



# Minnesota Concrete Flatwork Specifications



## MINNESOTA LTAP UNIVERSITY OF MINNESOTA

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**Notes to Specifier:**

**The MnDOT State Aid Office recommends using these specifications that were developed for local agencies. The intent of this specification is to create uniformity for contractors and ready-mix producers as well as the agencies administering contracts. Use this specification in its entirety, not only one part or another.**

**These specifications cover the following types of concrete:**

- A. Concrete Pavement
  1. The Concrete Pavement Specifications are intended for small urban projects that consist of several blocks. Contact the Concrete Engineering Unit if you have a larger project and would like to discuss what specifications would best fit.
- B. Concrete Curb and Gutter
- C. Driveway Pavement Entrances
- D. Sidewalk and Concrete Median

**When putting plans together, consider the following:**

- E. Typical Section and Detail Sheets
  1. The designer needs to include typical section and detail sheets to show manhole locations, dowel bars, joint spacing, joint sealing if required, other pavement reinforcement, integral curb, intakes, water valves, and fire hydrants, etc.
  2. Identify all incidental items in a note somewhere on the plan sheets.
  3. Under the Concrete Pavement Pay Item – include the actual plan sheet pages for reference for the Contractor.

**When using these specifications, designers need to pick one or more of the following as additional bid items for additional quality improvements:**

- F. Concrete Testing Rates for the Engineer's Representative - Table 5
    1. **Use this pay item only when an Engineer desires to have a third party accomplish the Engineer testing and get paid through the Contract.**
  - G. Smoothness
  - H. Maturity Testing for Strength, and
  - I. Enhanced Aggregate Qualities
    1. This was included in the specification to allow the Contractor the flexibility in what aggregate to use instead of specifying a single class of aggregate, which in some cases can eliminate competition in the concrete bids. The intent is to use this coarse aggregate specification when the Engineer desires less than 20 popouts per square yard. This specification will result in a much lower chance of seeing spalling on your flatwork. Use of Class A aggregate does increase the chances of mortar flaking occurring in late season placements with improper curing.
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**PART 1. GENERAL**

**1.1 Concrete Street Items**

- A. Concrete Pavement
- B. Curb and Gutter and Driveways and Aprons
- C. Concrete Sidewalks and Median Pavement

**1.2 Description of Work**

This specification includes the requirements for the construction of concrete flatwork including pavements, curb and gutter, sidewalks, driveways, and aprons.

**1.3 Storage and Handling**

Follow these *Minnesota Concrete Flatwork Specifications* and any local covenants, as well as the following:

- A. Aggregate Storage: Store aggregates so that segregation and inclusion of foreign materials are prevented. Do not use the bottom 12 inches of aggregate piles in contact with the ground.
- B. Cementitious Materials: Store cement, slag cement, and fly ash in suitable moisture-proof enclosures. Do not use cementitious materials that have become caked or lumpy.
- C. Admixtures: Store in suitable weather-tight enclosures that will preserve quality.
- D. Reinforcing Steel: Store off ground on timbers or other supports.

**1.4 Definitions**

- A. Engineer, or owner's representative, is defined as the individual, firm, or corporation delegated with the responsibility for the Engineering supervision of the construction.
- B. Contractor is defined as the individual, firm, or corporation contracting for and undertaking execution of the prescribed work.

**1.5 Measurement and Payment**

- A. Concrete Pavement
  - 1. Measurement: Measurement will be in square yards for each different thickness of concrete pavement. The area of manholes, intakes, or other fixtures in the pavement will not be deducted from the measured pavement area. When the curb is integral with the pavement, the width for pavement square yards will be measured from back of curb to back of curb.

2. Payment: Payment will be at the unit price per square yard for each thickness of concrete pavement in accordance with typical sections and details in the plan sheets.

B. Curb and Gutter

1. Measurement: Measurement will be in linear feet measured along the face of the curb for each different width and thickness of curb and gutter. If integral curb is used, the curb measurement will be in linear feet measured along the face of the curb.
2. Payment: Payment will be at the unit price per linear feet of curb and gutter.

C. Driveway Pavement Entrances

1. Measurement: Measurement will be in square yards of concrete area including apron and sidewalk areas through the driveway.
2. Payment: Payment will be at the square yard price for each thickness of driveway: residential (6 inches) and commercial (8 inches).

D. Sidewalk and Concrete Median

1. Measurement: Measurement will be in square yards of concrete area.
2. Payment: Payment will be at the unit price per square yard of concrete area.

E. Concrete Testing for the Engineer's Representative - Table 5

1. Measurement: Lump sum item; no measurement will be made. Minimum testing requirements will be as defined for the Engineer's Representative in Table 5 of this specification.
2. Payment: Payment will be at the lump sum price for concrete street items under the Concrete Sampling and Testing rates as required by Table 5 of this specification.

F. Concrete Pavement Smoothness Testing for Areas of Localized Roughness (ALR)

1. Measurement: Lump sum item; no measurement will be made. Testing rate will be determined by the number of lanes of concrete pavement placed on the project.
2. Payment: Payment will be at the lump sum price for "Concrete Pavement Smoothness Testing for Areas of Localized Roughness (ALR)" within this specification.
3. Includes: Lump sum price includes the use of a MnDOT-certified profiler and MnDOT-certified operator to test the smoothness and submit all reports showing the ALR. It will also include a second run after any correction work is done if needed to verify that the ALR specification is met.

G. Maturity Testing for Compressive Strength

1. Measurement: Lump sum price includes, but is not limited to, maturity curve establishment and five locations on the project.
2. Payment: Payment will be at the lump sum price for concrete maturity for each mix tested.
3. Includes: All the testing and necessary equipment to complete the maturity determination for five different locations on a project.

H. Enhanced Coarse Aggregate Quality – Table 4

1. Measurement: Lump sum price includes providing coarse aggregate meeting the requirements of Table 4, “Enhanced Coarse Aggregate Quality.”
2. Payment: Payment will be included in the price for the concrete item: curb and gutter, sidewalks, or concrete pavement.
3. Includes: All the testing to ensure that the aggregate quality passes the requirements of Table 4 as defined in Table 5.

## **PART 2. PRODUCTS**

### **2.1 Materials**

- A. Cement: Cement shall be from MnDOT-certified sources only and be listed on the MnDOT approved products list and follow MnDOT 3101.
- B. Supplementary Cementitious Materials (SCM)
  1. Fly ash: Fly ash shall be from certified sources only and be listed on the MnDOT-approved list under MnDOT 3103.
  2. Slag cement (ground granulated blast furnace slag or GGBFS): Slag cement shall be from certified sources only and be listed on the MnDOT-approved list under MnDOT 3102.
- C. Fine Aggregate for Concrete
  1. Fine aggregate gradation shall comply with ASTM C33 or MnDOT 3126. The quality requirements shall comply with MnDOT 3126.
  2. The fine aggregate shall be washed.
  3. The quantity of deleterious substances, as determined by mass (weight), shall not exceed the following limits:
    - a. Coal and lignite: 0.3%.
    - b. Other deleterious substances such as shale, alkali, mica, soft and flaky particles, cumulative total: 2.5%.

4. Mitigation for fine aggregates:

- a. For any fine aggregate used in curb and gutter, sidewalks, or driveway entrances: the maximum allowable expansion at 14 days is 0.300.
- b. For any fine aggregate used in concrete pavement, the maximum allowable expansion at 14 days is defined in Table 1 below.

If the fine aggregate has been previously tested by MnDOT, use the highest expansion result of any of the tested fine aggregate and cement combinations to determine necessary mitigation in accordance with the 14-day fine aggregate expansion limits in Table 1 for concrete pavements. The Contractor may contact MnDOT to access the list of previously tested fine aggregate sources or review the MnDOT Concrete Engineering website for the latest test results.

If the fine aggregate has not been previously tested by MnDOT, the fine aggregate shall be tested by an independent testing laboratory in accordance with ASTM 1260, to determine the necessary mitigation based on the proposed fine aggregate and cement combination in accordance with the 14-day fine aggregate expansion limits in Table 1.

<b>Table 1</b>	
<b>Fine Aggregate ASR Mitigation Requirements for Concrete Pavements</b>	
<b>14-day Fine Aggregate Expansion Limits</b>	
≤ 0.150	Use of the fine aggregate is acceptable with or without a mitigator
> 0.150 – 0.250	Mitigate the fine aggregate with 35 percent ground-granulated blast furnace slag or at least 20 percent fly ash
> 0.250 – 0.300	Mitigate the fine aggregate with 35 percent ground-granulated blast furnace slag or 30 percent fly ash in accordance with 3115, modified with at least 66.0 percent SiO <sub>2</sub> + Fe <sub>2</sub> O <sub>3</sub> + Al <sub>2</sub> O <sub>3</sub> on a dry weight basis and at least 38.0 percent SiO <sub>2</sub>
> 0.300	The fine aggregate will not be acceptable for use in concrete pavement

- 5. The fine aggregate shall comply with MnDOT 3126 gradation requirements as shown in Table 2, unless otherwise reviewed by the Engineer. The fineness modulus of the delivered fine aggregate shall not deviate by more than 0.20 from the submitted gradation, unless otherwise reviewed by the Engineer.

<b>Table 2 Concrete Fine Aggregate Gradation</b>	
<b>Sieve Size</b>	<b>Percent Passing</b>
3/8"	100
#4	95-100
#8	80-100
#16	55-85
#30	30-60
#50	5-30
#100	0-10
#200	0-2.5

D. Coarse Aggregate for Concrete

1. Coarse aggregate shall be crushed rock, washed gravel, or other inert granular material meeting ASTM C33 Class 4S Quality requirements or MN/DOT 3137 except as modified in Table 3 or Table 4.\*
2. Coarse aggregate gradation shall comply with ASTM C33, Size 67 or MnDOT 3137 requirements for the individual classification.

