted. When Class III material is specified, Class I, Class II, Class IIA or Class IIIA material may be substituted.
Material with cementitious properties or with permeability characteristics that do not meet design parameters will not be used for fill or subbase.

When used for trench backfill, no aggregate particles larger than two inches will be placed within 12 inches of the pipe.

Granular material produced by crushing Portland cement concrete is an acceptable material for swamp backfill, embankment (except the top three feet below subgrade) and as trench backfill for non-metallic culvert and sewer pipes without associated underdrains. All other uses are unacceptable.

Granular material produced from steel furnace slag will be acceptable below the top three feet of the embankment and fill when permitted by the contract documents.

902.09 Fine Aggregates for Portland Cement Concrete and Mortar. The aggregate will be free from organic impurities to the extent that when subjected to the test for organic impurities, AASHTO T 21, it shall not produce a color darker than Plate 3 (light brown). Fine aggregate failing this requirement may be approved for use provided the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles; or the relative 7 day strength of the concrete under test is found to be at least 95 percent per AASHTO T 71.

The aggregate shall be uniformly graded from coarse to fine and meet the grading requirements and fineness modulus variation requirements, specified in Table 902-4. The specified gradation represents the extreme limits which determine suitability for use from all sources of supply. The gradation from any one source must be reasonably uniform and not subject to the extreme percentages of gradation specified in Table 902-4.

Fine aggregate produced by crushing Portland cement concrete is not permitted.

902.10 Fine Aggregates for Bituminous Mixtures. Fine aggregate for bituminous mixtures will consist of clean, hard, durable, uncoated particles, free from clay lumps, organic materials, soft or flaky materials, and other foreign matter. These aggregates will be natural sand, manufactured fine aggregate, or a uniformly graded blend meeting the grading and physical requirements specified in the proposal.

902.11 Fine Aggregates for Bituminous Surface Treatments.

A. **Slurry Seal.** The 2FA fine aggregate will be a crushed material from a quarried stone, natural gravel, slag source or a blend meeting the grading requirements of Table 902-4. Sands with Angularity Index less than 2.0 will not exceed 50 percent of the fine aggregate blend. This fine aggregate will have a maximum L.A. Abrasion value of 45 percent (MTM 102).

B. **Micro-Surfacing.** The 2FA and 3FA fine aggregates, will be a crushed material from a quarried stone, natural gravel, slag source, or a blend meeting the grading requirements of Table 902-4. Micro-surfacing aggregate must have a minimum AWI of 260 (MTM 111), a minimum sand equivalent (ASTM D 2419) of 60 percent and a minimum angularity index (MTM 118) of 4.0 for natural gravel, quarried stone or slag. These fine aggregates will have a maximum L.A. abrasion value of 45 percent (MTM 102).

902.12 Mineral Filler for Bituminous Mixtures. Mineral filler, 3MF, must be limestone dust, dolomite dust, fly ash collected by an electrostatic precipitation method, slag or hydrated lime. The free carbon in the fly ash will not exceed 12 percent by weight as measured by the loss on ignition test according to ASTM C 311. Sources for fly ash must be selected from the Qualified Products List. Fly ash from a new source must show satisfactory performance on the basis of both laboratory mix stability tests and actual construction field experience.

Mineral filler will be dry and have 100 percent passing the Number 30 and 75 to 100 percent passing the Number 200 sieves, respectively.

The fraction passing the Number 200 sieve must have 15-60 percent finer than 10 micron diameter. The sub-sieve particle size distribution will be determined according to AASHTO T 88, using Tucker dispersing agent.

Mineral filler will be free of objectionable characteristics as measured by MTM 101.

Table 902-1 Grading Requirements for Coarse Aggregates, Dense-Graded Aggregates, and Open-Graded Aggregates (2003)

