

**Supplement No. 1 to the 2013 Edition
Standard Construction Specifications
City of Duluth, MN
March 21, 2013**

The following items are additions, corrections or amendments to the City of Duluth Standard Construction Specification, 2013 Edition. These items shall be incorporated into the specification.

2461 STRUCTURAL CONCRETE
(2013 Version)

The provisions of MnDOT 2461 are modified in accordance with the following:

2461.1 DESCRIPTION

This work consists of producing, providing, placing, curing, and protecting portland cement concrete for placement in structures, pavements and incidental construction.

2461.2 MATERIALS

A Cementitious Materials

Provide cementitious materials from certified sources listed on the Approved/Qualified Products list.

Use Type I or Type I/II portland cement to produce Type 1 non-air-entrained concrete.

Use Type I or Type I/II portland cement and an air-entraining admixture listed on the Approved/Qualified Products List to produce Type 3 air-entrained concrete.

Use Type III portland cement as allowed by the Contract or the Engineer.

A.1 Portland Cement	3101
A.2 Ground Granulated Blast Furnace Slag.....	3102
A.3 Blended Hydraulic Cement.....	3103
A.4 Fly Ash	3115

A.5 Cementitious Content

Provide concrete with the minimum cementitious content for the grades and slumps of concrete in accordance with Table 2461-1:

Table 2461-1								
Minimum Cementitious Content,								
<i>lb per cu. yd [kg per cu. m]</i>								
Specified Slump Limit, in [mm]	Grades							
	U	V	W	X	Y	A	B	C
1 [25]	800 [475]	730 [435]	—	—	—	—	—	—
2 [50]	830 [490]	765 [455]	660 [390]	630 [375]	570 [340]	530 [315]	490 [290]	420 [250]
3 [75]	850 [505]	730 [475]	695 [410]	665 [395]	605 [360]	560 [335]	515 [305]	445 [265]
> 3 [75]	—	—	730 [475]	700 [415]	640 [380]	590 [350]	540 [320]	470 [280]

Except for grout mixtures, limit the maximum cementitious content for a cubic yard [cubic meter] of concrete to 850 lb [505 kg].

A.6 Cementitious Substitutions

The Contractor may replace Type I or Type I/II portland cement with other cementitious materials in accordance with the following restrictions:

- (1) Maximum of 15 percent substitution of Class C or Class F Fly Ash, on a one for one basis, by weight of the designed portland cement;
- (2) For Department designed mixes, the Department will adjust the batch weight of coarse aggregates to compensate for volume changes due to cementitious substitutions;
- (3) Maximum of 33 percent substitution of Class C or Class F Fly Ash for concrete pavement, on a one for one basis, by weight of the designed portland cement;
- (4) Maximum of 35 percent substitution of slag, on a one for one basis, by weight of the designed portland cement; and
- (5) Ternary mixes (portland cement and two other supplementary cementitious materials) are allowed when approved by the Engineer, in conjunction with the Concrete Engineer, or required by or allowed in the Contract.

B Fine Aggregate.....3126

C Coarse Aggregate3137

Unless otherwise required by the Contract, the Contractor may select the class of coarse aggregate as defined in 3137.2.B, "Classification."

D Water.....3906

E Concrete Admixtures3113

The Contractor may use the following admixtures listed on the Approved/Qualified Products List:

- (1) Type A, "Water Reducing and Mid Range Water Reducing Admixtures,"
- (2) Type B, "Admixtures Identified as Hydration Stabilizers,"
- (3) Type D, "Water Reducing and Retarding Admixtures"
- (4) Type S, "Viscosity Modifying Admixtures."

Use of any other admixtures in the concrete requires approval of the Concrete Engineer unless otherwise required by or allowed in the Contract.

When incorporating admixtures into the concrete:

- (1) Use admixture dosage rates recommended by the manufacturer.
- (2) Add all admixtures at the plant.
- (3) Provide admixture additions at the job site that are the same products as originally incorporated into the mix.
- (4) Use calcium chloride in concrete as approved by the Engineer, in conjunction with the Concrete Engineer. Do not use calcium chloride in units containing prestressing steel or in bridge superstructure concrete.