<b>Table 3 Coarse Aggregate for General Use</b>		
<b>Quality Test</b>		<b>Maximum Percent by Weight</b>
(a)	Shale:	
	Fraction retained on the 1/2-inch sieve	0.4
	Fraction retained on the No. 4 sieve, as a percentage of the total material	0.7
(b)	Soft iron oxide particles (paint rock and ochre)	
		0.3
(c)	Total spall materials*:	
	Fraction retained on the 1/2-inch sieve	1.0
	Fraction retained on the No. 4 sieve, as a percentage of the total material	1.5
(d)	Soft particles	
		2.5
(e)	Clay balls and lumps	
		0.3
(f)	Sum of (c) total spall materials, (d) soft particles, and (e) clay balls and lumps†	
		3.5
(g)	Slate	
		3.0
(h)	Flat or elongated pieces‡	
		15.0
(i)	Quantity of material passing No. 200 sieve:	
	Class A and Class B aggregates#	1.5
	Class C and Class D aggregates§	1.0
(j)	Los Angeles Rattler, loss on total sample	
		40.0
(k)	Soundness of magnesium sulfate**	
		15.0

<b>Table 3 (continued)</b>	
*	Includes the percentages retained by shale and soft iron oxide particles, plus other iron oxide particles, unsound cherts, pyrite, and other materials with similar characteristics.
	Exclusive of shale, soft iron oxide particles, and total spall materials.
†	Sum of the total spall materials, soft particles, and clay balls and lumps. For total spall materials, use the percent in the total sample retained on the No. 4 sieve.
‡	Thickness less than 25 percent of the maximum width. Length greater than three times the maximum width.
#	Each individual fraction at the point of placement consists of dust from the fracture and is free of clay or shale.
§	For each individual fraction at the point of placement.
**	Loss at five cycles for any fraction of the coarse aggregate. Do not blend materials from multiple sources to obtain a fraction meeting the sulfate soundness requirement.

3. Provide Coarse Aggregate in accordance with Table 4 instead of Table 3 when the Contract includes a bid item for Enhanced Coarse Aggregate Quality.

<b>Table 4 Enhanced Coarse Aggregate Quality Specification</b>		
<b>Quality Test</b>		<b>Maximum Percent by Weight</b>
(a)	Shale:	
	Fraction retained on the 1/2-inch sieve	0.2
	Fraction retained on the No. 4 sieve, as a percentage of the total material	0.3
(b)	Soft iron oxide particles (paint rock and ochre)	0.2
(c)	Total spall materials*:	
	Fraction retained on the 1/2-inch sieve	1.0
	Fraction retained on the No. 4 sieve, as a percentage of the total material	0.5
(d)	Soft particles	2.5
(e)	Clay balls and lumps	0.3
(f)	Sum of (c) total spall materials, (d) soft particles, and (e) clay balls and lumps †	2.5
(g)	Slate	3.0
(h)	Flat or elongated pieces ‡	15.0
(i)	Quantity of material passing No. 200 sieve:	
	Class A and Class B aggregates #	1.5
	Class C and Class D aggregates §	1.0
(j)	Los Angeles Rattler, loss on total sample	40.0
(k)	Soundness of magnesium sulfate **	15.0
(l)	Absorption for Class B aggregate	1.75
(m)	Carbonate in Class C and Class D aggregates by weight	30.0

**Table 4 (continued)**

*	Includes the percentages retained by shale and soft iron oxide particles, plus other iron oxide particles, unsound cherts, pyrite, and other materials with similar characteristics.
	Exclusive of shale, soft iron oxide particles, and total spall materials.
†	Sum of the total spall materials, soft particles, and clay balls and lumps. For total spall materials, use the percent in the total sample retained on the No. 4 sieve.
‡	Thickness less than 25 percent of the maximum width. Length greater than three times the maximum width.
#	Each individual fraction at the point of placement consists of dust from the fracture and is free of clay or shale.
§	For each individual fraction at the point of placement.
**	Loss at five cycles for any fraction of the coarse aggregate. Do not blend materials from multiple sources to obtain a fraction meeting the sulfate soundness requirement.

- D. Water Requirements: Mixing water used in the production of concrete shall meet ASTM C1602 / C1602M or MnDOT 3906.
- E. Admixtures: Unless otherwise acceptable to the Engineer, all admixtures shall be from one manufacturer and shall be compatible. Only use admixtures found on the MnDOT-approved/qualified list according to MnDOT 3113.
- F. Reinforcement Bars and Dowel Bars: Comply with the requirements of ACI 301, Section 3.2 (provide Grade 60 reinforcing and dowel bars unless noted otherwise) or according to MnDOT 3301 and 3302.
- G. Joint Fillers and Sealers
  - 1. Preformed isolation/expansion joint fillers and sealers: Comply with ASTM D1751, preformed, resilient, non-extruding, asphalt impregnated joint filler, 1/2-inch thick unless otherwise indicated. Joint filler shall be a single piece the full depth thickness of the concrete.
  - 2. Hot-pour joint sealer: Comply with MnDOT 3725.
- H. Liquid Membrane Curing Compound: Comply with MnDOT 3754 AMS.
- I. Curing Covering Materials
  - 1. Plastic film: Comply with ASTM C171.
  - 2. Insulating blanket: Provide waterproof insulating blankets with a minimum R-value of 1 or greater.

## 2.2 Concrete Mixes

### A. Mix Design

1. Prepare design mixes for each type and strength of concrete in accordance with ACI 301 by the field experience method or, if available, by laboratory trial batch methods. Mix proportions shall produce consistent and workable concrete that can be readily worked into forms and around reinforcement without segregation or excessive bleeding.
  - a. Field experience method: If field test data is available, in accordance with ACI 301, submit for acceptance the mixture proportions along with the field test data.
  - b. Trial batch method: Use an AMRL-accredited laboratory for preparing and reporting proposed mix designs.
2. Ensure compatibility of all material combinations. If the concrete materials are not producing a workable concrete mixture, a change in the material may be required. Changes will be at no additional cost to the Engineer.
3. Proportion normal mixtures to provide concrete with the following properties:
  - a. Minimum compressive strength (28 days): 4000 psi.
  - b. Minimum cement content: 400 pounds.
  - c. Minimum cementitious content: 530 pounds.
  - d. Maximum cementitious content: 658 pounds.
  - e. Maximum water-cementitious materials ratio at point of placement:
    1. For machine placement: 0.42
    2. For hand placement: 0.45
  - f. Slump limit: As needed for proper placement; 5-inch maximum. No minimum as long as proper consolidation is being performed.
  - g. Early-strength concrete mixes shall be designed to reach opening compressive strength of 3000 psi at a predetermined time (i.e., 48 hours, 24 hours, etc.).
4. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content of 6.5 percent plus 2.0 percent or minus 1.5 percent.
5. If using calcium chloride, limit the water-soluble, chloride-ion content in hardened concrete to 0.08 percent by weight of cementitious materials.

6. Chemical admixtures: Use admixtures according to manufacturer's written instructions. Contractors may use the following approved admixtures at their discretion as listed on the MnDOT-approved products list:
  - a. Type A, water-reducing and mid-range water-reducing admixtures
  - b. Type B, retarding/hydration stabilizer admixtures
  - c. Type C, accelerating admixtures
  - d. Type D, water-reducing and retarding admixtures
  - e. Type S, viscosity-modifying admixtures
  - f. Admixtures containing more than 0.15 percent chloride ions, by weight of admixture, are not permitted.
7. Supplementary cementitious materials: The Engineer will not allow ternary mixes (combination of three or more cementitious materials) . Limit percentage by weight of supplementary cementitious materials according to ACI 301 requirements for concrete exposed to deicing chemicals as follows:
  - a. Fly ash: 30 percent maximum for concrete pavement, 25 percent maximum for everything else , OR
  - b. Slag cement: 35 percent maximum.

### **PART 3. EXECUTION**

#### **3.1 Personnel**

- A. The Concrete Contractor, or Subcontractor, shall have at least two people with a current ACI concrete flatwork technician or flatwork finisher certification, and at least one of them must be onsite for all concrete pours.
- B. Use either MnDOT- or ACI-certified personnel to perform all process control and quality control testing.

#### **3.2 Pre-Pour Meeting**

- A. When the concrete quantities for the project are greater than 500 cubic yards, the Engineer will require a pre-pour meeting before the concrete project begins. If the project is constructed over multiple years, the Engineer will require a pre-pour meeting annually. An example checklist of discussion items is given in Section 5.1 of this specification.

### 3.3 Mixing Equipment

#### A. Batching and Mixing Equipment

##### 1. General

- a. Weighing and proportioning equipment: Comply with ASTM C94.
- b. Mixing equipment: Comply with ASTM C94.
- c. Material bins: Involves any structure in which materials are stored. Each part of any bin, including foundations and supports, must be adequate to withstand any stress while in use.

##### 2. Batching

- a. Batching plants shall be NRMCA- or MnDOT-certified with a current MnDOT Concrete Plant Contact Report, Form 2163. Provide copy of current calibrations and approvals.
- b. Coordinate the batch plant operation with the placement operation in order to ensure a steady supply of concrete.
- c. Operate the batch plant and trucks to minimize dust, noise, or truck nuisances as part of the quality control plan.

##### 3. Mixing (Ready-mixed Concrete)

- a. Ensure the concrete is uniform in composition and consistency. If non-uniform, concrete producers must take corrective action.
- b. Ready-mixed concrete is defined as concrete proportioned in a central plant and mixed in a stationary mixer for transportation in trucks without agitation; proportioned at a central plant, and only partially mixed in a stationary mixer for transportation and finish mixing in a transit mixer; or proportioned at a central plant and then mixed in a transit mixer prior to or during transit.
- c. When necessary to add additional mixing water at the site of placement, mix the batch at least an additional 50 revolutions of the drum at mixing speed or five minutes, whichever is faster.
- d. All methods: Deliver each truck load of concrete with a computerized certificate of compliance showing plant name, Contractor, project data, batch quantities and total yardage, w/cm, mix designation, time batched, and water available to add on-site. Give a record of the certificates of compliances for each pour to the Engineer.
- e. Ensure the methods of delivering and handling the concrete are such that objectionable segregation or damage to the concrete will not occur, and concrete placement will occur with a minimum of re-handling.

