Division 800 Material Details

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SECTION 800 MATERIAL DETAILS

Where any Specification or test has an AASHTO or ASTM number followed by the word "Modified", it shall mean as modified by the Delaware Division of Highways Materials Manual in effect on the date of advertisement for bids.

Whenever any material is required for the work, the Contractor warrants and agrees that such material has been tested and shall be suitable, compatible, and useable in the work and for the Project.

QUALITY CONTROL.

The Contractor shall perform all tests required by the Contract and such other tests that the Contractor shall determine are necessary to verify the quality and suitability of all materials used in the Project. For all required tests, the Contractor shall submit test results or samples as requested by the Department, and shall obtain necessary approvals prior to use on the Project. The approval of any material or source of supply of such material shall not relieve the Contractor of the responsibility to supply a material which is compatible with all other materials to be used on the Project, as such materials are normally used, without defect and for the anticipated life of the Project. The Contractor warrants that all materials used in the work or Project shall be made, manufactured, processed, or produced by suitable means, that all materials have been tested with satisfactory results, and that all materials may be compatibly incorporated into the work or Project without defect. The Contractor further warrants with respect to all materials used on the Project that:

(a) The ownership and title to such materials shall be clear when incorporated and used in the work or Project and the Contractor shall have the right to lawfully transfer ownership or title of all materials used in the work to the Department. All materials used in the work shall be free from any security interest, lien, or other encumbrance. It shall be the sole responsibility of the Contractor to resolve any security interest, lien, or other encumbrance placed on materials used in the work or Project.

(b) All materials used in the work shall be merchantable, shall be fit for the ordinary purpose for which such material is used, and shall be fit and useable for the particular purpose for which such material is intended to be used in the work or Project, as such terms are used in the Delaware Uniform Commercial Code.

Any material which is not merchantable, not fit for the ordinary purpose for which such material is used, or which is not satisfactory for use for the particular purpose required in the work or Project shall be considered as defective. It shall be the Contractor’s responsibility to determine that the material meets these criteria, and the Contractor warrants that any and all necessary tests or

evaluations of such material have been made to determine material compatibility and suitability for use in the work or Project.

SECTION 801 PORTLAND CEMENT AND BLENDED HYDRAULICCEMENTS
This material consists of Portland cement and blended hydraulic cements conforming to the following requirements:

(a) Portland Cement. Portland cement shall conform to the requirements of AASHTO M 85, except "Fineness" shall be measured by the air permeability test, and a maximum specific surface of 420 m^2/kg will be permitted. Unless otherwise specified, cement shall be either Type I or Type II.

(b) Blended Hydraulic Cements. Type IP or Type I(PM) or Type IS or Type I(SM) cement, conforming to the requirements of AASHTO M 240, will be permitted as an alternate to Type I or Type II cement in all classes of concrete, subject to the following conditions:

Type IP or I(PM): (fly ash)	1. The pozzolan that is blended with the Portland cement shall conform to Section 822. 2. The pozzolan constituent, fly ash, shall be a minimum 20% by weight of the Portland cement and fly ash total weight. 3. The concrete mixture incorporating Type IP or Type I(PM) cement shall conform to the requirements applicable to its use.
Type IP or I(PM): (silica fume)	1. The silica fume that is blended with the Portland cement shall conform to the requirements of AASHTO M 307. 2. The silica fume shall be a minimum of 7% and a maximum of 10% by weight of the Portland cement and silica fume total weight. 3. The concrete mixture incorporating Type IP or Type I(PM) cement shall conform to the requirements applicable to its use.
Type IS or I(SM): (ground granulated blast furnace slag)	1. The ground granulated blast furnace slag that is blended with the Portland cement shall conform to the requirements of ASTM C 989, Grade 100 or Grade 120. 2. The slag shall be a minimum of 35% and a maximum of 50% by weight of the Portland cement and slag total weight. 3. The concrete mixture incorporating Type IS or Type I(SM) cement shall conform to the requirements applicable to its use.

Reserved bins shall be sampled by the Department or its authorized representative, and all tests shall be completed before the cement is accepted. Only pretested and accepted cement shall be used.

Orders for cement shall be placed with the manufacturer at least ten days before the first shipment is made.

Railroad cars and truck transports used to transport bulk cement shall be of a design that can be properly and completely unloaded. They shall be loaded and sealed by authorized representatives of the Department, and the seals will be removed by authorized representatives of the Department.

All cement used in any one Contract item shall be of a single brand, from a single mill, unless otherwise authorized in writing by the Engineer.

Upon approval from the Engineer, the preceding requirements for reserved bins and sealed shipments may be waived if the cement manufacturer qualifies for inclusion in the program of certification.

A manufacturer may become qualified by establishing a history of satisfactory quality control of cement produced as evidenced by results of tests performed by the Department and the manufacturer's testing laboratory, and upon approval of production and storage facilities by the Engineer. The manufacturer shall conduct sufficient tests to ensure that adequate quality control is maintained and that cement furnished conforms to the specification requirements. The manufacturer shall maintain a record of all tests for review by the Engineer. Samples for tests of any cement may be taken at any time necessary as determined by the Engineer.

Cement manufacturers will be furnished specific details on requirements; however, the Engineer reserves the right to modify the program for all participants, as required, or to impose additional or special requirements on manufacturers as considered necessary to maintain control.

Any manufacturer who fails to cooperate in a satisfactory manner or cannot furnish cement within the established limits of acceptance will be required to cease participation in the certification program. In such cases, pretesting, reserved bins, and sealed shipments will be required.

The temperature of the Portland cement at the time of delivery to the paver or mixer shall not exceed 66 C.

SECTION 802 NORMAL FINISHING HYDRATED LIME
Finishing hydrated lime shall conform to the requirements of ASTM C 206, Type N.

SECTION 803 WATER FOR MIXING PORTLAND CEMENTCONCRETE
Water used in mixing, curing, or other designated applications shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product. Water will be tested in accordance with AASHTO T 26. Water known to be of potable quality may be used without testing. Where the source of water is relatively shallow, the intake shall be enclosed to exclude silt, mud, grass, or other foreign materials.

