City of Duluth, Minnesota

Public Works & Utilities Department - Engineering Division

Standard Construction Specifications - 2019 Edition

APPENDIX E

Supplemental Concrete Specifications

(Sections 2301, 2302, 2461, 2462, 2472, 3137)

S-1 (2301) CONCRETE PAVEMENT

REVISED 01/04/19

SP2018-124

MnDOT 2301 is hereby modified as follows:

S-1.1 Table 2301-4 of MnDOT 2301.2.L.1 shall be deleted and replaced with the following:

Table 2301-4
Concrete Mix Design Requirements

Concrete Grade	Estimated Concrete Contract Quantity (yd^3) *	Mix Number	Maximum w/c ratio		Minimum Cement Content (lbs/yd^3)	Cementitious Content (lbs/ yd^3) ‖	Air Content %	Gradation Requirements	Minimum Aggregate Size Required	Maximum %SCM (Fly Ash/ Slag/ Ternary) †	Slump Range	3137 Spec.
			Fly Ash	Slag/ Ternary								
A	≥ 3,500	3A21	0.40	0.42	385	530 – 615	7.0	Job Mix Formula	1 1/2" nominal	33/35/40	½ - 2" ‡	2.D.3
		3A41	0.40	0.42							2 – 5"	
	< 3,500 and Minor work and fill-ins not provided by the primary paving plant #	3A21S	0.42	0.42	385	530 – 615	7.0	3126 and Table 3137-4 Or Job Mix Formula	3/4" nominal	33/35/40	½ - 2" ‡	2.D.3
		3A41S	0.42	0.42							2 – 5"	
		3A42 §	0.42	0.42	385	530 – 615	7.0	3126 and Table 3137-4	3/4" nominal	33/35/40 §	2 – 5"	
	Engineer Approved or Plan Allowed High-Early	3A21HE **	0.40	0.42	385	> 615 – 750	7.0	3126 and Table 3137-4 Or Job Mix Formula	3/4" nominal	33/35/40	½ - 2" ‡	2.D.3
		3A41HE **	0.40	0.42							2 – 5"	

* Determined by multiplying the planned pavement area by the planned pavement thickness.
‖ Provide additional cementitious material to meet requirements in accordance with this section at no additional cost to the Department.
† Refer to Table 2301-2 and Table 2301-3 for ASR mitigation requirements.
‡ Adjust slump in accordance with 2301.3.E.1, "Consistency."
# The 5th digit "S" indicate the concrete is for a small concrete paving project or delivered from a secondary concrete plant for minor work or fill-ins. The Concrete Engineer considers minor work or fill-ins as gaps in concrete pavement, turn lanes, intersections or other pavement sections as determined by the Engineer, in conjunction with the Concrete Engineer.
§ The Concrete Engineer will allow a non-project specific 3A42 mix design provided by a MnDOT certified ready-mix plant submitted in accordance with the first two paragraphs of 2461.2.F.3, "Submittal Requirements." If the sand source requires mitigation with a minimum of 30% Class C fly ash in accordance with Table 2301-2, the Concrete Engineer will require a minimum of 30% Class C fly ash, 30% Class F fly ash or 35% slag for all 3A42 mixes.
**The Contractor may use 100% Portland cement for High Early Concrete, provided no mitigation is required for the fine aggregate and intermediate aggregate in accordance with Table 2301-2 and coarse aggregate in accordance with Table 2301-3. If mitigation is required, the Contractor is required to use a minimum of 15% of any supplementary cementitious material when designing High Early Concrete.

S-1.2 Add the following sentence to second paragraph of MnDOT 2301.2.L.2:

Always use the most current forms available from the MnDOT Concrete Engineering Website.

S-1.3 The third paragraph of MnDOT 2301.2.L.3.c and Table 2301-7 shall be deleted and replaced with the following:

If the gradation tests on any split sample from that day's testing result in a variation between the Producer and the Engineer greater than that set forth in Table 2301-7, the Engineer will substitute the Agency test results into the moving average calculation to determine acceptance and the well-graded aggregate optional incentive.

Table 2301-7
Allowable Variations on Percent Passing Sieves

Sieve Size	Allowed Percentage
2 in – 1 in	± 8
¾ in – ⅜ in	± 6
No. 4 – No. 30	± 4
No. 50	± 3
No. 100	± 2
No. 200	± 0.6

S-1.4 MnDOT 2301.2.M.2 and 2301.2.M.2.a shall be deleted and replaced with the following:

M.2 Water/Cement (w/c) Ratio

Provide and place concrete with a water/cement ratio not to exceed 0.40 when using cement only or fly ash and 0.42 when using slag or ternary. Make any adjustments immediately when the water/cement ratio exceeds 0.40 when using cement only or fly ash and 0.42 when using slag or ternary.

The Engineer will not make incentive payments for water/cement ratio on high-early mixes.

The Engineer will determine the water/cement ratio for concrete hauled in dump or agitator trucks (concrete hauled in truck mixers are not eligible for w/c ratio incentives) in accordance with the following:

M.2.a Sampling and Determination of Lots

The Engineer will sample, test, and record the individual results in accordance with 2301.2.M.2.b, "Water Content Determination," and 2301.2.M.2.c, "Cementitious Content Determination," at a rate defined in the Schedule of Materials Control. The Engineer will use the *W/C Ratio Calculation Workbook* for moisture testing and determining the incentive/disincentive.

The Engineer will base the statistical analysis of acceptance for water/cement ratio on a per lot basis representing one day's paving. Each individual water/cement ratio determination is considered a sublot. The lot will represent the cumulative average of the sublot values. The Engineer will start a new lot and test if either of the following occur:

(1) Mix design change due to a water/cement ratio test result exceeding 0.40 when using cement only or fly ash and 0.42 when using slag or ternary, or
(2) Supplementary cementitious type change from fly ash to slag or ternary mix design, or vice versa.

If the quantities of concrete produced results in no Engineer moisture testing for any given day, include the untested quantity of concrete into the next day's production and include that quantity of concrete in the sampling rate. If the untested quantity is on the last day of production, add that quantity to the previous day's production.

S-1.5 MnDOT 2301.2.M.2.e shall be deleted and replaced with the following:

M.2.e W/C Ratio Incentive/Disincentive

Do not place concrete mix not meeting the water/cement ratio requirements in accordance with Table 2301-4. The Engineer may accept inadvertently placed material not meeting the contract requirements in accordance with Table 2301-11.

Table 2301-11
W/C Ratio Incentive/Disincentive

When using cement only or fly ash		When using slag or ternary	
W/C Ratio Lot Result	**Payment incentive/disincentive per cu. yd**	**W/C Ratio Lot Result**	**Payment incentive/disincentive per cu. yd**
≤ 0.37	+$3.00	≤ 0.39	+$3.00
0.38	+$1.75	0.40	+$1.75
0.39	+$0.50	0.41	+$0.50
0.40	$0.00	0.42	$0.00
0.41	−$0.50	0.43	−$0.50
0.42	−$1.75	0.44	−$1.75
≥ 0.43	Determined by the Concrete Engineer	≥ 0.45	Determined by the Concrete Engineer

The Contractor may remove and replace concrete represented by water/cement ratio results greater than 0.40 when using cement only or fly ash and 0.42 when using slag or ternary. If the Contractor elects to not remove the concrete and the level of payment is not defined in the Table 2301-11, the Engineer, in conjunction with the Concrete Engineer, will evaluate the concrete based on the adequacy for the use intended. Remove and replace unsatisfactory concrete as determined by the Engineer at no additional cost to the Department.

S-1.6 The first sentence of MnDOT 2301.2.M.3 shall be deleted and replaced with the following:

The Engineer will use the Contractor's combined aggregate gradation (JMF) test results (QC and Verification Companion) documented in the *JMF Concrete Aggregate Workbook*, as verified by the Engineer in accordance with 2301.2.L.3.c, "Agency Verification of JMF," to determine eligibility for the incentive.

S-1.7 Table 2301-12 shall be deleted and replaced with the following:

Table 2301-12
Well Graded Concrete Aggregate Gradation Band

Sieve Size	% Retained
2 in	0%
1½ in	≤ 5%
1 in	≤ 16%
¾ in	≤ 20%
½ in	4 – 20%
⅜ in	4 – 20%
No. 4	4 – 20%
No. 8	≤ 12%

Table 2301-12 Well Graded Concrete Aggregate Gradation Band	
Sieve Size	**% Retained**
No. 16	≤ 12%
No. 30	4 – 20%
No. 50	4 – 20%
No. 100	≤ 10%
No. 200	≤ 2%
Coarse Sand % Retained (No. 8 to No. 30 Sieve)	> 15%
Fine Sand % Retained (No. 30 to No. 200 Sieve)	24% – 34%

S-1.8 MnDOT 2301.3.B.3.b shall be deleted and replaced with the following:

3.B.3.b Paving Plant Sampling and Testing

Provide the following personnel:

(1) QC Plant Technician(s) to perform all testing and quality control requirements of 2301. The QC Plant Technician shall hold a current MnDOT Concrete Plant Certification.

(2) Quality Control Supervisor responsible for oversight of all QC testing and daily paving batch plant operations. The Quality Control Supervisor shall hold a current MnDOT Concrete Plant Certification and is required to remain on-site during concrete production or have cellular phone availability.

(3) Quality Control Manager responsible for oversight of the Quality Control Supervisor and all batch plant operations. The Quality Control Manager and Quality Control Supervisor can be the same person.

The Engineer will provide MnDOT Certified Concrete Plant Technician(s) to perform all testing in accordance with the requirements of 2301.

Perform testing in accordance with the Concrete Manual and determine testing rates in accordance with the requirements of the Schedule of Materials Control. The Engineer performs testing in accordance with the Concrete Manual and determines testing rates meeting the requirements of the Schedule of Materials Control.

S-1.9 MnDOT 2301.3.F.3.a(6) shall be deleted and replaced with the following:

(6) Adhere the geotextile to the underlying substrate using manufacturer recommended cylinder spray adhesive for geotextiles to attach the geotextile to the underlying concrete or asphalt. Apply a minimum 12 in wide adhesive bond to attach any edge of geotextile to the underlying substrate or to another piece of geotextile. Apply pressure to the geotextile to set the adhesive prior to placing the concrete. The Contractor may propose and demonstrate alternate methods for satisfactorily anchoring the geotextile to the Engineer for approval.

S-1.10 The first paragraph of MnDOT 2301.3.F.5 shall be deleted and replaced with the following:

Use any approved construction header method as shown in the Standard Plate 1150 when constructing construction headers, temporary headers, and permanent headers as shown on the plans. The Contractor may propose and demonstrate alternate construction header methods to the Engineer for approval. In the plastic concrete, the Engineer may evaluate headers for vertical surface deviations with a 10 foot straight edge. Correct all high and low spots identified within the 10 foot straight edge.

S-1.11 MnDOT 2301.3.F.6.b(3) shall be deleted and replaced with the following:

F.6.b(3) Non-Conforming Air Content After Consolidation

If the Contractor or Engineer test results in an air content after consolidation of less than 4.5%, take the following action:

(1) Immediately retest and verify the ACF is correct.
(2) If the results are still < 4.5%, make immediate adjustments to the concrete or the consolidation process, test any loads that have not been discharged or adjusted at the plant and apply the ACF to determine compliance.
(3) Test every load of concrete until the air content after consolidation test results are ≥ 4.5%.
(4) Test at least 3 additional trucks to ensure the concrete remains in compliance.
(5) Perform additional testing on the hardened concrete as required by the Engineer in conjunction with the Concrete Engineer.

S-1.12 MnDOT 2301.3.I.2(3) shall deleted and replaced with the following:

(3) 2301.3.L.2, "Contractor Quality Control Probing."

S-1.13 MnDOT 2301.3.K.1.a shall modified to include the following:

(4) For concrete roundabouts (not including the truck apron), perform a minimum of 3 texture tests

S-1.14 MnDOT 2301.3.K.1.b(3) shall be deleted and replaced with the following:

(3) Run additional tests at 100 ft intervals before and after the failing test location until an acceptable minimum texture of 1.00 mm is obtained.

S-1.15 MnDOT 2301.4.B.1(4) shall be deleted and replaced with the following:

(1) Apply incentives or disincentives based on the daily cubic yards batched of *Structural Concrete* as verified by the computerized batch ticket printouts from the plant, with consideration of any waste.

S-2 (2302) CONCRETE PAVEMENT REHABILITATION (CPR)

REVISED 01/25/19
SP2018-131

2302.1 DESCRIPTION

This work shall consist of performing concrete pavement repairs, load transfer restoration, and joint/crack sawing and sealing in accordance with the Concrete Pavement Rehabilitation (CPR) Standard details, and the following.

2302.2 MATERIALS

A Structural Concrete 2461

A.1 Partial Depth Repairs, Type B, Mix No. 3U18 3105

A.1.a Pre-bagged Grade 3U18 Concrete Patch Mix

Provide a dry, bagged MnDOT Grade 3U18 concrete patch mix, in accordance with 3105.

A.1.b Field-Proportioned Grade 3U18 Concrete Patch Mix

Provide Grade 3U18 concrete mix by mass in accordance with Table 2302-1.

Table 2302-1
Mix Proportions

Material	Weight, *lb.*
Type I Cement	100
Coarse Aggregate, ASTM #89	159
Fine Aggregate	162

A.1.c Coarse Aggregate Gradation Requirements, ASTM #89 or CA-80

Provide either an ASTM #89 or CA-80 Gradation in accordance with Table 3137-4 for use in Grade 3U18 concrete patch mix or Dowel Bar Retrofit Repairs. Provide coarse aggregate meeting the quality requirements of 3137.2.D.3, "Coarse Aggregate for Concrete Pavement."

A.2 Full Depth Repairs, Type C and Type CX, Mix No. 3R52 and 3RHE52 2461

B Reinforcement Bars 3301

C Dowel Bars Used in Dowel Bar Baskets 3302

C.1 Dowel Bars Used in Drill and Grout or Dowel Bar Retrofits Applications 3302.2.A

D Curing Materials

D.1 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound 3754

D.2 Linseed Oil Membrane Curing Compound 3755

D.3 Plastic Curing Blankets 3756

D.4 Insulation Board 3760

E Joint Sealant 3725

F Preformed Joint Filler 3702

G Form Coating Material 3902

H Dowel Bar Retrofit (DBR) Repair Materials 2302

H.1.a Approved Non-Shrink Rapid Set Concrete for Dowel Bar Retrofit Repairs

Provide a Packaged, Dry, Non-Shrink, and Rapid- Hardening Concrete Material for backfilling Dowel Bar Retrofits repairs from the MnDOT Approved/Qualified Product List.