- f. Thoroughly clean the truck compartment in which concrete is transported, and flush with water to ensure that hardened concrete will not accumulate. Discharge the flushing water from the truck compartment to the designated discharge point before it is charged with the next batch.
  - g. Delivery requirements: Place concrete into the work in accordance with the following:
    - i. Type 1 concrete: within 90 minutes of batching, and
    - ii. Type 3 concrete: within 90 minutes of batching when all admixtures are added at the plant at the manufacturer's recommended dosage rates listed on the Approved Products list.
    - iii. In any case, do not add additional mixing water once the concrete is 60 minutes old.
    - iv. Mix the load a minimum of five minutes or 50 revolutions at mixing speed after addition of any admixture.
    - v. The Contractor may transport Type 3 concrete in non-agitating equipment if the concrete is discharged within 45 minutes of batching.
    - vi. Batch time starts when the batch plant or the transit mix truck adds the cement to the other batch materials.
- B. Concrete Washout Guidance
- 1. These specifications will be governed by the Minnesota Pollution Control Agency's written guidance in February 2009. This document, which details the NPDES/SDS construction stormwater permit requirements, is titled "wq-strm2-24'February 2009."

### **3.4 Concrete Placement Equipment**

#### **A. Slipform Construction Equipment**

##### **A.1 Curb and Gutter Construction**

1. Place concrete curb and gutter using a slipform machine capable of placing and forming the concrete to the dimensions, quality, workmanship and appearance as required by the Contract. Hand finish the surface and texture as required by the Contract.

##### **A.2 Concrete Pavement Construction**

1. Place concrete pavement using a slipform paver or combination of pavers designed to spread, consolidate, screed, and float-finish the freshly placed concrete with minimum hand-finishing. Provide a slipform paver with a non-oscillating extrusion plate with an adjustable angle of entry.

2. Place the concrete pavement before placing curb and gutter when possible. If the sequence of operations includes placing the curb and gutter before the concrete pavement, submit a jointing plan to the Engineer for approval before placing the curb and gutter.
3. If no jointing plan is shown in the plans, the Contractor will provide a jointing plan to be approved by the Engineer.
4. Consolidate the full width and depth of concrete pavement placed by a single pass of a series of internal vibrators. Operate full-width vibrators from 3,600 VPM to 7,000 VPM (60 Hz to 117 Hz) in concrete, and from 4,150 VPM to 8,000 VPM (70 Hz to 133 Hz) when checked in air. Deliver the vibrator impulses directly to the concrete and operate at an intensity to consolidate the concrete uniformly throughout the entire depth and width of the concrete. The Contractor may increase the vibrator frequency as approved by the Engineer. Perform additional testing as directed by the Engineer at no additional cost to the Engineer. If the vibrator fails, suspend operations and remove unconsolidated concrete.
5. Provide an electronic monitoring device meeting the following characteristics and requirements to display the operating frequency of each individual internal vibrator for concrete pavement placed by the slipform method:
  - Contains a readout display near the operator's controls; visible to the paver operator and to the Engineer,
  - Operates continuously as the paving machine operates,
  - Displays all the vibrator frequencies with manual and automatic sequencing for each of the individual vibrators, and
  - Records the following at least every 25 feet [7.62 m] of paving or at least every five minutes of time:
    - Clock time,
    - Station location,
    - Paver track speed, and
    - Operating frequency of individual vibrators.

Provide an electronic copy containing the record of data after the completion of the concrete paving operation. Provide vibration data daily as directed by the Engineer.
6. Regulate the rate of progress of the vibratory equipment and the duration of the application to fully, but not excessively, vibrate the concrete. If the forward progress of the paver stops, suspend the operation of vibrators.
7. Attach vibrators to spreading or finishing equipment. Do not allow vibrators to come in contact with preset dowel basket assemblies, the grade, pavement reinforcement, or side forms. Do not allow the operation of vibrators to cause separation or segregation of the mix ingredients, including the downward displacement of large aggregate or the accumulation of laitance on the concrete surface. The Contractor may reduce the vibration frequency within the specified range if reducing the forward progress of the paver to avoid segregation of the concrete mix. Connect the power to all vibrators so that they cease when the machine motion is stopped. Stop paving operations if a vibrator fails to operate within the range specified above.

8. Operate the slipform paver with a continuous forward movement, and coordinate all operations of mixing, delivering, and spreading concrete to provide uniform progress with minimal stopping and starting of the paver.
9. At the Contractor's option: equip the paver with automatic grade control capable of maintaining the elevation shown on the plans at both sides of the paver. Control the elevation of one side and control the crown, or control the elevation of each side independently. The Contractor may elect to use stringless paving, as long as he meets the required grade and cross slope.
10. Tightly stretch a wire or string line set parallel to the established grade for the pavement surface to achieve the grade reference. Set the control reference and support the line at intervals to maintain the established grade and alignment.

B. Fixed-Form Construction

1. Place concrete using one or more machines to spread, screed, and consolidate between previously-set side forms. Vibrate these areas using hand-held or machine-mounted internal vibrators.
2. Use a tachometer or similar device to demonstrate to the Engineer that the paving equipment vibration meets the requirements in this section.
3. Use hand-held vibrators to consolidate concrete adjacent to side forms and fixed structures. Operate the hand-held vibrators at a speed of at least 3,600 VPM (60 Hz). Do not allow the vibrator head to contact the joints, load transfer devices, reinforcement, grade, or side forms. If the vibrator fails, suspend operations and remove unconsolidated concrete.
4. Continue vibration to achieve adequate consolidation, without segregation, for the full depth and width of the area placed.
5. Provide an adequate number and capacity of machines to perform the work at a rate equal to the concrete delivery rate.
6. Strike off concrete with a vibrating screed, laser screed, or a roller/clary screed as reviewed by the Engineer. Finish small or irregular areas that are inaccessible to finishing equipment using other methods as reviewed by the Engineer.
7. Discontinue any operation that displaces the side forms from the line or grade or that causes undue delay, as determined by the Engineer, due to mechanical difficulties.

C. Hand-Finishing Equipment: Provide all finishing tools necessary for proper finishing of the concrete including straightedges for checking and correcting finished concrete surfaces.

D. Forms

1. Rigid forms: Steel, minimum thickness of five gage and height at least equal to design thickness of pavement with base width at least 6 inches.

- a. Minimum section length of 10 feet and joint connections designed to allow horizontal and vertical adjustment with locking device to hold abutting sections firmly in alignment.
- b. Bracing, support, and staking must prevent deflection or movement of forms.
2. Flexible forms: Use steel, plastic, or wood flexible forms for curves with a radius less than 100 feet.
  - a. Bracing, support, and staking must prevent deflection or movement of forms.
  - b. Ensure that forms used to shape back of curbs at returns have height at least equal to design thickness of pavement and curb height.
  - c. Forms must be free from scale and surface irregularities.
- E. Curing Equipment: 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. An airless spraying machine is required to have the following:
  1. A recirculating bypass system that provides for continuous agitation of the reservoir material,
  2. Separate filters for the hose and nozzle, and
  3. Multiple or adjustable nozzle system that provides for variable spray patterns.
- F. Concrete Saws: Use power-operated concrete saws capable of cutting hardened concrete without damage.
- G. Joint Sealing Equipment: Use equipment capable of cleaning the joint and heating and installing sealant in joints according to manufacturer's recommendations.

### **3.5 Concrete Pavement Construction**

- A. Removal of Pavement: Comply with plans.
- B. Final Subgrade/Subbase Preparation
  1. General
    - a. Meet the requirements of the plans for subgrade construction, subgrade treatment, and subbase construction.
    - b. Trim the subgrade or subbase to the final grade for placement of concrete.
    - c. Unless otherwise ordered by the Engineer, the subgrade or subbase, at time of placing concrete for concrete pavement, must be in a uniformly moist but not muddy condition to a depth of not less than 1 inch.

2. Subgrade and subbase loading

- a. Travel of construction traffic including concrete delivery trucks on a subgrade or subbase must be with written approval by the Engineer. In such cases, watering of the subgrade or subbase must be limited to just ahead of the paving machine.
- b. Enter and exit from side streets to minimize repetitive loading on the subgrade or subbase by concrete trucks.
- c. Do not allow loads in excess of the legal axle load on the completed subgrade or subbase.
- d. Partially loaded trucks may be required.

3. Paving suspended

- a. Suspend the paving operation where subgrade or subbase stability has been lost.
- b. Do not place concrete on a subgrade or subbase that has become unstable, bears ruts or tire marks of equipment, or that is excessively softened by rain until such subgrade or subbase has been reconsolidated and reshaped to correct the objectionable condition.
- c. If necessary, scarify to a minimum depth of 6 inches, aerate, and recompact at no additional cost to the Engineer. Meet the compaction requirements of the plans.

4. Maintenance of subgrade or subbase: Maintain the completed subgrade or subbase during subsequent construction activities.

C. Surface Fixture Adjustment

1. Adjust manhole frames and other fixtures within area to be paved to conform to finished surface. Comply with plans for manhole adjustments and water fixture adjustments.
2. Clean outside of fixture to depth of pavement before concrete placement.
3. Construct boxouts if necessary for later adjustment of fixtures. See plans for the size and shape of the boxout.

D. Setting of Forms: When forms are used, meet the following requirements:

1. Ensure forms have sufficient strength to support paving operations being used.
2. Set base of forms at or below subgrade elevation with top of forms at pavement surface elevation. With Engineer approval, extra height forms may be used to shape the back of integral curb and edge of pavement; set base at or below subgrade elevation with top of form at top of curb elevation.

3. Place and secure forms to required grade and alignment. Do not vary the top face of the form from a true plane by more than 1/8 inch in 10 feet, and do not vary the vertical face from a true plane by more than 1/4 inch in 10 feet.
4. If the soil supporting the forms is softened by rain or standing water so that the forms are inadequately supported, or if voids occur under the forms, remove forms. Rework subgrade to proper elevation and density, and reinstall forms.
5. Ensure forms are free of latent concrete and coated with release agent before concrete is placed.
6. In the event of rain, remove and reset the forms as necessary to permit drainage.

