4 Aggregate Specifications and Requirements

CHAPTER FOUR:
AGGREGATE SPECIFICATIONS and REQUIREMENTS

The Specifications for aggregates are detailed in Section **904** and other sections for the various types of construction. These specifications are to be followed when inspecting aggregates. There are two general types of requirements for aggregate: quality and gradation.

PHYSICAL QUALITY REQUIREMENTS

Physical quality requirements are all specification provisions other than gradation or usage requirements. These requirements may be divided into five distinct groups as follow:

1) Absorption

2) Abrasion resistance

3) Soundness

4) Restriction on deleterious constituents

5) Special requirements

FINE AGGREGATES

Section **904.02** defines the acceptable limits for all uses of fine aggregates.

Fine aggregates are not divided into classes. The quality ratings assigned to fine aggregates regarding their approval for use on highway construction contracts are:

A5 = approved for all uses

B5 = approved for all uses where manufactured fine aggregate is allowed

G5 = not approved

The "A" rating is for all natural sands. The "B" rating is for manufactured fine aggregates.

COARSE AGGREGATES

Section **904.03** defines the acceptable limits for all uses of coarse aggregates.

Coarse aggregates are divided into classes based on quality requirements as noted in the Classification of Aggregates table. Class AP is the highest class and is assigned to aggregates which meet the requirements for all INDOT uses. Some INDOT contracts specify type AP aggregates for use in specific applications of portland cement concrete. Parameters concerning type AP aggregate are contained in **ITM 210**. Aggregates having restricted approval are rated Classes A, AS, B, C, D, E, and F.

PHYSICAL QUALITY TESTS

Approval and use of aggregates is based upon meeting test requirements in the following physical tests.

ABSORPTION

The absorption quality requirement applies only to coarse aggregates, but this data is necessary on fine aggregate for other purposes, such as mix design and water/cementitious ratios.

All aggregates are porous, but some are more porous than others. How porous an aggregate is determines how much liquid may be absorbed when soaked in water. **AASHTO T 85** defines absorption as the increase in the weight of aggregate because of water in the pores of the material, but not including water adhering to the outside surface of the particles. Absorption is expressed as a percentage of the dry weight.

Absorption requirements are of concern only regarding aggregates used in hot mix asphalt and portland cement concrete. The intent is to avoid using highly porous, absorptive aggregates because extra water and cement or asphalt is needed to make a good mix. However, some aggregates, such as blast furnace slag, may be used despite their high absorptive capacity because of other characteristics that make them desirable, including skid resistance, economics, etc.

ABRASION RESISTANCE

Abrasion resistance applies only to coarse aggregates. Aggregates vary in their resistance to fracturing under impact (toughness) and breaking down into smaller pieces from abrasive action (hardness). The acceptable limits are set by the Los Angeles Abrasion Test **AASHTO T 96**. The limits vary from 30.0 to 50.0 percent, depending on the classification of the aggregate. The percentage is a measure of the degradation or loss of material as a result of impact and abrasive actions. Section **904.03** details the requirements. Abrasion requirements do not apply to blast furnace slag.

SOUNDNESS

The quality of soundness applies to both fine and coarse aggregates. The durability of aggregates or their resistance to the forces of weathering is one of the most important considerations in the selection of a material for highway construction. Alternate freezing and thawing of the aggregates is the major concern.

INDOT uses three different test methods to evaluate soundness:

1) The water freeze and thaw test in accordance with **AASHTO T 103, Procedure A**

2) The sodium sulfate test in accordance with **AASHTO T 104**

3) The brine freeze and thaw test in accordance with **ITM 209**

The water freeze and thaw test requires the aggregate to be sealed and totally immersed in water and then be subjected to 50 cycles of freeze and thaw. The sodium sulfate test requires the aggregate to be immersed in a sodium sulfate solution and then be subjected to 5 cycles of alternate immersion and drying. The brine freeze and thaw test requires the aggregate to be enclosed in a bag containing a 3 percent sodium chloride solution and then be subjected to 25 cycles of freeze and thaw.