The water shall conform to the following requirements:

- Hydrogen ion concentrations - 4.5 to 8.5 pH
- Total solids - 5000 ppm
- Total chlorides - 300 ppm
- Soluble SO_4 - 500 ppm
- Total alkalis as Na_2 plus $0.658K_2O$ - 500 ppm
- Organic content - 2000 ppm
- Compressive strength, minimum - 90% of control
- Time of setting, Vicat - ±60 minutes from control and within the specifications of AASHTO M 85

SECTION 804 FINE AGGREGATE

Fine aggregate for use in Portland cement concrete shall conform to the requirements of AASHTO M 6, except the grading shall be:

Sieve Size	Percent Passing
9.5 mm	100
4.75 mm	95-100
300 µm	5-30
150 µm	1-10
75 µm	0-4

Fineness Modulus: 2.3 to 3.1

The organic impurities requirement will be waived for fine aggregate specified for uses other than in Portland cement concrete.

SECTION 805 COARSE AGGREGATE
Coarse aggregate shall conform to the requirements of AASHTO M 80 except no gravel, crushed gravel, or crushed concrete shall be used. Also, the requirements of Section 2.1, percentage of wear, Los Angeles Test, shall not be more than 45%. If air-cooled, blast-furnace slag is used, it shall weigh not less than 1.12 metric tons per cubic meter when tested according to AASHTO T 19/T 19M.

SECTION 806 CALCIUM CHLORIDE
Calcium chloride shall be Type S, Grade 1, and Class A conforming to AASHTO M 144.

SECTION 807 MATERIAL FOR RESEALING JOINTS AND CRACKS
This material shall consist of a blend of asphalt cement and 18 ± 2% by weight of a mixture of recycled, reclaimed crumb rubber.

MATERIALS.

(a) Asphalt. The asphalt used shall have a maximum penetration of 150 as determined by AASHTO T 49.

(b) Crumb Rubber. The recycled, reclaimed crumb rubber used in the mixture:

(1) shall be produced from a process that crushes, tears, grinds, or abrades the used rubber at or above ordinary room temperature, and produces rubber particles with a very ragged, sponge-like surface. Grinding rubber at cryogenic temperatures is prohibited.

(2) shall contain recycled, vulcanized crumb rubber or reclaimed, devulcanized rubber, or both.

(3) shall contain a minimum of 25% natural rubber by weight of the total rubber portion of the mixture.

(4) shall contain no more than a trace of fabric.

(5) shall be free of wire and other contaminating materials, except that up to 4% calcium carbonate or talc may be included to prevent the rubber particles from sticking together.

(6) shall have no rubber particles greater than 6 mm in length.

(7) shall conform to the following gradation requirements:

Sieve Size	Percent Passing
2.00 mm	100
1.18 mm	90-100
600 µm	40-80
180 µm	0-10

MIXTURE REQUIREMENTS.

(a) Pour Point. The pour point shall be at least 11 C lower than the safe heating temperature, which is the maximum temperature to which the material may be heated without exceeding the permitted flow.

(b) Cone Penetration. Penetration shall not exceed 90 at 25 C, 150 g, five seconds.

(c) Flow. The flow shall not exceed 5 mm at 60 C.

(d) Bond. The sealant shall be tested at -18 C for five complete cycles. The development at any time during the test procedure of a crack, separation, or other opening that at any point is over 6 mm deep in the sealant or between the sealant and mortar block, shall constitute failure of the test specimen. The depth of the crack, separation, or opening shall be measured perpendicular to the side of the sealant showing the defect. At least two test specimens in a group of three representing a given sample of sealant shall meet this requirement for bond.

(e) Packaging. The pre-mixed sealant shall be packaged in units weighing no more than 13.6 kg with a maximum of two 13.6 kg units per shipping container. The plastic film used in packaging the units shall readily melt at normal application temperatures when placed in the installation equipment. Bonding or sticking of the packaged units to each other or to the shipping container or packaging causing unnecessary contamination of the sealant with staples and fasteners, as determined by the Engineer, shall be sufficient cause for rejection of the material.

SECTION 808 JOINT SEALS AND SEALANTS

808.01 Description. This material shall consist of seals and sealants for Portland cement concrete joints.

808.02 Portland Cement Concrete Pavement. Materials for sealing joints in Portland cement concrete pavement shall be as follows:

(a) Hot-Poured Joint Sealant. Hot-poured joint sealant shall conform to AASHTO M 301 or AASHTO M 282.

(b) Preformed Elastomeric Compression Joint Seals. Preformed elastomeric compression joint seals shall conform to the requirements of AASHTO M 220. The lubricant used to install the preformed elastic joint sealant shall be a one-component, polychloroprene compound containing only soluble phenolic resins blended together with anti-oxidants and acid acceptors in an aromatic hydrocarbon solvent mixture and shall have the following physical properties:

(1) Average net weight per liter: 0.94 kg +5%.

(2) Solids content by weight: 22 to 28%.

(3) Viscosity shall be such that the lubricant performs suitably with the installation equipment.

(4) The lubricant shall remain fluid from -15 to 49 C.

(5) Film strength (ASTM D 412): 16 MPa minimum tensile strength, 750% minimum elongation before breaking.

(6) The lubricant shall be stored at a temperature between 10 and 27 C. Any lubricant not used within 270 days of its manufacture shall be unacceptable.

(c) Low-Modulus Silicone Rubber Joint Sealant. Low-modulus silicone rubber joint sealant to be used on the Project shall be submitted for approval by the Engineer.

808.03 Continuously Reinforced Portland Cement Concrete Pavement. Materials for sealing joints in continuously reinforced Portland cement concrete pavement shall conform to AASHTO M 282.

808.04 Portland Cement Concrete Structures. Materials for sealing joints in Portland cement concrete structures shall be as follows:

(a) Preformed Elastomeric Compression Joint Seals. Preformed elastomeric compression joint seals shall be composed of open cell polychloroprene and conform to AASHTO M 220.

(b) Rubber Joint Sealant. Rubber joint sealant shall be a multipart chemically curing polyurethane or polysulfide sealant which meets or exceeds the curing requirements of Federal Specification TT-S-00227E(3), Type I (Flow Type) and Type II (Nonsag Type), Class A, (Compounds resistant to 50% total joint movement). The color shall be gray to match the concrete.