E.1 Use of Additional Admixtures

On a case by case basis, the Engineer, in conjunction with the Concrete Engineer, will consider the use of the following admixtures, added either at the plant or at the job site, as listed on the Approved Products list:

- (1) Type C, "Accelerating Admixtures"
- (2) Type E, "Water Reducing and Accelerating Admixtures"
- (3) Type F, "Water Reducing, High Range Admixtures"
- (4) Type G, "Water Reducing, High Range and Retarding Admixtures"

E.1.a Delivery Time Beyond 90 Minutes

If the haul time does not facilitate mixing and placing the concrete within 90 minutes, perform the following procedures for pre-qualifying a concrete mix to extend the delivery time to 120 minutes. Extending the delivery time beyond 120 minutes will require additional testing at 30 minute intervals up to the maximum desired delivery time as directed by the Concrete Engineer.

- (1) Provide a Contractor mix design in accordance with 2461.3G2 for each combination of materials.
- (2) Specification 2461.3D is modified to allow up to 25% fly ash replacement for cement. All other requirements of 2461 apply.
- (3) Laboratory trial batching on the proposed mix includes the following testing requirements:
 - (a) Perform all laboratory trial batching at an AMRL accredited laboratory.
 - (b) Perform all plastic concrete testing after adding all admixtures to the concrete mixture.
 - (c) Perform slump, air content, unit weight and temperature testing immediately after batching and at 90 and 120 minutes.
 - (d) Fabricate concrete cylinders for compressive strength at 90 and 120 minutes (sets of 3) and cylinders for hardened air content testing at 90 and 120 minutes (sets of 5).
 - (e) Test the cylinders for compressive strength at 28 days.
 - (f) Determine the hardened air content (ASTM C457) at a minimum of 7 days. The Contractor is required to test at 2 samples representing 90 minutes and 2 samples representing 120 minutes and provide MnDOT with the other 6 samples for testing at their discretion. Retain any hardened concrete test specimens for a minimum of 90 days for MnDOT to examine at their discretion.
 - (g) Ensure the admixture manufacturer's technical representative is present during the trial batching.
 - (h) Contact the MnDOT Concrete Engineering Unit a minimum of 2 days prior to mixing. This same 2 day notification is required prior to any physical testing on hardened concrete samples.
 - (i) Once accepted by the Concrete Engineer, the laboratory trial batching is considered acceptable for use for 5 years, unless it is determined the material sources have changed significantly since the initial laboratory testing and acceptance. In all cases, the Engineer will require field trial batching on a project specific basis.

- (4) Field trial batching on the proposed mix for each specific project shall include batching in the presence of the Engineer and the following:
- (a) Provide a QC Plan for extending the delivery time beyond 90 minutes.
 - (b) Mix and transport the concrete using the same materials as were utilized in the laboratory trial batching.
 - (c) Batch a minimum 5 cu. yd (4 cu. m) of concrete utilizing the same methods intended for use when supplying concrete placed into the permanent work.
 - (d) Maintain the ready mix truck in transit; by either driving around the yard or on the roadway; and maintain the drum speed at 5 to 7 revolutions per minute for the entire 120 minutes.
 - (e) Perform all plastic concrete testing after adding admixtures to the concrete mixture.
 - (f) Perform slump, air content, unit weight and temperature testing at 90 and 120 minutes.
 - (g) Fabricate concrete cylinders for compressive strength at 90 and 120 minutes (sets of 3) and cylinders for hardened air content testing at 90 and 120 minutes (sets of 2).
 - (h) Test the cylinders for compressive strength at a minimum of 7 days.
 - (i) Determine the hardened air content (ASTM C457) at a minimum of 7 days. The Contractor is required to test 1 sample representing 90 minutes and 1 sample representing 120 minutes and provide MnDOT with the other 2 samples for testing at their discretion. Retain any hardened concrete test specimens for a minimum of 90 days for MnDOT to examine at their discretion.
 - (j) Incorporate the trial batch concrete into other work with the approval of the Engineer.
 - (k) The Contractor must demonstrate to the Engineer the ability to properly mix, control and place the concrete.
- (5) The Concrete Engineer, in coordination with the Engineer, will review the trial batch results and all related concrete testing for compliance with the QC Plan and the Contract. Final approval of the mixture is based on satisfactory field placement and performance.

