F. APPLICABLE SECTIONS OF PENNDOT SPECIFICATIONS, FORM 408
SECTION 206—EMBANKMENT

206.1 DESCRIPTION—This work is the construction of embankments and backfills.

206.2 MATERIAL—

(a) Embankment Material. Obtain material for embankment construction from the various classes of excavation on the project, including Common Borrow Excavation, Foreign Borrow Excavation, and Selected Borrow Excavation, all conforming to the following requirements:

1. General. Material of maximum size that can be readily placed in loose 200 mm (8-inch) layers, except as specified and classified as follows:

1.a Soil. Includes earth material with the following physical characteristics:

- Gradation—More than 35% passing 75 µm (No. 200) sieve.
- Minimum dry mass density—1522 kg/m³ (95 pounds per cubic foot) determined according to PTM No. 106, Method B.
- Maximum liquid limit—65, determined according to AASHTO T 89.
- Plasticity index—Not less than liquid limit minus 30, determined according to AASHTO T 90 for soils with liquid limits of 41 to 65.

1.b Granular Material. Includes natural or synthetic mineral aggregates having 35% or less passing the 75 µm (No. 200) sieve.

1.c Shale. Includes rock-like material formed by natural consolidation of mud, clay, silt, and fine sand; usually thinly laminated, comparatively soft, and easily split.

1.d Rock. Includes natural material that cannot be excavated without blasting or using rippers; also boulders and detached stones of a size that cannot be readily placed and compacted in loose 200 mm (8-inch) layers and having insufficient soil to fill the voids in each layer.

1.e Random Material. Includes any accepted combination of the above classifications and may include concrete, brick, stone, or masonry units from demolition.

2. Suitable Material. Reasonably free of organic matter, coal or coal blossom, or other objectionable matter. Wet, dry, or frozen material may be suitable when dried, wetted, or thawed, respectively.

The Contractor may waste suitable material, including wet or frozen material, after obtaining written authorization. This suitable material is subject to replacement in equivalent volume.

(b) Select Granular Material (2RC). Section 703.3

206.3 CONSTRUCTION—

(a) General. Prepare the embankment foundation area as specified in Section 201.

Backfill existing depressions in embankment areas, such as gullies, old stream channels, stump holes, and areas of undercutting and topsoil or pavement removal, to the adjacent ground elevation.
Where undercutting is not directed, loosen embankment foundation areas to a depth of at least 200 mm (8 inches) and compact to the required dry mass (dry weight) density as determined in AASHTO T 99, Method C. In wet areas or unstable areas, the Representative may waive this requirement.

Break existing pavements, more than 1 m (3 feet) below the finished grade, as follows:

- break bituminous pavements to a maximum size of 0.1 m² (1 square foot) and recompact;
- break concrete pavements to a maximum size of 0.8 m² (1 square yard); and
- scarify bituminous, surface-treated roadways to a depth of 150 mm (6 inches) and recompact.

When constructing embankment on an existing slope, bench the slope to the width and depth indicated, or as directed.

Where required for installation of transverse drainage, construct embankment as shown on the Standard Drawings.

(b) Placement and Compaction.

1. General. Except as specified in Section 206.3(b)2 or except for rock, place embankment material for the full width in uniform horizontal layers of not more than a loose 200 mm (8-inch) depth, unless otherwise directed. The Contractor may end-dump material in water to the elevation necessary to establish a satisfactory working platform if rock is used, as approved by the Representative.

Other than rock, compact each embankment layer to the following requirements:

- Compact embankment for its full width to not less than 97% of the required dry mass (dry weight) density as determined according to PTM No. 106, Method B.
- Compact top 1 m (3 feet) of embankment for full width to 100% of the required dry mass (dry weight) density.
- In-place density will be determined according to AASHTO T 191 or AASHTO T 310.
- Maintain material to within minus 3% of optimum and the optimum moisture content at the time of compaction.
- When material is too coarse (more than 20% retained on the 19 mm (3/4-inch) sieve and less than 35% passing the 75 μm (No. 200) sieve, or more than 30% retained on the 19 mm (3/4-inch) sieve) to satisfactorily use these methods, compaction will be determined based on nonmovement of the material under compaction equipment as specified in Section 108.05(c)3,a, 3,b, 3,e, 3,h, or 4. Compact until embankment does not rut under a loaded triaxle (GVW 34 tonnes (75,000 pounds)).

Place rock, shale, and random material with coarser material in the outside and place finer material in the center of the embankment to produce a gradual transition in size. Using equipment, break the large pieces until most voids are filled.

Shape the top layer of the compacted embankment to drain during construction.

2. Wet and/or Unstable Foundation Areas. Where the embankment foundation is in water or swamp areas or is saturated or unstable, construct embankment with rock to the indicated elevation or as directed.
3. **Existing Embankment.** Existing embankment is defined as material placed and compacted during prior construction not associated with the current project, or material placed and compacted as part of the current project during a prior construction season and has wintered over. When an existing embankment requires additional material to bring it to the required elevation, proof roll the entire existing surface. Proof rolling shall be conducted with a minimum 9 tonne (10-ton) smooth drum roller (static or in static mode) in a systematic manner ensuring complete coverage of the existing embankment surface. Operate the roller at a speed between 5 km/h and 8 km/h (3 miles per hour and 5 miles per hour). Remove and recompact any unstable material before placing additional material. Material unstable due to excessive moisture should be thoroughly scarified to a minimum depth of 150 mm (6 inches), dried to the required moisture content, and recompacted.

4. **Inaccessible Areas.** Place embankment material in uniform loose layers not exceeding 100 mm (4 inches) in depth in areas inaccessible to compaction equipment; compact to required density by means of mechanical tampers.

5. **Structure Areas.** Construct structure backfill behind bridge abutments and adjacent to structures under structure backfill with Selected Borrow Excavation, as shown on the Standard Drawings and as specified in Sections 1001.3(g)2.b. Material requirements for structure backfill are indicated in the Standard Drawings. Do not place rock where piles are to be driven.

6. **Rock.** Do not place rock in embankment without acceptance of the planned excavation and embankment operations.

   When used to form the base of embankment, place rock the full cross-section width. Place rock on embankment side slopes, where indicated. With the Representative’s verification, the Contractor does not need to compact excess rock disposed of on side slopes.

   Before placing rock on other compacted embankment material, slope the top of the embankment from centerline to the sides, at a rate of approximately 85 mm per meter (1 inch per foot), and compact the embankment top.

   Place rock in uniform loose layers not exceeding in depth the approximate average size of the larger rock, but limited to a maximum depth of 900 mm (36 inches). Remove oversize rock or reduce in size until it can be readily incorporated in a 900 mm (36-inch) layer. Do not dump rock in final position, unless specified, but distribute by blading or dozing; keep voids, pockets, and bridging to a minimum. Place rock embankment so larger pieces are evenly distributed and voids are filled as completely as possible.

   When rock and other embankment material are placed at the same time, place the other material sufficiently above rock layers to allow for compaction when rock and other embankment material are placed at the same time.

   When rock embankment is to be constructed to subgrade elevation, place a scratch lift of select granular material of sufficient thickness to completely fill all voids in the rock, and permit fine grading as specified by the requirements in Section 210.

   When transitioning from rock to other embankment materials, place a scratch lift of select granular material of sufficient thickness to completely fill all voids in the rock. Place a second lift of select granular material to a compacted thickness of 150 mm (6 inches). Only one transition from rock to other embankment material is permitted in an embankment section.

   When lifts of rock and other finer embankment material are placed at the same time, place the finer material sufficiently above the rock layer to allow for proper compaction.

7. **Frozen Material.** Do not place frozen material on embankment. Do not place embankment material on any material frozen to a depth of 75 mm (3 inches) or more. Remove frozen material, if the embankment top freezes to a depth of 75 mm (3 inches) or more, before placing additional material.

8. **Wet Material.** Dry material to at least the optimum moisture content before compacting in embankment. Do not place material on embankment made unstable by excessive moisture.

9. **Dry Material.** Moisten material to within minus 3% of optimum and the optimum moisture content before compacting in embankment.

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*Initial Edition*
(c) Stability. Assume responsibility for the stability of embankment. Replace embankment that, in the
Representative's judgment, has been damaged or displaced due to the following: carelessness or negligence, natural
causes such as storms and floods, shrinkage of embankment material, and all other reasons not attributable to other
than movement of the natural ground upon which embankment is placed.

Dry, reshape, and recompact material if construction equipment on embankments causes movement, rutting, or
displacement of the material, and test for density and moisture requirements.

206.4 MEASUREMENT AND PAYMENT—

(a) Embankment. When measurement is required, embankment will be measured in its final position as
specified in Section 203.4(a)2 by the cubic meter (cubic yard).

Embarkment construction is incidental to excavation or borrow excavation.

(b) Select Granular Material (2RC). Tonne (Ton)
SECTION 703—AGGREGATE

703.1 FINE AGGREGATE—

(a) General. Fine aggregate is natural or manufactured sand consisting of hard, durable, and uncoated inert particles reasonably free from clay, silt, vegetation, and other deleterious substances such as reactive chert, gypsum, iron sulfide, amorphous silica, and hydrated iron oxide. Substances that are present in amounts large enough to cause inconsistent performance in the properties of bituminous concrete or plastic or hardened Portland cement concrete are considered deleterious. Spent foundry sand may be used as fine aggregate in asphalt concrete and flowable fill.

Obtain fine aggregate with physical properties conforming to Table A from a source listed in Bulletin 14 or approved by the MTD.

1. Natural Sand. Natural sand is fine aggregate resulting from glacial or water action. Fine aggregate produced simultaneously with gravel coarse aggregate may contain crushed particles.

2. Manufactured Sand. Manufactured sand is fine aggregate from the controlled mechanical breakdown of rock, air-cooled blast furnace slag, or air-cooled steel slag into sound, approximately cubical particles. The Department will accept manufactured sand only if it is the primary product of the crushing operation and sized by a sand classifier. However, for fine aggregate used in bituminous concrete mixtures, a sand classifier is not required.

Fine aggregate manufactured from limestone may not be used in concrete wearing surfaces.

Fine aggregate manufactured from steel slag may not be used in cement concrete or mortar mixtures. Steel slag fine aggregate may only be used in bituminous wearing courses with the approval of the MTD; however, do not use steel slag fine aggregate in conjunction with steel slag coarse aggregate. Provide steel slag fine aggregate that is uniform in density and quality. Cure steel slag fine aggregate according to the following procedure:

- After gradation preparation, place steel slag fine aggregate, whether reclaimed from an old stockpile or processed directly from the steel-making process, in a controlled stockpile. Completely soak the steel slag fine aggregate with water before or during stockpiling. Submit the method of constructing and controlling the stockpile to the Representative for review.

- Maintain the stockpile in a uniform moist condition for a period of not less than 6 months. After the minimum cure period, the Representative will sample and test the stockpile for expansive characteristics according to PTM No. 130. The Representative will approve the stockpile for use if the average total volumetric expansion according to PTM No. 130 is less than 0.50%.

- If the stockpile fails expansion criterion, continue curing the stockpile for a minimum of 2 additional months. The Representative will resample and retest the stockpile after the required additional cure period.

The MTD will evaluate the quality of fine aggregates by conducting petrographic analysis according to ASTM C 295 and other tests necessary to demonstrate that required construction of acceptable durability can be achieved.

(b) Production Testing.