(c) Bituminous Joint Sealant. Bituminous joint sealants may be hot applied conforming to AASHTO M 173 or equivalent, or cold applied elastomeric sealant conforming to Federal Specification SS-S-200E(2), Type H.

(d) Preformed Expansion Joint Material. Unless otherwise specified on the Plans or in the Special Provisions, preformed expansion joint material for Portland cement concrete structures shall conform to the requirements of AASHTO M 153, Type III, self-expanding cork.

808.05 Concrete Slope Paving. Materials for sealing joints in concrete slope paving shall be as follows:

(a) Hot-Poured Joint Sealant. Hot-poured joint sealant shall conform to the requirements of Subsection 808.02 (a).

(b) Preformed Expansion Joint Material. Preformed expansion joint material shall conform to the requirements of AASHTO M 153, Type I.

808.06 Portland Cement Concrete Curb and Integral Curb and Gutter. Materials for Portland cement concrete curb and integral curb and gutter shall be preformed expansion joint material of 13 mm nominal thickness and shall conform to the requirements of AASHTO M 153, Type II or Type III. Preformed expansion joint material of other types may be used for Portland cement concrete curb and integral curb and gutter provided they are approved by the Engineer.

SECTION 809 EMULSIFIED ASPHALT FOR STABILIZATION

Asphalt for soil stabilization shall be a high-float, medium setting emulsion conforming to the requirements of AASHTO M 140, Grade HFMS-2s.

SECTION 810 ASPHALT CEMENT

Asphalt cement shall be prepared by the refining of crude petroleum using methods conforming to industry standards. The asphalt cement shall conform to the requirements of AASHTO M 226, Table 2.
When tested by ignition, the inorganic insoluble residue content of the asphalt cement shall not exceed 0.25% by weight.

SECTION 811 EMULSIFIED ASPHALT

Emulsified asphalt shall conform to the requirements of AASHTO M 140 for anionic emulsions or AASHTO M 208 for cationic emulsions.

SECTION 812 PORTLAND CEMENT CONCRETE

812.01 Description. This material consists of Portland cement, fine aggregate, coarse aggregate, water, and admixtures mixed in the specified proportions for the various classes of concrete.

812.02 Materials.

a. Portland Cement. Portland cement shall conform to the requirements of Section 801.
b. Water. Water shall conform to the requirements of Section 803.
c. Fine Aggregate. Fine aggregate shall conform to the requirements of Section 804.
d. Coarse Aggregate. Coarse aggregate shall conform to the requirements of Section 805.
e. Gradation. Coarse aggregate shall conform to the requirements of Section 813, No. 57.
f. Air Entrainment Agent. An air-entrainment agent conforming to the requirements of AASHTO M 154 shall be introduced into the mixer by an approved automatic dispenser.
g. Chemical Admixtures. Chemical admixtures shall conform to the requirements of AASHTO M 194 for the seven types as follows:

Type A - Water Reducing

Type B - Retarding

Type C - Accelerating

Type D - Water Reducing and Retarding

Type E - Water Reducing and Accelerating

Type F - Water Reducing, High Range

Type G - Water Reducing, High Range and Retarding

For concrete Classes A and D, calcium chloride or other admixtures containing detrimental amounts of chloride salts shall not be used in the concrete. The chloride content of bridge deck concrete shall not exceed 0.10% by weight of cement.

h. Fly Ash. Fly ash may be used as an additive in concrete in order to promote workability and plasticity.

i. Fly ash shall conform to the requirements of Section 822.

Curing Materials. Curing materials shall be as follows:

1. Liquid Membrane Compounds. The material shall conform to the requirements of AASHTO M 148, for Type 2, Class A or B white-pigmented liquid curing compound. Acceptance for continued use will be based upon satisfactory field performance.
2. Polyethylene Sheeting. Polyethylene sheeting shall conform to the requirements of AASHTO M 171.
3. Waterproof Paper. Waterproof paper shall conform to the requirements of AASHTO M 171. The name of the manufacturer shall be marked or imprinted clearly on the paper for proper identification.
4. Water Cure. The water shall conform to Section 803.

j.

Samples. The source of fine aggregate, coarse aggregate, cement, additives, and admixtures shall be submitted to the Department’s Materials and Research Section prior to any concreting operations in sufficient time so mix design verification may be performed.

Coarse and fine aggregates for use in Portland cement concrete mixtures will also be evaluated for potential alkali-silica reactivity using ASTM C 1260 Mortar Bar Method and may be evaluated by ASTM C 295 Petrographic Examination. Furthermore, if available, field service records of the aggregate in concrete will be evaluated. Aggregate sources determined to be reactive with cement alkali will be permitted in concrete mixtures using either low alkali (0.6% or less) cement or Type IP cement. Use of high alkali cement will be permitted with these aggregates provided one of the following options is used to modify the cement matrix:

1. Substitution of 35 to 50% of the Portland cement with ground granulated blast furnace slag conforming to ASTM C 989, Grade 100 or Grade 120;
2. Substitution of 7 to 10% of Portland cement with silica fume conforming to the requirements of AASHTO M 307; or
3. A minimum 20% substitution of Portland cement with fly ash conforming to Section 822; or
4. Use of a lithium-based admixture at a dosage rate based upon the sodium oxide equivalent (ASTM C 150) of the Portland cement component of the concrete. The lithium dosage shall be 1 kg of lithium hydroxide monohydrate per 1 kg of sodium oxide equivalent of the Portland cement, with a minimum dosage of 0.60% by weight of the Portland cement. Other approved lithium compound may be used but shall be dosed in equivalents of lithium hydroxide monohydrate. All lithium salts shall be certified as non-hazardous based on the heavy metal content. Mixing shall be as per manufacturers recommendation.

812.03 Handling and Storing Materials.

(a) Aggregate. Aggregate stockpiles shall be placed on hard, clean, and well drained surfaces of acceptable materials such as Portland cement concrete, or hot-mix bituminous concrete and be of sufficient thickness to withstand the loadings of construction equipment. If, at any time, the surfaces break up so as to possibly contaminate the aggregate stockpiles, the concrete operation shall be immediately stopped until such time that the surfaces may be repaired. Prior to stockpiling aggregates, the Department's Materials and Research Section shall be contacted for approval of the base surface material. Coarse and fine aggregate shall be kept separate during transportation, handling, and storage until batched. If necessary, suitable partitions shall be constructed to prevent mixing of the fine and coarse aggregates.