The Engineer will allow on site addition (extension) of coarse aggregate in accordance with the following:

(1) Limit coarse aggregate extension to same source/same percent mass extension as was utilized in the AMRL certified laboratory trial-batch testing.
(2) Limit the coarse aggregate extension to the manufacturer's recommended maximum or to a maximum of 50 percent by mass, whichever is less.
(3) Meets aggregate quality requirements of Standard Specification 3137.2.D.3.

H.1.b DBR Project Submittal Requirements

At least 21days prior to performing DBR repairs, submit the following information to the MnDOT Concrete Engineering Unit for review:

(1) A concrete mix design including the coarse aggregate source at the proposed extension percentage.
(2) A signed letter from the Rapid-Hardening Cementitious Material manufacturer stating the means and methods specified in both MnDOT Special Provision 2302 and outlined on the Dowel Bar Retrofit detail sheets are acceptable procedures.
(3) Any field testing requirements recommended by the manufacturer of the Rapid-Hardening Cementitious Material.

The Engineer in conjunction with the Concrete Engineer will determine final acceptance of the DBR repair backfill material based on satisfactory field placement and performance, in accordance with 2302.3.F.4 “Test Section” and 2302.3.G “Repair Warranty.”

H.2 End Caps

Provide tight fitting, nonmetallic non-organic end caps that will allow for a ¼ inch expansion movement of the dowel bar at each end.

H.3 Compressible Foam Board

Provide either a Type D-1 or D-2 preformed foam joint filler, in accordance with MnDOT Specification 3702 “Preformed Joint Filler.” Provide foam joint filler that is at least 3/8 inch thick and is a minimum of 1/8 inch thicker than the joint / crack to ensure no leakage of patching material into the crack. Cut foam preformed joint filler to fit the full width and depth of the saw slot, as shown in the Dowel Bar Retrofit detail. The Engineer will not permit multiple pieces to obtain the proper height or width of the saw slot.

H.4 Dowel Bar Support Chairs

Provide two, nonmetallic support chairs that are either epoxy coated steel in accordance with ASTM A 884/A 884M or fabricated of commercial quality nonmetallic, non-organic material to support each dowel bar. The chairs when placed shall press securely against the slot face to firmly hold the dowels in the proper position while the backfill material is placed and consolidated.

H.5 Caulking Filler

Provide any commercial caulk that is designed as a crack sealant that is compatible with the proposed patching material. Use the caulking filler for sealing the existing joint or crack at the bottom and sides of the slot as shown in the Dowel Bar Retrofit detail. Do not extend/over band the caulk filler beyond the limits of the crack by greater than 1/2 inch.

2302.3 CONSTRUCTION REQUIREMENTS

A 3U18 Concrete Mixture Requirements for Partial Depth Repairs

Incorporate concrete into the concrete pavement rehabilitation repairs in accordance with Specification 2302, the Plan, Concrete Pavement Rehabilitation (CPR) Standard details, and the following.

Mix all dry pre-bagged grade 3U18 concrete patch mix on site, in a paddle type mixer for at least 5 minutes.

The Engineer may also allow batching by volume in a calibrated mobile type mixer to produce grade 3U18 concrete. Calibrate the mobile mixer to the weights shown in Table 2302-1. Proportion the cement, coarse and fine aggregate by volume (± 2.0 percent) in accordance with 2404.3.E.1, “Mixer Requirements” and 2461.3.D.2 “Batching by Volume.”

Adjust water additions to achieve a maximum slump of 1 inch 5 minutes after batching concrete mix.

Do not accelerate concrete strength gain to facilitate early strength of pavement repairs solely for construction traffic unless approved by the Engineer.

If the Engineer approves the use of accelerating (Type C or E) admixtures, take extra precautions as necessary to ensure satisfactory finishing, curing, and protection of the concrete repairs. The Contractor assumes full responsibility for the performance of the concrete. The Engineer will determine final acceptance of the Type B repair concrete based on satisfactory field placement and performance, in accordance with 2302.3.G "Repair Warranty."

Refer to Table 2302-2, "MnDOT Mix 3U18 Opening Times", to determine the allowable mix adjustments to Grade 3U18 concrete. When anticipated time to opening for construction equipment or general traffic is less than 7 calendar days, and the ambient temperatures are anticipated to remain at or above 60°F during the curing time, provide approved admixture as outlined in Table 2302-2. The mix design will include the admixtures solution as part of the total recommended mixing water.

TABLE 2302-2
MnDOT Mix 3U18 Opening Times

Anticipated Minimum Time to Opening *	**Concrete Mix Grade**	**Admixture Dosage & Type** Based on manufacturer's recommended dosage rate	**Mix Design Responsibility**	**Testing and Strength Required for Opening**
≥ 7 calendar days	3U18 ‖	None Required	2302	None *
72 hours to 7 calendar days	3U18 ‖	Type A ‡	2302	None *
36 hours to < 72 hours	3U18 ‖	Type A ‡	2302	Control Cylinders as per 2302.3.B.4(c) # π
12 hours to < 36 hours	3U18 ‖ †	As Needed §	2302	Control Cylinders as per 2302.3.B.4(c) # π

* If at any time the ambient temperature falls below 60°F during the curing time, use control specimens to determine opening times in accordance with 2302.3.B.4.
‖ The maximum slump for 3U18 mixes measured after 5 minutes is 1 inch.
† Accelerating admixtures are not allowed when the ambient air temperature exceeds 80°F without the approval of the Concrete Engineer.
‡ Use manufacturer's recommended dosage rate to achieve 3000 psi minimum compressive strength or 500 psi flexural strength at the time of opening.
# The Engineer may reduce the number of control specimens required based on previous control specimen strengths gains and site conditions.
§ Use a Type A, C or E admixture in accordance with 2302.3.A and the manufacturer's recommended dosage rate to achieve 3000 psi minimum compressive strength or 500 psi flexural strength at the time of opening.
π Do not allow construction vehicles or general traffic on Type B repairs unless a minimum of 12 hours have elapsed and control cylinders achieve a minimum compressive strength of 3000 psi or 500 psi flexural strength.

A.1 3R52 or 3RHE52 Concrete Mixture Requirements for (Type C) Full Depth Repairs

Provide a contractor designed concrete in accordance with Specification 2461, the Plan, Concrete Pavement Rehabilitation (CPR) Standard details, and the following.

Design either a concrete grade 3R52 or 3RHE52 for use in Type C Repairs in accordance with specification 2461 "Structural Concrete."

Refer to Table 2302-3, "Mix 3R52 and 3RHE52 Opening Requirements," to determine the criteria for opening 3R52 and 3RHE52 concrete to traffic.

Do **not** accelerate concrete strength gain to facilitate early strength of pavement repairs solely for construction traffic unless approved by the Engineer.

If the Engineer approves the use of accelerating (Type C or E) admixtures, take extra precautions as necessary to ensure satisfactory finishing, curing, and protection of the concrete repairs. The Contractor assumes full responsibility for the performance of the concrete. The Engineer will determine final acceptance of the Type C repair concrete based on satisfactory field placement and performance, in accordance with 2302.3.G. "Repair Warranty."

TABLE 2302-3
Mix 3R52 and 3RHE52 Opening Requirements

Anticipated Minimum Time to Opening *	Concrete Mix Grade	Admixture Dosage & Type Based on manufacturer's recommended dosage rate	Mix Design Responsibility	Testing and Strength Required for Opening
≥ 7 calendar days	3R52	2461* ‖	Contractor	None
< 7 calendar days to ≥ 12 hours	3R52 3RHE52	2461* ‖	Contractor	Control Cylinders as per 2302.3.B.4(c) † ‡

* Accelerating admixtures are not allowed when the ambient air temperature exceeds 80°F without the approval of the Concrete Engineer.

‖ Use manufacturer's recommended dosage rate to achieve 3000 psi minimum compressive strength or 500 psi flexural strength at the time of opening.

† The Contractor may request to the Engineer a reduction in the number of control specimens required based on the results of the control specimen strengths and site conditions.

‡ Do not allow construction vehicles or general traffic on Type C repairs unless a minimum of 12 hours has elapsed and control cylinders achieve a minimum compressive strength of 3000 psi or 500 psi flexural strength.

A.2 Placement Limitations

A.2.a Type A Repairs

(1) Do not place joint sealant when the ambient temperature is below 40°F**,** nor when the joint faces show signs of frost or moisture.
(2) Do not perform Type A repairs until the concrete grinding operations are completed.
(3) If the pavement joints are widened, seal the joints before traffic is placed on the repairs.
(4) Do not place joint sealant outside of the manufacturer's temperature recommendations.

A.2.b Type B Repairs

(1) Do not place concrete at ambient temperatures less than 50°F.
(2) Do not place concrete when in-place pavement temperatures are below 50°F.
(3) **Do not place any concrete mixture after October 15th**.

(4) Do not place epoxy resin adhesive or non-shrink grout for bonding reinforcement bars to in place concrete outside of the manufacturer's temperature recommendations.
(5) Do not use accelerating admixtures (Types C and E) when the ambient air temperature exceeds 80°F without the approval of the Concrete Engineer.

A.2.c Type C Repairs

(1) The Engineer will consider all drill and grout dowels bars installed and anchored to the in place concrete pavement prior to performing the **Dowel Bar Anchoring Test Section (2302.3 E.5)**, as Unacceptable and Unauthorized Work, in accordance with Standard Specification 1512.
(2) Place concrete in accordance with 2461 and 2302.3.B.3.c in these provisions.
(3) Do not place any concrete mixture after October 15th, unless approved by Concrete Engineer, in conjunction with the Engineer, and an approved cold weather protection plan is in place.
(4) Do not place epoxy resin adhesive or non-shrink grout for bonding reinforcement bars or dowel bars to in place concrete outside of the manufacturer's temperature recommendation.

A.2.d Dowel Bar Retrofits

(1) Do not place pre-blended Non-Shrink Rapid Set Concrete Material when the pavement temperatures are above 90°F.
(2) Maintain pre-blended Non-Shrink Rapid Set Concrete Material temperature at or below 90°F.

A.2.e Concrete Grinding

(1) Do not grind the concrete unless the openings times and minimum strengths established in either Table 2302-2, Table 2302-3 or, 2302.3.B.5.a of these provisions have been met.
(2) The Engineer will schedule a pre-grinding meeting at the project site. At the pre-grinding meeting, submit to the Engineer in writing the proposed Slurry Management Plan the grinding contractor will utilize to remain in conformance with Specification 1717. At the pre-grinding meeting, the Engineer and Contractor will review the site to identify the environmentally sensitive areas.

B General

Establish traffic control 1-day in advance of the beginning of the rehab operation for rehab surveys and locations.

B.1 Removals

Dispose of all removals outside the right of way in accordance with Specification 2104 to the satisfaction of the Engineer.

Repair any damage to any in-place pavement, roadway structure, joints, shoulders or appurtenance caused by the Contractor's operations as directed by the Engineer prior to final acceptance at no cost to the Department. Replace bituminous shoulder pavement, as directed by the Engineer, as an incidental cost to performing adjacent concrete repairs.

To prevent concrete pavement blow ups, saw full-depth relief cuts in the adjacent lanes and remove a transverse section 4 inches wide by full-width of the slab as the Contractor determines necessary to protect the existing concrete pavement. If the Contractor chooses not to saw a relief cut and damage is caused to the remaining concrete pavement, the Contractor shall make repairs as directed by the Engineer, at no cost to the Department. Prior to opening to traffic, backfill the void formed after concrete removal with Class 5 or other material as approved by the Engineer at no cost to the department. Maintain the backfill material flush within a tolerance of +/- 1/2 inch with adjacent concrete.

B.2 Placing and Finishing Concrete

Use concrete placing and finishing procedures that do not result in rounding of the surface at any joints or headers.

Reestablish longitudinal and transverse joints and cracks according to Joint Repair (Type A1) detail.

Tool rounded edges adjacent to all inserts and forms.

Limit overcutting into adjacent lanes to the nominal radius of the saw blade. At no cost to the Agency, seal overcuts into adjacent lanes in accordance with the Joint Repair Type A1 detail.

Assure that concrete repairs do not protrude beyond the original cross-section of the pavement by more than 3/8 inch by forming or sawing the edges.

Provide broomed surface texturing for skid resistance to all repairs, including when concrete grinding is to take place.

B.3 Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1.1) For Type B Repairs, place the membrane curing compound conforming to 3754 or 3755 within 10 minutes of concrete placement or once the bleed water has dissipated unless otherwise directed by the Engineer in accordance with 2302.3.B.3.a.1.

(1.2) For Type C Repairs, place the membrane curing compound conforming to 3754 or 3755 within 30 minutes of concrete placement or once the bleed water has dissipated unless otherwise directed by the Engineer in accordance with 2302.3.B.3.a.1. Place the membrane-curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets unless otherwise specified in the Contract.

(1.3) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2302.3.B.3.a.2.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions or equipment failures occur, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, remove the covering for the minimum time required to complete that work.

Failure to comply with the above provisions will result in the Engineer, in conjunction with the Concrete Engineer, applying a monetary deduction in accordance with 1503 and 1512 and the following:

(2.1) For Type B Repairs, the Department will apply a monetary deduction of 100% of the unit bid price for the concrete in question.

(2.2) For Type C Repairs, the Department will apply a monetary deduction of $100.00 per cu. yd. or 50% of the Contractor-provided invoice amount for the concrete in question, whichever is less.

The Contractor may remove and replace the Type B or Type C Repairs at their own expense in lieu of the monetary deduction.

B.3.a Curing Methods

B.3.a.1 Membrane Curing Method

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane-curing compounds from freezing before application. Handle and apply the membrane-curing compound in accordance with the manufacturer's recommendations.

Use an airless spraying machine for applying the curing compound on the concrete that complies with the following:

(1.1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(1.2) Separate filters for the hose and nozzle, and
(1.3) Multiple or adjustable nozzle system that provides for variable spray patterns.