F Concrete Mix Designs

F.1 Department Designed

The Department will provide the estimated composition of concrete mixes unless otherwise required by the Contract.

The Department may adjust the mix composition of the concrete without adjusting the Contract unit price for any Contract items.

F.1.a Concrete Yield

The Department defines concrete yield as the ratio of the volume of mixed concrete, less accountable waste, to the planned volume of the work constructed. The Department will not assume responsibility for the yield from a given volume of mixed concrete.

F.1.b High-Early Strength Concrete

When the Engineer requires high-early strength concrete, the concrete is designed in accordance with the following:

- (1) Increasing the cement content of the concrete up to 30 percent; using an approved accelerator as allowed by the Engineer, in conjunction with the Concrete Engineer; or both.
- (2) Using 100 percent portland cement, unless allowed by the Contract or the Engineer.
- (3) A maximum cement content for a cubic yard [cubic meter] of concrete not to exceed 900 lb [535 kg].
- (4) A water/cement ratio not to exceed 0.38 for Type 3 Concrete unless otherwise required by the Contract.

F.2 Contractor Designed

Design the concrete mix based on an absolute volume of 27.00 cu. ft \pm 0.10 cu. ft [1.000 cu. m \pm 0.003 cu. m] for the following:

- (1) Concrete paving mixes in accordance with 2301, "Concrete Pavement;"
- (2) Concrete mixes with an anticipated or required 28-day compressive strength of at least 5,000 psi [34 MPa];
- (3) Precast concrete in accordance with 2405, "Prestressed Concrete Beams," 2412, "Precast Concrete Box Culverts," 3236, "Reinforced Concrete Pipe," 3238, "Precast Concrete Box Culverts," 3621, "Concrete Masonry Units," 3622, "Sectional Concrete Manhole and Catch Basin Units," and 3630, "Precast Concrete Median Barriers;"
- (4) Colored concrete;
- (5) Stamped concrete;
- (6) Cellular Concrete Grout – Controlled Low Strength Material (CLSM);
- (7) Extended Delivery Times Beyond 90 minutes; and

(8) Concrete as otherwise required by the Contract.

Submit the concrete mixes using the MnDOT Contractor Mix Design Submittal Package available on the Department’s website at least 21 calendar days before initial placement of the concrete mix. The Engineer, in conjunction with the Concrete Engineer, will provide specific gravity and absorption data for mix design calculations.

The Concrete Engineer, in coordination with the Engineer, will review the mix design submittal and will approve the materials and mix design for compliance with the Contract.

The Contractor assumes full responsibility for the mix design and performance of the concrete.

The Engineer determines final acceptance of the concrete for payment based on satisfactory field placement and performance.

F.3 Classification of Concrete

The Department will classify concrete by type, grade, consistency, and aggregate size. Refer to the mix number and Table 2461-2 to determine the mix requirements for each item of work.

Table 2461-2				
Mix Number Identification				
First Digit	Second Digit	Third Digit	Fourth Digit	Additional Digits
Type	Grade	Slump range	Coarse aggregate gradation range	Class A coarse aggregate when required, modified mix designation, or both

Refer to individual Contract items in the Standard Specification for Mix Numbers. Deviations from the specified Mix Numbers require coordination with the Concrete Engineer.

If the Contract does not show a concrete mix number, provide Type 3, Grade Y concrete with a slump and aggregate gradation determined by the Engineer.

The Department will designate grout by type and grade followed by the word “GROUT.” Do not provide grout containing coarse aggregate. If the plans do not show a type or grade for grout, provide 3A GROUT.

F.3.a Type Designation

Provide Type 1 or Type 3 concrete in accordance with Table 2461-3:

Table 2461-3 Concrete Type Designation		
Concrete Type	Target Air Content*, %	Maximum Water/Cement Ratio
1	2.0	≤ 0.53 for 1A43 ≤ 0.68 for 1C62 ≤ 0.64 for 1C Grout
3	6.5 †	≤ 0.45 † #
* For concrete mix design purposes only. The water/cement ratio is defined as the ratio of the total water weight to the total cementitious weight. † Unless otherwise required by 2301 or elsewhere in the Contract. #The maximum water/cement ratio for machine placed concrete is 0.42.		