Aggregate stockpiles shall be constructed in horizontal layers not exceeding 1.5 m in depth in order to avoid segregation. Segregated material shall be removed from stockpiles and disposed of or remixed to the satisfaction of the Engineer.

Fine aggregate shall be stockpiled at the batch plant a minimum of 24 hours prior to batching or longer if required until surplus water has disappeared and the material has a uniform free moisture content. Wet fine aggregate shall not be placed where it becomes mixed with material being used for batching. Suitable partitions shall be constructed to prevent mixing of the wet fine aggregate and the fine aggregate being used for batching. Batching direct from the washing plant will not be permitted.

Haul roads to the concrete plants shall be of such base as to prevent any deleterious materials from being incorporated into the stockpiles and into the concrete itself. If at any time, deleterious materials are found in the stockpiles, the concrete operation shall be immediately stopped.

(b) Cement. Reclaimed cement or cement that shows evidence of hydration, such as lumps or cakes, shall not be used. All cement shall be stored in suitable weatherproof structures that protect the cement from dampness.

(c) Fly Ash. Fly ash that shows evidence of hydration, such as lumps or cakes, shall not be used. All fly ash shall be stored in suitable weatherproof structures that protect the fly ash from dampness and other contamination.

(d) Admixtures. Admixtures shall be stored and handled in such a manner that contamination or deterioration is prevented. Admixtures shall not be used unless thoroughly agitated to the satisfaction of the Engineer or the Engineer's agent. Partially frozen admixtures shall not be used. When the amount of admixture required to give the specified results deviates appreciably from the manufacturer's recommended dosage, the use of this material shall be discontinued unless conditions justify a change in the dosage.

812.04 Composition of Mix. The Engineer will determine the proportions of materials to be used that will produce a workable, dense, concrete conforming to the requirements of Table 812-A for the class of concrete specified. ACI design methods will be used as a guide in determining aggregate proportion.
Exceptions to these requirements are as follows:

(a) The producers of prestressed, precast reinforced concrete items complying with these specifications shall determine mix design proportions for concrete proposed for use. The mix design proportions shall be submitted to the Department's Materials and Research Section for approval prior to use.

(b) The Contractor shall submit to the Department's Materials and Research Section sources of all materials and mix design proposed for production of Class D concrete prior to any work. Such submission shall be made in sufficient time for preparation of laboratory or field trial mixes and 28-day strength determinations. Field trial mixes shall be made at the concrete supply location and shall consist of 2.3 m^3 (minimum) batches of concrete. All materials, equipment, and labor required to produce the field trial mixes shall be supplied by the Contractor.

(c) For slip-form paving, concrete shall be Class B with the following restrictions:

1. The composition of the mix shall be such to produce concrete with a slump of 25 to 65 mm when tested at the time of placement in accordance with AASHTO T 119.
2. Concrete shall be "central mixed".
3. Transportation of the concrete shall be only by approved trucks that demonstrate satisfactory loading at the central mix plant and unloading at the Project site.
4. The design strength shall be 24 MPa compressive strength at 28 days.

The Engineer will determine the proportions of materials to be used that will produce a workable, dense concrete conforming to the requirements of this Section, Class B as modified above. Should proportions determined by the Engineer vary due to changes in the material originally submitted, no additional compensation will be made. To improve mix workability and consistency, the Contractor may substitute at its expense up to 50% of the Type I Portland cement in the Class B mix with ground granulated blast-furnace slag meeting the requirements of ASTM C 989, Grade 120. The ground slag-Portland cement blend will be approved by the Engineer prior to use and may be adjusted at the discretion of the Engineer as field conditions warrant. ACI design methods will be used as a guide in determining aggregate proportions that will produce a workable, plastic concrete having the specified design strength. Should the proportions determined by the Engineer vary due to changes in the materials originally submitted by the Contractor, no additional compensation will be made.

(d) Producers wishing to use fly ash as an additive or a partial replacement for Portland cement, shall determine the mix design proportions for the concrete proposed for use. Fly ash use as partial replacement for Portland cement in mixtures containing Type I (PM) or IP cement is prohibited.

For mixes containing fly ash, laboratory testing, which is the responsibility of the producer, shall be performed documenting the design's conformance to all requirements and noting that air entrainment is of special concern. Identification of the sources of materials, the mix design proportions, and the results of the laboratory testing of the proposed mix design shall be submitted to the Department's Materials and Research Section for approval prior to use of the design. The producer shall supply appropriate samples of the design materials. The Contractor shall allow for up to five weeks for evaluation by the Department's Materials and Research Section.

When a mix containing fly ash is used, the Contractor shall perform extra sampling and testing of the concrete mixture, as deemed necessary by the Engineer, in order to detect possible harmful variations in the quality of the mix before forms and supports are removed and loading applied.

Samples shall be cured in the same ambient temperature as the placed material, in order to more accurately represent the strength of the placed material. Delays due to slow strength gain from a fly ash mix shall not be considered for an extension of time allowed for the completion of the Project.

The requirements of each class of concrete specified are included in the following table:

Table 812-A

Class of Concrete	A	B	C	D
Design Compressive Strength, f'_c at 28 days, MPa (Note 1)	30	20	15	30
Design Cement Content, minimum, sacks/m^3 (kg/m^3) (Note 2)	9.8 (418)	7.8 (334)	5.9 (251)	9.8 (418)
Design Water to Cement Ratio, W/C = [Weight Water/Weight Cement] (Note 3)	0.40	0.45	0.60	0.40
Required Air Content, % (Note 4)	4 - 7	4 - 7	4 - 7	4 - 7
Required Slump, mm (Note 5)	50 - 100	50 - 100	50 - 100	50 - 100
Required Admixtures (AASHTO M 194) (Notes 6 and 7)	A, D, F, G	A, D, E, F, G	A, D, E, F, G	A, D, F, G

Notes 8, 9, 10, and 11 refer to all classes of concrete.