Apply the curing compound in accordance with the following:

(2.1) At a rate of 1 gal per 150 sq. ft of surface area.
(2.2) Apply curing compound homogeneously to provide a uniform, solid, white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper). If using a Department - approved curing compound with a non-white base color, apply the compound to provide a uniform, solid, opaque consistency meeting the intent of the requirement in this section.
(2.3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.
(2.4) If the Engineer determines that the initial or corrective spraying result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method at no additional cost to the Department.

B.3.a.2 Blanket Curing Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

B.3.b Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until corrective action is taken and may subject the rain-damaged concrete to 1503 and 1512.

B.3.c Protection Against Cold Weather for Full Depth (Type C) Repairs

If the national weather service forecast for the construction area predicts air temperatures of 36 °F or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plan.

Protect the concrete from damage including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until corrective action is taken and may subject the damaged concrete to 1503 and 1512.

B.3.c.1 Cold Weather Protection Plan

Submit a proposed time schedule and Plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Include a method of monitoring the concrete temperatures. Ensure concrete pavement repair temperatures remain above 32° F for the entire cure time as defined in 2302.3.B.4 (c). Do not place concrete until the Engineer accepts the Contractor's cold weather protection plans.

B.4 Opening to Construction Equipment and Traffic

The Engineer will not allow the Contractor to open concrete pavement repairs to construction equipment / vehicles, concrete grinding equipment, cleanup equipment or, public traffic unless one of the following requirements has occurred:

(1) When MnDOT designed 3U18 concrete or Contractor designed 3R52 / 3RHE52 concrete attains a minimum age of 7 calendar days, **or**

(2) When MnDOT designed 3U18 concrete attains a minimum age of 72 hours **and** the admixture type, dosage rate, and minimum ambient temperature requirements outlined in Table 2302-2 are met, **or**

(3) MnDOT designed 3U18 concrete or Contractor designed 3R52 or 3RHE52 concrete attains a minimum age of 12 hours **and** control strength specimens obtain minimum compressive strength of 3000 psi, or minimum flexural strength of 500 psi.

(4) For dowel bar retrofits repairs, reached a minimum age of 4 hours **and** control strength specimens obtain minimum flexural strength of 500 psi, or minimum compressive strength of 3000 psi.

(5) For both (3) and (4) above, the Contractor will cast and cure the control specimens in accordance with 2461. The Engineer will test the control specimens in accordance with ASTM C39. If the Engineer is unable to test the control specimens the Contractor will test the control specimens in accordance with the following:

(5.1) Supply and operate (in the presence of the Engineer) a calibrated mechanical or hydraulic concrete cylinder testing machine, in accordance with ASTM C39;

(5.2) Perform testing at a distance no greater than 30 miles from the control specimen fabrication site; and

(5.3) At no additional cost to the Department.

When opening times are less than 3 days, provide the Engineer with a letter from the manufacturer stating the required minimum cure times of the Epoxy Resin Adhesive (ERA) or Non-Shrink Grout (NGS) used to anchor either the dowel bars or reinforcement bars comply with the early opening times. Do not open to construction equipment or traffic until the manufacturer's recommended minimum cure times are met.

Once one of the above conditions has been met, sweep the portion of the closed traffic lane with a power pick-up broom prior to opening. Use water to control dust at the discretion of the Engineer.

C Type A Repairs

Type A repairs include: Variable Width Joint Crack Repair / Joint Repair (Type A1) and Variable Width In place Joint or Crack Repair / Joint Repair (Type A2).

Saw and clean transverse and longitudinal joints or cracks as specified below, in preparations for sealing, seal joints or cracks.

C.1 Removals

When performing Variable Width Joint Crack Repair / Joint Repair (Type A1):

Remove the in place joint sealer if applicable. The Contractor may remove the in place joint sealer in conjunction with widening of the in place joint or crack.

Widen in place or newly constructed transverse or longitudinal joint or crack by saw cutting and to a depth shown on the Variable Width Joint Crack Repair / Joint Repair (Type A1) detail. Freshly saw both joint faces. Do not widen the in place joint or crack greater than 1/4 inch from its existing width.

When performing the Variable Width in Place Joint or Crack Repair / Joint Repair (Type A2):

Remove all of the existing joint seal material from the in place joint insofar as possible with ripping teeth, wire brush, sawing or other reasonable equipment to the satisfaction of the Engineer.

Do not use equipment that will cause spalling of the pavement surface.

C.2 Preparation

Thoroughly clean all joints and cracks by water flushing immediately after sawing.

After joint has dried, sandblast then air blast.

Assure that the joints or cracks are clean, dry, and free of all incompressible material before applying sealant.

C.3 Repair

Install a closed cell backer rod when joints or cracks are 1/4 inch or greater. Install backer rod of a diameter and to the depth shown on the Joint Repair (Type A) details.

Use a MnDOT Approved hot pour joint sealer meeting the requirements of Specification 3725.

Apply joint sealer in accordance with the Manufacturer's recommendations.

Fill joints or cracks to 1/16 inch below the pavement surface. Any overfilling of hot pour joint sealer will require removal and replacement by the Contractor at no cost to the Department.

D Type B Repairs

Type B Repairs include: Partial Depth Repair (Type BA), Partial Depth Repair Special (Type BE), and Joint and Crack Repair (Type B3).

Remove deteriorated concrete at designated (Type B) repair areas, reestablish joints and cracks, furnish, place, and cure 3U18 concrete to the original slope and grade, saw and seal reestablished joints.

D.1 Removals

The Engineer will not allow "Jackhammers" for partial depth concrete removals. Removal chipping hammers are limited to a maximum rated weight of 35 pounds.

Equip milling machines used for concrete removal with a device for stopping at preset depths to prevent damage to the dowel bars.

Remove the concrete surface and all deteriorated concrete in the designated repair areas to a minimum depth of 2 inches.

Do not damage the dowel bars during the removal process. Any damage is the responsibility of the Contractor.

Remove the concrete surface in the designated repair area by either of the following:

(1) Milling transversely or longitudinally. Chip-out secondary spalling resulting from the contractor's removal operations at no cost to the Department.

(2) Delineate the repair area by saw cuts and chipping back the saw cuts to a 30°- 60° angle.

D.2 Preparation

If dowel bar or reinforcement bars cross-sectional loss due to corrosion is slight, place duct tape over the dowel bar, or another bond breaking material approved by the Engineer. Cut or burn-off the bar if the dowel bars are misaligned, exhibit corrosion to a greater degree or if the end of the dowel is exposed. If this involves more than three adjacent dowels, remove and replace the entire joint with a Full Depth Repair (Type CD).

Sandblast then air blast Type B Repairs clean.

Drill and grout No.4 epoxy coated reinforcement bars for Partial Depth Repair Special (Type BE). Maintain a minimum of 1 in concrete cover around bar. Install additional drill and grout No.4 epoxy coated bars at 6 in center-to-center while maintaining the minimum concrete cover.

The installation of the preformed joint filler is required before concrete placement in order to reestablish the joint or crack within the repair and to prevent the infiltration of the concrete into the crack or joint that runs through the repair. Allowing concrete to infiltrate into the joint or crack may cause a compression failure.

In some instances (mainly when concrete is removed under dowel bars), the preformed joint filler will not completely plug the joint or crack within the repair. If this circumstance is encountered, remove a section of the dowel to allow the placement of the preformed joint filler or place clean concrete sand to fill the void below the joint filler.

The practice of using sand in places where joint filler installation is impractical may result in a reduced repair life and is meant to be used on an occasional basis. Therefore, the Engineer should make an early determination of the extent of this type of fix and may want to use a Full Depth Repair (Type CD) in lieu of the Crack and Joint Repair (Type B3). The practice of using sand in places where joint filler installation is impractical may result in a reduced repair life and is meant to be used on an occasional basis. Therefore, the Engineer should make an early determination of the extent of this type of fix and may want to use a Full Depth Repair (Type CD) in lieu of the Crack and Joint Repair (Type B3).

The Engineer may allow sawing for joint establishment when **all** of the following conditions exist:

(1.1) Precautions are taken to prevent infiltration of concrete into underlying joint,
(1.2) Depth of the entire Type B repair remains above dowel bars,
(1.3) In order to prevent compression spalls, saw cut the entire depth of the Type B repair,
(1.4) Green sawing takes place in a timely manner, to prevent random cracks, and
(1.5) Green sawing does not produce excessive spalling.

The Engineer will not allow sawing for joint establishment if any of the following conditions exist:

(2.1) Type B repair depth extends below the top of the dowel bars, or
(2.2) Type B repair is used to repair a random crack.

D.2.a Application of Bonding Agent

The Contractor will choose a method for bonding the 3U18 mix to the in-place concrete in accordance with the following:

(1) Bonding Grout/Slurry Method
- (1.1) Provide and place bonding grout to the prepared concrete repair surface consisting of 2 parts of Type I or Type I/II portland cement and 1 part sand, mixed with sufficient water to form a slurry.
- (1.2) Mix the grout mechanically and apply by brushing or scrubbing (with a stiff bristle broom) on to the in place concrete surface. After applying the grout/slurry, immediately backfill repair with concrete.
- (1.3) If the bonding grout dries or whitens prior to backfilling, discontinue the concrete backfill operation. Re-sandblast the repair prior to reapply grout and concrete backfill.
- (1.4) The life of the grout shall not exceed one hour.

(2) Water Bonding Method
- (2.1) Apply clean potable water to the sandblasted concrete surface to achieve a saturated condition prior to concrete (3U18) backfilling. Apply multiple applications of potable water as necessary to achieve a saturated condition.
- (2.2) If standing water is visible within the limits Type B repair, discontinue concrete backfill operations.

(2.3) In accordance with 2302.3.D.3, an application of slurry/grout is still required at the repair surface.

D.3 Repair

Furnish concrete (MnDOT Grade 3U18), mix, place, surface finish, apply broom texture, apply grout slurry, cure and, saw and seal.

Provide a repaired surface tolerance that does not vary by more than 1/8 inch from the existing pavement surface as measured with a straight edge placed over the repair. Replace or grind the repair as necessary to correct deficiencies.

After radius edging all inserts, final finishing and providing broomed surface texture; apply a heavy application of bonding grout/slurry at the surface interface (around the perimeter) of the Type B repair and the in place concrete pavement. Position the grout/slurry band so 1 inch is over the in place pavement and 3 inches is located over the newly placed repair.

Apply the concrete cure in accordance with 2302.3.B.3, and protect the concrete repair from damage.

Saw and seal reestablished joints and cracks within Type B repairs in accordance with the Variable Width Joint Crack Repair / Joint Repair (Type A1).

E Type C Repairs

Type C Repairs include: Full Depth Repair (Type CD-LV), Full Depth Repair (Type CD-HV), Pavement Replacement (Type CX), Full Depth Repair (Type CA-LV), Spot Full Depth Repair (Type C1-LV) and Utility Trench Full Depth Repair (Type C2).

All repairs with the designation LV are intended for use on non-state designated roadways only. The Full Depth Repair (Type C1-LV, Type C2-LV and CA-LV) are for use on projects with small quantity of repairs. Contact the Concrete Engineering Unit for recommendations.

Saw cut concrete full depth and perform full-depth concrete removal; restore and compact the grade; install reinforcement bars, dowel bars, or both; and furnish, place, finish, and cure concrete and saw and seal joints.

E.1 Removals

Saw cut the concrete pavement full depth.

Remove in place concrete pavement. Removal of the concrete pavement must take place within 48 hours of the full depth saw cutting, unless otherwise allowed by the Engineer.

Repair or replace any damage to the adjacent pavement that occurs during the removal process to the satisfaction of the Engineer and at no cost to the Department.

E.2 Preparation

Furnish and install 18 in x 1.25 inch diameter dowel bars in conformance with Specification 3302 and details, or when the Full Depth Repair is used in the longitudinal direction furnish and install 18 in No. 8 epoxy coated reinforcement bars, in lieu of the dowel bars, in conformance with Specification 3301 and details. Provide dowel bars or reinforcement bars that are free of dirt, grease, oil or other foreign material.

Use drill bit(s) 1/8 inch **or** greater than the nominal outside diameter of the dowel bar or epoxy coated reinforcing steel that are anchored to the in place concrete pavement.

Provide a drill assembly or gang drill assemblies capable of drilling straight and true holes, to the required penetrating depth, drilling at mid concrete pavement thickness, and to the tolerances shown below.

Install dowel bars in Full Depth Repair (Type CD-LV), Full Depth Repair (Type CD-HV) and if applicable the Spot Full Depth Repair (Type C1-LV) in accordance with the following tolerances:

(1) The final placement of the dowel bars is 9 in into the face of the in place concrete slab,
(2) Parallel to the top of the pavement within +/- 1/4 inch,
(3) Parallel to the other dowel bars within +/- 1/8 inch, and
(4) Parallel to the roadway centerline +/- 1/2 inch.

Place dowel bar baskets assemblies as outlined in the Pavement Replacement (Type CX) and Full Depth Repair (Type CA-LV) details.

Use either the Epoxy Resin Adhesive (ERA) or Non-Shrink Grout (NSG) Installation Method to anchor the dowel bars and reinforcement bars into the concrete. Clean and prep the drilled holes in accordance with adhesive manufacturer's recommendations.

Final approval of the methods used to anchor dowels or reinforcement bars is based on actual field performance as verified by random coring.

E.2.a Epoxy Resin Adhesive (ERA) Installation Method

From the approved products list furnish an ERA material with a stated application of anchoring dowel bars or reinforcement bars. Provide to the Engineer an installation data sheet from the manufacturer. The ERA will meet AASHTO M 235 Type IV (Load Bearing Applications), Grade 3 (Non-sagging consistency) and of a Class (Temperature Range) to match the pavement temperature at the time of application. ERA Class (Temperature Range) designations are as follows:

(1) Class A, for use below 40°F.
(2) Class B, for use between 40°F and 60°F.
(3) Class C, for use above 60°F the highest allowable temperature to be defined by the manufacturer of the ERA.

When pavement temperatures are below 40°F use Class A, when pavement temperatures are between 40°F and 60°F use either Class A or B, when pavement temperatures are above 60°F use Class A, B or C.

