



Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATIONS FOR QUALITY MANAGEMENT CONCRETE (QM-C)

Effective Date
October 16, 2012

THE STANDARD SPECIFICATIONS, SERIES 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

12034.01 DESCRIPTION.

- A.** This specification identifies a concrete mixture design with an optimum combined aggregate gradation, and the Contractor's testing and quality control responsibilities. Optimization of the aggregates should produce concrete with low water requirement as well as improved workability and finishing characteristics. While concrete strength is important and is measured, it is not the basis for optimization of the concrete mixture design.
- B.** Testing and quality control apply to all Contractor produced concrete using the Concrete Design Mixture (CDM). The CDM applies to mainline slip form pavement. At the Contractor's option, the CDM may apply to any other slip form paving.

12034.02 MATERIALS.

For all materials, meet the quality requirements for the respective items in Division 41 of the Standard Specifications. Compatibility of all material combinations is the Contractor's responsibility based on acquired field experience with proposed materials.

12034.03 LABORATORY DESIGN MIXTURE.

- A.** Develop a CDM based on a unit volume of 1.000 according to industry standard practice, and containing proportions of materials, including admixtures. Base the proportions upon saturated surface dry aggregates to produce a workable concrete mixture meeting the constraints of Table DS-12034.03-1:

Table DS-12034.03-1: Concrete Mixture Constraints

Nominal Maximum Coarse Aggregate Size	Greater than or equal to 1 inch (25 mm)
Gradation	Materials I.M. 532
Cementitious Content	Minimum, 560 pounds per cubic yard* (333 kg/m ³ *)
Fly Ash Substitution Rate	See Article 2301.02, B, 6
Water/Cementitious Ratio	Maximum, 0.45
Air Content	6% ± 1%, Design Absolute Volume = 0.060
28 Day Flexural Strength, Third Point	Minimum, 640 pounds per square inch (4.40 MPa)
<p>* The minimum cement content assumes the use of Type I/II cement with a specific gravity of 3.14 for an absolute volume of 0.106. If cement other than Type I/II is used, use an absolute volume of 0.106 and determine the weight (mass) of cement from the specific gravity of the cement. For Type IP cement, use an absolute volume of 0.111. Cement content may need to be increased to maintain the water to cementitious ratio during hot weather conditions.</p>	

- B.** Use normal production gradations to determine the relative percentage of each individual aggregate used in the CDM. Select the relative percentage of each individual aggregate to produce the desired combined aggregate gradation using the following sieves: 1.5 inch, 1 inch, 0.75 inch, 0.5 inch, 0.375 inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, and No. 200 (37.5 mm, 25 mm, 19 mm, 12.5 mm, 9.5 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm, 150 µm, and 75 µm).
- C.** Develop a target combined gradation for each CDM based on normal production gradations and the relative percentages of each individual aggregate. Limit the percent passing the No. 200 (75 µm) sieve to no more than 1.5% for the combined aggregate gradation. When the coarse aggregate used meets the increase in percent passing the No. 200 (75 µm) sieve, according to Section 4109, Aggregate Gradation Table, Note 11 of the Standard Specifications, limit the percent passing the No. 200 (75 µm) sieve to no more than 2.0% for the combined aggregate gradation. The Contractor may use water reducing admixture, Type A, or water reducing and retarding admixture, Type D, in the CDM.
- D.** Comply with AASHTO T 126 for laboratory development of the CDM. Mix designs may be conducted in a ready mix or central mix batch plant provided the following conditions are met:
 - All non-mix design materials are emptied,
 - Mix design materials are used, and
 - Batch size is at least 3 cubic yards (2 m³).
- E.** An Iowa DOT PCC Level III Certified Technician is required to oversee the development of the CDM. Allow the Engineer to witness the development of the CDM. Provide notice 7 calendar days prior to this event. Perform the tests in Table DS-12034.03-2 in the development of the CDM:

Table DS-12034.03-2: Tests for CDM

Specific Gravity of Each Individual Aggregate	Materials I.M. 307
Gradation of Each Individual Aggregate	Materials I.M. 302
Unit Weight of Plastic Concrete	AASHTO T 121
Air Content of Plastic Concrete	Materials I.M. 318
28 Day Flexural Strength	AASHTO T 97
Temperature of Plastic Concrete	ASTM C 1064

12034.04 MIX DESIGN DOCUMENTATION.

- A.** At least 7 calendar days prior to the start of paving, submit a CDM report to the District Materials Engineer for approval. Contract extensions will not be allowed due to inadequate or additional CDMs. In the CDM report include the information shown in Table DS-12034.04-1:

Table DS-12034.04-1: Items to Include in CDM Report

Cover Page	Contractor name Project number Date and location of CDM laboratory development Date Submitted Signature of Contractor representative
Material Source Information	Brand Type Source
Material Proportion Information	Specific gravity Relative percentage of each individual aggregate Target combined gradation % passing (Materials I.M. 531) Target combined gradation charts (Materials I.M. 532) Design batch weight (mass) (SSD) As mixed batch weight (mass) (SSD)
Mix Properties	Unit weight (mass) of plastic concrete Air content of plastic concrete 28 day flexural strength Slump Temperature of plastic concrete

- B.** The District Materials Engineer may approve the mix design without laboratory mixture testing if the proposed mix design proportions fall within Zone II-A of Materials I.M. 532. If the mix design is approved without laboratory testing, cast a set of three beams on the first day of paving from concrete meeting the mix design criteria. Test the beams for 28 day flexural strength, third point loading. When the coarse aggregate for the mix design is quartzite, cast an additional set of three beams, and test at 90 days. Submit the strength results to the Engineer.

12034.05 QUALITY CONTROL.

A. General.

1. The Contractor is responsible for quality control of the concrete. An Iowa DOT PCC Level II Certified Technician is required to oversee quality control operations. The individual conducting the testing on grade is required to be an Iowa DOT PCC Level I Certified Technician. Calibrate and correlate testing equipment prior to and during paving operations.
2. At least seven calendar days prior to the preconstruction conference, submit to the Engineer a Quality Control Plan and Project Information Quality Control Plan complying with Materials I.M. 530. Do not begin paving until the plan is reviewed for compliance with the contract documents. Maintain equipment and qualified personnel to direct and perform all field quality control sampling and testing necessary to:
 - Determine the various properties of the concrete governed by the contract documents, and
 - Maintain the properties described in this specification.

B. Quality Control Testing.

1. Perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Plan. Take samples for quality control testing in a random manner according to the prescribed sampling rate. Perform the tests listed in Table DS-12034.05-1:

Table DS-12034.05-1: Quality Control Table

	Limits	Testing Frequency	Test Methods
Unit Weight (Mass) of Plastic Concrete	Monitor for changes, $\pm 3\%$	Twice/day	AASHTO T 121
Gradation Combined % Passing	See Paragraph 2 below	1/1500 cubic yard (1/1200 m ³)	Materials I.M. 216, 301, 302, 531
Aggregate Moisture Contents	See Materials I.M. 527	1/1500 cubic yard (1/1200 m ³)	Materials I.M. 308
Air Content Plastic Concrete In Front of Paver	See Article 2301.02, B, 4	1/350 cubic yard (1/275 m ³) See below	Materials I.M. 318
Water/Cementitious Ratio	0.45 maximum	Twice/day	Materials I.M. 527
Vibrator Frequency	See Article 2301.03, A, 3, a, 6, a	With Electronic Vibration Monitoring: Twice/day Without Electronic Vibration Monitoring: Twice/Vibrator/Day	Materials I.M. 384

- The running average of three combined aggregate gradation tests is required fall within the limits established by the CDM target gradation and the working ranges of Table DS-12034.05-2:

Table DS-12034.05-2: CDM Target Gradations

Sieve Size	Working Range
No. 4 or greater (4.75 mm or greater)	$\pm 5\%$
No. 8 to No. 30 (2.36 mm to 600 μm)	$\pm 4\%$
No. 50 (300 μm)	$\pm 3\%$
No. 100 (150 μm)	$\pm 2\%$
minus No. 200 (75 μm)	See Article DS-12034.03

C. Corrective Action.

For QM-C mixes only, plot all process control test results on control charts as described in Materials I.M. 530.

1. Aggregate Tests.

Take corrective action when the running average approaches the working range limits. When a combined gradation test result for a sieve exceeds the working range limits, adjust the target and notify the Engineer. If the verification test result for the minus No. 200 (75 μm) exceeds the limits in Article DS-12034.03 for the combined gradation, the material represented by that test for this sieve will be considered non-complying. Pay factors will be assessed based on Coarseness/Workability Factors as described in Article DS-12034.07.

2. Concrete Tests.

Take corrective action when an individual test result approaches the control limits. Notify the Engineer whenever an individual test result exceeds the control limits.