Note 1: In addition to meeting the specified f'_c design compressive strength, Class D concrete shall achieve f_{cr}, which is the required average compressive strength for f'_c. The required average compressive strength, f_{cr}, shall be the minimum compressive strength required for mix approval and shall be in excess of the 30 MPa design compressive strength, f'_c. The degree of excess compressive strength necessary shall depend on expected uniformity of concrete production as per criteria established in the ACI Standard 214. Upon establishment of standard deviation data, the following ACI 318M required average compressive strength values shall govern acceptance of the trial mix proportions:

f_{cr} = 33.8 MPa if standard deviation is less than 2.1 MPa

= 34.8 MPa if standard deviation is within 2.1 to 2.8 MPa

= 35.8 MPa if standard deviation is within 2.8 to 3.5 MPa

= 37.2 MPa if standard deviation is within 3.5 to 4.1 MPa

If the standard deviation exceeds 4.1 MPa, the concrete production facility shall be unacceptable for Class D concrete production. A probability of not more than one in ten tests falling below the specified compressive strength will be used to compute the required compressive strength. The average 28-day compressive strength of two companion molded 152 by 305 mm or 102 by 203 mm cylinders prepared from the same batch of concrete shall be considered a "test."

Note 2: For Class D concrete, the average compressive strength and coefficient of variations shall be computed upon the availability of 28-day compressive strength data comprising a minimum of 15 tests from the concrete production plant. Should these determinations indicate an excessive margin of safety, the concrete mix may be modified to produce a lower average compressive strength as approved by the Department's Materials and Research Section, but in no case shall the cement content be reduced to less than 9.2 sacks/m^3 (390 kg/m^3). Should determination indicate a lower average compressive strength or a higher coefficient of variation than anticipated, the quality of the concrete will be evaluated, and mix proportions adjusted as required; however, cement content may not exceed 10.5 sacks/m^3 (446 kg/m^3).

Note 3: Water to cement ratio may be expected to vary ±5% depending on varying atmospheric and other related conditions.

Note 4: Water reducing admixtures shall be required in all concrete. The quantity and AASHTO type or combination of AASHTO types of admixtures shall be determined by the Contractor depending on the ambient temperature, concrete temperature, time of day, thickness of concrete, concrete mix proportions, etc. and the amount and proper type of superplasticizer and/or retarder necessary. The Contractor shall be responsible for the quality of the concrete placed in any weather or atmospheric condition. Failure to achieve a satisfactory product shall be corrected as directed by the Engineer at the Contractor's expense.

Note 5: If a Type F or G admixture is used, the maximum slump shall be 200 mm.

Note 6: The total chloride content of concrete mixtures, when tested in accordance with the requirements of AASHTO T 260, shall not exceed the following:

a. Prestressed concrete: 0.06%.

b. Conventionally reinforced concrete in a moist environment and exposed to chloride deicing salts or marine conditions: 0.10%.

c. Conventionally reinforced concrete in a moist environment or areas with potential moisture condensation but not exposed to chloride: 0.15%.

Limits are expressed as a percentage of the total weight of the Portland cement and fly ash in the concrete mix.

Note 7: In calculating the "Water to Cement Ratio" for mixes containing cementitious materials other than Portland cement, the weight of the Portland cement plus the weight of the cementitious material represents

the weight of cement.
Note 8: Consistency of the mix shall be determined by AASHTO T 119. Air content shall be determined by AASHTO T 152, Modified, or AASHTO T 196. Making and curing concrete test specimens shall be in accordance with AASHTO T 23 and it shall be the responsibility of the Contractor to ensure that the seven- and 28-day cylinders are cured for the first 24 to 48 hours in an environment to provide satisfactory moisture and temperature control as per AASHTO T 23.
Note 9: Concrete shall be placed only if the surface evaporation rate, as affected by ambient air temperature, concrete temperature, relative humidity, and wind velocity is less than or equal to 0.73 kg/m^2 per hour. The Contractor shall determine and document the evaporation rate at the site of the concrete placement, subject to verification by the Engineer. The chart contained in "Plastic Cracking of Concrete" by Delmar Bloem for the National Ready Mixed Concrete Association and published in ACI 305R-89 shall be used to determine the loss of surface moisture for the concrete. The chart may be obtained from the Department's Materials and Research Section.
Note 10: Fixed-form concrete shall meet all requirements of Class B except the 28-day compressive strength shall be 24 MPa.
Note 11: The Contractor has the right to modify their mix design for any class of concrete. The modified mix design will be reviewed by the Engineer prior to approval. The approval will be based upon tests performed by the Contractor and approved by the Engineer.

812.05 Mix Temperature Limitations. The Contractor shall be responsible for the quality of the concrete placed in any weather or atmospheric conditions.

The concrete shall have a temperature of 21 ± 11 C at the time of placement unless prior permission has been granted to exceed these tolerances; however, concrete for bridge decks shall not exceed 30 C.
In hot weather, the water or aggregate, or both shall be cooled as necessary to maintain the concrete temperature within the specified limits. When the temperature of the plastic concrete reaches 29 C at the mixing plant, particular attention shall be given to the sprinkling and wetting of the foundation and forms, the maintenance of the coarse aggregate stockpile in a saturated surface-dry condition through use of stockpile sprinklers, the placing and finishing operations, and the prompt starting of the curing operation. When the temperature of the plastic concrete reaches 32 C at the mixing plant, immediate steps shall be taken to cool the mixing water or aggregate, or both in order to maintain a plastic concrete temperature of 32 C or less. If such actions are not successful in reducing the concrete temperature, mixing operations shall cease.

812.06 Delivery Restrictions. The time elapsing between the introduction of water to the mix and the placing of the concrete shall be 30 minutes maximum for non-agitating type haul equipment or 60 minutes maximum for agitating type haul equipment. For Class B slip-form concrete, the time elapsing between the introduction of water to the mix and the placing of the concrete shall be 45 minutes maximum for non-agitating type haul equipment of 60 minutes maximum for agitating type haul equipment. Any concrete that has not been placed within these time limits will be rejected for use in the work. These delivery time restrictions may be extended by the Department's Materials and Research Section when an approved water reducing and set retarding admixture is used provided the concrete remains workable for the use intended.