1. Personnel and Equipment. Provide and assign to the work a PENNDOT Certified Aggregate Technician who will test fine aggregate at the source according to the requirements listed in Bulletin 14.
Provide the following equipment for acceptance testing and for developing and maintaining a QC program to ensure compliance with specification requirements during production:

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fine aggregate mechanical sieve shaker with timer</td>
</tr>
<tr>
<td>1</td>
<td>Sample splitter having an even number of equal width chutes that discharge alternately to each side of the splitter. A minimum of twelve total chutes is required. The minimum width of the individual chutes is to be at least 50% larger than the largest particles in the sample and the maximum width of the individual chutes is to be 20 mm (3/4-inch). Include two receptacles to hold the samples following splitting. Splitter design must allow samples to flow smoothly without restriction or loss of material.</td>
</tr>
<tr>
<td>2</td>
<td>Set of standard sieves for fine aggregate.</td>
</tr>
<tr>
<td>1</td>
<td>Balance conforming to the requirements of AASHTO M 231 for the class of general purpose scale required for the principal sample mass (weight) of the sample being tested, PTM No. 616.</td>
</tr>
<tr>
<td>1</td>
<td>Oven capable of maintaining a uniform temperature of 110 °C ± 5 °C (230°F ± 9F).</td>
</tr>
<tr>
<td>1</td>
<td>Thermometer, ASTM E 1.</td>
</tr>
</tbody>
</table>

Provide a separate set of sieves for exclusive use by the Department for acceptance testing. The remaining equipment is to be shared by the producer and the Department. If time or space conflicts arise, or if the Department does not have consistent access to shared equipment when acceptance testing is to be performed, provide a separate set of equipment for the Department. Perform routine maintenance and repair all equipment whether shared or for exclusive Department use. Have balances calibrated annually by an independent agency acceptable to the Department. Verify oven temperatures every 120 days using the thermometer required above. Maintain accurate records of calibration and temperature checks. Ensure that the producer has back-up equipment available so that no acceptance tests are missed.

Provide the following office equipment for exclusive Department use:

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Desk and chair</td>
</tr>
<tr>
<td>1</td>
<td>Electronic calculator with tape</td>
</tr>
<tr>
<td>1</td>
<td>Work table 760 mm x 2100 mm x 760 mm high (2 1/2 feet by 7 feet by 2 1/2 feet high)</td>
</tr>
<tr>
<td>1</td>
<td>Four-drawer, fire resistant (D-label) metal file cabinet</td>
</tr>
<tr>
<td>1</td>
<td>Closet or locker for storage</td>
</tr>
</tbody>
</table>

If testing equipment is to be shared, provide a minimum of 14 m² (150 square feet) of office and workspace. If a separate set of testing equipment is provided for the Department, provide a minimum of 22 m² (240 square feet) of office and workspace to accommodate both the office and the testing equipment. The office and workspace area provided shall be heated/air-conditioned and have on-site access to a water cooler, telephone, fire extinguisher, and sanitary toilet facilities.

2. Testing and Documentation. During production, provide the necessary incidental equipment to conduct and document the specified tests. Perform strength ratio and soundness tests at intervals sufficient to ensure the quality of the material. The strength ratio and soundness tests may be performed by the producer, a laboratory accredited by the AASHTO Materials Reference Laboratory (AMRL), or other inspection agency approved by the MTD.

Document the results of tests made during production and make them available to the Department upon request. The equipment and test result documentation is a condition for source acceptance, source requalification, and listing in Bulletin 14.

(c) Grading and Quality Requirements.

1. Gradation. Table A lists the extreme limits for determining the suitability of supply sources. Control the grading of Type A Fine Aggregate so that the fineness modulus of at least nine out of ten consecutive test samples from a single source delivered to a project or plant varies less than ± 0.20 from the average fineness modulus of the consecutive test samples. Determine the fineness modulus according to PTM No. 501.
For bituminous mixtures:

- If directed, vary the gradations within the limits listed in Table A.
- A blend of fine aggregates may be used if the proposed gradation limits for blending are approved by the District Executive in writing.
- If filler is required, provide fine aggregate conforming to the gradation of Table A and use cement, cement dust, fly ash, or fines from the crushing of stone, gravel, or slag that are reasonably free of clay.

2. Material Finer than the 75 μm (No. 200) Sieve. Determine the loss by washing according to PTM No. 100.

3. Minimum Strength Ratio. AASHTO T 21. If color No. 5 or darker results, determine the minimum strength ratio according to AASHTO T 71.

4. Soundness Test. Determine the percentage of mass (weight) loss after five cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510.

### TABLE A
Fine Aggregate
Grading and Quality Requirements

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Cement Concrete Sand Type A</th>
<th>Bituminous Concrete Sand Type B</th>
<th>Mortar Sand Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#1</td>
<td>#2</td>
<td>#3</td>
</tr>
<tr>
<td>9.5 mm (3/8-inch)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm (No. 4)</td>
<td>95-100</td>
<td>95-100</td>
<td>100</td>
</tr>
<tr>
<td>2.36 mm (No. 8)</td>
<td>70-100</td>
<td>70-100</td>
<td>95-100</td>
</tr>
<tr>
<td>1.18 mm (No. 16)</td>
<td>45-85</td>
<td>40-80</td>
<td>85-100</td>
</tr>
<tr>
<td>600 μm (No. 30)</td>
<td>25-65</td>
<td>20-65</td>
<td>65-90</td>
</tr>
<tr>
<td>300 μm (No. 50)</td>
<td>10-30</td>
<td>7-40</td>
<td>30-60</td>
</tr>
<tr>
<td>150 μm (No. 100)</td>
<td>0-10</td>
<td>2-20</td>
<td>5-25</td>
</tr>
<tr>
<td>75 μm (No. 200)</td>
<td></td>
<td>0-10</td>
<td>0-5</td>
</tr>
</tbody>
</table>

Material Finer Than 75 μm (No. 200) Sieve Max. Percent Passing:

- 3
- 95

Strength Ratio Min. Percent:

- 95

Soundness Test Max. Loss Percent:

- 10

Fineness Modulus:

- 2.30-3.15
- 1.6-2.5

### 703.2 COARSE AGGREGATE

(a) General. Coarse aggregate consists of hard, tough, durable, and uncoated inert particles reasonably free from clay, silt, vegetation, and other deleterious substances such as reactive clay, gypsum, iron sulfide, amorphous silica, and hydrated iron oxide. Substances that are present in amounts large enough to cause inconsistent performance in the properties of bituminous concrete or plastic or hardened Portland cement concrete are considered deleterious.

The MTD will evaluate the quality of coarse aggregates by conducting petrographic analysis according to ASTM C 295 and other tests necessary to demonstrate that required construction of acceptable durability can be achieved.
Furnish coarse aggregate crushed and prepared from one of the materials described below with physical properties conforming to Tables B, C, and D. Obtain coarse aggregate from a source listed in Bulletin 14 or approved by the MTD before use.

1. **Stone.** Durable stone free from slate texture or cleavage planes.

2. **Gravel.** Durable gravel particles. For use in cement concrete, wash thoroughly during production. For use in heavy-duty bituminous base courses, heavy-duty binder courses, and all bituminous wearing courses, a minimum of 85% crushed particles with at least two faces resulting from fracture is required. For use as No. OGS, a minimum of 75% crushed particles with at least three faces resulting from fracture is required. For all Type A use, the maximum allowable absorption determined according to AASHTO T 85 is 3.0%; however, this restriction does not apply to dredged river gravel used in Portland cement concrete. For all Type B use, the maximum allowable absorption determined according to AASHTO T 85 is 3.5%.

3. **Blast Furnace Slag.** By-product of a pig-iron making process. Tough, hard, and durable pieces of air-cooled blast furnace slag. Blast furnace slag is excluded from the abrasion requirements. The density (unit weight) of blast furnace slag cannot be less than 1120 kg/m³ (70 pounds per cubic foot).

4. **Steel Slag.** By-product of a steel making process. Tough, hard, and durable pieces of steel slag reasonably uniform in density and quality. After crushing, grading, and forming a stockpile, take a sample from the stockpile and submit it to the MTD for testing of expansive characteristics. The MTD will accept the stockpile for use if the total expansion determined according to PTM No. 130 is less than 0.50%. Once a stockpile is accepted, do not add to it if it is for Department use. If the stockpile fails expansion requirements, cure the aggregate stockpile as follows:
   - Rework the stockpile and soak the aggregate completely with water.
   - Submit the proposed method of constructing and controlling the stockpile during the cure period for review and acceptance.
   - Maintain the aggregate in a uniformly moist condition in the stockpile for a period of at least 6 months. Take a sample after this curing period and submit it to the MTD for testing according to PTM No. 130.
   - The Representative will accept the stockpile for use if the total expansion is less than 0.50%. If the stockpile still fails the expansion requirement, continue curing for at least 2 additional months before resampling and retesting.

Aggregate manufactured from steel slag is not acceptable for pipe or structure backfill or in cement concrete. Steel slag may be used for subbase, selected granular material, shoulders, selected material surfacing, and in bituminous surface courses.

5. **Granulated Slag.** By-product of an iron-making process. Granulated blast furnace slag is the granular glassy material formed when molten slag from iron-making is rapidly quenched by immersion in water and contains not more than 3% total iron reported as Fe₂O₃. Provide material containing not more than 20% by mass (weight) of substances that are not granulated slag. Use material with a dry rodded density (unit weight) determined according to AASHTO T 19 of not more than 1200 kg/m³ (80 pounds per cubic foot). Provide uniform material having a maximum size of 50 mm (2 inches) and not more than 20% passing the 150 μm (No. 100) sieve. Granulated slag may only be used for subbase material as specified in Section 350.

6. **Lightweight Aggregate.** Acceptable types of lightweight aggregate are as follows:
   - Aggregate prepared by expanding or sintering products such as clay, shale, or slate.
   - Aggregate prepared by processing natural materials such as pumice, scoria, or tuff.
Furnish lightweight aggregate conforming to AASHTO M 195, the soundness and abrasion limits for Type A aggregate as specified in Table B, and the following durability requirements.

- **Aggregate Absorption Factor** (PTM No. 526)  
  Max. % 2.5

- **Freeze-Thaw Resistance of Concrete, Decrease of Dynamic Modulus at 300 Cycles** (AASHTO T161, Procedure B, except that after 14 days of moist cure, dry the beams 76 mm x 102 mm x 406 mm at 22 °C ± 2 °C (3 inches by 4 inches by 16 inches at 72F ± 3F) and approximately 50% relative humidity for 14 days. Then soak the beams in water for 3 days before starting the freezing and thawing test.)  
  Max. % 60

- **Freeze-Thaw Resistance of Aggregate** (PTM No. 525)  
  Max. % 25

### TABLE B

**Coarse Aggregate Quality Requirements**

<table>
<thead>
<tr>
<th></th>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soundness, Max. %</td>
<td>10</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Abrasion, Max. %</td>
<td>45*****</td>
<td>45*****</td>
<td>55*****</td>
</tr>
<tr>
<td>Thin and Elongated Pieces,</td>
<td>15</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>Max. %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Finer Than 75 µm</td>
<td>*</td>
<td>*</td>
<td>10</td>
</tr>
<tr>
<td>(No. 200) Sieve, Max. %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crushed Fragments, Min. %</td>
<td>55**</td>
<td>55**</td>
<td>50</td>
</tr>
<tr>
<td>Compact Density (Unit Weight), Min. kg/m³ (lbs./cu. ft.)</td>
<td>1100 (70)</td>
<td>1100 (70)</td>
<td>1100 (70)</td>
</tr>
<tr>
<td>Deleterious Shale, Max. %</td>
<td>2</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Clay Lumps, Max. %</td>
<td>0.25</td>
<td>0.25</td>
<td>3</td>
</tr>
<tr>
<td>Friable Particles, Max. %</td>
<td>1.0</td>
<td>1.0</td>
<td>—</td>
</tr>
<tr>
<td>(excluding shale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal or Coke, Max. %</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Glassy Particles, Max. %</td>
<td>4 or 10***</td>
<td>4 or 10***</td>
<td>—</td>
</tr>
<tr>
<td>Iron, Max. %</td>
<td>3*****</td>
<td>3*****</td>
<td>3*****</td>
</tr>
<tr>
<td>Absorption, Max. %</td>
<td>3.0****</td>
<td>3.5****</td>
<td>—</td>
</tr>
<tr>
<td>Total of Deleterious Shale, Clay Lumps, Friable Particles, Coal, or Coke Allowed, Max. %</td>
<td>2</td>
<td>2</td>
<td>15</td>
</tr>
</tbody>
</table>

* See Section 703.2(c)4.
** See Section 703.2(a)2.
*** See Section 703.2(c)10.
**** Gravel only. See Section 703.2(a)2.
***** See Section 703.2(c)11.
****** Blast Furnace Slag excluded. See Section 703.2(a)3.