E. Removal of Forms

1. Do not remove side forms of pavement and back forms on integrant curb earlier than 12 hours after placing the concrete, unless otherwise approved by the Engineer. Remove forms without exerting shock or strain, including temperature variations, on the pavement or curb. Cure concrete in accordance with Section 3.8 of this specification.

F. Paving Protection

1. In the area adjacent to the curbs and pavement edge, immediately place backfill of soil or aggregate according to the plans, without vibration (according to Section 3.10.C), after the forms are removed, to prevent soil erosion during a rain event. Construct dams or other protection to ensure that no saturation or erosion of the subgrade under or near the pavement occurs. This may include check dams, pumping, etc.

G. Reinforcement Protection

1. Ensure bars are clean, straight, free from distortion and rust, and are firmly secured in position as specified in the contract documents. Place all bars in approved storage to prevent damage; do not distribute along the work site except as needed to avoid delay in paving.

H. Placing Reinforcement: Provide and place reinforcement meeting the following requirements and characteristics:

1. Provide epoxy-coated reinforcement in accordance with MnDOT Specification 2472, "Metal Reinforcement."
2. Provide and place reinforcement bars including keyway bars, tie bars, taper steel, and stopper bars.
3. Place keyways as shown on the plans. Keyways are not recommended for pavements 7 inches or less.
4. Provide and place supplemental pavement reinforcement as shown on the plans.

5. Provide and place reinforcement bars on chairs, in stakes, utilizing tie bar basket assemblies or by appropriate equipment for pressing the bars to the specified location.
6. For slipform paving, stake the tie bar steel to the roadbed, or use a mechanical device attached to the spreader or paver to place tie bar steel required for L1T joints as shown on the plans. Space and press the tie bar steel to the depth and location shown on the plans. Do not place tie bars over a dowel bar assembly.
7. Place supplemental pavement reinforcement bar mats for reinforced pavement over culverts when necessary and in accordance with the most current MnDOT Standard Plate 1070 as designated in the plans.
  - a. When reinforced pavement is specified, assemble bar mats accordingly, and firmly fasten together at all bar intersections.
  - b. Place, secure, and tie mats for a continuous mat as specified in the contract documents. Displacement during concrete placement operations is not allowed.
  - c. Use chairs to ensure proper placement of bar mats.
- I. Dowel Bar Assemblies: Provide dowel bar assemblies manufactured in single units for the lane widths shown on the plans, unless otherwise approved by the Engineer. Do not use more than two assembled sections in any one joint for ramps, loops, and tapered sections.
  1. Secure the dowel bar assemblies to prevent movement during concrete placement in accordance with Standard Plate 1103 and the following:
    - a. Provide a Quality Control Plan for Dowel Basket Assemblies in accordance with 2301.3.H.1.a.
    - b. Fasten the baskets to the surface so that they do not move vertically or horizontally more than 1/8 inch [3 mm] from surface.
    - c. Type, location, number and length of anchors are dependent upon field conditions;
    - d. Before paving, demonstrate the fastening method to the Engineer for approval.
  2. Within one hour before covering with concrete, coat the dowel bars with a thin uniform coating of a form coating material in accordance with MnDOT 3902, "Form Coating Material."
  3. Before placing the concrete, mark the location on both sides of each transverse joint as approved by the Engineer. Transfer the markings to the fresh concrete immediately after completing the final finishing operations.
  4. The Contractor may use a mechanical dowel bar inserter to place dowel bars in the pavement as reviewed by the Engineer. Immediately before inserting the dowels, coat the dowels with a thin uniform coating of a form coating material in accordance

with MnDOT 3902, "Form Coating Material." If using a dowel bar inserter, initially and on each production day, demonstrate to the Engineer that the inserted dowel bars in the completed concrete pavement are parallel to the surface and centerline slab and are located at the proper depth according to the plans.

J. Drill and Grout Tie Bars and/or Dowel Bars in Existing Pavement

1. When anchoring in existing concrete, use either a MnDOT-approved epoxy system according to the manufacturer's instructions, or provide and place a bonding grout into the drilled hole by using the steel to push the epoxy or grout into the drilled hole and placing the grout or epoxy around the edge of the steel. The bonding grout shall consist of two parts Portland cement and one part sand, mixed with sufficient water to form slurry with the consistency of thick cream. The Contractor shall mix the grout mechanically.

K. Concrete Pavement Placement

1. Dump or discharge concrete without causing grade displacement or damage to the existing asphalt or bond breaker layer. Repair damage to the grade, existing asphalt, or bond breaker layer as approved by the Engineer. Provide protection for turning concrete trucks.
2. Maintain the grade in a moist condition until placement of concrete.
3. Construct mainline pavement in a single layer of concrete. Place the concrete pavement in one complete pass of the paving machine to minimize the need for hand-finishing.
4. Coordinate paving operations for mixing, delivering, spreading, and extruding the concrete to provide uniform progress of the paver. Use sufficient trucks to ensure a steady forward progress of the paver. If the forward movement of the paver stops for a period long enough to create a cold joint or honeycombing, construct a header joint in accordance with Section 3.5.O "Constructing Joints" of this specification.
5. Do not add water to the surface of the concrete to aid in finishing.
6. When placing concrete on asphalt or asphalt bond breakers, comply with the following:
  - a. Do not place concrete on an asphalt surface with an asphalt surface temperature greater than 120 °F.
  - b. Maintain the asphalt surface in a moist condition as necessary and at a surface temperature not greater than 120 °F before placing the concrete. The Engineer will allow the Contractor to apply water, whitewash of hydrated lime and water, or both to cool the asphalt surface, or other methods allowed by the Engineer.
  - c. Before placing concrete on a milled asphalt surface, clean the milled surface by sweeping and patch as shown on the plans or as directed by the Engineer.
7. When placing concrete adjacent to in-place concrete pavement, protect the following:
  - a. All ends of transverse joints  $\frac{3}{16}$  inch or wider to the satisfaction of the Engineer. The Engineer will allow sawing through the existing joint when sawing the newly placed concrete.
  - b. The in-place pavement to prevent damage.

- c. Do not allow the edges of the pavement, including longitudinal joints, to deviate from the line shown on the plans by greater than  $\frac{1}{2}$  inch at any point.

L. Integral Curbs

Integral curbs are placed with the pavement in a single paving machine operation; however, hand methods may be allowed for radius, returns, and sections of curb and gutter 100 feet or less in length or in other special sections where mechanical equipment cannot be used.

1. Pave, edge, protect, saw, and cure curb in same manner as pavement.
2. Finish curb as rapidly as finishing operations on pavement permit. Maximum distance behind paving machine is 100 feet.
3. Complete final finish on curbs by hand methods, including the use of a 6-foot straightedge.
4. Check surfaces of curb and gutter with 10-foot straightedge; correct variations greater than  $\frac{1}{4}$  inch.
5. For drop curb at driveways and where sidewalks intersect streets, use forms to shape the backs of such curbs.
6. When using hand methods for building curb, the following additional requirements will apply:
  - a. Remove free water, latency, dust, leaves, or other foreign matter from the slab prior to placing concrete for curb.
  - b. Use freshly mixed concrete; do not store concrete in receptacles at side of pavement for use in curb at a later time; do not use concrete requiring retempering.
  - c. Consolidate curb concrete to obtain adequate bond with the pavement slab and to eliminate honeycomb in the curb. Avoid disturbing the alignment of forms or the gutter flow line.

M. Finishing

1. Grade and crown: Strike off the surface to the true section by the screed promptly after concrete has been placed and vibrated. Finish the surface true to crown and grade.
2. Watering the surface: Do not add water to the surface of the concrete to aid in finishing.
3. Floats: Finish surface with wood or magnesium floats; finish from both sides simultaneously if pavement is placed to full width with one pass of paving machine.
4. Straightedging
  - a. After the longitudinal floating has been completed and the excess water has been removed, and while the concrete is still plastic, test the pavement surface for trueness.
  - b. Immediately fill any depressions found with freshly mixed concrete, strike off, consolidate, and refinish.

- c. Check surface longitudinally while concrete is still plastic; correct any surface deviations greater than ¼ inch in 10 feet.
5. Surface treatment
- a. Drag surface treatment: Unless otherwise specified, texture the finished surface with an artificial turf or broom to produce a minimum depth of texture of 0.8 mm.
    - i. Pull the artificial turf or burlap drag longitudinally over the finished surface to produce a tight, uniform, textured surface, and round the edges in a workmanlike manner.
    - ii. Remove the artificial turf or brooms from the pavement surface at regular intervals and clean with water to remove accumulated concrete from the fabric in order to maintain a consistent finished texture.
6. Edge finish: Before the concrete has taken its initial set, finish all edges of the pavement with an 1/8-inch-radius edging tool.
- N. Curing – See Section 3.8 of this specification for curing requirements.
- O. Construction of Joints
1. General
- a. Construct joints of the type and dimensions and at the locations specified in the contract documents.
  - b. Place longitudinal joints coincident with or parallel to the pavement centerline.
  - c. Place all transverse joints at right angles to the centerline and extend the full width of the pavement.
  - d. Place all joints perpendicular to the finished grade of the pavement and do not allow the alignment across the joint to vary from a straight line by more than 1 inch.
  - e. Exercise care in placing, consolidating, and finishing the concrete at all joints.
2. Saw joints
- a. Submit a jointing plan to the Engineer for approval prior to placing concrete.
  - b. Saw all mainline concrete pavements; no tooling of joints will be allowed.
  - c. Mark joint locations with a string line before sawing.
  - d. Begin transverse joint sawing as soon as the concrete has hardened sufficiently to allow sawing without raveling or moving of aggregate. Saw joints before uncontrolled cracking takes place.
  - e. Provide either wet-cut saws referred to as a “conventional concrete saw,” or a lighter weight dry-cut saw, referred to as an “early entry concrete saw,” to establish joints sooner than the conventional saw.
  - f. Saw all joints in a single cutting operation for a specific joint. Make saw cuts true to line and to the dimensions specified in the contract documents. Extend transverse joints in the pavement through the integrant curb at the same time as the pavement joint is cut.