The interval between placing successive loads shall be as directed, however, in no case shall the interval exceed 20 minutes in order that concrete in place shall not have become partially hardened prior to placing successive batches, unless approved in writing by the Engineer.

The method and time of delivery shall be controlled by plant slips signed by the Engineer and issued to the truck driver. The slips shall indicate the name and location of the plant, the size and proportions of the batch, type of admixture used, and the time the mixer is charged. Upon arrival on the job, each slip shall be delivered to the Engineer and will be completed to show the time the concrete is discharged from the truck.

The Contractor shall notify the Department's Project and plant inspectors at least 24 hours prior to the placement of any concrete so that inspection services can be provided.

812.07 Plant and Equipment Requirements

(a) General Requirements. All concrete batch plants offered for Department approval shall be equipped for automatic batching and proportioning of all cement, aggregates, and water and for visual observation of automatic insertion of admixtures.

All currently approved concrete batch plants shall retain approved status, unless the approval is rescinded for failure to comply with the batch plant requirements specified herein and the requirements of the current version of AASHTO M 157 for concrete batch plants. In the case where approval is rescinded, reinstatement shall be on the basis of the requirements for automation as specified for approval of plants in the previous paragraph.

The batch plant and all equipment and facilities necessary for performing the work will be inspected and approved by the Engineer as to design, capacity, and condition well in advance of the start of construction. The batch plant shall conform to the requirements of AASHTO M 157, except as modified herein.

A laboratory of 14 m^2 minimum shall be provided for the exclusive use of the Engineer at all Portland cement concrete facilities. The producer shall furnish all heat, lights, air conditioning, telephone, electric, bottled drinking water, tables, desk, chairs, file cabinets, and all testing equipment or devices to control the production and quality of the concrete. Approved sanitary facilities shall be furnished and maintained.

Inspection of all equipment incidental to the production and transportation of concrete will be performed by the Engineer either on an annual basis or prior to commencement of work on the Contract. If at any time during construction, the equipment is not performing satisfactorily, it shall be repaired prior to re-use. If the concrete plant is to be used for night pours, ample lighting shall be provided to satisfactorily illuminate the aggregate stockpiles along with all areas where the Engineer or the Engineer's representative will be performing testing.

(1) Bins and Hopper. The bins shall be in good condition and have adequate separate compartments for fine aggregates and for each required size of coarse aggregate. Each compartment shall be designed to discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision.

The hopper and its appurtenances shall be constructed to eliminate the retention of varying tare materials on any of its parts and operated to ensure a rapid and complete discharge without shaking and jarring the scales.

(2) Weighing Equipment. The scales for weighing material shall be either of the horizontal beam or the springless dial type and shall be the product of an established manufacturer. They shall be of rugged design, constructed to support the hopper or hoppers and with minimum adjustments consistent with the accuracy required. Scale levers shall be of such design, construction, and material to permit frequent handling without damage.

Pivots shall be of steel, sufficiently hardened and tempered to ensure minimum wear under a heavy volume of weighing. They shall be accurately set in substantial mountings to ensure a permanent spacing of

the knife edges under all conditions of loading and to prevent them from being loosened by the vibration incident to usage.

Multiple weigh beams on scales to be used for weighing more than one kind of material shall have as many beams as there are different kinds of material to be weighed on the scales. All weigh beams shall be horizontal. The trig loop shall allow movement of the weigh beam above and below the horizontal position for proper operations of the telltale dial as hereinafter specified. The free end of the weigh beam shall be equipped with a suitable device for indicating clearly and accurately the horizontal position of the weigh beam.

Provisions such as a telltale dial shall be made for indicating to the scale operator that the required load in the weighing hopper is being approached. Such a device shall indicate at least the last 90 kg of load.

Poises shall be constructed so they cannot be easily removed from the beam and shall be equipped with a device to hold them firmly in place. Poises and weigh beam shall be made of noncorrosive material and shall be of sufficient hardness to prevent excessive wear.

Graduated dials shall be provided with suitable markers placed outside the glass cover and set closely in front of the dial for use in determining the position of the dial indicator for predetermined loads in the weigh hopper. Provisions shall be made to prevent dirt from collecting in and around the dial mechanism. Means shall be provided for obtaining and maintaining proper alignment between the dial and the part of the scale that transmits the load to the dial. The dial face shall be of a material that is not affected by moisture. The value of the graduations of scales weighing 2250 kg or less shall not be greater than 2.25 kg. The value of the graduations of scales used in weighing over 2250 kg shall not be greater than 0.1% of the rated capacity of the scales.

Scales shall be so constructed that they are maintained within a maximum tolerance of 0.5% of the net load in the hopper.

Clearance shall be provided between the scale parts and the hopper or bin structure to prevent displacement of or friction between the scales due to vibration or any other cause.

Each scale installation shall be provided with at least eleven standard 20 kg, one standard 5 kg, and two standard 1 kg (ten standard 50 lb.) weights, available for use at the plant at all times for checking scale accuracy. These weights shall be checked for true weight at the Engineer’s discretion.

The weights shall be made of high quality cast iron and shall be cast and finished in such a manner that foreign material will not adhere to the surface.

All batching controls shall be positioned so as to allow the operator full view of all scales and admixture dispensers.

The weighing equipment, including dials, weigh beams, bins, and operating levers shall be so arranged that the Department’s representatives have a clear and unobstructed view of the weighing operations at all times.

All working parts of the scales, particular knife edges, shall be protected to prevent any material, except airborne material, from falling upon or

against them. Suitable windbreaks shall be constructed, when necessary, to prevent variation of the scale mechanism by winds. All working parts of the scales shall be readily accessible for inspection and cleaning.

The individual aggregates, as weighed, shall be within 1% of the required weight, and the total weight of the aggregates shall be within 1% of the required total weight.

All scales shall be checked regularly as determined by the Engineer.

(3) Water Supply. Water shall be measured by volume or by weight. The device for the measurement of water shall be readily adjustable and shall under all operating conditions be accurate within 1% of the quantity of water required for each batch. The device shall be so arranged that the measurements are not affected by variable pressure in the supply line. Measuring tanks shall be equipped with outside taps and valves to provide for calibration unless other means are provided.