7. **Recycled Concrete.** Salvaged and crushed concrete pavements and concrete highway structures from Department, county, or municipal projects for use as aggregate in subbase only. Other recycled concrete may be used in subbase if the concrete was made using materials approved by the Department. Provide recycled concrete conforming to Table B and Table C.
(b) Production Testing.

1. Personnel and Equipment. Provide and assign to the work a PENNDOT Certified Aggregate Technician who will test coarse aggregate at the source according to the requirements listed in Bulletin 14.

Provide the following equipment for acceptance testing and for developing and maintaining a QC program to ensure compliance with specification requirements during production.

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coarse aggregate mechanical sieve shaker with timer</td>
</tr>
<tr>
<td>1</td>
<td>Sample splitter having an even number of equal width chutes that discharge alternately to each side of the splitter. A minimum of eight total chutes is required. The minimum width of the individual chutes is to be at least 50% larger than the largest particles in the sample. Include two receptacles to hold the samples following splitting. Splitter design must allow samples to flow smoothly without restriction or loss of material.</td>
</tr>
<tr>
<td>2</td>
<td>Set of standard sieves for coarse aggregate.</td>
</tr>
<tr>
<td>1</td>
<td>Cylindrical metal measure (25 L (1 cubic foot)) AASHTO T 19</td>
</tr>
<tr>
<td>1</td>
<td>Balance conforming to the requirements of AASHTO M 231 for the class of general purpose scale required for the principle sample mass (weight) of the sample being tested, AASHTO T 85.</td>
</tr>
<tr>
<td>1</td>
<td>Platform scale conforming to the requirements of AASHTO M 231 for the class of general purpose scale required for the principle sample mass (weight) of the sample being tested, PTM No. 616.</td>
</tr>
<tr>
<td>1</td>
<td>Oven capable of maintaining a uniform temperature of 110 °C ± 5 °C (230°F ± 9°F).</td>
</tr>
<tr>
<td>1</td>
<td>Thermometer, ASTM E 1.</td>
</tr>
</tbody>
</table>

Provide a separate set of sieves for exclusive use by the Department for acceptance testing. The remaining equipment is to be shared by the producer and the Department. If time or space conflicts arise, or if the Department does not have consistent access to shared equipment when acceptance testing is to be performed, provide a separate set of equipment for the Department. Perform routine maintenance and repair of all equipment whether shared or for exclusive Department use. Have balances calibrated annually by an independent agency acceptable to the Department. Verify oven temperatures every 120 days using the thermometer required above. Maintain accurate records of calibration and temperature checks. Ensure that the producer has back-up equipment available so that no acceptance tests are missed.

Provide the following office equipment for exclusive Department use:

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Desk and chair</td>
</tr>
<tr>
<td>1</td>
<td>Electronic calculator with tape</td>
</tr>
<tr>
<td>1</td>
<td>Work table 760 mm x 2100 mm x 760 mm high (2 1/2 feet by 7 feet by 2 1/2 feet high)</td>
</tr>
<tr>
<td>1</td>
<td>4-drawer, fire resistant (D-label) metal file cabinet</td>
</tr>
<tr>
<td>1</td>
<td>Closet or locker for storage</td>
</tr>
</tbody>
</table>

If testing equipment is to be shared, provide a minimum of 14 m² (150 square feet) of office and workspace. If a separate set of testing equipment is provided for the Department, provide a minimum of 22 m² (240 square feet) of office and workspace to accommodate both the office and the testing equipment. The office and workspace area provided shall be heated/air-conditioned and have on-site access to a water cooler, telephone, fire extinguisher, and sanitary toilet facilities.

2. Testing and Documentation. During production, provide the necessary incidental equipment to conduct and document the specified tests.

Perform soundness and abrasion tests at intervals sufficient to ensure the quality of the material. The soundness and abrasion tests may be performed by the producer, a laboratory accredited by the AMRL, or other inspection agency approved by the MTD.

Document the results of tests made during production and make them available to the Department upon request. The equipment and test result documentation is a condition for source acceptance, source requalification, and listing in Bulletin 14.
(c) **Quality Requirements.** The following notes are applicable to Table B.

1. **Soundness.** Determine the percentage of mass (weight) loss after five cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510. The MTD may accept aggregate failing the test if it can be demonstrated in writing that the aggregate has a satisfactory service record in both pavements and structures. Acceptable aggregate produced from recycled concrete need not conform to soundness requirements since cementitious material cannot be evaluated with this test.

2. **Abrasion.** Determine the percentage of mass (weight) loss according to AASHTO T 96.

3. **Thin and Elongated Particles.** When directed, determine the percentage of particles retained on the 9.5 mm (3/8-inch) sieve that have a ratio greater than 1:5 (5:1) between the maximum and minimum dimensions of an imaginary enclosing rectangular prism. If the material retained on the 9.5 mm (3/8-inch) sieve constitutes less than 5.0% of the total mass (weight) of the test sample, do not determine the percentage of thin and elongated particles.
### TABLE C
Size and Grading Requirements for Coarse Aggregates
(Based on Laboratory Sieve Tests, Square Openings)

<table>
<thead>
<tr>
<th>AASHTO Number</th>
<th>100 mm (4&quot;)</th>
<th>90 mm (3 1/2&quot;)</th>
<th>63 mm (2 1/2&quot;)</th>
<th>50 mm (2&quot;)</th>
<th>37.5 mm (1 1/2&quot;)</th>
<th>25.0 mm (1&quot;)</th>
<th>19.0 mm (3/4&quot;)</th>
<th>12.5 mm (1/2&quot;)</th>
<th>9.5 mm (3/8&quot;)</th>
<th>4.75 mm (No. 4)</th>
<th>2.36 mm (No. 8)</th>
<th>1.18 mm (No. 16)</th>
<th>150 µm (No. 100)</th>
<th>75 µm (No. 200)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>90-100</td>
<td>25-60</td>
<td>0-15</td>
<td>0-5</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>90-100</td>
<td>35-70</td>
<td>0-15</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>467</td>
<td>100</td>
<td>95-100</td>
<td>35-70</td>
<td>10-30</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>90-100</td>
<td>20-55</td>
<td>0-10</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>100</td>
<td>95-100</td>
<td>25-60</td>
<td>0-10</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>100</td>
<td>90-100</td>
<td>20-55</td>
<td>0-10</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>90-100</td>
<td>40-70</td>
<td>0-15</td>
<td>0-5</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>85-100</td>
<td>10-30</td>
<td>0-10</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>85-100</td>
<td>10-30</td>
<td>0-10</td>
<td>0-5</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A**</td>
<td>100</td>
<td>52-100</td>
<td>36-70</td>
<td>24-50</td>
<td>16-38*</td>
<td>10-30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OGS**</td>
<td>100</td>
<td>52-100</td>
<td>36-65</td>
<td>8-40</td>
<td>0-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Applies only for bituminous mixtures.
** PENNDOT Number
*** For 75 µm (No. 200), see Table D.

**Note A:** A combination of No. 7 and No. 5 may be substituted for No. 57, provided that not more than 50% or less than 30% of the combination is No. 7 size.

**Note B:** Provide No. OGS material that has a minimum average coefficient of uniformity of 4.0. The average coefficient of uniformity is defined as the average of the sublots within each lot. Determine the coefficient of uniformity according to PTM No. 149 each time the gradation is determined. The required minimum coefficient of uniformity for individual samples is 3.5. If the coefficient of uniformity of any sample falls below 3.5, reject the lot. Do not use the coefficient of uniformity in the multiple deficiency formula.

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4. **Material Finer than the 75 µm (No. 200) Sieve.** Determine the loss by washing according to PTM No. 100 and Table D.

This test is not required for aggregate processed through a mechanical dryer for use in bituminous concrete; however, the aggregate is required to be clean and free of fines that would adversely affect the coating of the aggregate with bituminous material.

<table>
<thead>
<tr>
<th>Section</th>
<th>Specification</th>
<th>% Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>Subbase (No. 2A)</td>
<td>10</td>
</tr>
<tr>
<td>350</td>
<td>Subbase (No. OGS)</td>
<td>5</td>
</tr>
<tr>
<td>430</td>
<td>Bit. Wear. Crse. FB-2</td>
<td>2</td>
</tr>
<tr>
<td>431</td>
<td>Bit. Bind. Crse. FB-2</td>
<td>2</td>
</tr>
<tr>
<td>439</td>
<td>Bit. Wear. Crse. FB-1</td>
<td>2</td>
</tr>
<tr>
<td>440</td>
<td>Bit. Bind. Crse. FB-1</td>
<td>2</td>
</tr>
<tr>
<td>441</td>
<td>Bit. Bind. Crse. CP-2</td>
<td>2.0</td>
</tr>
<tr>
<td>450</td>
<td>Bit. Bind. Crse. DP-1</td>
<td>2.0</td>
</tr>
<tr>
<td>470</td>
<td>Bit. Seal Coat</td>
<td>1.0</td>
</tr>
<tr>
<td>471</td>
<td>Bit. Seal Coat w/ Precast. Aggr.</td>
<td>2.0</td>
</tr>
<tr>
<td>480</td>
<td>Bit. Surf. Treatment</td>
<td>1.0</td>
</tr>
<tr>
<td>704</td>
<td>Cement Concrete</td>
<td>1</td>
</tr>
<tr>
<td>—</td>
<td>All other uses</td>
<td>2</td>
</tr>
</tbody>
</table>

**TABLE D**

**Material Passing the 75 µm (No. 200) Sieve —**

*(Based on Laboratory Sieve Tests, Square Openings)*

5. **Crushed Fragments.** ASTM D 5821

6. **Compact Density.** AASHTO T 19, for slag.

7. **Deleterious Shale.** Determine the percentage of mass (weight) by four cycles of wetting and drying according to PTM No. 519. The MTD will use petrographic analysis to confirm the results.

8. **Friable Particles.** PTM No. 620, by percentage of mass (weight).

9. **Coal or Coke.** Determine the percentage of mass (weight) by visual identification and hand separation. If required, the MTD will use petrographic analysis to confirm the results.

10. **Glassy Particles.** Determine the percentage of mass (weight) by visual identification and hand separation. Pieces of slag containing more than 50% glass are considered to be glassy particles. Waste glass is also considered to be glassy particles. For coarse aggregate used in cement concrete, the maximum percentage of glassy particles allowed is 4%. For other uses, the maximum percentage of glassy particles allowed is 10%. Coarse aggregate containing glassy particles consisting of waste glass may not be used in cement concrete or bituminous wearing courses.

11. **Metallic Iron.** The MTD will use petrographic analysis to determine the content of metallic iron. Pieces of slag containing metallic iron are considered to be metallic iron. This requirement is waived when aggregate with metallic iron is used in bituminous mixtures or subbase.

12. **Clay Lumps.** Determine the percentage of mass (weight) by visual identification and hand separation. If required, the MTD will use petrographic analysis to confirm the results.

**(d) Testing and Acceptance.** Section 703.5(b)
703.3 SELECT GRANULAR MATERIAL (2RC)—

(a) General. Select granular material consists of durable bank or crushed gravel, stone, or slag mixed or blended with suitable filler materials to provide a uniform mixture. Obtain select granular material from a source listed in Bulletin 14. Stockpile, sample, and test material before it is used to ensure reasonable uniformity and acceptability. Use material free from vegetable or organic matter, lumps, or an excessive quantity of clay or other objectionable or foreign substances, and not more than 10% deleterious shale by mass (weight).

(b) Gradation. Conforming to the following gradation, determined according to PTM No. 619:

- Passing 50 mm (2-inch) sieve—100%
- Passing 4.75 mm (No. 4) sieve—15% to 60%
- Passing 150 μm (No. 100) sieve—0% to 30%

703.4 ANTI-SKID MATERIAL—

(a) General. For use on ice or snow-covered pavement surfaces, furnish anti-skid material conforming to Table E from a supplier listed in Bulletin 14. Do not use material containing metal, glass, or substances that may be harmful to automotive equipment and vehicles. Use material reasonably free of deleterious substances or foreign materials including, but not limited to, dirt, shale, slate, incinerated bituminous coal mine waste, and as specified in Section 703.2(a), Table B, Type C.

(b) Description.