- g. Discontinue sawing a joint if a crack develops ahead of the saw and rout open the crack for sealing.
  - h. If necessary, continue the sawing operations both day and night. Night operations will require the approval of local agencies in regard to any noise regulations.
  - i. The concrete must be capable of supporting the sawing operations to allow the use of an early green concrete saw.
  - j. Repair or replace pavement with uncontrolled or random cracking at no additional cost to the Engineer. Use repair methods approved by the Engineer. Repair or replace at the direction of the Engineer.
  - k. Use wet sawing for dust control when specified in the contract documents.
  - l. Where boxouts occur in pavement, construct joints as shown on the plans.
3. Contraction joints
- a. Place longitudinal and transverse construction joints where specified in the contract documents, at boxouts, and at headers.
  - b. Locate and place forms for boxouts on grade prior to paving as shown on the plans.
  - c. If concrete placement is delayed for more than 60 minutes or at the end of each day, construct a header transverse construction joint within 5 feet of a planned transverse contraction joint.
  - d. Finish the edges of the pavement at construction joints with an 1/8-inch-radius edging tool.
  - e. If a random crack occurs away from the planned joint location, repair the crack with one of the following techniques.
    - i. If the pavement is undoweled and the random crack is at least 3 feet from the planned joint: Rout and seal the random crack and epoxy the planned joint closed if it has not cracked open.
    - ii. If the pavement is undoweled and the random crack occurs within 3 feet of the planned joint and the planned joint has cracked open: Repair with a 4-foot full-depth repair. If the planned joint has not cracked open, then rout and seal as above.
    - iii. If the pavement is doweled and the random crack occurs at least 3 feet from the planned joint: Repair with a dowel bar retrofit repair and rout and seal the crack.
    - iv. If the pavement is doweled design and the crack occurs within 3 feet of the planned joint: Repair with a 4-foot full-depth repair.
4. Isolation/expansion joints
- a. Install isolation joints as specified in the contract documents.
  - b. Prevent movement of or damage to joint assembly when placing concrete.
  - c. Use supplemental vibration equipment for proper consolidation of the concrete.

- d. After the surface finishing has been completed, finish the edge of the joint with an 1/8-inch edging tool.
5. Constructing headers
    - a. Construct construction headers, temporary headers, and permanent headers as shown on the plans.
    - b. The Engineer will not allow incorporating any concrete accumulated in the grout box of the paver into the pavement. Construct all headers such that the concrete contained in the grout box is removed from the project. Use any approved construction header method as shown in the Standard Details.
    - c. Use internal vibration to consolidate the concrete along header joints before final finishing.
- P. Joint sealing
1. Timing
    - a. Unless otherwise allowed or reviewed by the Engineer, before any portion of the pavement is opened to the Contractor's equipment or to general traffic, clean and seal joints that require sealing.
    - b. The Engineer may limit the wheel loads and axle loads of equipment operating on the pavement during this operation prior to the age of seven days and/or until a strength of 3000 psi is achieved. If the Contractor wants to proceed sooner, he will need to perform additional strength tests to determine the pavement strength.
  2. Cleaning: Perform joint sealing as shown on the plans and in accordance with the following:
    - a. Seal joints after the Engineer inspects and approves the joints.
    - b. Perform joint sealing on surface dry concrete after cleaning the joints of debris, dirt, dust, and other foreign matter, including accumulations of concrete.
    - c. Lightly sandblast the joint walls before final compressed air cleaning.
    - d. Immediately before sealing the joints, clean the joints with a jet of compressed air under pressure of at least 85 psi.
    - e. Seal transverse integrant curb joints with the same joint sealer used to seal the pavement joints.
    - f. Seal joints in accordance with the tolerances shown on the plans.
    - g. Provide backer rod material compatible with the sealer as shown on the plans.
    - h. Remove and replace sealer at joints filled above the permissible level shown on the plans at no additional cost to the department.
    - i. Handle and place joint sealer material as recommended by the manufacturer and in accordance with the following requirements.
- Q. Hot-Poured Sealers
1. Heat hot-poured sealers in a double-boiler-type kettle or melter. Fill the space between inner and outer shells with oil or other material as allowed by the manufacturer.

2. Provide heating equipment with automatic temperature control, mechanical agitation, and recirculating pump. Use heating equipment as recommended by the manufacturer of the sealer material.
3. Do not melt quantities of sealer material greater than the quantity used within the same day. After heating the sealer material to the application temperature, maintain the material temperature until placement. Place the sealer material within four hours after the initial heating to the application temperature.
4. Apply hot-poured sealant to the pavement at ambient pavement temperatures greater than 39 °F.

### **3.6 Curb and Gutter Construction**

#### **A. Slipform Paving**

1. Use a slipform machine for all curb and gutter sections except in areas where the curb machine is not able to work.

#### **B. Joint Construction**

1. Place ½-inch expansion joints transversely at the ends of curved sections and at the ends of the curved portions of entrance and street returns. Place longitudinal expansion joints as shown on the plans. Place expansion joints at locations where the concrete surrounds or adjoins an existing fixed object, such as a fire hydrant, building foundation, or other rigid structure.
2. Provide contraction joints at the following intervals, except as otherwise shown on the plans:
  - a. Adjacent to bituminous mainline, every 10 feet.
  - b. Adjacent to concrete mainline, match concrete mainline transverse joints.
  - c. In solid median construction, every 10 feet.
3. Form or saw the contraction joints, as reviewed by the Engineer, to a depth of at least 2 inches deep.
4. Align joints with joints in adjoining work unless a ½-inch preformed isolation/expansion joint isolates the work. Place transverse joints at right angles to the centerline of the pavement unless otherwise required by the contract.
5. Use an edging tool with a radius no greater than ½ inch to round edges of longitudinal construction joints between a concrete median or gutter section and a concrete pavement.
6. Do not saw or seal longitudinal construction joints between a concrete median and concrete pavement, or between a gutter section and concrete pavement.

C. Surface Treatment

1. Surface finish with a fine concrete finishing broom in the transverse direction.

**3.7 Sidewalk Construction**

A. Joint Construction

1. Divide the walk into square panels of uniform size no greater than 36 square feet and outlined with contraction or expansion joints as shown on the plans.
2. Provide straight joints parallel with or at right angles to the walk centerline. Align the joints with joints in adjoining work unless isolated by ½-inch preformed isolation material.
3. The Contractor may form or saw the joints in walking surfaces as approved by the Engineer. If forming the joints, round joints within the walking surface with a ¼-inch-radius grooving tool, and round edges of the walk with an edging tool having a radius no greater than ½ inch.
4. Extend contraction joints to a depth of at least 1/3 of the walk thickness. If saw cutting, provide a minimum of ⅛-inch-wide contraction joints.
5. Provide isolation/expansion material in accordance with MnDOT 3702, "Preformed Joint Fillers," that is, ½-inch wide and equal in depth to the full thickness of the walk.
6. Modify joint construction if a fixed object or structure extends through the walk, as directed by the Engineer. Place isolation/expansion material ½-inch thick adjacent to fixed objects to separate the object from the abutting concrete edges.

B. Surface Treatment

1. Surface finish with a fine concrete finishing broom.

**3.8 Curing of All Concrete**

An airless spraying machine is required for curing all concrete. Airless sprayers may be used for small and irregular areas provided they have the ability to mix the curing compound in the container and maintain open nozzles.

Apply the curing compound in accordance with the following:

- A. Apply liquid curing compound in a fine spray to form a continuous, uniform film on the horizontal surface and vertical edges of pavement, curbs, and back of curbs immediately after surface moisture has disappeared, but no later than 30 minutes after finishing. With approval of the Engineer, the timing of cure application may be adjusted due to varying weather conditions and concrete mix properties to ensure acceptable macro texture is achieved and bleed has evaporated.
  1. For concrete pavement, use MnDOT-approved 3754 AMS white pigment liquid curing compound for all concrete surfaces.

2. For all other concrete and colored concrete pavement, use either a MnDOT-approved 3754 AMS white pigment liquid curing compound or a MnDOT approved 3753 curing compound with a fugitive dye. The Engineer may approve the use of a clear curing compound.
  3. Apply curing compound to all concrete surfaces at an application rate of 150 square feet per gallon. Apply homogeneously to provide a uniform solid coverage on all exposed concrete surfaces (equal to a white sheet of typing paper when using pigmented curing compound). Some MnDOT-approved curing compounds may have a base color (i.e., yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
- B. Ensure liquid curing materials are well agitated in the supply drum or tank immediately before transfer to the sprayer. Keep curing materials well agitated during application.
  - C. If forms are used, apply to pavement edges and back of curbs within 30 minutes after forms are removed.
  - D. Failure to comply with these curing specifications will result in a monetary deduction of at least \$50.00 per cubic yard or 50 percent of the Contractor-provided invoice amount for the concrete in question
  - E. If the curing compound is damaged during the curing period, immediately repair the damaged area by respraying.
  - F. If the Engineer determines that the initial or corrective spraying may result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method, at no additional cost to the Engineer.

### **3.9 Concrete Protection – Include These Plans in the Contractor’s Quality Control Plan**

- A. Protection Against Rain: Protect the concrete from damage due to rain. Have available materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until corrective action is taken.
- B. Protection Against Cold Weather
  1. If the National Weather Service forecast for the construction area predicts air temperatures of 36 °F or less within the next 24 hours and the Contractor wishes to place concrete, submit a cold weather protection plan.
  2. 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.
  3. Cold Weather Protection Plan: Submit in writing to the Engineer a proposed time schedule and plans for cold weather concrete protection that provide provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the Contractor's cold weather protection plans.

C. Protection Against Hot Weather

1. If the National Weather Service forecast for the construction area during concrete placement is such that the combined factors of temperature, wind, and humidity are detrimental to concrete placement, develop a hot weather protection plan.
2. The definition of hot weather conditions is defined in the *PCA Design and Control of Concrete Mixtures* as when the rate of evaporation of bleed water per hour exceeds 0.2 lb. of water per square foot per hour. A chart published by ACI and PCA can be used to predict the bleed water rate.
3. Hot Weather Protection Plan: Submit in writing to the Engineer a proposed time schedule and plans for hot weather concrete protection that provide provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the Contractor's hot weather protection plans.