(4) Admixture Dispensers. Equipment for dispensing air entrainment or other admixtures shall be of approved design and calibrated prior to being approved. Recalibrations will be made as required by the Engineer.

The flasks and discharge hoses shall be transparent and so arranged that the Engineer has a clear and unobstructed view of the dispensing operation at all times.

(5) Automatic Batch Selector. The automatic batch plant shall be controlled by means of an approved automatic batch selector set to deliver accurately, and in proper sequence, the designated weight of cement and aggregates, and the weight or volume of water and admixtures required for the concrete mixture. The batch selector controls shall be locked or sealed during the operation, and no changes in selector controls or weight settings shall be made except in the presence of the inspector.

For safety reasons, pozzolans, if used, shall be weighed and added after the Portland cement has been weighed and added.

Provisions may be included to vary the size of the batch without affecting the basic proportions of the concrete mix being produced.

(6) Interlocks. All batching equipment in automatic plants shall be interlocked so that a new weighing cycle cannot be started until the weigh hopper is empty, the scales are in balance, and the discharge gates and the supply valves included in the system are closed.

(7) Mixer. The mixer shall be of approved design and shall be operated as recommended by the manufacturer. The pickup and throw-over blades shall be replaced or repaired when any part or section is worn 25 mm or more below the original height of the manufacturer’s design. The mixer shall be kept free from accumulations of hardened concrete inside the mixing drum.

The mixer shall be equipped with an approved timing device or, in the case of truck mix concrete, the use of revolution counters or other methods acceptable to the Engineer.

(b) Specific Requirements.

(1) Central Mixed Portland Cement Concrete.

a. Description. Central mixed Portland cement concrete shall consist of Portland cement concrete manufactured from previously approved materials, proportioned and mixed in a central mixing plant and transported to the Project in approved vehicles.

b. Mixing. Concrete shall be mixed in a batch mixer, as previously described, for a period of not less than 60 seconds for mixers with capacities of 7.65 m^3 or less. For mixers of greater capacity, the Engineer shall determine the mixing time, based on mixing efficiency. The Engineer reserves the right to adjust the mixing time to any extent necessary to obtain concrete of desired uniformity. Mixing time starts when all the materials, excluding water, are in the mixer. The batch shall be so charged into the drum that some water shall enter in advance of the aggregates and shall continue to flow for a period of not less than five nor more than ten seconds after all aggregates are in the drum. The entire contents shall be removed from the drum before succeeding batches are introduced. Unless otherwise permitted, the maximum batch size shall be the manufacturer's rated capacity for that mixer.

c. Moisture Meter. An automatic electrical moisture meter, equipped with adjustable controls, shall be installed at the Engineer's discretion to measure accurately and continuously the moisture content of the fine aggregate. The meter probe shall be kept cleaned and maintained at all times.

(2) Truck Mixed Portland Cement Concrete.

a. Description. Truck mixed Portland cement concrete shall be proportioned and dry batched using previously approved materials, with water added for mixing at the plant. Delivery shall be made in approved mixer trucks. Batching and mixing shall be under the supervision of the Engineer.

b. Mixer Truck. Truck mix units shall be designed for both mixing and agitation and shall be equipped with a watertight drum suitably mounted and powered, and fitted with properly designed blades. The mixing unit shall be capable of combining the aggregates into a thoroughly mixed and uniform mass of concrete and of transporting and discharging the concrete without segregation. The pickup and throw-over blades shall be replaced or repaired when any part or section is worn 25 mm or more below the original height of the manufacturer's design. The inside of the mixer drum shall be kept free from accumulations of hardened concrete.

Water supply equipment for truck mixers shall include a water storage compartment of sufficient capacity to hold

mixing water for concrete and wash water required to wash the mixer after depositing concrete in all cases. The equipment shall include an external water gauge calibrated to 5 L intervals and suitable cut-off valves to regulate the quantity of water delivered to the mixer. These cut-off valves must be maintained in first class working order. A truck mixer with a leaky valve will not be permitted on the Project.

The size of the batch that may be charged into the truck mix unit shall not exceed the manufacturer's rated capacity for the unit when operated as a mixer. If the manufacturer's rating is not stamped on each mixing unit, the rated capacity will be determined by the Engineer. Any mixer which shows a variation in consistency of concrete of more than 25 mm slump during the discharge of any single batch shall not be permitted to operate until repaired so as to produce concrete of the required uniformity.

c. Mixing. Each batch of concrete mixed in truck units shall be mixed not less than 70 nor more than 100 revolutions of the mixer and at the rate of rotation specified by the manufacturer as the mixing speed. Additional mixing of more than 100 revolutions, if required, shall be done at the rate of rotation specified by the manufacturer as agitation speed. Immediately prior to the addition of water, the drum shall be operated at mixing speed. The mixing period shall be started at the time the cement and water come in contact and there shall be a minimum of 30 revolutions. This operation will be supervised by the Engineer who will indicate on the delivery ticket the time the mix started, the time that the drum is empty, and the time that the entire batch is in place.

d. Inspection Platform. An inspection platform of suitable dimensions and with reasonable access and safety shall be provided at the plant for the viewing of truck mix concrete by the inspector.

(c) Transportation.

(1) Vehicle. The vehicle in which Portland cement concrete is transported shall be an approved type of agitator truck, equipped with a watertight revolving drum, suitably mounted and powered, and fitted with properly designed blades capable of transporting and discharging the concrete without excessive abrasion and segregation.

The agitator unit shall be so constructed as to ensure rapid delivery of the concrete without loss of ingredients and to effect complete discharge of each batch.

Low slump Portland cement concrete as used in slip-form paving may also be transported in open trucks designed for that purpose and may be either agitator or non-agitator types, provided that no segregation or loss of water detrimental to the mix, as determined by the Engineer, occurs during transportation and that the concrete delivered to the Project meets the requirements specified.

Both agitator and non-agitator truck types shall be capable of having the dump end elevated so that the concrete will be discharged at sufficient height to permit chuting without segregation.