D. Acceptable Field Adjustments.

- All mix changes must be mutually agreed upon between the Contractor and Engineer. Document all mix changes on the QM-C Mix Adjustment form. Determine batch weights using a basic water cement ratio of 0.40. When the water cement ratio varies more than ± 0.03 from the basic water cement ratio, adjust the mix design to unit volume of 1.000. A change in the source of materials or an addition of admixtures or additives requires a new CDM. The following are small adjustments that may be made without a new CDM being required:

- Increase cementitious content.
 - Decrease fly ash substitution rate.
 - Aggregate proportions may be adjusted from CDM proportions by a maximum of $\pm 4\%$ for each aggregate.
 - Change water reducer to water reducer retarder.
 - Adjustment in water reducer or water reducer retarder admixture dosage.
 - Change in source of fly ash.
 - Change in source of sand, provided target gradation limits are met.
2. When circumstances arise, such as a cement plant breakdown, that create cement supply problems, a change in cement source may be allowed with the Engineer's approval. Consult the District Materials Engineer for approval of other changes to the mix design. A set of three beams for 28 day flexural strength testing may be required to document the changes. Should conditions beyond the Contractor's control prevent completion of the work with the CDM, a Class C mix, or a mix based on Class C mix proportions using project materials, will be allowed, at no additional cost to the Contracting Authority. Mutual agreement between the Contractor and Engineer is required.
 3. Prior to 28 days strength test results, paving with QM-C mix may begin if the Engineer approves when the mix design strength, based on the average of three beams, meets or exceeds 640 psi (4.4 MPa).

E. Hand Finished Pavement.

Use project materials based on Class C or Class M concrete mix proportions. With approval of the Engineer, the Contractor's CDM may be used for hand finished pavement. Quality control, as required in this specification, will not apply to hand finished pavement.

12034.06 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Quality Management Concrete (QM-C).

Cubic yards (cubic meters) of QM-C computed using the number of batches produced for which quality control and testing were performed. This QM-C quantity will also include: 1) the quantity of QM-C produced at the Contractor's option as referenced in Article DS-12034.01; and 2) Class C mixture used according to Article DS-12034.05, C. The amount of concrete produced for hand finished pavement and waste will be excluded from this quantity.

B. Standard or Slip-Form Portland Cement Concrete Pavement, QM-C.

Square yards (square meters) shown in the contract documents.

C. Portland Cement Concrete Overlay, QM-C, Furnish Only.

Article 2310.04, A, of the Standard Specifications applies.

D. Portland Cement Concrete Overlay, QM-C, Placement Only.

Article 2310.04, B, of the Standard Specifications applies.

E. Class C and Class M Mixtures.

Square yards (square meters) of Standard or Slip-Form Portland Cement Concrete Pavement, QM-C, constructed using Class C or Class M mixtures. For overlays, the Engineer will compute the number of:

- Square yards (square meters) of Portland Cement Concrete Overlay, QM-C, Placement Only, constructed using Class C or Class M mixtures, and
- Cubic yards (cubic meters) of Class C and Class M mixtures used.

12034.07 BASIS OF PAYMENT.

Payment will be the contract unit prices as follows:

A. Quality Management Concrete (QM-C).

1. Predetermined price per cubic yard (cubic meter).
2. Payment is full compensation for furnishing all labor, equipment, and materials for the work required by the Contractor to design, test, and provide process control for the production of QM-C.

B. Standard or Slip Form Portland Cement Concrete Pavement, QM-C.

1. Contract unit price for Standard or Slip-Form Portland Cement Concrete Pavement, QM-C, per square yard (square meter).
2. The contract unit price per square yard (square meter) for Standard or Slip-Form Portland Cement Concrete Pavement, QM-C, constructed will be adjusted according to Table DS-12034.07-1 based upon the average coarseness and workability factors for each lot according to Materials I.M. 530.

Table DS-12034.07-1: Pay Factor Chart

Gradation Zone (Materials I.M. 532)	Pay Factor
II-A	1.03
II-B	1.02
II-C	1.01
II-D	1.00
IV	0.98
I	0.95

C. Portland Cement Concrete Overlay, QM-C, Furnish Only.

Article 2310.05, A, of the Standard Specifications applies. Average coarseness and workability factor for each lot will be determined according to Materials I.M. 530. The contract unit price will be adjusted according to Table DS-12034.07-1.

D. Portland Cement Concrete Overlay, QM-C, Placement Only.

Article 2310.05, B, of the Standard Specifications applies. Average coarseness and workability factor for each lot will be determined according to Materials I.M. 530. The contract unit price will be adjusted according to Table DS-12034.07-1.

E. Class C and Class M Mixtures.

1. Standard or Slip-Form Portland Cement Concrete Pavement, QM-C: per square yard (square meter).
2. Portland Cement Concrete Overlay, QM-C, Placement Only: per square yard (square meter)
3. Portland Cement Concrete Overlay, QM-C, Furnish Only: per cubic yard (cubic meter).
4. Pay Factor incentives/disincentives in Table DS-12034.07-1, will not be applied to Class C and Class M mixtures.