ERA injection can be by either a mechanical caulking apparatus or a pneumatic injection system and have a nozzle capable of reaching and filling the back of the drill hole. In accordance with the manufacturer's recommendations, fill drill hole with adhesive and insert dowel or reinforcement bars.

E.2.b Non-Shrink Grout (NSG) Installation Method

From the approved products list furnish a NSG material with a stated application of anchoring horizontal dowel bars or reinforcement bars. Provide to the Engineer an installation data sheet from the manufacturer of NSG material.

Provide either self-contained grout capsule or pre bagged NSG utilizing an injection system capable of reaching and filling the back of the drill hole.

E.3 Prior to Concrete Placement

When placing concrete adjacent to in place concrete pavement joints, protect all ends of transverse joints to the satisfaction of the Engineer to prevent concrete mortar from infiltrating into the existing joints, resulting in compression spalls.

Do not remove any preformed joint filler used in the re-establishment of joints in Type C repairs, except by sawing or as allowed by the Engineer.

E.4 Repair

Furnish, place, finish, and cure concrete grades 3R52 or 3RHE52 for all Type C repairs.

In accordance with full depth repair details Types CD-HV, CD-LV, and CA-LV, furnish, and place transverse No. 4 epoxy coated reinforcing steel.

In accordance with the full depth repair detail Type C2-LV, furnish both transverse and longitudinal reinforcing steel.

In accordance with Pavement Replacement (Type CX) repair detail, drill and grout No. 4 by 18 in long epoxy coated reinforcing (tie) steel into the adjacent lane at a spacing of 30 in.

The Engineer will require corrective work on vertical surface deviations greater than 1/4 in within the span of the 10 ft straightedge in any direction. For corrected variations, the Engineer will accept deviations less than or equal to 1/4 in within the span of a 10 ft straightedge in any direction.

Restore contraction joints by green sawing to a depth of 1/3 of the pavement thickness.

In accordance with Joint Repair (Type A1) detail, prepare and seal all saw cuts and reestablished cracks.

E.5 Dowel Bar Anchoring Test Section

Provide a dowel bar anchoring test section consisting of a complete Full Depth Repair (Type CD) at a site directed by the Engineer at least one (1) day prior to startup of major Full Depth Repair (Type CD) operations. Perform the dowel bar anchoring test section as follows:

(1.1) Saw cut and remove in place pavement to the dimensions shown on the Full Depth Repair (Type CD) detail.
(1.2) In the test section drill and install either 6 or 11 dowels in accordance with appropriate Full Depth Repair (Type CD).
(1.3) Use either an MnDOT approved Epoxy Resin Adhesive or Non-Shrink Grout as an adhesive to secure the dowel bars to the in place concrete pavement.
(1.4) Cure the dowel bar anchoring adhesive at least 4 hours before coring.
(1.5) DO NOT PLACE CONCRETE IN THE DOWEL BAR TEST SECTION.
(1.6) The Engineer will identify and mark three (3) core locations on a single side of the Full Depth Repair (Type CD).
(1.7) Take three (3) – 4 inch diameter full depth cores centered on the dowel and 1 inch from the sawed vertical face.

The Engineer in conjunction with the Concrete Engineer will determine if the anchoring of the dowels is acceptable. The Concrete Engineer considers the anchoring method acceptable if no air voids are greater than ¼ inch in any direction. All cores will become the property of the Engineer.

If the Engineer determines the anchoring of the dowels **is** acceptable:

(2.1) The Engineer will notify the Contractor to begin production operations.
(2.2) The Engineer's continued acceptance is based on satisfactory placement and performance.
(2.3) Place a full depth saw cut offset 1 foot from the vertical face of the test section.
(2.4) Completely remove the cored side of the dowel bar test section.
(2.5) Drill and anchor a new set of dowels as shown on the Full Depth Repair (Type CD).
(2.6) The Engineer will pay for the work in this paragraph at the unit bid price of Full Depth Repair (Type CD) and Pavement Replacement (Type CX).
(2.7) The working days for the test section are built into the total Contract Time.

If the Engineer determines the anchoring of the dowels is **not** acceptable:

(3.1) The Engineer will require the removal of the first test section.
(3.2) The Engineer will require another test section at the contractor's expense.
(3.3) The Engineer will not extend the contract time for the additional test section.

The Engineer will consider the work in this section as incidental to the unit bid price for Full Depth Repair (Type CD) and Pavement Replacement (Type CX).

Provide traffic control for the test section in accordance with "Temporary Traffic Control Zone Layouts" or as shown in the Plans.

E.6 Dowel Bar Anchoring Assurance

At the Engineer's discretion, the Contractor will take additional cores to confirm consistent dowel bar or reinforcing steel anchoring. For each 1500 Lineal Feet of Full Depth Repair (Type CD), the Engineer will randomly choose two separate repairs and mark a dowel bars for an assurance core. The Engineer will review the cores to determine if the anchoring operations remain acceptable. If the dowel bars show air voids greater than that specified in 2302.3.E.5, take additional cores as directed by the Engineer to determine the severity.

The Engineer will suspend Full Depth Repair operations if dowel bars are anchored improperly. Operations will not resume until the Contractor has demonstrated to the Engineer that the problem which caused the air voids is corrected.

If the cores show proper anchoring, back fill core holes with concrete mix 3U18.

When the coring operations have shown no problems with the Contractor's dowel bar anchoring operations, the Engineer may decrease the frequency to two (2) assurance cores for every 3000 lineal feet of Full Depth Repair (Type CD).

The Engineer will consider the work in this section as incidental to the unit bid price for Full Depth Repair (Type CD) and Pavement Replacement (Type CX).

F Dowel Bar Retrofit

Retrofit dowel bars in mainline joints and/or mid panel cracks as shown on the Plans. Perform Dowel Bar Retrofits only after all other repairs are completed on the joint or crack.

F.1 Removal

Schedule operations so that all concrete removed during any work shift is replaced with dowel bars and backfill material prior to the time the lane is re-opened to traffic.

Employ saws equipped with gang mounted diamond blades capable of cutting the required amount of slots in each wheel path simultaneously. Vacuum up and remove water and saw residue from the pavement surface. Skewed joints or cracks may require slots longer than that specified in the details. The Engineer will not provide compensation for the additional sawing or any component of the dowel bar retrofit beyond the limits shown on the detail required to ensure at least 7 inches of dowel bar is placed on each side of the joint or crack. Limit traffic to five (5) days on sawn slots prior to completing the retrofit operation. For smaller projects (100 bars or less), the Engineer may allow walk-behind saws instead of slot saws as long as a template is used to ensure the slot locations are within the tolerances specified on the Dowel Bar Retrofit detail and below.

Make two saw cuts in the pavement to outline the longitudinal sides of each dowel bar slot. Saw the slots to the depth and length that allows placing the dowel at mid-depth in the pavement slab. Place the slot saw cuts:

(1) Parallel to the top of the pavement within +/- 1/4 inch,
(2) Parallel to the other slots within +/- 1/8 inch, and
(3) Parallel to the roadway **centerline** +/- 1/2 inch.

NOTE: Always measure dowel bar offsets from the roadway centerline.

Remove the concrete between the parallel saw cuts with a chipping hammer. Do not punch through the bottom of the slot or dislodge the pavement that is to remain in place. During concrete removal

operations, use a small brush hammer as necessary to produce a flat, level surface within the slot for placing the bar in the proper location. Dispose of the removal debris on a daily basis, unless otherwise approved by the Engineer.

F.2 Preparation

F.2.a Slot Cleaning and Preparation

Sufficiently clean the bottom of the slots with a chipping or brush hammer to allow the dowel bar assembly to sit parallel to the pavement surface.

If needed dry the slot before sandblasting with a high pressure air blasting heat lance.

Sandblast the vertical sides and bottom of the slot after the concrete removal operations to remove all loose debris and saw residue. Continue to sandblast until all the sawing residue is removed and the vertical sawed faces are rough to the touch. The Contractor may recommend alternative methods of roughening for approval by the Engineer. The Engineer will require additional sandblasting if the slots become wet from any source after initial sand and air blasting other than 2302.F.3.

Immediately before beginning sealing of the joint or crack inside the slot, further clean all exposed surfaces and cracks with a “moisture and oil free” high pressure air blasting of 150 psi minimum.

Protect traffic from sand and air blasting in a manner approved by the Engineer.

F.2.b Sealing Joints and Cracks in Slot

After sand and air blasting the slot, seal the bottom and sides of the crack with caulking material to keep the patching material from leaking into the joint or crack. Cure caulking material for a minimum of 2 hours or until tack free or according to the manufacturer's recommendations, whichever is longer, prior to placing the approved rapid set non-shrink concrete. The caulking filler shall not extend 1/2 inch beyond each side of the existing joint or crack. The Contractor may complete sealing of the cracks in conjunction with furnishing and installing the dowel assembly.

F.2.c Placing Dowel Assembly into Slot

Supply dowel bar chairs that provide a minimum of 1/2 in clearance between the bottom of the dowel and the bottom of the slot and with sufficient rigidity to hold the dowel bar in place during concrete placement and vibratory consolidation.

Furnish and install preformed joint filler in accordance with 2302.2.H.3, Dowel Bar Retrofit details, and the following:

(1.1) Provide a round hole in the preformed joint filler the same nominal diameter as the specified dowel bar. Use a slightly larger hole when necessary to accommodate a skewed joint or crack.

(1.2) Slots cut into the preformed joint filler to accommodate the dowel bar are not allowed.

(1.3) Locate the hole to provide enough preformed joint filler below the dowel to extend to the bottom of the slot.

(1.4) The preformed joint filler is required to remain centered over the joint or crack and tight to the bottom and edges of the slot during placement of the concrete. If the preformed joint filler shifts during construction operations or if a crack forms adjacent to the preformed joint filler, the Engineer will require removal and replacement of the dowel bar retrofit at the Contractor’s expense.

Apply form release agent as a bond breaker on dowel bars **prior** to their placement in the slots.

Install dowel assembly that has the bond breaker applied and is fitted with the compressible foam core board material, the support chairs, and the ¼ inch expansion caps on both ends into the slot in accordance with the following:

(2.1) Parallel to the top of the pavement within +/- 1/4 inch,

(2.2) Parallel to the other slots within +/- 1/8 inch,
(2.3) Parallel to the roadway **centerline** +/- 1/2 inch
NOTE: Measure dowel bar offsets from the roadway centerline
(2.4) Minimum of 1/2 inch clearance between the bottom of the dowel and the bottom of the slot.

F.3 Repair

Thoroughly moisten (with potable water) all surfaces of the slot immediately prior to filling with backfill material. The Engineer will not allow standing water in the slot.

Fill each prepared slot with an approved rapid set non-shrink concrete for dowel bar retrofit repairs. Ensure the compressible foam core board remains upright over the existing joint or crack during the backfill operation. Vibrate the rapid set non-shrink concrete with a small 1 inch diameter hand-held vibrator capable of thoroughly consolidating the concrete around the dowel bar and support chairs and without segregation.

Finish the concrete flush to within a tolerance of 1/16 inch above the adjacent concrete surface. When concrete grinding is part of the Contract, leave the surface of the backfill material 1/4 inch above the adjacent concrete surface.

Immediately after final finishing, coat concrete with a membrane curing compound in accordance with 2302.3.B.3.

F.4 Test Section

Provide a test section consisting of complete dowel bar retrofit at a site directed by the Engineer at least three (3) days prior to startup of major operations as follows:

(1.1) Install 24 retrofit dowels in the test section.
(1.2) The Engineer will identify and mark three (3) locations for coring.
(1.3) Take three – 4 inch diameter full depth cores through the dowel bar retrofits at least 4 hours after completion of the test section.

The Engineer will determine if the retrofitting operation is acceptable.

If the Engineer allows the retrofitting operation to continue:

(2.1) The Engineer will notify the Contractor to begin production operations.
(2.2) The Engineer's continued acceptance is based on satisfactory placement and performance.
(2.3) Completely remove and replace the dowel installation where the core samples were taken.
(2.4) The Engineer will pay for the work in this paragraph at the unit bid price for Dowel Bar Retrofit.
(2.5) The working days for the test section are built into the total Contract Time.

If approval of the retrofitting operation is not given:

(3.1) The Engineer will require the removal of the first test section.
(3.2) The Engineer will require another test section.
(3.3) The Engineer will not extend the contract time for the additional test section.

Provide traffic control for the test section in accordance with "Temporary Traffic Control Zone Layouts" or as shown in the Plans.

The Engineer will consider the work in this section as incidental to the unit bid price for Dowel Bar Retrofit.

F.5 Opening to traffic

The Engineer will not permit traffic by the public or Contractor on the newly placed concrete patching material until adequate strength is achieved, according to the manufacturer's recommendations or 3000 psi whichever is greater.

F.6 Retrofit Dowel Bar Placement Alignment Assurance

At the Engineer's discretion, the Contractor will take additional cores to confirm consistent dowel placement and proper consolidation for each 600 bars placed. The Engineer will randomly mark two retrofit locations for assurance coring. The Engineer will review the cores to determine if the retrofitting operation is acceptable. If the dowels are located incorrectly or air voids exist around the dowel bars, take additional cores, as directed by the Engineer, to determine the severity.

The Engineer will suspend dowel retrofitting operations if dowels are installed improperly. Dowel retrofitting operations will not resume until the contractor has demonstrated to the Engineer that the problem which caused the improper dowel positions or air voids is corrected. Replace any individual Dowel Bar Retrofit not functioning or damaged at the expense of the Contractor.

The Engineer will not allow water from the coring operation to flow across lanes occupied by public traffic or flow into closed drainage facilities.

After removal of the cores, completely remove and replace the dowel installation where the core samples were taken.

When the coring operations have shown no problems with the Contractor's placement operations, the Engineer may decrease the frequency of assurance cores to every 1200 bars placed or more at the discretion of the Concrete Engineer.

Provide traffic control for the coring in accordance with "Temporary Traffic Control Zone Layouts" or as shown in the Plans.

The Engineer will consider the work in this section as incidental to the unit bid price for dowel bar retrofit.