1. Types 1 and 1A. Cinders, coke, crushed coal boiler bottom ash, or a combination of these. Bottom ash is residue of molten ash obtained from coal-burning boilers.

1.a Furnish bottom ash having no pyritic material or mill rejects commingled, mixed, or combined with it.

1.b Furnish Type 1 or 1A anti-skid material conforming to the following requirements:

- An air-dry loose density (weight) of not less than 560 kg/m³ (35 pounds per cubic foot), determined according to AASHTO T 19, Section 7;
- Type 1, having a density (unit weight) of 1220 kg/m³ (76 pounds per cubic foot) or less, or Type 1A, having a density (unit weight) of more than 1220 kg/m³ (76 pounds per cubic foot);
- Crushed brick, crushed stone, blast furnace slag, steel slag, or gravel may be present in amounts not exceeding a total of 3% by mass (weight) of total dry mass (weight) of the sample, determined by the mass (weight) of this material retained on the 12.5 mm (1/2-inch) sieve;
- Unburned or partially burned coal or coke may be present in amounts not exceeding 7% by mass (weight) of total dry mass (weight) of the sample, determined by the mass (weight) of this material retained on the 9.5 mm (3/8-inch) sieve, except unburned coal, partially burned coal, or coke may not be present in bottom ash.

2. Type 2. Crushed stone, crushed gravel, or crushed slag, conforming to the following requirements:

- Not exceeding 1680 kg/m³ (105 pounds per cubic foot);
• Los Angeles Abrasion loss not exceeding 55% by mass (weight), determined according to AASHTO T 96, Gradation D; and

• If crushed gravel is furnished, not less than 85% of the fragments retained on the 2.36 mm (No. 8) sieve are required to be crushed, one face, determined according to ASTM D 5821.

• Total of individual anti-skid particles containing metallic iron may not exceed 1.0% by mass (weight) of material, determined by the mass (weight) of particles retained on the 4.75 mm (No. 4) sieve and by the total dry mass (weight) of the sample.

3. Types 3, 3A, and 3B. Either natural sand, with not less than 35% of the material retained on the 2.36 mm (No. 8) sieve being crushed fragments, determined according to ASTM D 5821; or manufactured sand, except limestone sand; or a combination of these.

Total of individual anti-skid particles containing metallic iron may not exceed 1.0% by mass (weight) of material, determined by the mass (weight) of particles retained on the 4.75 mm (No. 4) sieve and by the total dry mass (weight) of the sample.

4. Type 4. Burned anthracite coal mine refuse with a Los Angeles Abrasion loss not exceeding 55% by mass (weight), determined according to AASHTO T 96.

5. Type 6S. Crushed stone, crushed gravel, or crushed slag conforming to the following requirements:

• Not exceeding 1680 kg/m³ (105 pounds per cubic foot);

• Los Angeles Abrasion loss not exceeding 55% by mass (weight), determined according to AASHTO T 96, Gradation D; and

• If crushed gravel is furnished, not less than 60% of the fragments retained on the 4.75 mm (No. 4) sieve are required to be crushed, one face, determined according to ASMT D 5821.

• Total of individual anti-skid particles containing metallic iron may not exceed 1.0% by mass (weight) of material, determined by the mass (weight) of particles retained on the 4.75 mm (No. 4) sieve and by the total dry mass (weight) of the sample.

(c) Gradations. Conforming to Table E.

<table>
<thead>
<tr>
<th>Anti-Skid Type</th>
<th>Maximum Percent Passing Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31.5 mm (1 1/4&quot;)</td>
</tr>
<tr>
<td>Type 1</td>
<td>100</td>
</tr>
<tr>
<td>Type 1A</td>
<td>100</td>
</tr>
<tr>
<td>Type 2</td>
<td>100</td>
</tr>
<tr>
<td>Type 3</td>
<td>100</td>
</tr>
<tr>
<td>Type 3A</td>
<td>100</td>
</tr>
<tr>
<td>Type 3B</td>
<td>100</td>
</tr>
<tr>
<td>Type 4</td>
<td>100</td>
</tr>
<tr>
<td>Type 6S</td>
<td>100</td>
</tr>
</tbody>
</table>

* Determined by PTM No. 100.

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(d) Testing. If shipping to Department stockpiles, test material for moisture content according to PTM No. 513. A minimum of two tests per day is required. If conditions exist that would cause a change in moisture content, conduct additional tests. A Department representative will verify the test results.

Document tests at the end of delivery quantity at the end of the day and determine the average moisture content. The Department will adjust the delivery quantity by deducting the average moisture content from the aggregate quantity shipped. Payment is based on the calculated oven dry mass (weight).

703.5 ACCEPTANCE OF CONSTRUCTION AGGREGATES—

(a) General. The following describes the certification acceptance of construction aggregates. Accept AASHTO No. 1 Coarse Aggregate as specified in Section 850.2(a).

(b) Testing and Acceptance. Certify each day's shipment of aggregate as specified in Section 106.03(b).

1. QC. Section 106.03(b)2 and as follows:
   
   - Submit for annual review a QC Plan conforming to the minimum Department requirements for aggregate suppliers.
   
   - Establish and positively identify aggregate stockpiles that have been tested according to the approved QC Plan and conform to Department Specifications. Material may be added to or shipped from stockpiles at the producer's discretion.

2. Source Verification Samples. Under the direction and supervision of the Representative, obtain a verification sample (n=3) from each stockpile to be tested. Obtain the sample from the stockpile according to AASHTO T 2 or from a mini-stockpile. If the mini-stockpile method is chosen, obtain the sample according to the following procedure:
   
   - Place approximately 10 tonnes (10 tons) of aggregate into a mini-stockpile on a suitable surface. Use a loader to strike off the top of the mini-stockpile.
   
   - Obtain sufficient material for sampling from random locations on the mini-stockpile using a square faced shovel.

   Immediately deliver the sample to the Representative for testing using the equipment provided as specified in Sections 703.1(b) and 703.2(b). The Representative will test all three increments for compliance with Tables A, B, C, and D, as applicable. If the test results verify that the material conforms to the specifications, use the material under certification.

   If the material does not conform to the specifications, the Representative will determine the percent within limits (PWL) according to Section 106.03(a). If results indicate a PWL for the material of less than 90, the Representative will reject the stockpile.

   If a stockpile is rejected, increase QC testing according to the reviewed QC Plan. Construct another stockpile of the aggregate to be tested consisting of 300 tonnes to 500 tonnes (300 tons to 500 tons) of material or the remainder of the quantity identified for Department projects, whichever is less. The Representative will accept the material under certification if test results verify that the material from the new stockpile conforms to the specifications.

3. Project Verification Samples. Under the direction and supervision of the Inspector, obtain verification samples (n=3) according to Table F for each type of aggregate at the point of placement (loose aggregate sample immediately before compaction):
TABLE F
Verification Samples

<table>
<thead>
<tr>
<th>Aggregate Quantities</th>
<th>Number of Samples (n=3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 tonnes (500 tons) or more, but less than 2000 tonnes</td>
<td>1</td>
</tr>
<tr>
<td>(2,000 tons)</td>
<td></td>
</tr>
<tr>
<td>2000 tonnes (2,000 tons) or more, but less than 10 000</td>
<td>2</td>
</tr>
<tr>
<td>tonnes (10,000 tons)</td>
<td></td>
</tr>
<tr>
<td>10 000 tonnes (10,000 tons) or more, up to 25 000 tonnes</td>
<td>3</td>
</tr>
<tr>
<td>(25,000 tons)</td>
<td></td>
</tr>
<tr>
<td>Each additional increment of 25 000 tonnes (25,000 tons)</td>
<td>1</td>
</tr>
</tbody>
</table>

The Inspector will select sample locations according to PTM No. 1.
Under the direction and supervision of the Inspector, immediately deliver the sample(s) to the test site at either the producers' location or the project site. The Inspector will test the sample(s) using the equipment provided as specified in Sections 703.1(b) and 703.2(b). The Inspector will test all three increments for compliance with Tables C and D, plus the Crushed Fragments Test of Table B when applicable. The Department will continue to accept material under certification if test results verify that the material conforms to the specifications.
If the material does not conform to the specifications, the Inspector will determine the average PWL of the material as specified in Section 106.03(a)3. If results indicate a PWL for the material of less than 90, immediately obtain an additional verification sample (n=3) at the project site from the next 150 tonnes (150 tons) of material.
Discontinue all operations using that type of aggregate until the results of the second verification sample are evaluated. If results indicate a PWL of 90 or more, resume operations using the evaluated aggregate. If the results indicate a PWL of less than 90, conduct acceptance testing at the point of placement according to the following procedure:

- Provide a separate field laboratory as specified in Section 609 at no additional expense to the Department. Do not resume operations using the material until the field laboratory is in place at the project site.
- Under the direction and supervision of the Inspector, obtain an acceptance sample (n=3) at the point of placement (loose aggregate sample immediately before compaction) for each day's placement. The Inspector will select sample locations according to PTM No. 1. Immediately transport the sample from the sampling point to the testing site. The Inspector will test all three sample increments for compliance with Section 703.2(c), Tables C and D.
- The Department will continue project acceptance testing until ten consecutive day’s placements are accepted with no rejected material. The Contractor will be charged $200 per day, for each day the material is placed, for project acceptance testing performed by the Department.
- For test values not conforming to the specifications, the Department will determine the PWL according to Section 106.03(a)3. If results indicate a PWL for the material of less than 90, remove and replace the material at no additional cost to the Department.

4. QA Samples. BOCM QA samples (n=3) may be taken at the source of supply or at the point of placement on the project. Submit samples to the MTD for testing. If results for any type of material indicate a PWL of less than 90, the District will immediately obtain an additional verification sample (n=3) at the appropriate site (project or source). The Department will test all three sample increments at either the producer's location or at the project site and determine the PWL for the material. If results indicate a PWL for the material of less than 90, obtain source verification samples and project verification samples as specified in Section 703.5(b)2 and Section 703.5(b)3.

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(c) **Weighing Responsibilities.** Prepare weight slips and certifications attesting to the accuracy of the weights recorded and ensuring conformance with Section 107.23(b). Designate a licensed weigh person(s) to act as the Contractor’s agent. Ensure that scales are calibrated annually by an independent agency acceptable to the Department. A Department Inspector may provide random checking.

Weigh empty trucks used to haul material measured by mass (weight) daily unless otherwise directed. If the invoice mass (weight) exceeds the net mass (net weight) determined by a Department mobile weigh team by more than 3%, the Department will consider the deviation to be excessive. Take immediate corrective action upon notification of an excessive deviation. Within 30 days of notification, provide the District Executive with a written description of corrective actions and safeguards and the time that they were implemented.
SECTION 704—CEMENT CONCRETE

704.1 GENERAL—

(a) Description. Furnish the indicated class of cement concrete according to the requirements of Table A. Cement concrete is a mixture of Portland cement, fine aggregate, coarse aggregate, water and air-entraining admixture, with or without water reducing admixture, retarding admixture, or pozzolan.

The methods of producing concrete referred to in these Specifications are defined as follows:

1. **Plant Mixed Cement Concrete.** Concrete proportioned and mixed in either a stationary, commercial, and central plant or a stationary plant located near the project. Concrete is delivered to the work site by truck, agitator truck, or mixer truck.

2. **Truck Mixed Cement Concrete.** Concrete prepared by dry batching in a proportioning plant and placing the dry ingredients in a truck mixer. Measured water is then added to the truck drum from the plant water system and the concrete is mixed in the truck at the plant. Mixing is not allowed en-route to or at the work site.

3. **Volumetric Mixed Cement Concrete.** Concrete proportioned and mixed in a truck-mounted mobile mixer. The unit is capable of proportioning concrete ingredients from self-contained bins and mixing the materials with measured water in a self-contained mixer. The concrete is mixed and discharged at the work site.

(b) Material.