**3.10 Opening Concrete to Traffic**

A. Opening Pavement and Driveways to Traffic

1. Do not open a new pavement slab to general public traffic or operate paving or other heavy equipment on it until the concrete has attained an age of seven days or it has reached a minimum compressive strength of 3,000 psi, as reviewed by the Engineer.
2. If the pavement joints are widened, seal the joints before operating paving or other heavy equipment and allowing general public traffic on the pavement.
3. Cast the compressive strength control specimens in accordance with ASTM C31, "Making and Curing Concrete Test Specimens in the Field." Cure the control specimens in the same manner and under the same conditions as the pavement represented. The Engineer will test the control specimens in accordance with Concrete Sampling and Testing, Table 5 or 6.
4. Perform operations on new pavement as reviewed by the Engineer and in accordance with the following:
  - a. When moving on and off the pavement, construct a ramp to prevent damage to the pavement slab.
  - b. Operate the paving equipment on protective mats to prevent damage to the pavement surface and joints. Before placing the protective mats, sweep the pavement surface free of debris.
  - c. Operate equipment on a slab without causing damage. If damage results, suspend operations and take corrective action as reviewed by the Engineer. Do not operate the equipment wheels or tracks within 4 inches of the slab edge.

B. Opening of Sidewalks and Medians to Pedestrian Traffic

1. Normal pedestrian foot traffic can walk on the finished concrete as soon as practical without causing damage to the fine broom finish.
2. Construction traffic shall not be allowed for three days or until the concrete reaches a compressive strength of 3000 psi.

C. Backfill Construction – Operating Vibratory Equipment

1. Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours.
2. Do not perform vibratory operations and backfilling until 72 hours after placing the concrete or after the concrete reaches a compressive strength of at least 3000 psi.

**3.11 Contractor Submittal Requirements**

A. Submittals: Follow these *Minnesota Concrete Flatwork Specifications* and any local covenants, as well as the following:

1. All submittals of drawings; manufacturers' certificates of compliance, recommendations, and test data, reports, catalog data sheets; and other data shall be in accordance with the submittals section, unless otherwise specified herein.
2. Two weeks prior to commencing any concrete placement, submit a concrete mix design for each different source of aggregate for review by the Engineer.
3. Two weeks prior to commencing any concrete placement, submit a Quality Control plan which includes all of the following:
  - a. Traffic control plan.
  - b. A list of all process control or quality control testing technicians.
  - c. Concrete placement plan.
  - d. Concrete washout guidance plan.
  - e. Pre-pour meeting dates for pours over 500 cubic yards.
  - f. Procedure for placing dowel bars and reinforcement.
  - g. Concrete curing plan.
  - h. Rain protection plan.
  - i. Cold weather protection plan.
  - j. Hot weather protection plan.

- k. Submit to the Engineer an organizational chart listing names and phone numbers of individuals and alternates responsible for mix design, quality control administration, and inspection.
- l. Submit the smoothness profiler information, including which machine and operator, when specified by the Engineer for concrete pavement.
- m. The Contractor is responsible for developing the maturity curve for the specified mix, taking maturity readings, and delivering a copy of the results to the Engineer when required in the contract. The Contractor will provide any equipment necessary to monitor the maturity in the field.

### 3.12 Concrete Sampling and Testing Requirements

- A. Turn in all field test results to the Engineer or owner's representative using MnDOT's weekly concrete report form 2448 and the Concrete Ready-Mix Plant QC Workbook turned in weekly.
- B. Prior to the first pour at each concrete plant, the Contractor needs to submit a Contact Report /Ready Mix Form 2163 and the Aggregate Quality report.
- C. The testing rates shown in this section are minimums. Take all samples in a random manner using an appropriate random number generator. Take as many tests as necessary to ensure quality control.
- D. If any field test fails, reject the concrete, or if the producer makes adjustments to the load to meet requirements, record the adjustments on the certificate of compliance and the weekly concrete report. Retest the load and record the adjusted test results. Make sure the load is tested before it gets into the work.
- E. All people performing field testing of plastic concrete will carry either a current MnDOT or ACI Concrete Field 1 concrete testing certification. All people performing gradations and moistures will carry either a current MnDOT Concrete Plant 1 or an ACI Aggregate Testing Technician Level 1 certification.
- F. All concrete shall come from a MnDOT-certified ready-mix plant, and all people performing plant testing will carry a current MnDOT Concrete Plant 1 certification.
- G. Fabricate strength specimens in accordance with ASTM C31. Provide moist curing environments of adequate size and number for initial and final curing of strength specimens in accordance with ASTM C31.
- H. Record the results of each field test of plastic concrete on the Certificate of Compliance ticket and note whether it is a Contractor test or an Agency test.
- I. The Producer shall perform all plant testing according to Table 5 for **all concrete** placed.
- J. The Engineer shall perform testing according to Table 5 for **all concrete placed**. If the Engineer includes a Pay Item for Concrete Testing according to Table 5, the Contractor will inform the Engineer at the pre-construction meeting who the third party is that will perform testing for the Engineer.

<p align="center"><b>Table 5</b>  <b>Minimum Testing Rates</b>  <b>for Curb and Gutter, Sidewalks, and Pavements</b></p>			
<b>Test Type</b>	<b>MnDOT Spec or ASTM No.</b>	<b>Producer Testing Rates</b>	<b>Engineer Testing Rates</b>
Gradation	MnDOT 3126 MnDOT 3137 ASTM D75 ASTM C702 ASTM C117	Coarse and fine: 1 per 400 yd <sup>3</sup> or as directed by the Engineer	1 per project
Moisture Content	MnDOT 2461	1 every four hours	At Engineer's discretion
Aggregate Quality	Table 3 Table 4	Minimum of 1 per project – use of MnDOT test results for the same 30-day time period is acceptable	Minimum of 1 per project – use of MnDOT test results for the same 30-day time period is acceptable
Coarse Aggregate Testing (% Passing 200)	MnDOT 3137 ASTM C117	Minimum of 1 per project – use of MnDOT test results for the same 30 -day time period is acceptable	Minimum of 1 per project – use of MnDOT test results for the same 30 -day time period is acceptable
Air Content	ASTM C231		Test first load each day per mix, then 1 test per 200 yd <sup>3</sup>
Slump	ASTM C 143		Test first load each day per mix, then 1 test per 200 yd <sup>3</sup> , slump test not required for slipform placement
Temperature	ASTM C 1064		Record temperature each time air content, slump, or strength test specimen is performed/fabricated
Compressive Strength	ASTM C 31		Test first load each day per mix, then 1 test (set of 3) per 200 yd <sup>3</sup> , minimum of 1 (set of 3) per day if production is more than 50 yd <sup>3</sup> . Record slump, temperature, and air content for each cylinder
Concrete Pavement Thickness			Observation of probing or coring at their discretion.

**K. Air Content**

1. Evaluate air content of the concrete according to ASTM C231, the pressure meter; ASTM C138, using the gravimetric unit weight method; or ASTM C 173, the volumetric method.
2. For concrete paving, once per day run an air test in front of the paver and then run an air test immediately behind the paver to aid in identifying air loss through the paver. A test result between 5 percent and 8 percent behind the paver will be considered compliant. This test will represent all concrete from the back of the paver back to the last documented complying test. Make immediate adjustments to the mix production and placement process to bring the air content back within tolerance. Do not use succeeding loads below the lower target air content tolerance by more than 0.5 percent. Test each subsequent load until air content is within tolerance for two consecutive loads. For all incorporated, non-complying concrete that is out of tolerance, the Engineer will review and determine if removal and replacement is required or if a price adjustment according to Table 6 will be applied.

<b>Table 6 Air Content Penalties Target of 6.5% with a Range of 5% – 8.5%</b>	
<b>Air Content, %</b>	<b>Adjusted Contract Unit Price for the Type of Concrete Placed</b>
> 10.0	The Engineer will determine the concrete suitability for the intended use in accordance with “Conformity with Contract Documents” and “Unacceptable and Unauthorized Work” as reviewed by the Engineer.
>8.5 – 10.0	The Engineer will provide a monetary adjustment of -\$25.00 per cubic yard for the concrete placed as approved by the Engineer.
5.0 – 8.5	The Engineer will pay 100 percent of the contract unit price for the concrete represented, for material placed as approved by the Engineer.
>4.0 – <5.0	The Engineer will provide a monetary adjustment of -\$25.00 per cubic yard for the concrete placed as approved by the Engineer.
>3.5 – 4.0	The Engineer will provide a monetary adjustment of -\$75.00 per cubic yard for the concrete placed as approved by the Engineer. The Engineer may also require coating the surface with an approved epoxy penetrant sealer from the MnDOT Approved Products list.
≤ 3.5	Remove and replace concrete in accordance with “Conformity with Contract Documents” and “Unacceptable and Unauthorized Work” as reviewed by the Engineer. If the Engineer will determine if the concrete can remain in place, the Engineer will not pay for the concrete and the Engineer may also require coating the surface with an approved epoxy penetrant sealer from the MnDOT Approved Products list.

- L. **Concrete pavement smoothness.** All concrete pavement bid items are governed by the straightedge evaluation unless a bid item is used to pay for the ALR evaluation.
1. Straightedge evaluation: The Engineer will allow variations less than or equal to ¼ inch within the span of a 10-foot straightedge in the longitudinal or transverse direction to remain in place without correction or penalty. The Engineer will require corrective work on surface deviations greater than ¼ inch within the span of the 10-foot straightedge in any direction. For corrected variations, the Engineer will accept

deviations less than or equal to ¼ inch within the span of a 10-foot straightedge in any direction.