G Repair Warranty

Remove and replace areas of failure that appear within thirty (30) calendar days at no cost to the Department. The 30 calendar day warranty will commence after all Type B, Type C, Dowel Bar Retrofits repair **and** Concrete Grinding (when required) are completed in a single traffic lane. The continuity of a single traffic lane is not broken by either staging or project exceptions unless otherwise authorized by the Engineer. Any subsequent warranty repairs are subject to the 30 calendar day specification at no cost to the Department.

Failures include (but are not limited to) the loss of bonding to the in place concrete or crack apparent in the repair other than the desired crack in the newly constructed joint or re-established crack.

Supply traffic control as requested by the Department for inspection of repairs within the 30 calendar day warranty period and for the removal and replacement of repair failures.

2302.4 METHOD OF MEASUREMENT

The Engineer will:

(A) **Not** measure extra width to accommodate the Contractor's equipment. Any extra width to accommodate the Contractor's equipment is at the Contractor's expense.

(B) Measure Variable Width Joint or Crack Repair / Joint Repair (Type A1) by the lineal length. The Engineer will not take separate measurements for varying widths. The Engineer will **not** measure and pay the restoration of joints and cracks through or alongside any Type B, Type C or Dowel Bar Retrofit repairs under this item.

(C) Measure Variable Width In Place Joint or Crack Repair / Joint Repair (Type A2) by the lineal length. The Engineer will not take separate measurements for varying widths.

(D) Measure Partial Depth Repair (Type BA) by the actual area of the repair. Take the measurements for the area calculations at the pavement surface; include the 30 to 60 degree tapers in the measurements for the area calculations.

(E) Measure Joint and Crack repair (Type B3) by the lineal length. The Engineer will take additional measurements for payment under this or other Type B repairs only when the following requirement are met:

(1) In isolated areas the typical width of the repair is exceeded **and** the measured quantity is equal to or greater than 1 square foot. This is not a cumulative quantity within a single Type B3 repair.

(2) A full width pass with the mill is taken on both sides of the joint or crack as directed by the Engineer.

(3) The Type B3 repair is placed on only one side of the joint or crack, and the opposite side of the joint or crack requires an additional repair when directed by the Engineer, regardless of the size of the repair preformed.

(F) Measure Partial Depth Repair Special (Type BE) by the area of the repair. Take the measurements for the Partial Depth Repair Special (Type BE) area calculation at mid depth of the concrete pavement. Pay in conjunction with the Partial Depth Repair (Type BA) or Joint and Crack repair (Type B3). The Engineer will take measurements for the Partial Depth Repair Special (Type BE) only when the following requirements are met:

(1) When the in place concrete pavement is removed full depth, when the grade below the concrete pavement is visible and

(2) When reinforcement bars are furnished and installed as shown in Partial Depth Repair Special (Type BE) detail and at least one reinforcement bar is installed per unit of measure.

When the above requirements are not met the Engineer will only take measurements for payment on the Partial Depth Repair (Type BA) or Joint and Crack repair (Type B3) regardless of the depth of the repair.

(G) Provide measurement for payment for overlapping Type BA and Type B3 repairs for the most expensive repair only.

(H) Measure the Full Depth Repair (Type CD) by the lineal width. Take a single lineal measurement of the repair at a right angle from the standard dimension of 4 feet as shown on the Full Depth Repair (Type CD) detail. Unless the repair is placed at a skew to the roadway center line, then take the single lineal measurement along the skewed saw cut.

(I) Measure the Pavement Replacement (Type CX) by the area of the repair. Pay Pavement Replacement (Type CX) in conjunction with the Full Depth Repair (Type CD) or the Full Depth Repair (Type CA-LV). When the standard dimension of 4.0 feet as outlined on the Full Depth Repair (Type CD) or Full Depth Repair (Type CA-LV) detail is exceeded, measure the area that is outside the 4.0 feet dimension as Pavement Replacement (Type CX).

(J) Measure the Spot Full Depth Repair (Type C1-LV) by area of the repair.

(K) Measure the Utility Trench Full Depth Repair (Type C2-LV) by area of the repair.

(L) Measure the Full Depth Repair (Type CA-LV) by the lineal width. Take a single lineal measurement of the repair at a right angle from the standard dimension of 4 feet as shown on the

Full Depth Repair (Type CA-LV) detail. Unless the repair is placed at a skew to the roadway centerline, then take the single lineal measurement along the skewed saw cut.

(M) Measure individual Dowel Bars per each, as supplied in dowel bar basket assemblies for Pavement Replacement (Type CX) repairs.

(N) Measure Drill and Grout Reinforcement bars per each, as furnished and installed as tie bars for Pavement Replacement (Type CX) of 75 feet or greater in length.

(O) Measure Dowel Bar Retrofit per each dowel bar successfully installed.

(P) Measure Supplemental Reinforcement (Epoxy Coated) used for supplemental pavement reinforcement by mass.

2302.5 BASIS OF PAYMENT

The Engineer will pay for the various types of pavement, crack, joint and surface repairs in accordance with the schedule set forth below at the corresponding Contract unit bid price for each separate item of work. Which is compensation in full for costs of all materials, equipment, and labor required to complete the work as specified in the repair detail, to the satisfaction of the Engineer. Concrete mixes are considered incidental to the work in which they are incorporated.

(A) Payment for Variable Width Joint or Crack Repair / Joint Repair (Type A1) at the contract price per unit of measure is full compensation for all cost including but not limited to the cost of removing and disposing of the in place joint sealer, sawing cutting both faces of the joint or crack to the proper depth and width, cleaning, sandblasting. Furnishing and installing backer rod of the proper size and to the proper depth. Furnishing and installing (hot poured) Joint and Crack Sealer (3725). Cleanup, and any other materials, labor, or equipment necessary to complete the work as specified.

(B) Payment for Variable Width In Place Joint or Crack Repair / Joint Repair (Type A2) at the contract price per unit of measure is full compensation for all cost including but not limited to: Removing of the in place joint sealer, cleaning, sandblasting, furnishing and installing backer rod of the proper size and to the proper depth. Furnishing and installing (hot poured) Joint and Crack Sealer (3725). Cleanup, and any other materials, labor, or equipment necessary to complete the work as specified.

(C) Payment for Partial Depth Repair (Type BA) at the contract price per unit of measure is full compensation for all cost including but not limited to: Removing and disposing of the in place concrete pavement as marked by the Engineer, tapering the edges of the repair back at 30 to 60 degrees, cleaning, sandblasting and air blasting, furnishing and installing bonding grout, furnishing and installing preformed joint filler to reestablish the joint or crack within or along the repair. Furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, placing cement and sand slurry around the edges, curing and protecting the concrete. Sawing and sealing reestablished joints and cracks in accordance with the Joint Repair (Type A1) detail. Cleanup, and any other materials, labor, or equipment necessary to complete the work as specified.

(D) Payment for Joint and Crack repair (Type B3) at the contract price per unit of measure is full compensation for all cost including but not limited to: Removing and disposing of the in place concrete pavement as marked by the Engineer, tapering the edges of the repair back at 30 to 60 degrees, cleaning and sandblasting, furnishing and installing preformed joint filler to reestablish the joint or crack within or along the repair, furnishing and installing bonding grout. Furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, placing cement and sand slurry around the edges, curing and protecting the concrete. Sawing and sealing reestablished joints and cracks in accordance with the Joint Repair (Type A1) detail. Cleanup and any other materials, labor, or equipment necessary to complete the work as specified.

(E) Payment for Partial Depth Repair Special (Type BE) at the contract price per unit of measure is full compensation for all cost including but not limited to: Removing and disposing of the in place concrete pavement as marked by the Engineer, cleaning, sandblasting and air blasting, furnishing and grouting reinforcement bars (epoxy coated), furnishing and installing bonding grout, furnishing and installing preformed joint filler to reestablish the joint or crack within or along the repair. Furnishing and placing concrete within the repair and vibrating.

(F) If after removal the Engineer changes the initial Partial Depth Repair (Type BA) or Joint and Crack Repair (Type B3) to a Full Depth Repair (Type CD), the Department will pay the Contractor at a measured quantity of 40% of the Type B repair item plus the full cost for the Type C repair.

(G) Payment for full Depth Repair (Type CD) at the contract price per unit of measure is full compensation for all cost including but not limited to: Saw cutting the pavement full depth, removal and disposal of the in place pavement, restoring and compacting the base, furnishing and installing preformed joint filler, furnishing, drilling and anchoring dowel bars, coring both the dowel bar anchoring test section and the random assurance cores, and backfilling the assurance core holes with concrete mix 3U18. If the repair is used in the longitudinal direction, furnishing, drilling and anchoring reinforcement bars in lieu of dowel bars. Furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, curing and protecting the concrete. Sawing and sealing reestablished joints, cracks and saw cuts in accordance with the Joint Repair (Type A1) detail. Cleanup and any other materials, labor, or equipment necessary to complete the work as specified.

(H) Payment for Pavement Replacement (Type CX) at the contract price per unit of measure is full compensation for all cost including but not limited to: Saw cutting the pavement full depth, removing and disposal of the in place pavement, restoring and compacting the base, furnishing and installing preformed joint filler. Furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, curing and protecting the concrete. Sawing and sealing reestablished crack, joints and saw cuts in accordance with the Joint Repair (Type A1) repair detail. Cleanup and any other materials, labor, or equipment necessary to complete the work as specified.

(I) Payment for Spot Full Depth Repair (Type C1-LV) at the contract price per unit of measure is full compensation for all cost including but not limited to: Saw cutting the pavement full depth, removal and disposal of the in place pavement, restoring and compacting the base, furnishing and installing preformed joint filler, furnishing, drilling and grouting dowel bars, epoxy coated reinforcement bars or both. Furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, curing and protecting the concrete. Sawing and sealing reestablished joints, cracks and saw cuts in accordance with the Joint Repair (Type A1) detail. Cleanup and any other materials, labor, or equipment necessary to complete the work as specified.

(J) Payment for Utility Trench Full Depth Repair (Type C2-LV) at the contract price per unit of measure is full compensation for all cost including but not limited to: Saw cutting the pavement full depth, removal and disposal of the in place pavement, restoring and compacting the base. Furnishing and installing preformed joint filler, furnishing, drilling and grouting epoxy coated reinforcement bars. Furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, curing and protecting the concrete. Sawing and sealing reestablished joints, cracks and saw cuts in accordance with the Joint Repair (Type A1) detail. Cleanup, and any other materials, labor, or equipment necessary to complete the work as specified.

(K) Payment for Full Depth Repair (Type CA-LV) at the contract price per unit of measure is full compensation for all cost including but not limited to: Saw cutting the pavement full depth, removal and disposal of the in place pavement, restoring and compacting the base, furnishing and

installing preformed joint filler and dowel bar baskets assemblies, drilling and grouting reinforcement bars. Furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, curing and protecting the concrete. Sawing and sealing reestablished joints, cracks and saw cuts in accordance with the Joint Repair (Type A1) detail. Cleanup, and any other materials, labor, or equipment necessary to complete the work as specified.

(L) Payment for Drill and Grout Reinforcement Bars at the contract price per unit of measure is full compensation for all cost including but not limited to, drilling concrete and furnishing reinforcement bars (epoxy coated) and installing reinforcement bars with an approved grout or epoxy bonding agent.

(M) Payment for Dowel Bar Retrofit at the contract price per unit of measure is full compensation for all cost including but not limited to: Sawing the slot, removal of the concrete within the slot, removing and vacuuming debris, sandblasting and air blasting, sealing the crack inside of the slot, the dowel bar and expansion caps, chairs, release agent, preformed joint filler or cardboard material. Furnishing and placing non-shrink rapid setting concrete mixture, finishing, curing and protecting the concrete. Sawing and sealing reestablished joints and cracks in accordance with the Joint Repair (Type A1) detail. Cleanup, and any other materials, labor, or equipment necessary to complete the work as specified.

(N) Payment for Supplemental Reinforcement Bars (Epoxy Coated) at the contract price per unit of measure is full compensation for all cost including but not limited to, furnishing and installing reinforcement bars (Epoxy Coated) as specified.

(O) Payment for Dowel Bars at the contract price per unit of measure is full compensation for all cost including but not limited to, furnishing and installing dowel bars in dowel bar baskets assemblies.

(P) The Engineer will modify the provisions of MnDOT 1907 to the extent that when the actual usage of joint sealer material is less than specified, the surplus material shall remain the property of the Contractor. The Contractor is paid 15% of the material cost in lieu of handling and transportation costs, unless otherwise directed by the Engineer.

Item No.	Item	Unit
2302.602	Dowel Bar Retrofit	each
2302.602	Dowel Bar	each
2302.602	Drill and Grout Reinforcement Bar (Epoxy Coated)	each
2302.603	Joint Repair (Type A1)	linear foot
2302.603	Joint Repair (Type A2)	linear foot
2302.603	Joint and Crack Repair (Type B3)	linear foot
2302.603	Full Depth Repair (Type CA-LV)	linear foot
2302.603	Full Depth Repair (Type CD-LV)	linear foot
2302.603	Full Depth Repair (Type CD-HV)	linear foot
2302.604	Pavement Replacement (Type CX)	square yard
2302.604	Utility Trench Full Depth Repair (Type C2-LV)	square yard
2302.608	Supplemental Reinforcement Bars (Epoxy Coated)	pound
2302.618	Partial Depth Repair (Type BA)	square foot
2302.618	Partial Depth Repair Special (Type BE)	square foot
2302.618	Spot Full Depth Repair (Type C1-LV)	square foot

S-3 (2461) STRUCTURAL CONCRETE

REVISED 01/04/19

SP2018-156

MnDOT 2461 is modified as follows:

S-3.1 MnDOT 2461.2.F.1.c shall be deleted and replaced with the following:

F.1.c Slump Designation

The Department will designate the maximum slump as defined by the Grade Designation in accordance with Table 2461-6 and Table 2461-7.