- Cement—Section 701
- Fine Aggregate, Type A—Section 703.1
- Coarse Aggregate, Type A, No. 57, (Stone, Gravel, or Slag)—Section 703.2
- Water—Section 720.1
- Admixtures—Section 711.3
- Pozzolan—Section 724
### TABLE A (Metric)
**Cement Concrete Criteria**

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Use</th>
<th>Cement Factor$^{(3),(5)}$ (kg/m$^3$)</th>
<th>Maximum Water Cement Ratio$^{(6)}$ (kg/kg)</th>
<th>Minimum Mix$^{(4)}$ Design Compressive Strength (MPa)</th>
<th>Proportions Coarse$^{(1)}$ Aggregate Solid Volume (m$^3$/m$^3$)</th>
<th>28-Day Structural Design Compressive Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td></td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>AAA</td>
<td>Bridge Deck</td>
<td>376$^{(9)}$</td>
<td>446</td>
<td>0.43</td>
<td>—</td>
<td>25</td>
</tr>
<tr>
<td>AA</td>
<td>Slip Form</td>
<td>349</td>
<td>446</td>
<td>0.47</td>
<td>—</td>
<td>13</td>
</tr>
<tr>
<td>AA</td>
<td>Paving</td>
<td>349</td>
<td>446</td>
<td>0.47</td>
<td>—</td>
<td>21</td>
</tr>
<tr>
<td>AA</td>
<td>Paving</td>
<td>349</td>
<td>446</td>
<td>0.47</td>
<td>—</td>
<td>21</td>
</tr>
<tr>
<td>A</td>
<td>Structures and Misc.</td>
<td>335</td>
<td>446</td>
<td>0.50</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>234</td>
<td>390</td>
<td>0.66</td>
<td>—</td>
<td>19</td>
</tr>
<tr>
<td>HES</td>
<td></td>
<td>446</td>
<td>502</td>
<td>0.40</td>
<td>21</td>
<td>26</td>
</tr>
</tbody>
</table>

Notes 1 and 3 pertain to structure and miscellaneous concrete only.

1. Proportions shown in the table are shown on the reverse side of Form TR 4221-B and are controlled by class of concrete, fineness modulus of fine aggregate (PTM No. 501) and the solids percent in coarse aggregate (PTM No. 617).

2. Test Procedures: Slump—AASHTO T 119; Strength—PTM No. 604, Compressive.

3. For use in miscellaneous or structural concrete, if the Fineness Modulus (FM) is between 2.3 and 2.5, increase the minimum cement factor for the class of concrete 28 kg/m$^3$. This requirement may be waived after adequate strength data is available and analyzed according to the mix-design section in Bulletin 5.

4. If mixing bridge deck concrete with a truck mounted volumetric plant, use a minimum cement factor of 390 kg/m$^3$.

5. For exception, see Section 704.1(c).

6. If a portion of the cement is replaced by pozzolan, use a water to cement plus pozzolan ratio by mass.

7. For slip form paving, provide No. 57 coarse aggregate that has a minimum of 35% passing the 12.5 mm sieve. Base these results on the average of three samples, with no single sample result below 30% passing. Conduct testing at the concrete plant according to the QC Plan. Segregated stockpiles may be reworked and retested if material fails to conform to this requirement.
### TABLE A (English)
Cement Concrete Criteria

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Use</th>
<th>Cement Factor&lt;sup&gt;5&lt;/sup&gt;&lt;sup&gt;(6)&lt;/sup&gt; (lbs/cu. yd.)</th>
<th>Maximum Water Cement Ratio&lt;sup&gt;5&lt;/sup&gt; (lbs/lbs)</th>
<th>Minimum Mix&lt;sup&gt;5&lt;/sup&gt; Design Compressive Strength (psi) Days</th>
<th>Proportions Coarse&lt;sup&gt;5&lt;/sup&gt; Aggregate Solid Volume (cu. ft./cu. yd.)</th>
<th>28-Day Structural Design Compressive Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>Bridge Deck</td>
<td>634.5&lt;sup&gt;(5)&lt;/sup&gt;</td>
<td>0.43</td>
<td>—</td>
<td>3,600—4,500</td>
<td>4,000</td>
</tr>
<tr>
<td>AA</td>
<td>Slip Form Paving&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>587.5</td>
<td>0.47</td>
<td>—</td>
<td>3,000—3,750</td>
<td>11.00—13.10</td>
</tr>
<tr>
<td>AA</td>
<td>Paving</td>
<td>587.5</td>
<td>0.47</td>
<td>—</td>
<td>3,000—3,750</td>
<td>9.93—13.10</td>
</tr>
<tr>
<td>AA</td>
<td>Structures and Misc.</td>
<td>587.5</td>
<td>0.47</td>
<td>—</td>
<td>3,000—3,750</td>
<td>9.93—13.10</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>564</td>
<td>0.50</td>
<td>—</td>
<td>2,750—3,300</td>
<td>10.18—13.43</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>394.8</td>
<td>0.66</td>
<td>—</td>
<td>1,500—2,000</td>
<td>11.45—15.10</td>
</tr>
<tr>
<td>HES</td>
<td></td>
<td>752</td>
<td>0.40</td>
<td>3,000—3,750</td>
<td>9.10—12.00</td>
<td>3,500</td>
</tr>
</tbody>
</table>

Notes 1 and 3 pertain to structure and miscellaneous concrete only.
1. Proportions shown in the table are shown on the reverse side of Form TR 4221-B and are controlled by class of concrete, fineness modulus of fine aggregate (PTM No. 501) and the solids percent in coarse aggregate (PTM No. 617).
2. Test Procedures: Slump—AASHTO T 119; Strength—PTM No. 604, Compressive.
3. For use in miscellaneous or structural concrete, if the Fineness Modulus (FM) is between 2.3 and 2.5, increase the minimum cement factor for the class of concrete 47 lbs/cu. yd. This requirement may be waived after adequate strength data is available and analyzed according to the mix-design section in Bulletin 5.
4. If mixing bridge deck concrete with a truck mounted volumetric plant, use a minimum cement factor of 658 lbs/cu. yd.
5. For exception, see Section 704.1(c).
6. If a portion of the cement is replaced by pozzolan, use a water to cement plus pozzolan ratio by weight.
7. For slip form paving, provide No. 57 coarse aggregate that has a minimum of 35% passing the 1/2-inch sieve. Base these results on the average of three samples, with no single sample result below 30% passing. Conduct testing at the concrete plant according to the QC Plan. Segregated stockpiles may be reworked and retested if material fails to conform to this requirement.

### I. Density of Material
Except for admixtures, use the following material densities (unit weights) when proportioning cement concrete:

<table>
<thead>
<tr>
<th>Type of Material</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>1 000 kg/m³ (62.4 pounds per cubic foot)</td>
</tr>
<tr>
<td>Cement</td>
<td>1 510 kg/m³ (94.0 pounds per cubic foot)</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>Based on bulk specific gravity as specified in Section 704.1(b)2.</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>Stone or Gravel</td>
</tr>
<tr>
<td></td>
<td>Based on bulk specific gravity as specified in Section 704.1(b)2.</td>
</tr>
<tr>
<td></td>
<td>Slag</td>
</tr>
<tr>
<td></td>
<td>Based on field tests as specified in Section 704.1(b)2.</td>
</tr>
<tr>
<td></td>
<td>Pozzolan</td>
</tr>
<tr>
<td></td>
<td>Based on the MTD Tests</td>
</tr>
</tbody>
</table>

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2. Specific Gravity of Aggregates. For fine and coarse aggregates, use the bulk specific gravity (saturated, surface-dry basis) listed in Bulletin 14.

If slag is used, test at the site to determine its loose-struck density (unit weight), solid volume per cubic meter (cubic yard), and bulk specific gravity factor (saturated surface-dry basis). Establish the concrete proportions on the basis of the bulk specific gravity factor determined by the test. Check the density (unit weight) of the slag daily to maintain the established solid-volume proportions.

3. Adjustment of Mass (Weight) of Free Water. Adjust the batch mass (weight) of the aggregate to compensate for the free water on the aggregate. Base this adjustment on tests of representative samples taken from aggregate stockpiles.


(c) Design Basis.

1. General. Compute and prepare concrete mix designs according to Bulletin 5. Base concrete mix designs on the materials to be used in the work.

Make trial mixtures for each class of concrete and mold and cure test specimens. If the requirements of Table A cannot be achieved, furnish other acceptable materials or make necessary changes in the mixing procedure to conform to the specified requirements.

At the start of construction, mix a full-sized batch using the type of mixer and the mixing procedure planned for the project. Use this batch to provide the basis for final adjustment of the accepted design.

2. Cement Factor. For all classes of concrete, use the minimum cement factor (cement or cement and pozzolan combined) specified in Table A, except as follows:

Portland cement may be replaced with pozzolan (flyash or ground granulated blast furnace slag) weighing as much as or more than the Portland cement replaced. If pozzolan is used, do not place flyash and ground granulated blast furnace slag in the same mix. The maximum limit of the cement factor may be waived if pozzolan is added to the mix provided the Portland cement portion does not exceed the maximum cement factor specified. If flyash is used, the Portland cement portion may be reduced by a maximum of 15%. If ground granulated blast furnace slag is used, the Portland cement portion may be reduced by a minimum of 25% to a maximum of 50%.

3. Air Content. Design cement concrete to have an air content of 6.0% in the plastic state. Obtain the air content through the addition of a solution of an air-entraining admixture as specified in Section 704.1(c). Use the quantity of air-entraining admixture necessary to maintain the plastic concrete air content, determined according to AASHTO T 152 (DO NOT APPLY AN AGGREGATE CORRECTION FACTOR) for stone and gravel and AASHTO T 196 for slag coarse aggregate, within a tolerance of ± 1.5% during the work. The plastic concrete air content includes entrapped and entrained air.

If the hardened concrete exhibits deficiencies or the Representative suspects the hardened concrete to have deficiencies, and, if directed, determine the percent of entrained air in the hardened concrete according to PTM No. 623. Voids 1 mm (40 mils) or more in size are considered entrapped air and voids less than 1 mm (40 mils) in size are considered entrained air. The entrained air in the hardened concrete must be between 3.5% and 7.5%, inclusive.

4. Mix Design Acceptance. Submit a copy of each completed mix design to the Representative before its use in the work. The Department reserves the right to review any design through plant production before its use in Department work at no additional cost to the Department. The concrete design submitted for review is required to comply with the specified concrete class requirements, supported by slump, air content, and compressive strength test data according to Bulletin 5.

The Department will accept concrete designs on the basis of the 7-day strength tests (Class high early strength (HES) may be accepted on the basis of 3-day strength tests); however, conduct 28-day tests to show the potential of the design mix. The Department may also accept designs based on the 28-day tests.

A higher class concrete may be used in place of an indicated lower class concrete if the higher class concrete conforms to all of the requirements of the indicated lower class, and if approved by the Department.
(d) Testing and Acceptance.

1. QC Plan. Prepare a QC Plan as specified in Section 106.03 and submit it for review before the start of the project and at least annually thereafter. Include in the QC Plan testing frequencies and action points to initiate corrective measures. Do not start work until the Department has reviewed the QC Plan. Furnish a copy of the QC Plan to be maintained in the Department's project field office.

1.a Field Operation QC Plan. Prepare a field operation QC Plan for the Representative's review, as outlined on Form CS-704, to evaluate concrete field operation. Submit the field operation QC Plan at the Pre-construction conference or at least 2 weeks before the first concrete pour. Describe the construction equipment, personnel, and methods necessary to construct and test concrete courses for all structural elements. Include testing frequencies and action points to initiate corrective measures. Do not establish action points at either the upper or lower specification limits.

2. Concrete Technician. Provide, and assign to the work, a concrete technician properly instructed and trained to develop the concrete design, to control the quality and gradation of aggregates used, to perform required concrete tests, and to control the operations and concrete deliveries so that the completed mixture conforms to the specifications at the point of placement.

The Department's concrete plant Inspector will not allow concrete that is considered unacceptable to be shipped to the project. The Inspector will not assume, by act or by word, any responsibility for batch control adjustments; calculations; or for setting of any dials, gauges, scales, or meters. Failure of the Inspector to reject unacceptable concrete will not relieve the Contractor's obligation to provide concrete conforming to the specifications.

2.a Concrete Field Testing Technician – Grade I. Provide, and assign to the work, an ACI/PENNDOT certified field testing technician during placement of material to perform the required acceptance testing. The technician must carry a valid ACI and PENNDOT certification card during placement of material.