Material Type	Class	Item of Work by Section Number (Sequential) (a)	Sieve Analysis (MTM 109) Total Percent Passing (b)										Loss by Washing (MTM 108) % Passing No. 200 (b)
			2.5 in	2 in	1.5 in	1 in	3/4 in	½ in	3/8 in	No. 4	No. 8	No. 30	
Coarse Aggregates	4 AA (c)	602	100	90 - 100	40 - 60		0-12						2.0 max.
	6 AAA (c)	602			100	90-100	60-85	30-60		0-8			1.0 max.(d)
	6 AA (c)	601,706,708,806			100	95-100		30-60		0-8			1.0 max.(d)
	6 A	205,401,402, 601,603,706,806			100	95-100		30-60		0-8			1.0 max.(d)
	17 A					100	90-100	50-75		0-8			1.0 max.(d)
	25 A	508					100	95-100	60-90	5-30	0-12		3.0 max.
	26 A	706,712					100	95-100	60-90	5-30	0-12		3.0 max.
	29 A	508						100	90-100	10-30	0-10		3.0 max.
Dense-Graded Aggregates	21 AA	302,304,503			100	85-100		50-75			20-45		4-8(e)(f)
	21 A	302,503											
	22 A	302,306,307,503				100	90-100		65-85		30-50		4-8(e)(f)(g)
	23 A	306,307				100			60-85		25-60		9-16(f)
Open-Graded Aggregates	2 G	303(h)			100	85-100		40-70			0-10	0-8	5.0 max.
	3 G				100	85-100		40-70			0-30	0-13	5.0 max.
	4 G(i)	303			100		60-80	35-65			10-25	5-18	6.0 max.
	34 R	404						100	90-100		0-5		3.0 max.
	34 G	404						100	95-100	0-10			3.0 max.

Table 902-1 Grading Requirements for Coarse Aggregates, Dense-Graded Aggregates, and Open-Graded Aggregates (2003) (Continued)

a. Designated Item of Work (Section)

205	Roadway Earthwork	404	Underdrains - Trench Backfill
302	Aggregate Base Courses	503	Temporary Patching with HMA Mixture
303	Open-Graded Drainage Courses	508	Chip Seals
304	Rubblizing Existing PCC Pavement - Filler Aggregate	601	PCC Pavement Mixtures
306	Aggregate Surface Course	603	Concrete Pavement Repair
307	Aggregate Shoulders and Approaches	706	Structural Concrete Construction
401	Culverts	708	Prestressed Concrete Beams
402	Storm Sewers	712	Bridge Rehabilitation - Concrete
		806	Bicycle Paths

b. Based on dry weights.
c. Class 6AAA will be used exclusively for all mainline and ramp concrete pavement when the directional commercial ADT is greater than or equal to 5000 vehicles per day.
d. Loss by Washing will not exceed 2.0 percent for material produced entirely by crushing rock, boulders, cobbles, slag, or concrete.
e. When used for aggregate base courses, surface courses, shoulders and approaches and the material is produced entirely by crushing rock, boulders, cobbles, slag, or concrete, the maximum limit for Loss by Washing will not exceed 10 percent.
f. The limits for Loss by Washing of dense-graded aggregates are significant to the nearest whole percent.
g. For aggregates produced from sources located in Berrien County, the Loss by Washing will not exceed 8 percent and the sum of Loss by Washing and shale particles will not exceed 10 percent.
h. For use with stabilized aggregate base.
i. Acceptance gradation at production site only.

Table 902-2 Physical Requirements for Coarse Aggregates, Dense-Graded Aggregates, and Open-Graded Aggregates 2003

Material	Series/ Class	Gravel, Stone, and Crushed Concrete						Slag (a)		All Aggregates
		Crushed Material, % min (MTM 110,117)	Loss, % max, Los Angeles Abrasion (MTM 102)	Soft Particles, % max (MTM 110)	Chert, % max (MTM 110)	Sum of Soft Particles and Chert, % max (MTM 110)	Freeze-Thaw Dilation, % per 100 cycle max (MTM 115) (d)	Sum of Coke and Coal Particles, % max (MTM 110)	Freeze-Thaw Dilation, % per 100 cycles max (MTM 115) (d)	Flat and Elongated Particles, ratio - % max (ASTM D 4791)
Coarse Aggregates	4 AA (b)		40			2.0 (c)	0.020	1.0	0.020	3:1 - 15.0
	6 AAA		40	2.0 (e)	2.5	4.0	0.040 (f)	1.0	0.040 (f)	
	6 AA (g)		40	2.0 (e)		4.0	0.067 (h)	1.0	0.067	
	6 A (g)		40	3.0 (e)	7.0	9.0	0.067	1.0	0.067	
	17 A (g)		40	3.5 (e)	8.0	10.0	0.067	1.0	0.067	
	25 A	95	45	8.0 (j)		8.0		1.0		3:1 - 20.0
	26 A (g)		40	2.0 (e)		4.0	0.067	1.0	0.067	
	29 A	95	45	8.0 (j)		8.0		1.0		3:1 - 20.0
Dense-Graded Aggregates (j)	21 AA	95	50							
	21 A	25	50							
	22 A	25	50							
	23 A	25	50							
Open-Graded Aggregates (e)	2 G	90	45 (k)							
	3 G	95	45 (k)							
	4 G	95	45 (k)							
	34 R	20 max	45 (k)							
	34 G	100	45 (k)							