The freezing and thawing in water test is the method that most accurately simulates actual field conditions; however, the test requires a long period of time to conduct. The "quick" checks for soundness of the aggregate are the brine freeze and thaw and sodium sulfate tests. If the aggregate fails either the brine freeze and thaw or the sodium sulfate test, the aggregate is tested using the freeze and thaw in water method. An aggregate that passes the freeze and thaw in water test is an acceptable material for use on INDOT contracts.

DELETERIOUS MATERIALS

Certain substances in aggregates are undesirable for use in portland cement concrete. Therefore, the Specifications limit the amount of deleterious constituents to a level consistent with the quality sought in the final product.

Organic impurities are the only concern in fine aggregates. Section **904.02** places a restriction for fine aggregate for use in portland cement concrete and mortar. No restrictions are placed on organic impurities in fine aggregate for use in other types of construction.

The limitations on the amount of organic impurities allowed in fine aggregates are determined by the test method for organic impurities in **AASHTO T 21** and the test method for Mortar Strength in **AASHTO T 71**. According to the Specifications, materials failing the organic impurities test are to be tested for the effect of organic impurities using the mortar strength test. The results of the test are the basis for acceptance or rejection of the fine aggregate.

Section **904.03** includes a general statement regarding deleterious substances that applies to all classes of coarse aggregates. Section **904.03** also details more specific restrictions for other harmful substances as a maximum allowable percentage of the mass of each of the deleterious materials in a total sample of aggregates being tested. Figure 4-1 illustrates the materials which are classified as deleterious and the specification limits for each.