3. Testing Facilities and Equipment. Provide sufficient thermometers, air meters (AASHTO T 196 and T 152) and slump cones (AASHTO T 119) for each separate project operation as needed. In the presence of the Inspector, calibrate all air meters a maximum 2 weeks before beginning concrete placement. Re-calibrate all air meters, in the presence of the Inspector, every 2 weeks during concrete placement. Have back-up equipment available to ensure that no tests are missed. Provide sufficient 150 mm x 300 mm (6-inch by 12-inch) cylinder molds and tight-fitting domed caps (PTM No. 611) for QC, acceptance, verification, and QA samples. Provide sufficient incidental equipment such as wheelbarrows, shovels, and scoops as needed.

Provide acceptable means to conduct compressive strength testing using a compression machine and capping device conforming to PTM No. 604. Provide a curing tank conforming to PTM No. 611. Provide curing boxes, or other acceptable equipment, conforming to PTM No. 611 and capable of maintaining the air temperature immediately adjacent to the field-cured cylinders in the range of 16 °C to 27 °C (60°F to 80°F) for the first 24 ± 2 hours. Provide sufficient high-low thermometers or other temperature recording devices to monitor the temperatures next to the test cylinders. If required, cap cylinders at the testing site under the Representative's supervision.

Maintain all equipment used for testing in an operable condition. Using an independent agency acceptable to the Department, calibrate scales, balances, and the compression machine at least once per year. Re-calibrate the compression machine whenever it is reloacted. Maintain accurate records of calibration. If the compression machine is out of tolerance or malfunctions, return it to working order within 24 hours or supply a back-up machine until the problem is corrected.

Provide the necessary facilities for inspection, including a plant office as specified in Section 714.5(a), with the exception of a minimum floor space of 11.1 m² (120 square feet).

4. QC Testing. Perform QC testing according to the reviewed QC Plan and as follows:

4.a QC Sampling and Testing of Plastic Concrete. Select an appropriate slump value that will provide a workable mix for the construction element. The Contractor's technician must have a copy of the Department reviewed QC Plan in their possession during testing and must be aware of the target slump for the structural element being placed. Do not exceed the following slump upper limits:

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Perform plastic concrete slump, air, and temperature tests on the first three consecutive trucks at the beginning of concrete placement operations or after a significant stoppage such as plant or equipment breakdown to determine if material control has been established. Material control is established when all test results of concrete slump, air, and temperature for three consecutive trucks are determined to be within the established action points. Obtain samples of fresh concrete according to PTM 601. Perform slump tests according to AASHTO T 119, air content tests according to AASHTO T 152 (DO NOT APPLY AN AGGREGATE CORRECTION FACTOR) or T 196 and temperature tests according to ASTM C 1064. Report test data to the concrete technician promptly in order to facilitate necessary changes. Continue testing consecutive trucks until material control is established. Once material control is established, the frequency of testing may be reduced to a minimum of one test per 40 m³ (50 cubic yards). Select concrete batches for sampling according to the reviewed QC Plan or as directed by the Inspector. Notify the Inspector when sampling and QC testing are to be performed. The Inspector will witness the sampling and QC testing. If a QC test fails to conform to the specified requirements or exceeds the upper or lower action points included in the reviewed QC Plan, increase the testing frequency to every truck until material control has been reestablished.

Maintain the cement concrete consistency within 40 mm (1 1/2 inches) of the selected target slump value (target range). If the upper slump limit is exceeded on any slump test, the Contractor’s technician shall reject the cement concrete. If any slump test result falls outside the target range and has not exceeded the upper limit, immediately perform the air content and temperature tests. If the air content and concrete temperature is within the specified limits, the Contractor may incorporate the material into the work provided a full set of quality control and acceptance cylinders are molded in addition to the cylinders made for the originally selected PTM No. 1 sample location, for compressive strength testing according to PTM No. 611 and PTM No. 604. If one or more truckloads of cement concrete exceeds the slump target range, make additional quality control and acceptance cylinders from each truck. Use the lowest compressive strength cylinders for acceptance of the lot.

Do not incorporate any concrete into the work that does not conform to the specified requirements.

4.b QC Compressive Strength Test Cylinders. From the same sample of concrete selected for acceptance testing as specified in Section 704.1(d)5, mold a sufficient number of concrete QC cylinders to be tested for 3-day or 7-day compressive strength, 28-day compressive strength, form removal strength, and loading strengths, as specified.

Field cure cylinders according to PTM No. 611, Section 11.2, for the specified curing period. After concrete curing is discontinued, QC cylinders may be relocated to a pre-approved, acceptable, secure area, to protect them from damage. Provide maintenance and security for the area at no additional cost to the Department. The secure area must be easily accessible for inspection at all times. Continue to provide the same field cure and protection from the elements on all surfaces of the cylinders as that provided for the in-place concrete the cylinders represent until the cylinders are tested for compressive strength. Remove cylinders from molds at the same time formwork is removed.

Perform QC testing for 3-day or 7-day compressive strength, 28-day compressive strength, and form removal and loading strengths according to PTM No. 611. Notify the Inspector when QC testing is to be performed. The Inspector will witness the QC testing.

Unless otherwise directed, use QC test results for 3-day or 7-day compressive strength and form removal and loading compressive strength to determine whether to place additional concrete in areas that will be impacted by the lot of concrete represented by the QC cylinders. Acceptable QC compressive strength test results do not relieve the Contractor’s responsibility for providing concrete conforming to the 28-day minimum mix design compressive strength acceptance requirements specified in Section 704.1(d)5.

4.0.1 3-Day or 7-Day QC Compressive Strength. If the 3-day (HES concrete only) or 7-day QC compressive strength test result is greater than or equal to the minimum mix design compressive strength requirement specified in Table A, the Contractor may discontinue the field cure on the lot of concrete represented by the QC cylinders unless otherwise directed.
If the 3-day (HES concrete only) or 7-day QC compressive strength test result is less than the minimum mix design compressive strength requirement specified in Table A, continue the field cure on the lot of concrete represented by the QC cylinders until the specified 28-day minimum mix design compressive strength is obtained, or for a maximum of 28 days.

4.b.2 28-Day QC Compressive Strength. If the 28-day QC compressive strength test result is greater than or equal to the 28-day minimum mix design compressive strength specified in Table A, acceptance of the concrete lot will be based on the compressive strength testing of acceptance cylinders as specified in Section 704.1(d)5.

If the 28-day QC compressive strength test result is less than the 28-day minimum mix design compressive strength specified in Table A, but greater than or equal to the 28-day structural design compressive strength specified in Table A, acceptance of the concrete lot will be based on the compressive strength testing of acceptance cylinders as specified in Section 704.1(d)5, and as follows:

- Perform an investigation of procedures for material sampling, testing, and concrete cylinder molding and curing, and evaluate the concrete mix design and specification compliance to determine possible causes for the QC test result not meeting the specified minimum mix design compressive strength.

- Implement corrective actions as required.

- Submit an investigation report to the District Executive within 10 working days for review and approval.

If the 28-day QC compressive strength test result is less than the 28-day structural design compressive strength specified in Table A, acceptance of the concrete lot will be based on compressive strength testing of cores obtained from the lot of concrete represented by the QC cylinders as specified in Section 110.10(d).

5. Acceptance Testing. Determine the lot size, or portion thereof for partial lots, for material acceptance according to Table B. Establish new lots daily for each class of concrete. Lots must be specific to a particular structural element, except for incidental concrete items. The Contractor may use a lot combining structural elements if allowed in writing before concrete placement and if the following conditions are met:

- The total volume is 80 m³ (100 cubic yards) or less.

- The combined structural elements are constructed using the same mix design concrete.

- The combined structural elements are cured using identical curing methods and conditions.

Cylinders (and cores when necessary) for this lot will represent all of the combined elements.

| TABLE B |
|------------------|------------------|
| Lot Size for Concrete Acceptance |

<table>
<thead>
<tr>
<th>Construction Area</th>
<th>Lot Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Concrete</td>
<td>80 m³ (100 cu. yd.)</td>
</tr>
<tr>
<td>Pavement Concrete</td>
<td>380 m³ (500 cu. yd.)</td>
</tr>
<tr>
<td>Pavement Patching Concrete</td>
<td>150 m³ (200 cu. yd.)</td>
</tr>
<tr>
<td>Incidental Concrete</td>
<td>80 m³ (100 cu. yd.)</td>
</tr>
<tr>
<td>Pavement Concrete RPS</td>
<td>Section 506.3(v)</td>
</tr>
</tbody>
</table>

The Representative will select sample locations for acceptance testing according to PTM No. 1 (n=1). Perform sampling and testing for acceptance in the presence of the Representative. Obtain samples of fresh concrete at the point of placement according to PTM No. 601. Perform concrete temperature tests. Perform air content tests according to AASHTO T 196 or T 152. Reject all concrete not conforming to the specification requirements at the point of placement.
If the results of plastic concrete testing conform to the specification requirements, mold a sufficient number of acceptance cylinders according to PTM No. 611 from the same sample of concrete taken for slump, air content, and temperature determination. Standard cure acceptance cylinders according to PTM No. 611, Section 11.1, for 28 days at an acceptable location. Conduct 28-day compressive strength testing of two acceptance cylinders according to PTM No. 604. If for any reason two testable acceptance cylinders are not available for compressive strength testing, obtain two cores of the representative concrete within 3 working days as directed, and at no additional cost to the Department. Conduct 28-day compressive strength testing of the cores according to PTM No. 604.

The Department will accept the lot of concrete when the 28-day acceptance cylinder compressive strength test result is greater than or equal to the 28-day minimum mix design compressive strength specified in Table A and when the 28-day QC compressive strength requirements specified in Section 704.1(d)4.b have been met.

If the 28-day acceptance cylinder compressive strength test result is less than the 28-day minimum mix design compressive strength specified in Table A, acceptance of the concrete lot will be based on the procedures specified in Section 110.10.

6. Verification Testing. The Representative will perform verification testing on the initial acceptance sample for each type of concrete specified in Table B and a minimum of one verification test for every ten acceptance samples thereafter. Verification testing will consist of testing for temperature, air content, and compressive strength. Verification tests will be performed on concrete from the same sample used for acceptance testing.

The Representative will obtain the temperature of the sample concurrently with the acceptance sample. Immediately after an acceptable air content test result for acceptance is obtained, the Representative will test the sample for air content according to AASHTO T 196 or T 152 using the same air meter.

The Representative will mold two verification cylinders according to PTM No. 611. Standard cure the verification cylinders along with the acceptance cylinders according to PTM No. 611, Section 11.1, for 28 days. Conduct 28-day compressive strength testing of the verification cylinders according to PTM No. 604 in the presence of the Representative. Conduct the testing at the same time the acceptance cylinders are tested and using the same equipment.

Verification test results will be compared to the associated acceptance test results and will not be used to determine acceptance of the lot. If there is a difference in test results of more than 3 °C (5°F) for temperature, 1.0% for air content, or 3.5 MPa (500 pounds per square inch) for compressive strength, the Representative will immediately review the testing procedures, equipment, and personnel used in the acceptance testing and implement corrective measures to ensure the tests are performed within the prescribed tolerances. The Representative will record the acceptance test results, the verification test results and applicable corrective measures in the Concrete Inspector's Daily Record Book, Form CS-472.

7. QA Testing. The BOCM QA personnel will obtain QA samples as part of the operation review process according to the QA Manual, Publication 25.

QA personnel will select concrete to be sampled. Obtain samples of fresh concrete at the point of placement according to PTM No. 601. Perform concrete temperature tests adjacent to those conducted by QA personnel. Perform air content tests according to AASHTO T 196 or T 152 with the air meter used for acceptance testing and the backup air meter. Immediately report all test results to the QA personnel. Reject all concrete not conforming to the specification requirements at the point of placement.

QA personnel will immediately perform an independent assurance evaluation of the temperature and air content test results. If the difference in test results is more than 3 °C (5°F) for temperature or 1.0% for air content, the Representative will immediately review the testing procedures, equipment, and personnel used in the acceptance testing and implement corrective measures to ensure the tests are performed within the prescribed tolerances.