2. Areas of Localized Roughness (ALR)

- a. “Areas of localized roughness” (ALR) is defined as areas greater than or equal to the limiting criteria for a continuous IRI calculation with a 25 feet [7.62 m] interval, as calculated using the FHWA’s Profile Viewing and Analysis (ProVAL) software.
- b. Provide a department-certified, calibrated, and documented IP meeting the requirements of ASTM E 950, Class 1 and procedures maintained by the MnDOT Pavement Engineering Section. Refer to the procedures maintained by the MnDOT Pavement Engineering Section or to the MnDOT Smoothness website for the required settings for individual certified profilers.
- c. The Contractor shall provide an operator trained in the operation of the particular Inertial Profiler they will use to measure the smoothness and knowledgeable in the use of the required “Profile Analysis Software, Proval.” Ensure profiler operators pass a proficiency test and possess a current certification issued by MnDOT. The Contractor may access a list of certified operators on the MnDOT Smoothness website. Provide documentation of operator certification to the Engineer.
- d. Remove objects and foreign material from the pavement surface before performing the pavement surface evaluation. Provide traffic control required for testing and performing corrective work on the final pavement surface.
- e. Run the IP in the direction of traffic. Measure the profile in the right wheel path of each lane.
- f. Areas that will be exempt from the ALR specification shall be 10 feet on either side of a manhole, water valve, or any other utility obstruction in the driving lanes. Intersections and areas purposefully designed for drainage will be exempt from the ALR specification, as approved by the Engineer.
- g. Test and evaluate each lane separately. The Engineer will determine the length in miles [kilometers] of each mainline traffic lane. Operate the IP at the optimum speed as recommended by the manufacturer.
- h. Separate each lane into segments 0.1 mi [0.1609 km] in length. Evaluate the remainder segment less than 0.1 mi [0.1609 km] in each lane as an independent segment. The Engineer will prorate pay adjustments for length.
- i. Make each pass continuously, regardless of length, and end passes before exclusions. Begin each subsequent pass 50 feet [15.24 m] before, and including, construction headers and end-of-day work joints. In concrete pavements, evaluate terminal headers tying into existing portland cement concrete pavement.
- j. Submit a printout containing the inertial profiler’s settings, each segment’s IRI values, and the signature of the operator to the Engineer on the same day of the profiling.

- k. Submit electronic files in ERD format representing the raw data from each pass on the same day of the profiling.
- l. If the Contractor fails to submit actual data to the Engineer on the day of profiling, the Engineer may require the Contractor to reprofile the measured segments.
- m. Identify ALR using the ProVAL “smoothness assurance” analysis, calculating IRI with a continuous short interval of 25 feet with the 250 mm filter. Use only the right wheel path to determine ALR.
- n. The Engineer will evaluate ALR in accordance with Table 7, “ALR Monetary Deductions and Corrective Work Requirements.”

<b>Table 7 Concrete Pavements Only ALR Monetary Deductions and Corrective Work Requirements</b>		
<b>Equation</b>	<b>25 ft. Continuous IRI, in/mi</b>	<b>Corrective Work or Monetary Deduction, per linear 1.0 ft.</b>
Concrete pavements with a posted vehicle speed greater than 45 mph	< 125.0	Acceptable
	≥ 125.0 to < 175.0	\$10.00
	≥ 175.0 to < 250.0	Corrective work or \$25.00, as directed by the Engineer
	≥ 250.0	Corrective work or \$50.00, as directed by the Engineer
Concrete pavements with a posted vehicle speed of 45 mph or less and concrete intersections constructed under traffic	< 175.0	Acceptable
	≥ 175.0 to < 250.0	\$10.00
	≥ 250.0	\$25.00

- o. Corrective work
  - i. If the summary reports indicate any ALR, submit a written corrective work plan to the Engineer in accordance with Table 7, “Corrective Work.” Include the beginning and ending points of locations planned for correction in the corrective work plan. Do not begin corrective work before the Engineer approves the plan.
  - ii. If the Engineer elects to assess a monetary deduction for ALR in accordance with Table 7 instead of requiring corrective work, submit a final spreadsheet summary.

- iii. Notify the Engineer at least 24 hours before beginning corrective work. Do not begin corrective work before the Engineer approves the methods and procedures in writing.
- iv. Perform corrective work using a surface diamond-grinding device consisting of multiple diamond blades, unless otherwise approved by the Engineer. Repair and replace joint sealant damaged by diamond grinding on concrete pavement as directed by the Engineer and at no additional cost to the department.
- v. Perform smoothness corrective work for ALR across the entire lane width. Maintain the pavement cross slope through corrective areas.
- vi. Perform surface corrections before placing permanent pavement markings. Replace permanent pavement marking damaged or destroyed by corrective work at no additional cost to the department.
- vii. The Engineer will consider ALR acceptable if the retested segment contains no ALR. The Engineer will reduce payment for ALR remaining after retesting as determined by the Engineer and in accordance with Table 7, "ALR Monetary Deductions and Corrective Work Requirements."
- viii. After reprofiling, submit a paper summary ProVAL report for each lane, indicating the results of updated "smoothness assurance" analyses to the Engineer. Submit a spreadsheet summary in tabular form, with each 0.1 mile segment occupying a row to the Engineer. The Contractor may access an acceptable spreadsheet summary template in electronic form on the MnDOT Smoothness website.

#### M. Pavement Thickness

1. Thickness requirements: Provide pavement with a finished pavement thickness as shown on the plans or as modified, in writing, by the Engineer.
2. Procedure: Construct pavement to the thickness shown on the plans. On each project and on each pavement, evaluate pavement thickness in accordance with the following:
  - a. The Engineer defines plan thickness lot (PTL) as concrete pavement of the same thickness added together lineally. Establish a separate PTL for each concrete plan thickness on the project. The Engineer defines a subplot as the rate at which an individual measurement is taken over a given length. The Engineer considers a subplot as one lane wide, measured in accordance with the following:
    - i. From the pavement edge to the adjacent longitudinal joint,
    - ii. From one longitudinal joint to the next, or
    - iii. In the absence of a longitudinal joint, between pavement edges.

- b. The Engineer will divide the PTL into sublots of 500 lineal lane feet to determine the QCP locations. The Engineer will add partial sublots less than 500 feet to the previous lot. The Engineer will consider partial sublots equal to or greater than 500 lineal lane feet as individual sublots. If the PTL for the entire project is less than 500 lineal lane feet, the Engineer will consider the PTL as an individual subplot. The Engineer will identify the QCP thickness measurement locations in accordance with the following:
  - i. Determine the longitudinal locations using random numbers multiplied by length of the subplot.
  - ii. Determine the transverse offset locations using a random number multiplied by the width of the traffic lane, ramp, or loop at the determined longitudinal location.
  - iii. Adjust the location to ensure the Contractor takes no measurements within 1 foot of the pavement edge and takes no measurements within 2 feet of any transverse or longitudinal joint or other obstructions.
- c. Contractor QCP Probing Equipment and Probing Method: Provide the following equipment as approved by the Engineer to perform QCP probing:
  - i. Probing rod meeting the following characteristics and requirements:
    - Non-flexing,
    - Length capable of completely penetrating the pavement for measuring,
    - Utilizes a circular or square top plate,
    - Contains a centrally located hole in the top plate with a diameter allowing for easy maneuvering along the length of the probing rod, and
    - Fitted with a locking device fixing the angle between the top plate and the probing rod at 90 degrees when locked.
  - ii. Work bridge meeting the following characteristics and requirements:
    - Spans the full width of the freshly laid concrete,
    - Supports a person, and
    - Height above the concrete allows for the use of the probing device.
  - iii. Tape measure accurate to nearest  $\frac{1}{8}$  inch and with a length capable of measuring the depth of penetration of the probing device into the plastic concrete pavement.
- d. Contractor Quality Control Probing (QCP)

- i. Measure the pavement thickness of freshly finished concrete pavement at a **rate of 1 per 500 lineal feet** per lane of pavement.
  - ii. Place the base plates at the randomly selected locations and anchor the plates to prevent movement during concrete placement. Mark the locations of the base plates to ensure ease of locating the plates after the paver has passed,
  - iii. Position the bridge at the selected locations to reach and locate each point,
  - iv. Assemble the probing device. Keeping the probing rod perpendicular to the pavement surface, insert the rod into the plastic concrete until the rod strikes the base plate,
  - v. Slide the top plate down the probing rod until it contacts the pavement surface, then lock to the probing rod,
  - vi. Withdraw the probing device, and
  - vii. Measure the length of the probing rod inserted into the plastic concrete from the underside of the top plate to the end of the probing rod. Record this measurement to the nearest  $\frac{1}{8}$  inch.
  - viii. Provide daily summary reports listing the results of the day's QCP thickness measurements and additional probing results to the Engineer.
- e. Non-conforming thickness
- i. The Engineer will base acceptance of the pavement thickness and price adjustment for deficient thickness on the QCP measurements.
  - ii. The Engineer defines the tolerance limit for pavement thickness as the plan thickness lot (PTL) minus  $\frac{1}{2}$  inch. If the QCP measurement shows a thickness deficiency greater than PTL minus  $\frac{1}{2}$  inch, take additional probings at the location of the deficient QCP. If any QCP reading shows a thickness deficiency greater than PTL minus  $\frac{1}{2}$  inch, consider the pavement defective and take exploratory QCP measurements to isolate the defective area.
  - iii. The Engineer defines the defective pavement area as the entire area surrounding the deficient QCP reading within a traffic lane and between acceptable QCP readings. The Engineer considers the pavement acceptable in the remaining areas as the increment where the probing shows a thickness deficiency no greater than PTL minus  $\frac{1}{2}$  inch.
  - iv. For QCP readings showing a pavement thickness greater than the PTL minus  $\frac{1}{2}$  inch to 1 inch, the Contractor may leave the pavement in place with a monetary deduction of \$20 per square yard for the defective pavement area, as approved by the Engineer.
  - v. For readings showing a pavement thickness greater than PTL minus 1 inch, the Engineer will determine whether the Contractor will remove and replace

concrete pavement or leave the pavement in place at no cost to the Engineer and apply a monetary deduction of \$20 per square yard for the defective pavement area.

- vi. The Engineer will consider the pavement thickness as conforming provided the deficiency of the final average PTL does not exceed PTL minus 0.10 inch. If the final average PTL is deficient by more than the PTL minus 0.10 inch, the Engineer will pay for the pavement in the PTL at the contract unit price less the monetary deductions in accordance with Table 8, excluding areas of defective pavement.