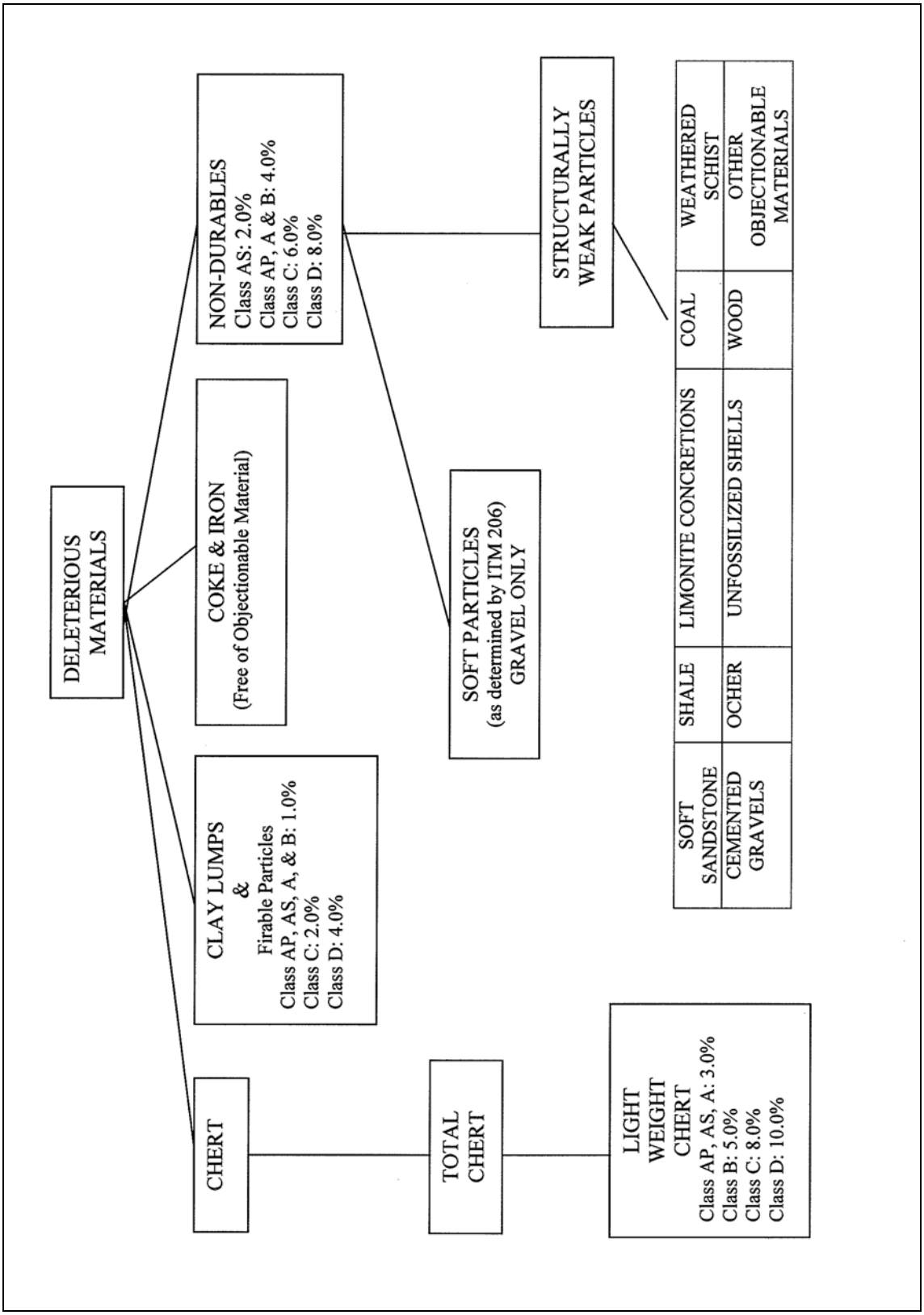

Figure 4-1. Deleterious Materials

Clay Lumps and Friable Particles

Clay lumps and friable particles are materials that are easily crumbled or mashed with the fingers. Testing for these particles is performed by **AASHTO T 112**, Clay Lumps and Friable Particles in Aggregates.

Non-Durable Particles

Non-durable particles are divided into two types: soft materials as determined by **ITM 206**, Scratch Hardness, and structurally weak material as determined by visual inspection. Structurally weak materials include the following:

1) Conglomerates -- cemented gravels

2) Soft sandstone

3) Shale -- laminated rock of clay-size minerals

4) Limonite -- iron oxide ranging in color from brown to black and is frequently a concretion around a soft core

5) Weathered schist -- structurally weak

6) Ocher -- soft rock clay to sand particles cemented with iron oxide which ranges in color from tan, through yellows, reds, and browns (looks and acts like chalk)

7) Shells -- unfossilized shell of fresh water clams

8) Coal, wood, and other foreign materials

9) Materials with loosely cemented grains and/or a weathered coating

Coke and Iron

Coke and iron are of concern only with the slag materials. Coke is an ingredient in the steel making process. Slag from air-cooled blast and steel furnaces normally are free of objectionable amounts of coke and iron.

Chert

Chert is a rock of almost any color and is composed of glassy silica and very fine-grained quartz. Chert breaks into rounded surfaces with sharp edges. Unweathered chert appears hard, dense and brittle with a waxy or greasy texture. Weathered chert appears chalky or earthy and porous with a dull texture.

Lightweight chert is defined as aggregate that has a bulk specific gravity less than 2.45. The bulk specific gravity is determined using the saturated surface dry condition.

SPECIAL REQUIREMENTS

In some cases, aggregates are required to meet special requirements for a particular use in construction as required by various Sections of **904**. Some contracts may specify a unique gradation or aggregate. Details pertaining to this special requirement appear in the Special Provision section of the contract.

Fine Aggregates

The fine aggregate, including blended fine aggregate, used in HMA Surface 4.75 mm mixtures is required to have an acid insoluble content of not less than 40 percent. For air-cooled blast furnace slag or granulated blast furnace slag sand, the acid insoluble content is required to not be less than 25 % for this application. Acid insoluble requirements do not apply to crushed gravel, limestone, or dolomite sands. The acid insoluble content is determined by **ITM 202**.

All fine aggregates used for HMA are required to be in accordance with **904.02** for soundness. If soundness testing cannot be conducted, the aggregate is required to originate from a Category I source in accordance with **ITM 203**.