Mold five QA cylinders from the selected sample according to PTM No. 611. Field cure the QA cylinders according to PTM No. 611, Section 11.2, for the specified curing period for the structural element the cylinders represent. After curing of the in-place concrete is discontinued, QA cylinders may be relocated to a pre-approved, acceptable, secure area, to protect them from damage. Provide maintenance and security for the area at no additional cost to the Department. The secure area must be easily accessible for inspection at all times. Continue to provide the same field cure and protection from the elements on all surfaces of the cylinders as that provided for the in-place concrete the cylinders represent until the cylinders are tested for 28-day compressive strength.

Conduct 28-day compressive strength testing on two QA cylinders according to PTM No. 604 using the same equipment used for acceptance and verification testing.
The Representative will forward the remaining three QA cylinders to the MTD for 28-day compressive strength testing according to PTM No. 604 and hardened air content testing according to PTM No. 623. Furnish packaging material and package cylinders under the direction and supervision of the Representative. Place the cylinders in individual containers cushioned with suitable material to prevent damage during shipment. The total mass (weight) of each container, cylinder and cushioning material must not exceed 22 kg (50 pounds).

QA personnel will perform an independent assurance evaluation of the 28-day compressive strength test results. If the difference between the test results of the cylinders tested at the project site and the cylinders tested at the MTD is more than 3.5 MPa (500 pounds per square inch), the Representative will immediately review the testing procedures, equipment, and personnel used in the acceptance testing and implement corrective measures to ensure the tests are performed within the prescribed tolerances.

(c) Measurement of Material.

1. **Cement.** AASHTO M 157 and as follows:
   For plant and truck mixed concrete, measure by mass (weight). The Contractor may measure the mass (weight) of the cement separately in an enclosed compartment in the aggregate hopper. The Contractor may measure the mass (weight) of the cement and discharge it simultaneously with the aggregates, except as specified in Section 106.05(c).
   For volumetric mixed concrete, measure by volume.

2. **Aggregates.** AASHTO M 157 and as follows:
   For plant or truck mixed concrete, measure by mass (weight) unless otherwise allowed. Base measurements on the material mass-volume (weight-volume) relationship, as specified in Section 704.1(b).
   For volumetric mixed concrete, measure by volume.

3. **Water.** AASHTO M 157 except as follows:
   Use water-measuring systems capable of discharging the total quantity of measured water into the plant or truck mixer drum in a time not greater than one-fourth of the specified mixing time. For truck mixed concrete, do not add water from the truck water system. Add water only from the plant water measuring system.

4. **Admixtures.** Incorporate the air-entraining admixture solution into the batch with the mixing water using a suitable visual measuring device. If another type of admixture is used with an air-entraining admixture, add it in solution to another portion of the mix water, as directed, by an additional suitable visual measuring device, except high range water reducing admixtures will be added according to the manufacturer's recommendations.
   Equip the measuring device with interlocks to prevent discharging during the charge cycle and to prevent charging during the discharging cycle. Provide a means to calibrate the measuring device to within ±3%.
   Dispense the air-entraining admixture solution into the batch from a bulk supply tank. For paving, and if directed, provide a bulk supply tank containing sufficient solution for the entire day's concreting operations.
   On the dispensing system, provide device(s) capable of detecting and indicating the presence or absence of admixture flow. Agitate admixtures, as required, to insure consistency of the solution.

5. **Pozzolan.** If the use of Pozzolan is allowed by the specification, add separately and measure cumulatively as specified in Section 704.1(e).

(f) **Mixing Conditions.**

1. **During Cool and Cold Weather.** If concrete is to be placed at air temperatures below 5 °C (40°F), or if the local weather bureau forecasts air temperatures to descend to 5 °C (40°F) or lower at any time during the 24-hour period following concrete placement, use an acceptable method to ensure that the aggregate is free of frozen lumps and at a temperature of not less than 5 °C (40°F) or more than 40 °C (100°F) at the time of charging into the mixer. Heat mixing water, if necessary, but do not exceed 65 °C (150°F). Do not allow water with a temperature above 32 °C (90°F) to come in contact with the cement until the cement has been mixed with the aggregates.

2. **During Hot Weather.** In hot weather, cool the aggregates and the mixing water as necessary to maintain the concrete temperature within the range of 10 °C to 32 °C (50°F to 90°F) at the time of placement. For bridge deck concrete placement, maintain the concrete temperature between 10 °C and 27 °C (50°F and 80°F) at the time of placement.
3. Retarding Admixtures. The Contractor may use retarding admixtures, or may be directed to use retarding admixtures, when any of the following conditions are anticipated:

- rapid drying of the concrete as a result of low humidity
- high winds
- high air temperatures

Introduce the retarder into the concrete mixture as specified in Section 704.1(e)(4). Adjust the proportions of the design as necessary but do not use the retarder to replace any portion of the specified volume of cement.

Use a retarder that is available in sufficient quantities to provide the required degree of retardation under the prevailing weather conditions at the time of concrete placement.

(g) Mix Designs Using Potentially Reactive Aggregate.

1. Definition of Terms.

1.a Alkalis. Oxides of sodium and potassium generally derived from Portland cement, but may also be available to concrete from other sources such as: admixtures, de-icing salts, and, in rare instances, aggregates. Alkalis are calculated according to AASHTO M 85.

1.b Pozzolan. A siliceous or siliceous and aluminous material that possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. The term “pozzolan,” includes flyash, ground granulated blast-furnace slag, and silica fume.

1.c Alkali- Aggregate Reaction. A chemical reaction in concrete between alkalis and certain constituents of some aggregates. The products of this reaction, under certain conditions, may cause deleterious expansion within the concrete.

1.d Alkali-Silica Reaction. An alkali-aggregate reaction involving certain siliceous aggregates and some calcareous aggregates containing certain forms of silica.\(^{(1)}\)

Note (1)—Siliceous substances that are known to react with alkalis are as follows: opal; chalcedony as a constituent of chert in carbonate rock or sand and gravel particles; tridymite and cristobalite, which are high temperature forms of silica found in andesite or rhyolite; acid glasses containing more than 65% silica; or intermediate glasses containing between 55% and 65% silica. Other siliceous substances that are potentially reactive with alkalis are strained quartz as a constituent of granite or granite gneiss and clay minerals as a constituent of graywackes, argillites, phyllites, and siltstones.

2. Aggregate Evaluation. The MTD will test aggregates according to AASHTO T 303. Aggregates that develop expansion greater than 0.10% after 14 days in solution (16 days - age of bar) are considered potentially reactive with cement alkalis. The Contractor may test aggregates according to ASTM C 227 to confirm potential reactivity of fine or coarse aggregate, but not to classify an aggregate as “nonreactive.” If ASTM C 227 mortar bars are made with cement having an alkali content greater than 0.80%, aggregates are considered to be “reactive” if expansion is greater than 0.05% at 3 months or greater than 0.10% at 6 months.

Use aggregates that are deemed potentially reactive only with cements or cement-pozzolan combinations as specified in Section 704.1(g)(2). If one or both of the aggregates (coarse or fine) used in a mix is reactive, mitigation is required as specified in Section 704.1(g)(3). This requirement applies to all concrete used in paving or permanent structures on Department projects, including latex modified overlays and precast and prestress concrete products.

3. Cement/Cement-Pozzolan Requirements. For use with aggregate deemed potentially reactive as specified in Section 704.1(g)(2), provide Portland cement, blended hydraulic cement, or Portland cement-pozzolan combinations conforming to the requirements of Section 704.1(b) and the following:
3.a Portland Cement. Conforming to the optional chemical requirement in AASHTO M 85 for a maximum alkali content of 0.60%.

3.b Blended Hydraulic Cement. Type IS or IP, ASTM C 595. From a manufacturer listed in Bulletin 15.

3.c Portland Cement-Pozzolan Combination. Furnish a combination of Portland cement with an alkali content no greater than 1.40% and flyash, ground granulated blast furnace slag, or silica fume tested and qualified by the MTD as follows:

- Flyash—Furnish flyash that conforms to the optional chemical requirement in AASHTO M 295 for a maximum alkali content of 1.5% and that produces a 50% minimum reduction in mortar expansion when tested by the MTD according to ASTM C 441. Use a quantity of flyash equal to a minimum of 15%, by mass, of the total cementitious material. If flyash is added to reduce alkali-silica reactivity, use a quantity of flyash between 15.0% and 25.0%, by mass, of the total cementitious material. If aggregate expansion, when tested according to AASHTO TP 14, is greater than 0.40%, use a quantity of flyash equal to a minimum of 20%, by mass, of the total cementitious material. Flyash may replace no more than 15.0% of the Portland cement; the remaining flyash is to replace the fine aggregate.

- Ground Granulated Blast Furnace Slag—Furnish slag producing a 50% minimum reduction in mortar expansion when tested by the MTD according to ASTM C 441. Use a quantity of slag between 25.0% and 50.0%, by mass, of the total cementitious material. If aggregate expansion, when tested according to AASHTO TP 14, is greater than 0.40%, use a quantity of ground granulated blast furnace slag equal to a minimum of 40%, by mass, of the total cementitious material.

- Silica Fume—Use a quantity of silica fume between 5% and 10%, by mass, of the total cementitious material. Use of silica fume will be allowed on an experimental basis only, until sufficient experience is gained.

The Department may waive flyash or ground granulated blast furnace slag requirements if the Contractor presents test results from an independent laboratory showing that a lesser amount of pozzolan will mitigate ASR expansion to below 0.10% when tested according to AASHTO TP 14.

4. Admixture Requirements. Furnish accelerators or other chemical admixtures as specified in Section 711.3.

5. Exceptions. If a service record of nonreactivity can be documented, the Department may exempt aggregates classified as potentially reactive, as specified in Section 704.1(g)2, from the cement/cement-pozzolan requirements of Section 704.1(g)3. The service record must include a minimum of 10 structures, each over 10 years of age, which have been exposed to moisture in service and contain high alkali content cement (more than 0.60%).

Include the following documentation in the service record:

- A report on the visual examination of each structure for cracking and expansion at joints.

- Petrographic analysis of cores according to ASTM C 856 to determine the presence or absence of alkali-silica gel formations and associated microcracking.

- Determination of the aggregate classification according to ASTM C 295.

(h) Extra Cement Concrete. If 25% extra cement is required as specified in Section 1004.3(k)3.a, the extra cement may be replaced with other cementitious material in the same proportions as established in the mix design or Section 704.1(c). Up to 50% of the water dose for the extra cementitious material, based on the water cement ratio of the mix being utilized, may be added. Add additional admixtures as required.
(a) Batching Plant. Proportion cement, aggregates, water, and admixtures in a plant conforming to the requirements of AASHTO M 157 for batching plants.

Install a moisture meter to accurately and continuously indicate the variability of the fine aggregate moisture content. If approved, automatic moisture compensating probes for fine and coarse aggregate may be used to control the amount of batched water. Calibrate moisture probes according to the reviewed QC Plan.

Provide scales with graduation increments no greater than 1/1000 of the total scale capacity to measure the mass (weight) of aggregates or cement. Increments of less than 2 kg (5 pounds) are not required. Provide scales with capacities approximately equal to the hopper capacity or the central mixer capacity under normal proportioning conditions.

Provide a minimum of ten 20 kg masses (50-pound weights) at the plant for checking the scale's accuracy. Store the masses (weights) in a manner to maintain their mass-calibration (weight-calibration) accuracy.

Check the accuracy of the bin scales according to PTM No. 410.