S-3.2 Table 2461-3 of MnDOT 2461.2.F.1.d shall be deleted and replaced with the following:

Table 2461-3
Coarse Aggregate Gradation Designation for Concrete

Designation	Coarse Aggregate Gradation
1	2301, Concrete Pavement Only
	Table 3137-4, "Coarse Aggregate Designation for Concrete"
2	ASTM #67
3	ASTM #7
4	ASTM #89
7	CA-70
8	CA-80

S-3.3 Table 2461-6 of MnDOT 2461.2.F.2.b(1) shall deleted and replaced with the following:

Table 2461-6
Concrete Mix Design Requirements (Not applicable to Mass Concrete)

Concrete Grade	OLD Mix Number	NEW Mix Number	Intended Use *	Maximum w/c ratio ‖	Maximum Cementitious Content (lbs/yd³)	Maximum %SCM (Fly Ash/ Slag/Ternary)	Slump Range	Minimum 28-day Compressive Strength, f'c	3137 Spec.
B Bridge Substructure	3Y43	3B52	Abutment, stems, wingwalls, paving brackets, pier columns and caps, pier struts	0.45	750	30/35/40	2 - 5"	4000 psi	2.D.1
F Flatwork	3A22 3Y22	3F32	Curb and gutter	0.42	750	30/35/0	½ - 3" #	4500 psi	2.D.1
	3A32 3Y32 3A34	3F52 3F57EX † 3F52CO ‡	Sidewalk, curb and gutter, slope paving, median sidewalk, driveway entrances, ADA pedestrian sidewalk	0.45	750	25/30/0	2 - 5"	4500 psi	2.D.1
G General Concrete	1A43	1G52	Footings and pilecap	0.55	750	30/35/40	2 - 5"	4500 psi	2.D.1
	3A43 3B42 3Y43	3G52	Footings, pilecap, walls, cast-in-place manholes and catch basins, fence posts, signal bases, light pole foundations, erosion control structures, cast-in-place box culverts, culvert headwalls, open flumes, cast-in-place wall stems	0.45	750	30/35/40	2 - 5"	4500 psi	2.D.1
M Median Barrier	3Y12	3M12	Slipform barrier, Median barrier, non-bridge	0.42	750	30/35/40	½ - 1" #	4500 psi	2.D.1
	3Y32	3M52	Barrier, Median barrier, non-bridge	0.45	750	30/35/40	2 - 5"	4500 psi	2.D.1
P Piling	1A43	1P42	MSE and gravity wall leveling pad	0.63	750	30/35/40	2 - 4"	3000 psi	2.D.1
	1C62	1P62	Piling, spread footing leveling pad	0.63	750	30/35/40	3 - 6"	3000 psi	2.D.1
R Pavement Rehabilitation	3A32 3B42	3R52	CPR - Full depth concrete repairs, concrete base	0.45	750	30/35/40	2 - 5"	4000 psi	2.D.3
S Bridge Superstructure	3Y16	3S12	Slipform bridge barrier, parapets, end post	0.42	750	30/35/40	½ - 1" #	4000 psi	2.D.2
	3A32 3A42 3Y43 3Y46 3Y46A	3S52	Median barrier, raised median, pilaster, curb, sidewalk, approach panel, formed bridge barrier, parapet, end post, collar	0.45	750	30/35/40	2 - 5"	4000 psi	2.D.2
X Miscellaneous Bridge	1X62 1X46	1X62	Cofferdam seals, rock sockets, drilled shafts	0.45	750	30/35/40	3 - 6"	5000 psi	2.D.1
	3X46	3X62	Drilled shafts above frost line	0.45	750	30/35/40	3 - 6"	5000 psi	2.D.1
Y Bridge Deck	3Y33 3Y33A 3Y36 3Y36A	3Y42-M § 3Y42-S §	Bridge decks, integral abutment diaphragms, pier continuity diaphragms, expansion joint replacement mix	0.45	750	30/35/40	2 - 4"	4000 psi	2.D.2
	3A37 3Y37	3Y47 **	Deck patching mix	0.45	750	30/35/40	2 - 4"	4000 psi	2.D.2

* If the intended use is not included elsewhere in the Specification or Special Provisions, use mix 3G52, unless otherwise directed by the Engineer.
‖ The minimum water/cement (w/c) ratio is 0.30.
† Mix 3F57EX requires the use of Coarse Aggregate Designation "7", "2" or "3" for the 4th digit in accordance with Table 2461-3.
‡ Identify specific color used on the certificate of compliance. Colored concrete is only allowed when specified in the plans or the Contract.
# Adjust slump in accordance with 2461.3.G.7.a for slipform concrete placement.
§ The "-S" indicates a bridge deck with a structural slab and "-M" indicates a monolithic bridge deck.
** Mix 3Y47 requires the use of Coarse Aggregate Designation "7" or "3" for the 4th digit in accordance with Table 2461-3.

S-3.4 Table 2461-7 of MnDOT 2461.2.F.2.b(3) shall be deleted and replaced with the following:

Table 2461-7
High-Early (HE) Concrete Requirements
(Not applicable to Bridge Superstructure or Mass Concrete)

Mix Number	Concrete Grades Allowed	Minimum Time to Opening	Maximum w/c ratio	Maximum Cementitious Content (lbs/ yd^3) *	Slump Range	Minimum Strength to Opening	Minimum 28-day Compressive Strength, f'c	3137 Spec.
1PHE62 ‖	P	-	0.63	750	3 - 6"	-	3000 psi	2.D.1
3HE32	F	48 hrs	0.42	750	1 – 3" †	3000 psi	4500 psi	2.D.1
3HE52	B, F, G	48 hrs	0.42	750	2 – 5"	3000 psi	4500 psi	2.D.1
3YHE52	Y (Repairs Only)	48 hrs	0.42	750	2 – 5"	3000 psi	4000 psi	2.D.2
3RHE52	R (Repairs Only)	48 hrs	0.42	750	2 – 5"	3000 psi	4000 psi	2.D.3

* Supplementary Cementitious Materials allowed.
‖ Used only for placing concrete in piles during freezing temperatures, provide 30 percent additional cement to the concrete mix for concrete 10 feet below the ground line or water line in accordance with 2452.3.D.6, "Cast-in-Place Concrete Piles."
† Adjust slump in accordance with 2461.3.G.7.a,"Concrete Placed by the Slip-form Method."

S-3.5 Table 2461-8 of MnDOT 2461.2.F.2.b(3) shall be deleted and replaced with the following:

Table 2461-8
Project Specific Contractor Designed Mixes

Concrete Grade	Intended Use	Specification	3137 Spec.
A	Concrete Pavement	2301	2.D.3
M, V, W, Z	Precast Concrete	2462	Varies
HPC	High Performance Concrete	Special Provision 2401	2.D.2
MC	Mass Concrete	Special Provision 2401	Varies
CLSM	Cellular Concrete Grout	2519	None
All concrete grades	Delivery time is > 90 minutes	2461.3.G.3.a	Varies

S-3.6 MnDOT 2461.2.F.3 shall be deleted and replaced with the following:

F.3 Submittal Requirements

At least 21 calendar days before initial placement of the concrete, submit the appropriate *General Concrete Mix Design Submittal* form to the Concrete Engineer for approval. Always use the most current forms available from the MnDOT Concrete Engineering Website.

Design the concrete mix to an absolute volume of 27.00 – 27.27 cu. ft.

The Concrete Engineer will:

(1) Provide specific gravity and absorption data using oven dry (OD) weights for mix design calculations.

(2) Review the mix design submittal and approve the materials and mix design for compliance with the Specifications.

Table 2461-9 defines the mix design submittal requirements for Level 1 and Level 2 Mixes.

S-3.7 Table 2461-9 of MnDOT 2461.2.F.3 shall be deleted and replaced with the following:

Table 2461-9
Mix Design Submittal Requirements

	SCM Substitution Limits	Fine Aggregate Limit	Gradation Requirements	Preliminary Test Data Requirements	Submittal Package
Level 1 Mixes *	Fly Ash: 0 – 15% Slag: 0 – 35%	40 – 45% of total aggregate by volume ‖	3126 and 3137	None	General Concrete Mix Design
Level 2 Mixes	Fly Ash: > 15% Ternary: Any	None	Use Either: • 3126 and 3137 • Job Mix Formula (JMF)	2461.2.F.3.a	Use Either: • General Concrete Mix Design • General Concrete Mix Design (JMF)

* High Early concrete in accordance with Table 2461-7 is defined as a Level 1 Mix.
‖ Fine aggregate limit does not apply to exposed aggregate concrete mixes.

S-3.8 The second paragraph of MnDOT 2461.2.F.3.a(1) shall be deleted and replaced with the following:

The Concrete Engineer considers a suitable experience record to have the following characteristics as compared to the proposed mix:

(A) A required average strength (f'cr) no greater than 1000 psi above the required 28-day compressive strength,
(B) Same type or grade of cementitious materials,
(C) Same class of coarse aggregate,
(D) Same supplementary cementitious proportion,
(E) Aggregate weights within 10% of the proposed,
(F) Water/Cement ratio no greater than 0.45,
(G) Total cementitious weight within 5% of proposed, and
(H) Batching conditions and testing procedures similar to those expected for the proposed work.

S-3.9 Table 2461-10 of MnDOT 2461.2.F.3.b shall be deleted and replaced with the following:

Table 2461-10
Required Average Strength (f'cr) Equations*

	Required Average Strength
f'c ≤ 5000 psi*	f'cr = f'c + 1.34S **OR** f'cr = f'c + 2.33S – 500
f'c > 5000 psi	f'cr = 0.90f'c + 2.33S

*When f'c ≤ 5000 psi, f'cr is the larger value computed from the equations.

S-3.10 Table 2461-11 of MnDOT 2461.2.F.4 shall be deleted and replaced with the following:

Table 2461-11
Mix Design Adjustments Requirements

	Type of Change or Adjustment	Mix Design Resubmittal Requirements

Level 1 Mixes	• Cementitious Sources • Admixture Sources • Admixture Dosage Rate	No resubmittal required
	• Aggregate Sources • Aggregate Proportions • Any cementitious proportion (≤ 15% max fly ash)	Resubmittal of Mix Design
	• Any cementitious proportion (> 15% max fly ash)	Resubmittal in accordance with 2461.2.F.3.a
Level 2 Mixes	• Cementitious Sources • Admixture Dosage Rate	No resubmittal required
	• Aggregate Source, no change in Aggregate Class • ≤ 5% Total Cementitious • ≤ 10% Aggregate Weights	Resubmittal of Mix Design
	• Aggregate Source and Class of Coarse Aggregate • Supplementary Cementitious Proportion • > 5% Total Cementitious • > 10% Aggregate Weights • Admixture Sources	Resubmittal in accordance with 2461.2.F.3.a
* Only one (1) increase in total cementitious allowed per mix design, next adjustment requires resubmittal in accordance with 2461.2.F.3.a, "Preliminary Test Data Requirements for Level 2 Mixes"		

S-3.11 MnDOT 2461.3.D shall be deleted and replaced with the following:

D Batching Requirements

The Concrete Engineer will allow only Large Capacity Scale companies authorized by the Minnesota Department of Commerce, Weights and Measures Division to calibrate weighting equipment and meters for MnDOT projects. A list of authorized companies is available from the MnDOT Concrete Engineering Unit website.

Calibration of weighing equipment is required within three months prior to plant certification each calendar year. Calibrate weighing equipment and perform spot checks in accordance with the Concrete Manual.

S-3.12 The second paragraph of MnDOT 2461.3.D.1.c shall be deleted and replaced with the following:

Calibration of the water meter is required within three months prior to plant certification each calendar year. Calibrate the water meter and perform spot checks in accordance with the Concrete Manual.

S-3.13 MnDOT 2461.3.F through MnDOT 2461.3.F.5.f shall be deleted and replaced with the following:

F Certified Ready-Mix Concrete

Provide concrete from a certified ready-mix plant listed on the MnDOT Concrete Engineering Unit website. Ensure the Producer performs quality control of concrete production and complies with the MnDOT Certified Ready-Mix Plant Program.

Provide batches for a delivered load of concrete in sizes of at least 1 cu. yd.

The Engineer may reject ready-mix concrete delivered to the work site that does not meet the specified requirements for delivery time, consistency, quality, air content, or other properties, as unauthorized or unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

F.1 Certified Ready-Mix Plant Program

The Producer will perform Quality Control (QC) under the certification program for ready-mix concrete plants in accordance with 2461.3.F.4, "Contractor Quality Control." The Engineer will perform Quality Assurance (QA) as part of the acceptance process in accordance with 2461.3.F.5, "Agency Quality Assurance."

F.1.a Plant Certification

Prior to the production of Department concrete each construction season, a MnDOT Certified Concrete Plant Technician, representing the Department, shall perform a thorough on-site inspection of the concrete plant with a MnDOT Certified Concrete Plant Technician, representing the Producer.

In order to obtain certification, complete the following:

(1) The Producer will complete MnDOT Form 2163, *Concrete Plant Contact Report,* prior to the on-site inspection with the Department Representative.
  (1.1) A MnDOT Certified Concrete Plant Technician, representing the Producer, signs the *Concrete Plant Contact Report* certifying compliance with the Certified Ready Mix requirements and continual maintenance of the plant to assure that the plant can produce concrete meeting MnDOT Specifications.
  (1.2) A MnDOT Certified Concrete Plant Technician, representing the Department, signs the *Concrete Plant Contact Report* signifying that the plant complies with all requirements prior to concrete production.
(2) Identify all persons responsible for testing and overseeing plant operations on MnDOT Form 2163, *Concrete Plant Contact Report*. Provide their email, cell phone number, and MnDOT Technical Certification number.
(3) Include a site map showing stockpile locations identified with the MnDOT pit number.
(4) Provide cementitious and admixture samples.
(5) Provide a computerized batching system capable of meeting the requirements of 2461.3.F.2, "Certificate of Compliance."
(6) Provide continuous access on-site to the Concrete Manual available from MnDOT's website.
(7) Supply a working email address, including an active internet connection, at the certified ready-mix plant.
(8) Provide calibrated electronic scales for weighing all materials.
(9) Provide facilities in accordance with 1604, "Plant Inspection – Commercial Facility," for the use of the plant technician in performing tests.

The Department Representative will submit the completed Contact Report and current Certificate of Compliance to the MnDOT Concrete Engineer for final determination of certification.

F.1.b Maintaining Plant Certification

The Producer will maintain plant certification by:

(1) Displaying the current Contact Report and site map in plain sight at all times.
(2) Updating the Contact Report with any material or equipment changes and submitting to the Department.
(3) Making Producer Plant QC Workbook and QC charts available electronically at all times.
(4) Performing the responsibilities identified in 2461.3.F.4, "Contractor Quality Control."
(5) Supplying the following information at the request of the Engineer:
  (5.1) Approved mix design sheets,
  (5.2) Agency cementitious and admixture test results,
  (5.3) Agency verification gradation test results,
  (5.4) Aggregate quality test results.
(6) Keeping plant reports, charts, and supporting documentation on file at the plant site for 5 calendar years.