The total blended aggregate from the fine and coarse aggregates, and recycled materials used in HMA are required to meet the fine aggregate angularity (FAA) requirements of Section **904.02(b)**. The procedure for determining the FAA value is described in Method A of **AASHTO T 304**.

The clay content of the blended aggregate is required to meet the requirements of Section **904.02(b)**. The procedure for determining this value is described in **AASHTO T 176**.

All Coarse Aggregates

A special requirement placed on all coarse aggregates concerns the restriction on the number of flat and elongated pieces. Section **904.03** sets the limits for the number of flat and elongated pieces. A flat and elongated piece is defined as one having a ratio of length to thickness greater than five. The test method for determining the actual percentage of elongated pieces is **ASTM D 4791**.

Dolomitic Aggregates

There is a special requirement to be met when dolomitic coarse aggregates are specified in HMA. These aggregates are specified for use under some conditions to obtain high-friction, skid-resistant HMA surface courses. **ITM 205** is used to veify that the aggregate is carbonate rock containing at least 10.3 percent elemental magnesium.

Polish Resistant Aggregates

Aggregates that meet the requirements of **ITM 214** may be used in place of dolomitic aggregates in HMA surface mixtures. The procedure for approval requires initial British Pendulum testing, placement of a test section on an INDOT contract, and subsequent skid testing for two years.

Sandstone Aggregates

Coarse sandstone is required to meet the Class B quality requirements, and may only be used in HMA or SMA surface mixtures. Sandstone is defined as a sedimentary rock composed of siliceous sandgrains containing quartz, chert, and quartzose rock fragments in a carbonite matrix or cemented with silica, calcite, or dolomite.

Slag Aggregates

When slag is furnished as an alternate to natural aggregate and payment is on a weight basis, adjustments are required to be made to compensate for the difference in specific gravity of the slag compared to the specific gravity of the natural aggregate. For any pay item less than 500 tons on a contract, no adjustment is made. The following typical values are used.

TYPICAL VALUES FOR SPECIFIC GRAVITY	
Natural aggregates (both fine and coarse)	**2.6**
Air cooled blast furnace slag coarse aggregate	**2.3**
Air cooled blast furnace slag fine aggregate	**2.6**
Granulated blast furnace slag fine aggregate	**2.1**
Steel furnace slag, both fine and coarse	**3.2**

Type AS Aggregates

Aggregates used for stone matrix asphalt mixtures are required to meet the requirements of AS aggregates in accordance with Section **904.03 (a)**. These requirements include testing with the Micro-Deval abrasion apparatus **(AASHTO T 327)** and determination of the aggregate degradation in accordance with **ITM 220**. Additional requirements for control of the specific gravity of the steel furnace slag are included in Section **904.01**.

Gravel Coarse Aggregates

There is a specific requirement for gravel coarse aggregates regarding crushed particles. This requirement applies, however, only when gravel coarse aggregates are used in HMA, compacted aggregates, and asphalt seal coats except asphalt seal coats used on shoulders. Crushed particles are defined as those particles having one or more sharp, angular, fractured faces. Fractured faces that have an area less than 25 % of the maximum cross sectional area of the particle are not considered crushed. **ASTM D 5821** is used to determine the crushed particle content. Crushed gravel is required to comply with the requirements in Section **904.03**.

Type AP Aggregates

INDOT requires specific applications of portland cement concrete to be constructed with AP aggregate. Details and parameters concerning AP aggregate are described in **ITM 210**.

GENERAL USAGE REQUIREMENTS

The general usage requirements describe the type of material which is considered acceptable for the type of construction, and the requirements which influence the acceptability of the material.

FINE AGGREGATES

Section **904.02** states that fine aggregate is required to consist of natural sand or manufactured sand produced by crushing limestone, dolomite, steel furnace slag, air cooled blast furnace slag, granulated blast furnace slag, or wet bottom boiler slag. At the time of use, these materials are required to be free from lumps or crusts of hardened or frozen materials.