F.3.b Grade Designation

The Department will designate concrete grade using a letter to represent the anticipated compressive strength and the minimum cementitious content in accordance with 2461.2.A.5, "Cementitious Content," and Table 2461-4:

Table 2461-4 Concrete Grade Designation		
Concrete Grade	Type 1 Anticipated Compressive Strength, <i>psi [MPa]</i> *	Type 3 Anticipated Compressive Strength, <i>psi [MPa]</i> *
U	6,300 [43]	5,600 [39]
V	6,000 [41]	5,300 [37]
W	5,700 [39]	5,000 [34]
X	5,400 [37]	4,700 [32]
Y	5,000 [34]	4,300 [30]
A	4,500 [31]	3,900 [27]
B	4,100 [28]	3,400 [23]
C	3,200 [22]	2,700 [19]
* Anticipated minimum strength produced in accordance with the Department specifications and cured for 28 days under laboratory conditions.		

The Concrete Engineer, in coordination with the Engineer, may increase the cement content for concrete with test cylinder results less than the anticipated compressive strength in accordance with Table 2461-4, “Concrete Grade Designation.” The Contractor may request an increase in the cement content as approved by the Engineer, in conjunction with the Concrete Engineer.

F.3.c Slump Designation

Refer to the slump designation for the upper limit of the slump range without a water reducer in accordance with Table 2461-5:

Table 2461-5 Slump Designation	
Slump Designation	Slump Range without Water Reducer, in [mm]
1	½ – 1 [12 – 25]
2	1 – 2 [25 – 50]
3	1 – 3 [25 – 75]
4	2 – 4 [50 – 100]
5	2 – 5 [50 – 125]
6	3 – 6 [75 – 150]

F.3.d Coarse Aggregate (CA) Designation

Refer to the coarse aggregate designation for the range of optional coarse aggregates gradations allowed in the mix in accordance with Table 3137-4, “Coarse Aggregate Designation for Concrete,” and Table 2461-6:

Table 2461-6 Coarse Aggregate Designation for Concrete	
Range	Optional Coarse Aggregate Designation
0	CA-00 only
1	CA-15 to CA-50, inclusive
2	CA-15 to CA-60, inclusive
3	CA-35 to CA-60, inclusive
4	CA-35 to CA-60, inclusive
5	CA-45 to CA-60, inclusive
6	CA-50 to CA-70, inclusive
7	CA-70 only
8	CA-80 only

F.3.e Additional Designations

For mix designs that require a specified class of coarse aggregate as defined in 3137.2.B, "Classification," an additional letter will follow the fourth digit of the Mix Number such as "A" (Class A Aggregate Requirement).

The Engineer may identify special concrete mix designations with additional letters following the last digit such as "HE" (High Early), "WC" (Water/Cement Ratio), "HPC" (High Performance Concrete), "MS" (Microsilica), or others.

2461.3 CONSTRUCTION REQUIREMENTS

A Batching Equipment

A.1 Mixer Requirements

Provide stationary mixers or truck mixers.

A.2 General Condition

Maintain mixers as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examine to detect wear of blades.

Replace or recondition pickup and throwover blades in mixers with a rated capacity less than 14 cu. ft [0.40 cu. m] showing a blade wear loss of greater than $\frac{1}{2}$ in [13 mm], and pickup and throwover blades in mixers of greater capacity, showing a blade wear loss of no greater than $\frac{3}{4}$ in [19 mm] from the original factory dimensions.

A.3 Manufacturer's Rating Plate

Provide mixers that include the manufacturer's rating plate, showing the following information:

- (1) Serial number of the unit,
- (2) Mixing speed of the drum or paddles, and
- (3) Maximum capacity in terms of volume of mixed concrete.

A.4 Drum Speed for Stationary Mixers

Operate the drum speed in the mixer as specified by the manufacturer or as directed by the Engineer.

A.5 Auxiliary Equipment Requirements

Provide mixers equipped with the following:

- (1) Timing device,
- (2) Discharge locking device,
- (3) Water measuring device that operates mechanically and automatically during each batching cycle, and
- (4) A graduated adjustable indicator device to represent the volume of discharge in increments no greater than $\frac{1}{4}$ gal [1 L] in full view.

A.6 Mixer Capacity

Do not exceed the manufacturer's rated capacity of the mixer when mixing a single batch of concrete.