F.1.c Certified Ready-Mix Plant Decertification

The Concrete Engineer, with coordination from the Engineer, may decertify the plant and halt production of concrete under any of the following conditions:

(1) Unauthorized procedural, material, or equipment changes made after the completion of the Concrete Plant Contact Report,
(2) Failure to meet the required testing rates,
(3) Failure to complete required documents,
(4) Failure to provide competent MnDOT Certified Plant Technicians,
(5) Disregard of any of the requirements of 2461.3.F, "Certified Ready-Mix Concrete," or
(6) Falsification of test records or certificates of compliance.

F.2 Certificate of Compliance

Provide a computerized Certificate of Compliance with each truckload of ready-mixed concrete at the time of delivery. The Department defines computerized to mean a document that records mix design quantities from load cells and meters.

If the computer that generates the Certificate of Compliance malfunctions, the Engineer may allow the Contractor to finish any pours in progress if the Producer issues a handwritten MnDOT Form 0042, *Certificate of Compliance* with each load. The Engineer will not allow the Producer to begin new pours without a working computerized Certificate of Compliance.

Provide a computerized Certificate of Compliance that includes all of the following information:

(1) Name of the ready-mix concrete plant,
(2) Name of the Contractor,
(3) Date,
(4) State Project Number (SP) or (SAP),
(5) Bridge Number (if applicable),
(6) Time concrete was batched,
(7) Truck number,
(8) Quantity of concrete in this load,
(9) Running total of each type of concrete, each day for each project,
(10) Type of concrete (MnDOT Mix Designation Number),
(11) Cementitious materials using MnDOT Standard Abbreviations,
(12) Admixtures using MnDOT Standard Abbreviations,
(13) Aggregate sources using 5 digit State Pit Numbers,
(14) Admixture quantity in fluid ounces per 100 lb of cementitious materials or ounces per cubic yard,
(15) Batch weights in columns in accordance with Table 2461-12:
    (15.1) Print in order a through k.
    (15.2) Use formula to calculate weights.
    (15.3) Head columns with Standard Labels.

Table 2461-12
Standard Certificate of Compliance Labels

	Formula Letter	Formula	Standard Label
a	Ingredients (aggregate, cementitious, water, admixture type)	—	Ingredient
b	Product Source (MnDOT Standard Abbreviation)	—	Source
c	Total Moisture Factor (in decimals to 3 places)	—	MCFac
d	Absorption Factor (in decimals to 3 places)	—	AbsFac
e	MnDOT mix design oven dry (OD) weights, *lb/cu. yd*	—	OD
f	Absorbed moisture in the aggregates, *lb/cu. yd*	(e × d)	Abs
g	Saturated surface dry (SSD) weights for aggregates, *lb/cu. yd*)	(e + f)	SSD
h	Free moisture, *lb/cu. yd*	(c - d) × e	Free Mst
i	Target weights for one cubic yard of concrete, *lb/cu. yd*	(g + h)	CY Targ
j	Target batch weights, *lb*	(cu. yd × i) [cu. m × i]	Target
k	Actual batch weights, *lb*	—	Actual

NOTE: Actual cubic yards batched may vary due to differences in air content, weight tolerances, specific gravities of aggregates, and other variables.

(16) Total Water (Batch Water + Free Moisture) in pounds,
(17) Water available to add [(Mix Design Water × Batch Size) – Total water] in gallons,
(18) Space to note the water adjustment information, including:
  (18.1) Water in gallons added to truck at plant (filled in by Producer, enter zero if no water is added),
  (18.2) Water in gallons added to truck at the jobsite (filled in by Producer or Engineer, enter zero if no water is added), and
  (18.3) Total actual water in pounds (Total Water from Certificate of Compliance plus any additions).
(19) The following information printed with enough room beside each item to allow the Engineer to record the test results:
  (19.1) Air content,
  (19.2) Air temperature,
  (19.3) Concrete temperature,
  (19.4) Slump,
  (19.5) Cylinder number,
  (19.6) Location or part of structure,
  (19.7) Time discharge, and
  (19.8) Signature of Inspector.
(20) Location for the Producer signature,
(21) For colored concrete, final color.

F.3 Definitions

The Department defines ready-mix concrete as one of the following:
(1) Central-mixed concrete proportioned and mixed in a stationary plant and hauled to the point of placement in revolving drum agitator trucks or a truck mixer, or
(2) Truck-mixed concrete proportioned in a stationary plant and fully mixed in truck mixers.

Table 2461-13 defines commonly used certified ready-mix terms.

Table 2461-13 Certified Ready-Mix Terminology	
Term	Definition
Mix design water	The maximum allowable water content for 1 cu. yd of concrete.
Total moisture factor	Factor used to determine total amount of water carried by a given wet aggregate.
Absorption factor	Factor used to determine the water contained within the pores of the aggregate and is held within the particles by capillary force.
Free moisture	The water that is carried on the surface of the aggregate that becomes part of the total water.
Batch water	Water actually batched into the truck by the batcher. Batch water includes potable water and clarified water.
Total water	Batch water added to free moisture. Total water may also include the water used in diluting admixture solutions.
Temper water	Water added in mixer to adjust slump.
Total actual water	The water in the concrete mixture at the time of placement from any source other than the amount absorbed by the aggregate. It includes all batch water placed in the mixer, free moisture on the aggregate and any water added to the ready mix truck prior to placement.
Ready-Mix Producer or "Producer"	Party that is producing the concrete for the Contract. It is understood that the Ready-Mix Producer is the agent of the Contractor.
Water/Cement (w/c) Ratio	W/C ratio is defined as the ratio of the total water weight to the total cementitious weight, which includes cement and supplementary cementitious materials.
Real time	The actual time during which something takes place.

F.4 Contractor Quality Control (QC)

The Producer's daily responsibilities include the following:

(1) Provide qualified personnel.
(2) Maintain laboratory equipment within allowable tolerances.
(3) Randomly spot check concrete batching to verify batch weights and tolerances.
(4) Check the bins and piles for segregation, contamination, or interblending of the aggregates.
(5) Check that mix trucks are clean, blades are not worn, and revolution counters are working properly.

F.4.a Personnel

The Producer will provide the following personnel:

(1) QC Plant Technician(s) to perform all testing and quality control requirements of 2461. The QC Plant Technician shall hold a current MnDOT Concrete Plant Certification.
(2) Quality Control Supervisor responsible for oversight of all QC testing and daily plant operations. The Quality Control Supervisor shall hold a current MnDOT Concrete Plant Certification and is required to remain on-site during concrete production or have cellular phone availability.
(3) Quality Control Manager responsible for oversight of the Quality Control Supervisor and the certified ready-mix plant program.

F.4.b Sampling and Testing

Take aggregate, cementitious, and admixtures samples in accordance with ASTM D 3665, Section 5, at a rate defined in the Schedule of Materials Control. Perform sampling and testing in accordance with the Concrete Manual. The Engineer may oversee the QC sampling and testing process.

Perform gradation and moisture testing at the certified ready-mix plant site. Use mechanical shakers for sieve analysis.

Provide equipment and perform calibrations meeting the requirements of the following:
(1) AASHTO T 27, "Sieve Analysis of Fine and Coarse Aggregates,"
(2) AASHTO T 255, "Total Moisture Content of Aggregate by Drying,"
(3) AASHTO M 92, "Wire-cloth Sieves for Testing Purpose," and
(4) AASHTO M 231, "Weighing Devices Used in the Testing of Materials."

F.4.c Aggregate Gradations

Complete the *Concrete Aggregate Worksheet* for each aggregate size and source:
(1.1) QC Gradations: If a QC gradation fails, retest immediately documenting both results. If an additional QC test is required for that week, the Engineer will not allow a retest gradation as a substitute for a QC gradation.
(1.2) Verification Companion Gradations: The Engineer will not allow a verification companion gradation as a substitute for a QC gradation.

Identify QC companion samples with the following information:
(2.1) Date,
(2.2) Test number,
(2.3) Time,
(2.4) Type of material,
(2.5) Plant, and
(2.6) Sampling location.

F.4.d Moisture Content

Determine the moisture content using the oven-dry method in the Concrete Manual. Complete the *Batching Report* for each aggregate size and source. Observe the batch person enter moisture contents into the batching system. Verify the moisture contents were entered correctly on the Certificate of Compliance.

F.4.e Concrete Ready-Mix Plant QC Workbook

Complete the *Concrete Ready-Mix Plant QC Workbook* which includes all of the following documents:
(1) Diary
(2) Batching Report
(3) Concrete Aggregate Worksheet
(4) Weekly Concrete Aggregate Report
(5) JMF Concrete Aggregate Worksheet
(6) JMF Weekly Concrete Aggregate Report

The Producer will maintain the *Concrete Ready-Mix Plant QC Workbook* in real time using their full name for the diary and each test performed.

Submit to the Engineer and the Concrete Engineering Unit by the Tuesday immediately following the previous week's production.

F.4.f Aggregate Gradation Control Charts and Sample Log

(1) Complete the *Aggregate Gradation Control Charts* in real time for each aggregate size and aggregate source:
  (1.1) Record Producer QC gradation and Verification Companion gradation results. These results are included in the moving average calculation.
  (1.2) Record Verification Gradation results. These results are <u>not</u> included in the moving average calculation.
(2) Complete *Sample Log* in real time for all samples taken:
  (2.1) Record all aggregate samples taken by the Agency.

(2.2) Record cementitious and admixture samples taken by the Producer and picked up by the Agency.

F.4.g Signing the Certificate of Compliance

The Producer's MnDOT Certified Concrete Plant Technician will:

(1) Review the first Certificate of Compliance for each mix type, each day, for accuracy; and

(2) Legibly hand sign the Certificate of Compliance at a location designated for Producer signature signifying agreement to the terms of this program and to certify that the materials comply with the requirements of the Contract; and

(3) Print their name and write their MnDOT Technical Certification Number next to their signature.

F.5 Agency Quality Assurance (QA)

The Engineer's responsibilities each time the plant is visited include the following:

(1) Confirm the *Concrete Ready-Mix Plant QC Workbook* and *Aggregate Gradation Control Charts* are accurate and up-to-date.

(2) Check Certificate of Compliance for completeness and accuracy.

(3) Spot check concrete batching to verify batch weights and tolerances.

(4) Check the bins and stockpiles for segregation, contamination, and interblending of the aggregates.

(5) Obtain aggregate samples per Schedule of Materials Control.

(6) Observe Producer's Certified Technician obtain aggregate samples and run gradation and moisture tests when possible.

(7) Verify cementitious and admixtures are certified and approved. Collect cementitious and admixtures samples per the Schedule of Material Control.

Provide the following Agency test results to the Producer in a timely manner:

(8.1) Cementitious Materials

(8.2) Admixtures

(8.3) Gradations

(8.4) Coarse Aggregate Quality

(9) If any equipment malfunctions, testing procedures or test results are questionable, or unusual activity is occurring during the plant visit perform the following:

(9.1) Continue monitoring at the plant and document observations in the diary.

(9.2) Investigate to determine the origin of the concern and document the resolution.

(9.3) Contact Independent Assurance Inspector, Project Engineer or Concrete Engineering Unit when necessary.

F.5.a Personnel

The Department will provide MnDOT Certified Concrete Plant Technicians to perform all of the duties of 2461.3.F.5, "Agency Quality Assurance."

F.5.b Sampling and Testing

Take all samples randomly in accordance with ASTM D 3665, Section 5, at a rate defined in the Schedule of Materials Control. Perform all sampling and testing in accordance with the Concrete Manual. Use mechanical shakers for sieve analysis.

F.5.c Aggregate Gradations

The Engineer will:

(1) Complete the *Weekly Ready-Mix Plant Report* for each aggregate size and source.

(2) Compare the Agency results with the Producer's companion gradation result for compliance with lab/field tolerance in accordance with 2461.3.F.6.b, *Lab Field Tolerance*.

F.5.d Batch Weight Verification

Each time the Engineer visits the plant, they will observe the actual water batched in a single load of concrete in accordance with the following:

(1) Watching the ready-mix truck reverse the drum after washing,
(2) Verifying use of the current moisture test,
(3) Verifying that any additional water added to adjust the slump is recorded, and
(4) Validating water weights on the load batched and comparing the total water with the design water.

The Engineer will document the actual water batched on the *Weekly Ready-Mix Plant Report*.

F.5.e *Concrete Ready-Mix Plant* QA Workbook

The Engineer will complete the *Concrete Ready-Mix Plant QA Workbook* in real time which includes all of the following documents:

(1) Diary
(2) Weekly Certified Ready-Mix Plant Report
(3) Concrete Aggregate Worksheet if gradation testing performed in the field
(4) JMF Concrete Aggregate Worksheet if gradation testing performed in the field

Submit to the Engineer and the Concrete Engineering Unit by the Tuesday immediately following the previous week's production.

F.5.f Non-compliance with Certified Ready-Mix Plant Program

If the Engineer observes the Producer not complying with the requirements of the Certified Ready-Mix Plant Program, the Engineer will perform the following:

(1) Verbally notify and promptly email the Producer and the Concrete Engineer the list of observed deficiencies and provide a deadline to correct the non-compliance.
(2) If non-compliance is not corrected by the deadline, notify the Contractor and Producer that concrete production is unauthorized in accordance with 1512, "Unacceptable and Unauthorized Work."

The Concrete Engineer will determine if the severity of the non-compliance results in decertification of the plant in accordance with 2461.3.F.1.c, "Certified Ready-Mix Plant Decertification."

S-3.14 MnDOT 2461.3.G.3.a(1) shall be deleted and replaced with the following:

(1) Provide a contractor mix design in accordance with 2461.2.F.2.b, "Contractor Designed Concrete Mixes," for each combination of materials;

S-3.15 MnDOT 2461.3.G.5(3.1) and 2461.3.G.5(3.2) shall be deleted and replaced with the following:

(3.1) A minimum of at least 16 hours after casting for all grades of concrete except mass concrete (Grade MC). Transport mass concrete a minimum of at least 24 hours after casting.
(3.2) A minimum of at least 12 hours after casting high early standard strength cylinders.