THE SPECIFIC REQUIREMENTS OF FINE AGGREGATES IN ACCORDANCE WITH SECTION 904.02:	
TYPE OF CONSTRUCTION	***ACCEPTABLE FINE AGGREGATE***
Portland cement concrete for pavement or bridge decks	Natural sand
Portland cement concrete for other construction	Natural sand or crushed limestone, dolomite, or air-cooled blast furnace slag
Hot mix asphalt	Natural sand or manufactured sand. Steel furnace slag sand is permitted only with steel furnace slag coarse aggregate. A combination of natural sand and manufactured sand is permitted. However, not more than 20 percent of the total aggregate used in HMA surface mixtures with ESAL equal to or greater than 3,000,000 may be crushed limestone sand if the limestone sand is from a source not on the Approved Polish Resistant Aggregate List.
Pneumatic placement	Natural sand suitable for use with a pneumatic sand cement gun
Mortar	Natural sand
Mineral Filler	Dust produced by crushing stone, portland cement, or other inert mineral matter
Snow and ice abrasives	Steel furnace slag, air-cooled blast furnace slag, granulated blast furnace slag, natural sand, crushed stone sand, or cinders

COARSE AGGREGATES

Section **904.03** includes the general requirements for coarse aggregate. This section lists several of the types of materials that may be used as coarse aggregate, and their applications and limitations.

CLASS OF COARSE AGGREGATES REQUIRED FOR VARIOUS TYPES OF CONSTRUCTION	
TYPE OF CONSTRUCTION	***REQUIRED QUALITY CLASSIFICATION***
Aggregate Base	Class A, B, C, or D
Subbase	Class A or B (No. 8) Class A, B, C, or D (No. 53)
Aggregate Pavements or Shoulders	Class A, B, C, or D
HMA base coarse	Class A, B, C, or D
HMA intermediate course	Class A, B, or C
HMA surface course	Class A or B
SMA surface course	Class AS
Asphalt seal coat	Class A or B
Portland cement concrete pavement	Class AP
Portland cement concrete structural--exposed	Class A or AP
Portland cement concrete structural --non-exposed	Class A or B
Cover (choke) coarse aggregate	Class A or B

Where more than one aggregate classification is allowed, the Contractor has a choice, unless specified by provisions within a given contract. The class of aggregate may never be less than the lowest class for the designated use. For example, the highest class of aggregate for HMA surface course, Class A, may be used (with no additional payment to the Contractor or Producer). Class B aggregate may be used as the minimum requirement.

GRADATION REQUIREMENTS

The gradation or particle-size distribution of an aggregate is usually specified to be within certain limits for various types of construction. There is a great difference between what is considered an acceptable grading for aggregates for the various HMA mixes, for portland cement concrete, or for base layers. The gradation that aggregates are to meet for specific types of construction is contained in the contract plans, Special Provisions, or Standard Specifications and is usually designated by the aggregate size.

Sections **904.02 and 904.03** contain tables describing the acceptable particle-size distribution for various sizes of both fine and coarse aggregates. Section **904.04** specifies the sizes for riprap and Section **904.05** lists the acceptable gradations for structure backfill.

FINE AGGREGATES

The table found in Section **904.02** is used to accept six aggregates used for HMA mixes, portland cement concrete, pneumatic placement mortar, mortar sand, mineral filler, and snow and ice abrasives. The six sizes of fine aggregates include No. 23, No. 24, No. 15, No. 16, PP, and S&I. No. 16 is the finest aggregate, because 100 percent of the fine aggregate is required to pass the No. 30 sieve. No. 23 is the coarsest of the six sizes. All fine aggregate particles are generally expected to pass the No. 4 sieve.

The aggregates for mortar sand are required to meet the gradation for size number 15 or an approved gradation from a CAPP source. The fine aggregates for pneumatic placement may meet size number 15, PP, or an approved gradation from a CAPP source. Mineral filler for SMA is required to meet size number 16.

Snow and ice abrasives are required to meet the gradation requirements of Section **904.02(f)**.