<b>Table 8 Deductions for Concrete Pavement Thickness Deficiencies</b>	
<b>Thickness Deficiency Exceeding Permissible Deviations, in.</b>	<b>Adjusted Unit Bid Price Per sq. yd. of Payment</b>
0.00 – ≤ 0.10	None (tolerance)
0.10 – ≤ 0.20	\$0.20
0.20 – ≤ 0.30	\$0.40
0.30 – ≤ 0.40	\$0.70
0.40 – ≤ 0.50	\$1.00
0.50 – ≤ 1.00 *	\$20.00

N. Acceptance of Concrete Compressive Strength

A **strength test** is defined as the average (28-day) strength of three (3) cylinders fabricated from a single sample of concrete and cured in accordance with ASTM C31 or the MnDOT Concrete Manual.

The Engineer will consider concrete acceptable provided **both** conditions are met:

- (1) No strength test is less than 3500 psi; and
- (2) The moving average of 3 consecutive strength tests is greater than or equal to 4000 psi. If a project does not establish a moving average of 3 consecutive strength tests, use either the single strength test or the average of 2 strength tests to determine acceptance.

**If the moving average of three (3) consecutive strength tests falls below 87.5% of f'c, the Contractor will make immediate adjustments to the Concrete Mix Design in question or use an alternate approved Concrete Mix Design.**

If any strength test falls below either condition (1) or (2) above, the Contractor and Engineer will mutually agree on an Independent Third Party to investigate the low strength results.

If the Independent Third Party determines the concrete in question is acceptable to remain in place with no additional testing, the Engineer will determine if a price adjustment is required in accordance with Table 10.

If it is determined that the concrete in question is not acceptable:

- (1) The Independent Third Party will core and test the concrete in question in accordance with ASTM C42.
- (2) The Engineer will identify a minimum of three (3) locations for the Independent Third Party to core. The Independent Third Party will take one (1) core at each location.
- (3) The Contractor is responsible for ensuring the core holes are repaired.
- (4) The Engineer will require the Contractor to complete all coring within 14 days of notification of the low-strength concrete.

The Independent Third Party will review the core test results and evaluate in accordance with Table 9, providing all other concrete tests meet requirements.

<b>Table 9 Evaluation of Core Test Results</b>			
<b>Core (average of 3 cores) Test Results:</b>	<b>Engineer Considers Concrete:</b>	<b>Cost of Coring and Testing:</b>	<b>Resolution:</b>
≥ 85% of f'c	Acceptable to remain in place	Engineer responsibility	No monetary adjustment, and consider any additional actions in accordance with Table 10.
< 85% of f'c	Unacceptable	Contractor responsibility	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 may not pay for the concrete or will pay at an adjusted Contract Unit Price, and consider any additional actions in accordance with Table 10.

**Non-Conforming Material**

If the Contractor inadvertently places concrete not meeting the strength requirements into the work, the Engineer will not accept nonconforming concrete at the contract unit price.

For concrete not meeting the moving average of three (3) consecutive strength tests, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the contract unit price for the contract item of the concrete in accordance with Table 10 based upon cylinder strength test results.

<b>Table 10 Deductions for Low-Strength Test Results</b>	
<b>Moving Average of 3 Consecutive Strength Tests</b>	<b>Adjusted Contract Unit Price</b>
> 93.0% of f'c	The Engineer will provide a monetary adjustment of \$12.50 per cubic yard for the concrete placed as approved by the Engineer.
≥ 87.5% and ≤ 93.0% of f'c	The Engineer will provide a monetary adjustment of \$25.00 per cubic yard for the concrete placed as approved by the Engineer.
< 87.5% of f'c	Remove and replace concrete in accordance with "Conformity with Contract Documents," and "Unacceptable and Unauthorized Work," as directed by the Engineer. If the Independent Third Party and the Engineer determine the concrete can remain in place, the Engineer will not pay for the concrete.

**PART 4. CONCRETE STRENGTH BY THE MATURITY METHOD**

**4.1 Concrete Strength by the Maturity Method**

- A. Determining concrete maturity (time temperature factor, TTF) and estimating in-place concrete strength is a two-step procedure as follows:
  - 1. Maturity curve: Establish a relationship between the maturity (TTF) and the concrete strength as measured by destructive methods (that is, through testing of concrete cylinders or beams). Develop the maturity-strength curve at the plant site at the beginning of construction using project materials and the project proportioning and mixing equipment.
  - 2. Field maturity: The second step is the temperature monitoring of the placed concrete. Install temperature probes in the concrete and measure the temperature. From those measurements, along with the age at which the measurements were taken, calculate the maturity (TTF) and use it to estimate the concrete strength. You may also use a maturity meter to determine the maturity value (TTF). Many products are available in the marketplace with embedded probes that transfer data either through a wire connection or wireless. This data is a complete record of the temperature and humidity or the concrete since it was embedded. Some chips can hold either 28 or 56 days' worth of data.
- B. Maturity can be used for any concrete mix on a project, but might be most helpful for early-strength concrete mixes. These mixes are used to open sections of pavement to traffic as soon as possible using maturity as a non-destructive testing method of estimating the concrete strength at any time.

- C. Early-strength concrete can be used for any pavement, crosswalks, median noses, valley gutter, and curb and gutter as needed. Early-strength concrete shall achieve sufficient strength to be opened to traffic within three days of placement, or earlier if the compressive strength of 3000 psi is achieved. Because of the accelerated rate of hardening of early-strength concrete, the Contractor shall take such extra precautions as necessary to ensure satisfactory finishing of early strength concrete.
- D. The Contractor shall place the maturity-measuring device in the final 15 feet of concrete placed, which will control the opening time for all the concrete placed that day. For concrete pavement, the maturity device shall be located on the outside edge of the slab, at least 1 foot and not more than 2 feet from the edge.
- E. The Contractor shall develop maturity relationships for each mix design in accordance with ASTM C 1074 with the following additions or modifications:
  - 1. The cylinders used to establish the strength vs. maturity relationship shall be cast and cured in the field in conditions similar to the project.
  - 2. These specimens shall be tested at 1, 2, 3, 5, 7, and 14 days.
  - 3. Testing to determine datum temperature will not be required.
- F. The Contractor shall provide the maturity-measuring devices, probes, meters, and all necessary wires and connectors. The Contractor shall be responsible for the placement, protection, and maintenance of the maturity devices, wires, and meters. The equipment will be the property of the Contractor. The cost will be paid under "Maturity Testing for Compressive Strength."

**PART 5. PRE-POUR MEETING**

**5.1 Pre-Pour Meeting for Concrete Pours > 500 cubic yards**

Guidelines for a concrete pre-placement meeting are only required for each concrete pour greater than 500 cubic yards of concrete. The Contractor is responsible for taking minutes at the pre-placement meeting and distributing to all parties who attended the meeting.

A. Project Participants

1. Owner

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

2. Engineer

3. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

4. General Contractor

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

5. Concrete Contractor

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

6. Concrete Producer

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

7. Testing Firm

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

B. Grading and Base

1. Base material type and source

2. Compaction method to be used

3. Are separate procedures for backfilling trenches in the grade specified?

4. Party responsible for approving final grade and elevation

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

b. Amount of advance notice needed to schedule inspection

5. Plan to protect finished grade from weather and vehicle traffic

6. Approximate completion date of base preparation

C. Proposed Concrete Pour Schedule

1. Number of pours and pour size
2. Approximate dates for pours
3. Is there a noise variance? What time can work start in the morning?
4. Has the concrete Contractor notified the concrete producer and discussed the pour schedule?

D. Concrete Mix and Concrete Production

1. Have concrete mix designs been submitted and approved?
  - a. What are the sources of the coarse and fine aggregate?
  - b. Do they meet the aggregate quality requirements?
  - c. Does the project require enhanced coarse aggregate quality?
  - d. Does the fine aggregate require mitigation?
2. Will high early mixes be needed? Have they been submitted and approved?

3. Mix Name	Use	Spec'd Air	Spec'd Slump	Spec'd Strength
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

4. Are there exterior concrete mixes approved for the project?
  - a. Are the water-to-cementitious ratios 0.45 or below?
  - b. Are the mixes air entrained?
5. Do the specifications allow the addition of water and/or admixtures to concrete on site?
6. Primary concrete batch plant location
7. Producer batch plant/quality control contact information
  - a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_
8. Travel time to job site
9. Back-up batch plant location and contact information

10. Will batch tickets be printed for loads of concrete delivered to job site?

11. Who is responsible for saving batch tickets for the project records?

E. Concrete Field Testing

1. Engineer Party responsible for testing

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

2. Contractor Party responsible for testing

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

3. Advance notice needed to schedule on-site testing

4. Frequency of testing

a. Plastic concrete

b. Hardened concrete

5. Cylinder storage and handling

a. What is the procedure for protecting cylinders on site?

b. Who is responsible for providing the concrete test cylinder curing environment?

6. Has the concrete producer been added to the distribution list for test results?

7. What criteria will be used to address concrete that doesn't meet plastic concrete specifications? Who is responsible for acceptance of the concrete?

a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_

F. Concrete Placement

1. Proposed placement sequence

a. Equipment to be used for each placement

b. Are there any special pours or unusual conditions on site?

2. Joints

a. What is the saw cutting window?

b. What is the joint layout / spacing?

c. Are there special considerations for joints around embedded objects?

d. Are the joints to be sealed?

- i. Proposed joint sealant product
  - ii. Proposed joint sealant procedure
3. Dowels and reinforcement as required by the plans.
4. Inclement weather
  - a. Will supplies be on site in case of unexpected rain?
  - b. Hot weather plan
    - i. What is the hot weather plan?
    - ii. When will the hot weather plan be used?
  - c. Cold weather plan
    - i. What is the cold weather plan?
    - ii. When will the cold weather plan be used?
5. Curing plan
  - a. Proposed curing product – is it MnDOT-approved?
  - b. Time frame to apply curing compound
  - c. Application rate
  - d. Proposed curing equipment
6. Party responsible for allowing concrete to be opened to any type of traffic:
  - a. Contact Name: \_\_\_\_\_ Contact Number: \_\_\_\_\_
  - b. Is the Contractor using the Maturity Method for Strength Development?