S-3.16 MnDOT 2461.3.G.5.a(2) shall be deleted and replaced with the following:

(2) Maintain the standard strength cylinders or beams in an ambient temperature range from 60 °F to 80 °F during the initial and intermediate curing periods.

S-3.17 The first paragraph of MnDOT 2461.3.G.5.b shall be deleted and replaced with the following:

G.5.b Standard Strength Cylinders

All standard strength cylinders have a minimum 28-day strength requirement unless modified elsewhere in the Contract.

The Engineer will perform the following for standard strength cylinders:

(1.1) Cast cylinders (sets of 3) for testing in accordance with the Schedule of Materials Control or as modified by the Contract.

(1.2) Mark cylinders for identification of the represented unit or section of concrete in accordance with the following: (1.1, 1.2, 1.3/ 2.1, 2.2, 2.3/ 3.1, 3.2, etc.). In order to differentiate between portions of a project, prefixes and suffixes are allowed.

(1.3) Cure the cylinders meeting the requirements of the 2461.3.G.5.a, "Moist Curing Environments."

(1.4) Complete the MnDOT Concrete Cylinder Identification Card including the results for air content, slump (if required), concrete, and air temperature testing from the same load.

S-3.18 MnDOT 2461.3.G.5.e shall be deleted and replaced with the following:

G.5.e Concrete Compressive Strength

The Concrete Engineer defines a **strength test** as the average strength of three (3) cylinders fabricated from the same sample of concrete and cured in accordance with the 2461.3.5.a and 2461.3.G.5.d.

The maximum allowable range between the individual cylinders in a strength test is 350 psi. The Concrete Engineer will remove all individual cylinder strengths that are more than 350 psi below the highest individual cylinder strength and recalculate the strength.

The Engineer will review standard strength test results for acceptance in accordance with Table 2461-17 and 2461.3.G.5.f.

Table 2461-17
Acceptance Criteria for Standard Strength Cylinders

	Strength Test	Moving average of 3 consecutive strength tests *
f'c ≤ 5000 psi	> (f'c – 500 psi)	≥ f'c
f'c > 5000 psi	> 0.90 * f'c	≥ f'c

* If a project does not establish a moving average of 3 consecutive strength tests, use the average of 2 strength tests to determine acceptance. If there is only a single strength test, contact the Concrete Engineer for recommendation.

S-3.19 MnDOT 2461.3.G.5.f shall be deleted and replaced with the following:

G.5.f Non-Conforming Material

If the Contractor places concrete not meeting the strength requirements of 2461.3.G.5.e, "Concrete Compressive Strength" into the work, the Engineer may not accept nonconforming concrete at the contract unit price. The Engineer will evaluate non-conforming strength results in accordance with the following:

G.5.f(1) Strength Test ≤ 500 psi Below f'c

If any strength test result shows a strength ≤ 500 psi below f'c and is not deficient due to erroneous/invalid strength tests as defined in 2461.3.G.5.f(4), "Moving Average Below f'c", no additional investigation will occur and the Engineer will include the low strength test result in the moving average.

G.5.f(2) Strength Test > 500 psi Below f'c

If any strength test result shows a strength > 500 psi below f'c and is not deficient due to erroneous/invalid strength tests as defined in 2461.3.G.5.f(4), "Moving Average Below f'c", the Engineer, in conjunction with the Concrete Engineer, will investigate to determine if the concrete has attained the critical load-carrying capacity.

The investigation may consist of, but is not limited to reviewing the following:

(A) Sampling and testing plastic concrete

(B) Handling of cylinders

(C) Cylinder curing procedures

(D) Compressive strength testing procedures
(E) Certificate of Compliances
(F) Evaluation using Rebound Hammer (ASTM C803), Penetration Resistance (ASTM C805), or other method approved by the Concrete Engineer
(G) Review of the design calculations for the concrete in question

If it is determined that the concrete represented by the standard strength test has attained the critical load carrying capacity, the Engineer will include the strength test in the moving average calculation.

If it is determined that the concrete has not attained the critical load carrying capacity, the Engineer will direct the Contractor to remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." The Contractor may dispute the remove and replace order within 7 days of written notification by the Engineer. If the Contractor disputes the order, follow the dispute resolution coring procedure in accordance with 2461.3.G.5.f(3), "Dispute Resolution Coring for a Strength Test Failure."

G.5.f(3) Dispute Resolution Coring for a Strength Test Failure

The Engineer and Contractor will mutually agree on an Independent Third Party to core and test the concrete in accordance with ASTM C42 and the following:

(A) The Engineer will identify a minimum of three (3) locations for the Independent Third Party to core.
(B) The Independent Third Party will take one (1) core at each location.
(C) The Independent Third Party will complete all coring within 14 days of notification of the low strength concrete.
(D) The Contractor is responsible for ensuring the core holes are repaired.

The Engineer, in conjunction with the Concrete Engineer, will review the core test results and evaluate in accordance with Table 2461-18, providing all other concrete tests meet requirements.

Table 2461-18
Evaluation of Core Test Results

Core (average of 3 cores) Test Results:	Engineer considers concrete:	Cost of Coring and Testing:	Resolution:
≥ 85% of f'c and No individual core is < 75% of f'c	Acceptable to remain in place	Agency	No monetary reduction for single strength test failure.
< 85% of f'c	Unacceptable	Contractor	Remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," as directed by the Engineer, in conjunction with the Concrete Engineer.

G.5.f(4) Moving Average Below f'c

If the moving average of three (3) consecutive strength tests is less than the required f'c, the Concrete Engineer will review the strength test results and determine if a new mix design is required.

The Concrete Engineer, in conjunction with the Engineer, will remove any strength test results from the moving average if the following occurs:

(A.1) After investigation, the deficient concrete strength is found to be caused by improper handling, curing, or testing of the cylinder;
(A.2) Cylinders kept in the field longer than 7 days that negatively impact the moving average calculation;

(A.3) The suspect concrete was removed and replaced;
(A.4) Dispute resolution coring identified the concrete acceptable to remain in place.

For the quantity of non-conforming concrete not meeting the moving average of three (3) consecutive strength tests, the Engineer will make determinations regarding the disposition, payment, or removal of the concrete in accordance with Tables 2461-19.

Table 2461-19
All Concrete Grades

Moving average of 3 consecutive strength tests	**Monetary Reduction for Moving Average Failure ***
> 98.0% of f'c	No deductions for the materials placed as approved by the Engineer.
93.0% to 98.0% of f'c	$20.00 per cubic yard or 10% of the Contractor-provided invoice for quantity represented by test that brought moving average into non-conformance
87.5% to < 93.0% of f'c	$50.00 per cubic yard or 25% of the Contractor-provided invoice for quantity represented by test that brought moving average into non-conformance
< 87.5% of f'c	Remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in place, the Engineer will adjust the concrete at a reduction of $100.00 per cubic yard or 50% of the Contractor-provided invoice for quantity represented by test that brought moving average into non-conformance.

S-4 (2462) PRECAST CONCRETE

REVISED 12/08/17
SP2018-157

MnDOT 2462 is hereby modified as follows:

S-4.1 Table 2462-4 of MnDOT 2462.2.F.2 shall be deleted and replaced with the following:

Table 2462-4
Precast Concrete Mix Design Requirements

Concrete Grade	Mix Number *	Intended Use ‖	Maximum w/c ratio	Cementitious Content (lbs/cy)	Maximum %SCM (Fly Ash/ Slag/ Ternary)	Slump Range ‡	Minimum Compressive Strength, f'c (28-day) #	3137 Spec.
M	3M82	Precast Concrete Barrier	0.45	530 – 750	30/35/40	1 – 8"	4500 psi	2.D.1
V	3V82	Wetcast retaining wall blocks, noisewall panels, equipment pad	0.45	605 – 850	30/35/40	1 – 8"	4000 psi	2.D.1
W	1W82	Bridge Girders	0.42	660 – 850	30/35/40	1 – 8"	Design Strength Per Plan	2.D.1
	3W82	Noisewall posts, box culverts, bridge girders†	0.42	660 - 850	30/35/40	1 – 8"	Design Strength Per Plan	2.D.1
Z	3Z82	Thin Panel Retaining Walls	0.45	605 – 850	30/35/40	1 – 8"	4000 psi	2.D.2

* The Precaster may choose to use the Coarse Aggregate Designation "1" for the 4th digit in accordance with Table 2462-3, if allowed by the structure.
‖ If the intended use is not included elsewhere in the Specification or Special Provisions, design concrete mix 3W82.
† Review the Plans to determine if the bridge girders require air entrainment.
‡ Flowable slumps exceeding the designated slump range require approval of the MnDOT State Materials Engineer.
\# Requires strength cylinders in accordance with 2462.3.G.4 for determining shipping strength.

S-4.2 The first sentence of MnDOT 2462.2.F.1.b shall be deleted and replaced with the following:

The Department will designation concrete grade in accordance with Table 2462-4 using a letter to represent the following:

S-4.3 MnDOT 2462.3.G.4 shall be deleted and replaced with the following:

G.4 Test Methods and Specimens

Perform sampling and testing in accordance with the Concrete Manual and test according to the requirements of the Schedule of Materials Control.

Anyone fabricating concrete cylinders is required to hold either a current ACI Field 1 Technician Certification or a MnDOT Field 1 Technician Certification.

Anyone performing concrete strength testing of cylinders is required to hold one of the following current certifications:

(1.1) ACI Strength Testing Technician Certification,
(1.2) MnDOT Strength Testing Technician Certification, or
(1.3) WisDOT Strength Testing Technician Certification.

Furnish molds based on the maximum size aggregate for the test specimens in accordance with the following:

(2.1) 4 in × 8 in cylinder molds,
(2.2) 6 in × 12 in cylinder molds for maximum aggregate sizes greater than 1¼ in.

G.4.a Strength Cylinders

The Precaster will cast all strength cylinders to determine the following:

(3.1) Handling or “Stripping” Strength
(3.2) Shipping Strength
(3.3) Verification

Cast all cylinders used for determining strength at each stage for all types of precast operations. Cure all cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of ASTM C31.

S-5 (2472) METAL REINFORCEMENT

REVISED 08/09/18
SP2018-158.1

The provisions of MnDOT 2472 are modified with the following:

S-5.1 Delete and replace MnDOT 2472.4A with the following:

A Reinforcement Bars

The Engineer will measure Reinforcement Bars, including reinforcement in bar mats, by the weight incorporated into the structure in accordance with 2472-3. The Engineer will only include quantities for splices shown in the plans.

Reinforcement bars may be marked in either U.S. Customary or metric sizes. The conversion shall be made per the following table:

Table 2472-3
Reinforcement Bars
Theoretical Weights
Nominal Dimensions

U.S. Customary Bar Size	Metric Bar Size*	Nominal Dimensions		
		Diameter, *in* *[mm]*	Area *in^2 [mm^2]*	Weight, *lb/ft* *[kg/m]*
3	10	0.375 [9.5]	0.11 [71]	0.376 [0.560]
4	13	0.500 [12.7]	0.20 [129]	0.668 [0.994]
5	16	0.625 [15.9]	0.31 [199]	1.043 [1.552]
6	19	0.750 [19.1]	0.44 [284]	1.502 [2.235]
7	22	0.875 [22.2]	0.60 [387]	2.044 [3.042]
8	25	1.000 [25.4]	0.79 [510]	2.670 [3.973]
9	29	1.128 [28.7]	1.00 [645]	3.400 [5.060]
10	32	1.270 [32.3]	1.27 [819]	4.303 [6.404]
11	36	1.410 [35.8]	1.56 [1006]	5.313 [7.907]
14	43	1.693 [43.0]	2.25 [1452]	7.650 [11.380]
18	57	2.257 [57.3]	4.00 [2581]	13.600 [20.240]

* Bar designation numbers approximate the nominal diameter of the bar in millimeters

S-6 (3137) COARSE AGGREGATE FOR PORTLAND CEMENT CONCRETE

NEW WRITE-UP 01/04/19
SP2018-252.1

MnDOT 3137 is modified as follows:

S-6.1 MnDOT 3137.2.D shall be deleted and replaced with the following:

D Quality

Provide coarse aggregate in accordance with 3137.2.D.1, 3137.2.D.2 or 3137.2.D.3 and the following:

For fractions greater than or equal to 1 in, base quality requirements on the individual result.

For fractions that have 100 percent passing the 1 in sieve:

(1) When using a single aggregate, base quality requirements on the individual result.

(2) When proportioning aggregates, base quality requirements on the composite result. Prior to proportioning, each individual fraction must meet the requirements of 3137.2.D.1.

(2.1) If proportioning for 3137.2.D.2, each individual fraction must also meet 3137.2.D.2(g) and 3137.2.D.2(i).

(2.2) If proportioning for 3137.2.D.3, each individual fraction must also meet 3137.2.D.3(a) and 3137.2.D.3(b) modified to a maximum percent carbonate by weight of 35.0%.

The Concrete Engineer may reject the proposed aggregate proportions if the composite result is of borderline quality in accordance with 1503, Conformity with Contract Documents.

Refer to Tables 2461-5, 2461-6, 2461-7 and 2462-6 to determine the coarse aggregate quality specification for the intended use.

S-6.2 Table 3137-4 shall be deleted and replaced with the following:

Table 3137-4
Coarse Aggregate Designation for Concrete,
percent by weight passing square opening sieves

	Coarse Aggregate Designation				
	2	**3**	**4**	**7**	**8**
Sieve Sizes	**ASTM #67***	**ASTM #7***	**ASTM #89**	**CA-70**	**CA-80**
2 in	-	-	-	-	-
1½ in	-	-	-	-	-
1 in	100	-	-	-	-
¾ in	90 – 100	100	-	-	-
5/8 in	-	-	-	100	-
½ in	-	90 – 100	100	85 – 100	-
⅜ in	20 – 55	40 – 70	90 – 100	50 – 100	100
No.4	0 – 10	0 – 15	20 - 55	0 – 25	55 – 95
No.8	-	-	5 – 30	-	-
No.16	-	-	0 – 10	-	-
No.50	-	-	0 - 5	-	0-5

*ASTM #67 and ASTM #7 Gradations are MnDOT Modified.