Provide the plant with the following equipment for developing the concrete design and to control the quality of aggregates used and the concrete produced:

<table>
<thead>
<tr>
<th>Number of Each</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sample splitter for fine aggregate having an even number of equal width chutes that discharge alternately to each side of the splitter. A minimum of 12 total chutes is required. The minimum width of the individual chutes is to be at least 50% larger than the largest particles in the sample and the maximum width of the individual chutes is to be 20 mm (3/4 inch). Include two receptacles to hold the samples following splitting. Splitter design must allow samples to flow smoothly without restriction or loss of material.</td>
</tr>
<tr>
<td>1</td>
<td>Sample splitter for course aggregate having an even number of equal width chutes that discharge alternately to each side of the splitter. A minimum of eight total chutes is required. The minimum width of the individual chutes is to be at least 50% larger than the largest particles in the sample. Include two receptacles to hold the samples following splitting. Splitter design must allow samples to flow smoothly without restriction or loss of material.</td>
</tr>
<tr>
<td>1</td>
<td>Adjustable sample splitter for both course aggregate and fine aggregate having an even number of equal width chutes that discharge alternately to each side of the splitter. A minimum of 12 total chutes is required. For course aggregate, the minimum width of the individual chutes is to be at least 50% larger than the largest particles in the sample. For fine aggregate, the minimum width of the individual chutes is to be at least 50% larger than the largest particles in the sample and the maximum width of the individual chutes is to be 20 mm (3/4 inch). Include two receptacles to hold the samples following splitting. Splitter design must allow samples to flow smoothly without restriction or loss of material.</td>
</tr>
<tr>
<td>1</td>
<td>Mechanical Sieve Shaker (with timer)—PTM No. 616</td>
</tr>
<tr>
<td>1 Set Each</td>
<td>Standard Sieves for Fine and Coarse Aggregate—AASHTO M92</td>
</tr>
<tr>
<td>1</td>
<td>Oven capable of maintaining a uniform temperature of 110 °C ± 5 °C (230°F ± 9F)—PTM No. 616</td>
</tr>
<tr>
<td>1</td>
<td>Calculating machine</td>
</tr>
<tr>
<td>1</td>
<td>Cylindrical Metal Measure (25 L (1 cubic foot))—AASHTO T 19 and T 121, C 136</td>
</tr>
<tr>
<td>1</td>
<td>Air Meter, acceptable type—AASHTO T 196 and T 152</td>
</tr>
<tr>
<td>1</td>
<td>Slump Cone—AASHTO T 119</td>
</tr>
<tr>
<td>1</td>
<td>Cylinder Compression Machine—PTM No. 604(1)</td>
</tr>
<tr>
<td>1</td>
<td>Curing Tank—PTM No. 611(2)</td>
</tr>
<tr>
<td>1</td>
<td>Capping Device—PTM No. 604(1)</td>
</tr>
<tr>
<td>1</td>
<td>Balance conforming to the requirements of AASHTO M 231 for the class of general purpose scale required, for the principle sample mass (weight) of the sample being tested—PTM No. 616.</td>
</tr>
<tr>
<td>1</td>
<td>Platform scale conforming to the requirements of AASHTO M 231 for the class of general purpose scale required, for the principle sample mass (weight) of the sample being tested—PTM No. 616, and AASHTO T 121 and C 136</td>
</tr>
<tr>
<td>Sufficient</td>
<td>150 mm x 300 mm (6-inch by 12-inch) Cylinder Molds—PTM No. 611</td>
</tr>
</tbody>
</table>

Necessary Incidental Equipment
Note (1)—Equipment requirements may be waived provided that arrangements for testing have been made at the producer's central facility or at a commercial testing laboratory that participates in the AASHTO Accreditation Program in the area of Concrete Testing. Commercial testing laboratories are to conform to ASTM E 329 for Concrete Inspection and Testing except for the equipment listed above. Note (2)—Equipment requirements may be waived provided that, after 24 hours (±2 hours), specimens made for checking the strength of trial mixes are properly transported to a central facility or commercial testing laboratory for curing according to PTM No. 611.

Provide the plant with proper laboratory equipment, space, and utilities as specified in Section 609.

(b) Mixers and Agitators. AASHTO M 157. If directed, test air content of individual mixed concrete samples taken approximately at the beginning, the midpoint, and the end of the batch. If the air content varies by more than 1.5%, discontinue the use of the mixer or agitator until the condition is corrected. If mixing in truck mixers at the plant, use inclined-axis, revolving-drum type mixers or horizontal-axis, revolving-drum high-discharge type mixers.

(c) Mixing and Delivery. Maintain concrete temperature after mixing between 10 °C and 32 °C (50°F and 90°F) for general concrete, and between 10 °C and 27 °C (50°F and 80°F) for bridge deck concrete. Do not ship concrete exceeding these temperature ranges. Maintain adequate two-way communications between the concrete plant and the work site to provide both uniformity and control of the concrete mixture.

For each truck, furnish a plant delivery slip signed at the plant by the technician or other designated person. Include the following information on the delivery slip:

- Contract number, complete state project number or purchase order number.
- The concrete plant supplier code.
- Method of concrete mixing (i.e., central or truck).
- Class of concrete, JMF number, and trial mix number (i.e., trial #1, 2, etc.).
- Number of cubic meters (cubic yards).
- Time of completion of mixing.
- Truck number.
- Number of mixing revolutions, if applicable.
- Total amount of batch water used in each truck (in kilograms (pounds)).
- The total mass (weight) in kilograms (pounds) of the total cementitious materials.
- The types of additives used in each truck (i.e., water reducer, AEA, retarder, etc.).

Submit the plant delivery slip and batcher-mixer slip (as specified in AASHTO M 157) to the Inspector-in-Charge. Do not use any concrete until it is approved for use by the Inspector-in-Charge.

Comply with the requirements of AASHTO M 157, except as follows:

- If mixing in a plant, mix for not less than 50 seconds or more than 90 seconds for normal strength concrete, and not less than 70 seconds for HES concrete.
If mixing in the truck drum at the plant, mix for not less than 70 or more than 125 truck-drum revolutions, at a mixing speed of not less than 6 truck-drum rpm nor more than 18 truck-drum rpm. Upon completion of the designated number of mixing revolutions, reduce the truck-drum speed to not less than 2 rpm or more than 6 rpm. Do not exceed a total of 300 truck-drum revolutions.

Deliver the mixed concrete to the work site and discharge within 1 1/2 hours after completion of mixing. Agitate, but do not mix the concrete en-route to the work site.

In hot weather, under conditions contributing to quick concrete stiffening, or if the concrete temperature is 27 °C (80°F) or above, do not allow the time between completion of mixing and discharge to exceed 1 hour. As an alternative to maintaining the concrete temperature below 27 °C (80°F), use an approved, set retarding admixture to extend the initial set time and enable the mix to remain workable for the full 1 1/2 hours of allowable mixing time.

If using mixer or agitator trucks, agitate concrete for at least 20 revolutions immediately before placement. Do not use concrete that has exceeded 45 minutes without agitation.

If wash water is used to clean the truck drum, completely discharge this wash water before the introduction of the succeeding batch.

Do not allow concrete to come in contact with aluminum unless the aluminum is coated with an acceptable coating (delivery of concrete in an aluminum truck bed is allowed).

704.3 VOLUMETRIC MIXED CEMENT CONCRETE—

(a) General. Use a plant inspected and listed in Bulletin 42. Make trial mixtures with a calibrated mixing plant. Provide plant equipment, facilities, and a concrete technician(s) as specified in Section 704.1. Do not begin production until the mixing plant and all equipment and facilities necessary for performing the work have been inspected and accepted. Mixing plants may be truck mounted.

(b) Usage. Volumetric mixing plants may be used to produce concrete for endwalls, inlets, manholes, end anchors, sign posts, and similar miscellaneous structures requiring small quantities of concrete. If allowed by the District Executive in writing, volumetric mixing plants may also be used for pavement patching and structures. Approved plants may produce concrete for precast items.

(c) Equipment. Prominently attach a permanent metal plate(s) to the plant plainly marking the gross volume in terms of mixed concrete, the operating speed, the plant auger mixing angle, and the plant mass-calibrated (weight-calibrated) cement constant in terms of a revolution counter or other output indicator, all as rated by the manufacturer.

1. Compartments. Provide separate compartments to carry the ingredients. Cover the aggregate bins and prevent contamination and intermixing of the fine and coarse aggregates during loading and transporting. Keep the cement bins free of moisture and contamination. Provide suitable means to carry water and additives and to incorporate the additives with the mixing water in the mix.

2. Feed System. Provide a feeder system mounted under the compartment bins to deliver the ingredients to the mixing unit. Equip each bin with an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from the bin compartment. Do not charge aggregate bins more than 4 hours before mixing.

Set the cement bin feeding mechanism to discharge a given volumetric mass (weight) equivalent of cement at a continuous and uniform rate during the concrete mixing operation. Coordinate the coarse and fine aggregate feeding mechanisms with the cement feeding mechanisms to deliver the required proportions.

3. Mixing Unit. Provide an auger-type mixer incorporated in the plant's discharge chute, or another suitable mixing mechanism that produces concrete of uniform consistency and discharges the mix without segregation. Examine the mixing screw daily and clean as necessary to prevent the build-up of mortar or concrete.

Initial Edition
4. **Dials and Measuring Devices.** Equip the plant with accurate revolution-counter indicators that allow the volumetric mass (weight) equivalent of cement, fine aggregate, and coarse aggregate discharged to be read during the concrete-mixing operation. Equip the counter with a ticket print-out to record this quantity.

Equip the plant with a water flow meter or gauge to indicate the discharge rate of water (by volume) entering the mix and a water meter to register the total amount of water discharged during the mixing operation. Also, equip the plant with suitable gauges for checking the rate of flow of any additive entering the mix. Coordinate the water and additive flow meters with the cement and aggregate feeding mechanisms. Equip the flow meters with scales appropriate for the type and amount of material being measured. Mount a tachometer indicating the drive shaft speed on the plant.

Place gauges, dials, and other devices that indicate the accuracy of concrete proportioning and mixing in full view so that the operator can accurately read or readjust them while concrete is being produced. Provide the operator convenient access to all controls.

**(d) Calibration.** Use a unit constructed to allow convenient calibration of the gate openings and meters. Conduct a calibration once a year in the presence of Department representatives. Make satisfactory arrangements with the Department at least 1 week in advance of calibration. During the yearly calibration, calibrate the cement meter according to the manufacturer's recommendation and check the aggregate gate settings against the calibration data for the plant. Maintain the calibration data in the plant and submit the data to the District.

After performing the yearly calibration and before starting work, provide a mix design for review and acceptance and run a yield test to verify the design. Adjustments to correct for yield may require recalibration or a design change.

Conduct a recalibration if there is a change in the source of fine or coarse aggregate or cement. Conduct additional calibrations if directed. Provide each plant with data on the accepted recalibration.

If hydraulic drive units are used, perform the following additional calibration procedure: At the beginning of the actual batching operation, check the cement meter against the count and time used for the cement during the calibration of the individual materials. If a discrepancy occurs, adjust the belt speed of the unit so that the actual cement meter count does not vary from the calibrated meter count by more than two counts per 60 seconds.

**(e) Mixing and Delivery.** Proportion, measure, and batch cement and aggregates by a volumetric mass (weight) equivalent method. The measuring and batching mechanism is required to produce the specified proportions of each ingredient within the following tolerances:

- Cement, Mass (Weight) 0 to +4%
- Fine Aggregate, Mass (Weight) ±2%
- Coarse Aggregate, Mass (Weight) ±2%
- Admixtures, Mass (Weight) or Volume ±3%
- Water, Mass (Weight) or Volume ±2%

The tolerances are based on a volume/mass (volume/weight) relationship established during the calibration of the measuring devices.

During mixing, maintain the drive shaft speed, as indicated by the tachometer, within 50 rpm of the operating speed. Set the auger mixer angle in the range determined by the manufacturer. Do not exceed 1/2 hour between the continuous placing of succeeding batches.

1. **Testing.** Conduct slump and air content tests according to PTM No. 601. Conduct the unit mass (weight) test, the concrete uniformity test, and the output meter calibration test according to AASHTO T 121, C 136, AASHTO M 157, and PTM No. 626. If there is any doubt in the uniformity of the concrete, perform further testing as directed.

2. **Recording.** Provide a batcher mixer slip with each load of ingredients. Include the following information on the batcher mixer slip:

- Aggregate gradation and moisture information.
• Class of concrete and the corresponding dial setting, as determined in the design.
• Water discharge rate limitations.

Use a separate batcher mixer slip for each class of concrete. Deliver the batcher mixer slip to the Inspector-in-Charge at the work site. Do not use the concrete until the Inspector-in-Charge verifies the data noted on the slip complies with the specifications.