(2) Size of Batch. The size of the batch that may be transported in these units shall not exceed the manufacturer's rating for the unit when used as an agitator. If the manufacturer's rating is not stamped on each mixing unit, the rated capacity will be determined by the Engineer.

(d) Portland Cement Concrete Made by Volumetric Batching and Continuous Mixing.

(1) Description. Portland cement concrete made by the volumetric batching and continuous mixing method is permissible for concrete used in bridge deck overlays using latex concrete, headwalls, steps, utility encasement, manhole and inlet bottoms, gutters, curbs, headers, barrier curbs, sidewalks, island pavements, fence and sign post footings, signals, light standard and meter cabinet footings, junction boxes, and small pour items as approved by the Engineer.

(2) Mixing on the Project in a Continuous Mixing Type Truck Mixer. Continuous mix concrete shall consist of materials accurately proportioned by volumetric measurement from bins on the truck mixer and shall be hydrated and mixed on the truck mixer at the site of the work.

The concrete shall be mixed in an approved type mixing unit that is part of the truck carrying the dry ingredients. The mixing unit shall be an auger type mixer incorporated in the truck's discharge chute or other suitable mixing mechanism approved by the Engineer, shall produce concrete of uniform consistency, and shall discharge the mix without segregation.

A metal plate or plates shall be attached to the truck mixer in a prominent place. The plate or plates shall be plainly marked with the gross volume of the unit in terms of mixed concrete, operating speed, and the cement constant of the mixer in terms of a revolution count required to deliver 42.6 kg of cement, all as rated by the manufacturer.

The truck mixer shall be equipped with a cement bin of sufficient capacity to store and supply the quantity of dry cement required to produce the maximum volume concrete capacity of the truck mixer as rated by the manufacturer. The cement bin shall be free of moisture and contamination at all times.

The truck mixer shall be equipped with aggregate bins of sufficient capacity to store separately the quantities of fine and coarse aggregates required to produce the maximum volume concrete capacity of the truck mixer as rated by the manufacturer. Suitable means, approved by the Engineer, shall be provided to prevent contamination or intermixing of the fine and coarse aggregates during loading and transporting. Aggregate bins shall be covered when there exists a possibility of moisture entering the bins.

The truck mixer shall be equipped with water tanks of sufficient capacity to store the quantity of water required to produce the maximum volume concrete capacity of the truck mixer as rated by the manufacturer and at the slump specified for each concrete section.

If concrete additives are to be used in the mix, suitable means, approved by the Engineer, shall be provided for storing the additives on the truck and incorporating them in the mix. Suitable means shall also be provided on the truck mixer to permit the Engineer to check the rate of flow of the additive into the mix.

The truck mixer shall include a feeder unit mounted under the compartment bins to deliver the ingredients to the mixing unit.

Each bin on the truck shall have an accurately controlled individual gate or feeding mechanism to form an orifice for volumetrically measuring the material drawn from each respective bin compartment. The cement bin feeding mechanism shall be set to discharge continuously and at a uniform rate a given volumetric weight equivalent of cement during the concrete mixing operation. The gates of the aggregate bins shall be calibrated at the various openings to discharge the volumetric weight equivalent of aggregate required for various concrete mixes.

The truck mixer shall be so constructed as to allow the Engineer to check the calibration of the gate openings and meters by means of weight test samples.

The calibration of the gate openings and meters shall be checked and certified either on a semi-annual basis or prior to work on the Contract. A copy of the Certification shall accompany the truck mixer at all times. If, at any time during construction, a piece of equipment is not performing satisfactorily, it shall be repaired satisfactorily prior to reuse.

A 0.19 m^3 box constructed of suitable rigid materials shall be with the machine at all times for calibration purposes.

Each truck mixer shall be equipped with an accurate revolution counter indicator permitting the reading of the volumetric weight equivalent of cement discharged during the concrete mixing operation.

Each truck shall be equipped with fine and coarse aggregate dials to permit accurate adjustments of the gates of the aggregate bins for volumetric proportioning of aggregates.

Each truck mixer shall be equipped with a water meter or gauge to register the discharge rate of water by volume entering the mix.

Each truck mixer shall be equipped with positive automatic means of maintaining the operating speed of the proportioning and mixing operation independent of the drive engine of the truck, and within 8% above or below that established by the manufacturer and noted on the aforementioned metal plate as the speed at which the machine will accurately proportion concrete. Such positive automatic means shall automatically shut down the proportioning and mixing operation when the operating speed varies by more than the above tolerance. A tachometer shall be mounted on the unit to indicate the operating speed.

All indicators, dials, meters, tachometer, and controls shall be in full view and near enough to be accurately read or adjusted by the operator while mixing concrete.

Handling, measuring, and batching of materials shall conform to the applicable requirements of the Section in which the concrete is being placed.

Cement and aggregates shall be proportioned, measured, and batched by a volumetric weight equivalent method. Separate batching equipment and storage bins will not be required and the materials shall be batched in a continuous mixing truck type mixer.

The concrete will be rejected if there is any evidence of improper batching, mixing, excessive segregation, use of excessive mixing water, or if the amount of entrained air is other than as specified.

Tolerances in proportioning the various ingredients are as follows:

Cement (weight percent)	0 to +4
Fine aggregate (wt %)	±2
Coarse aggregate (wt %)	±2
Admixtures (wt or volume %)	±3
Water (wt or volume %)	±3

Each truck load of ingredients shall be accompanied by a sufficient number of delivery tickets such that the operator may supply one copy of the delivery ticket to the Engineer for each project and for each kind of concrete delivered. The delivery tickets shall show the brand name and type of cement, the calibrated cement constant of the machine in terms of the revolution indicator count, the source of aggregates, and the size of the coarse aggregate. The delivery tickets shall be signed by the mixer operator. The mixer operator shall enter on the tickets the name of the Project, the name of the Contractor, the revolution counter readings indicating the volumetric weight equivalent of cement discharged during that mixing operation, the aggregate dial settings, and the section for which the concrete is delivered. The operator shall sign each completed ticket and furnish one copy to the Engineer.

812.08 Placing and Curing. Placement and curing of Portland cement concrete shall conform to the requirements of the Section for which it is being used.