COARSE AGGREGATES

The table found in Section **904.03** applies to coarse aggregates. The ten sizes of coarse aggregates include No. 2, No. 5, No. 8, No. 9, No. 11, No. 12, No. 43, No. 53, No. 73, and No. 91. No. 2 is the coarsest size and No. 12 is the finest. No. 53 and No. 73 are dense graded aggregates, and No. 91 is used for aggregates in precast concrete. The majority of the coarse aggregate is retained on the No. 4 sieve and larger.

B BORROW AND STRUCTURE BACKFILL

B Borrow and structure backfill requirements are listed in Section **211**.

Materials for B Borrow are required to contain no more than 10 % passing the No. 200 sieve and be otherwise suitably graded as noted in Section **211.02**. The use of an essentially one-size material is not permitted unless approved.

Materials for structure backfill are required to be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. Structure backfill gradations are included in Section **904.05**. Aggregate sizes No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, and No. 73 crushed stone or air cooled blast furnace slag are allowed. Additional aggregate sizes permitted for structure backfill are listed in the table in this section. The structural backfill types that allow aggregates and the specific uses of each type are as follows.

Type 1 structural backfill is used in longitudinal or transverse structures placed under, or within 5 ft of, the back of paved shoulders or the back of sidewalks of a new facility. This type is also used for a structure of an existing facility where all existing pavement is to be replaced. Structural backfill in accordance with Section **904.05** may be used for Type 1 applications.

Type 2 structural backfill is used in longitudinal or transverse structures placed under, or within 5 ft of, the back of the paved shoulder or back of the sidewalk where undisturbed existing pavement is to remain. This type is also used for precast concrete three-sided or four-sided structures with a height of cover of 2 ft or more. Crushed stone or ACBF in accordance with Section **904.05** may be used for Type 2 applications, except No. 30, No. 4, and 2 in. nominal size aggregate may <u>not</u> be used.

Type 3 structural backfill is used behind mechanically-stabilized earth retaining walls. Structural backfill in accordance with Section **904.05** may be used for Type 3 applications, except <u>only</u> nominal size aggregates 1 in., 1/2 in., or No. 4. or coarse aggregates No.5, No. 8, No. 11, or No. 12 may be used. No slag other than ACBF is permitted.

RIPRAP

Aggregate used for riprap is included in Section **904.04**. These materials are typically large and are used as a protective coating as specified. Revetment, Class 1, Class 2, Uniform A, and Uniform B Riprap are required to meet the requirements of Section **904.04(f).** The other ripraps listed have general size limitations.

AGGREGATE BASE

Section **301** includes the requirements for dense graded compacted aggregate material. No. 53 aggregate is used for this purpose.

SUBBASE

Section **302** includes the requirements for subbase placed on a prepared subgrade for portland cement concrete pavement. Subbase consists of a No. 8 aggregate as the drainage layer over a No. 53 aggregate as the separation layer. Where a dense graded subbase is required, only No. 53 aggregate is used.

AGGREGATE PAVEMENTS OR SHOULDERS

Section **303** includes the requirements for aggregates when used for pavements or shoulders. No. 53 and No. 73 aggregate are used for this purpose except that No. 73 aggregate is only used for surface courses.

SUMMARY OF GRADATION REQUIREMENTS

The gradation requirements for fine and coarse aggregates as specified in various sections of the Specifications for significantly different types of construction are summarized below. This listing is not all inclusive, but covers the major uses of aggregates.

TYPE OF CONSTRUCTION REQUIREMENTS	GRADATION
Aggregate Base	
Coarse Aggregate	No. 53
Subbase	
Coarse Aggregate	No. 8, 53
Aggregate Pavements or Shoulders	
Coarse Aggregate	No. 53, 73
Asphalt Seal Coat	
Fine Aggregate	Nos. 23 or 24
Coarse Aggregate	Nos. 8, 9, 11, 12
Portland Cement Concrete Pavement (PCCP)/Structural Concrete	
Fine Aggregate	No. 23
Coarse Aggregate	No. 8