Table 902-2 Physical Requirements for Coarse Aggregates, Dense-Graded Aggregates, and Open-Graded Aggregates 2003 (Continued)

a. Iron blast furnace and reverberatory furnace slag will contain no free (unhydrated) lime.
b. 2.50 percent maximum 24 hour soak absorption based on oven dry 6 series aggregate.
c. 1.0% maximum for particles retained on the one inch (25 mm) sieve.
d. If the bulk dry specific gravity is more than 0.04 less than the bulk dry specific gravity of the most recently tested freeze-thaw sample, the aggregate will be considered to have changed characteristics and be required to have a new freeze-thaw test conducted prior to use on Department projects.
e. Clay-ironstone particles will not exceed 1.0 percent for 6AAA, 6AA and 26A, and 2.0 percent for 6A and 17A. Clay-ironstone particles are also included in the percentage of soft particles for these aggregates.
f. Maximum freeze-thaw dilation is 0.067 when the directional commercial ADT is less than 5000 vehicles per day.
g. Except for pre-stressed beams, the sum of soft and chert particles may be up to 3.0 percent higher than the values determined from the sample tested for freeze-thaw durability. However, under no circumstances will the deleterious particle percentages exceed the specification limits in Table 902-2. In addition, a source may be restricted to a minimum percent crushed not to exceed 15 percent less than the percent crushed in the freeze-thaw sample. When the freeze-thaw dilation is between 0.040 and 0.067 percent per 100 cycles, more restrictive limits will be applied.
h. Maximum dilation of 0.010 for prestressed concrete beams.
i. Friable sandstone is included in the soft particle determination for chip seal aggregates.
j. Quarried carbonate (limestone or dolomite) aggregate will not contain over 10 percent insoluble residue finer than Number 200 (0.075 mm) sieve when tested in accordance with MTM 103.
k. If a blend of different aggregate sources, the abrasion value applies to each source.

Table 902-3 Grading Requirements for Granular Materials (2003)

Material	Sieve Analysis (MTM 109) Total % Passing (a)									Loss by Washing % Passing No. 200 (a)(b)
	6 in	3 in	2 in	1 in	½ in	3/8 in	No. 4	No. 30	No. 100	
Class I			100		45-85		20-85	5-30		0-5
Class II (c)		100		60-100					0-30 (d)	0-7 (d)
Class IIA (c)		100		60-100					0-35	0-10
Class III	100	95-100								0-15
Class IIIA						100			0-30	0-15

a. Test results based on dry weights.
b. Use test method MTM 108 for Loss by Washing.
c. Except for use in granular blankets and underdrain backfill, Class IIA granular material may be substituted for Class II granular material for projects located in the following counties: Arenac, Bay, Genesee, Gladwin, Huron, Lapeer, Macomb, Midland, Monroe, Oakland, Saginaw, Sanilac, Shiawassee, St. Clair, Tuscola, and Wayne counties.
d. Grading requirements are 0-20 for the No. 100 sieve and 0-5 for loss by washing when material is used as backfill for underdrains.

Table 902-4 Grading Requirements for Fine Aggregates (2003)

Material	Sieve Analysis (MTM 109) Total Percent Passing (a)							Loss by Washing % Passing No. 200 (a)(b)	Fineness Modulus Variation (c)
	3/8 in	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100		
2NS	100	95-100	65-95	35-75	20-55	10-30	0-10	0-3.0	±0.20 (d)
2SS (e)	100	95-100	65-95	35-75	20-55	10-30	0-10	0-4.0	±0.20 (d)
2MS		100	95-100			15-40	0-10	0-3.0	±0.20 (d)
2FA (f)	100	90-100	65-90	45-70	30-50	18-30	10-21	5-15 (g)	
3FA (f)	100	70-90	45-70	28-50	19-34	12-25	7-18	5-15 (g)	

a. Test results based of dry weights.
b. Use test method MTM 108 for Loss by Washing.
c. Aggregate having a fineness modulus differing from the base fineness modulus of the source by the amount exceeding the maximum variation specified in the table, will be rejected. Use ASTM C 136.
d. The base fineness modulus will be supplied by the aggregate producer at the start of each construction season and be within the range of 2.50-3.35. The base FM, including the permissible variation, will be within the 2.50 - 3.35 range.
e. Not for any application subject to vehicular traffic.
f. Gradation represents the final blended product.
g. The limits for loss by Washing of Fine Aggregates, 2FA and 3FA are significant to the nearest whole percent.