Batch concrete in volumes the mixer can accommodate without spilling, leaking, or segregating during the charging, mixing, or discharging operations. Provide mixers with a capacity of at least 1 sack [0.25 cu. m].

A.7 Mixing Time

The Department defines the mixing time as the time period beginning when the cement and aggregates enter the mixer drum and ending when the discharge begins.

Refer to the manufacturer's recommended minimum mixing time for single drum and dual drum mixers. In the absence of manufacturer's recommendation, the Engineer will designate the minimum mixing time. The minimum mixing time for any concrete batch is 60 s. The Contractor may reduce the manufacturer's recommended minimum mixing time or the Engineer designated mixing time if the Contractor obtains uniform mixing in accordance with 2461.3.E, "Mixing Requirements," and as approved by the Engineer, in conjunction with the Concrete Engineer.

If there is evidence of inadequately mixed concrete (unmixed or partially mixed materials) during concrete placement, the Engineer may direct an increase in the mixing time.

A.8 Turbine Type Mixers

Provide turbine type mixers meeting the applicable requirements for conventional type mixers (2461.3.A.1 through 2461.3.A.7) and in accordance with this subsection (2461.3.A.8). Maintain the mixer drum in a cylindrical shape within $\frac{3}{4}$ in [19 mm] from the original factory dimensions at any point. Maintain the mixer discharge gate in a mortar tight condition in the closed position.

Replace or recondition mixer paddles showing a wear loss greater than ½ in [13 mm] from the original factory dimensions.

Add the mixing water to the batch materials in a manner that distributes the water to the inner or central areas of the drum. Start the flow of water before introducing the solid batch materials into the mixer drum.

During mixing, operate the paddles at a speed between 20 revolutions and 30 revolutions per minute. After adding the batch materials to the drum, mix the concrete for an additional 60 s.

A.9 Horizontal Axial-Revolving Blade Type Mixers

Provide horizontal axial-revolving blade type mixers in accordance with the applicable requirements for conventional type mixers (2461.3.A.1 through 2461.3.A.7) and in accordance with this subsection (2461.3.A.9).

Charge the water, aggregates, and cement in the sequence approved by the Engineer. Test the concrete uniformity as directed by the Engineer. The Engineer will use concrete uniformity tests to determine the minimum mixing time.

B Transportation Units

B.1 General Requirements

Equip transportation units intended for both mixing and agitating with watertight revolving drums mounted and powered and fitted with properly designed mixing blades in accordance with 2461.3.A.1 through 2461.3.A.7. Provide units capable of combining all the ingredients into a homogeneous mixture and designed to provide two drum speeds, one for mixing and the other for agitating. Provide units capable of delivering the concrete without segregation or loss of any of the batch materials.

Equip the mixer drum with a working counting device to record the number of revolutions.

Equip dump trucks and agitator trucks with vibrators to aid in discharge.

B.2 Capacity of Transportation Units

Refer to the truck mixer manufacturer's certification plate attached to the unit for the maximum capacity of the unit. If the unit will not satisfactorily mix the maximum volume shown, reduce the batch volume to allow proper mixing or discontinue use of the mixing unit as directed by the Engineer until the problem is corrected.

C Handling and Storing Materials

C.1 Batch Material Requirements

Do not change the source, kind or gradation of batch materials after the start of concrete production for the work unless otherwise approved by the Engineer. If the Engineer approves use of different material, completely exhaust the supply on hand before changing to the different material.

If delivering freshly washed aggregates to the batching plant, drain the aggregates for at least 12 h before using in the batching operation. If draining freshly washed aggregates at the site of the batching plant, completely separate the drained material from the undrained materials, and provide for the disposal of water that accumulates from the drainage of materials.

Provide smooth, firm, and well-drained stockpile sites cleared of vegetable and extraneous matter. Where the natural foundation is unsatisfactory, as determined by the Engineer, construct the stockpiles on suitable platforms. Construct suitable bulkheads or partitions to separate different kinds of aggregate, gradation, or water content.

Construct stockpiles by methods that hold segregation and degradation to a minimum. If the Engineer sees segregation or degradation, the Engineer may designate that pile as unacceptable for use.

Do not use aggregates used to construct runways for loading or hauling equipment in concrete batches.

Use of aggregates from the bottom 1 ft [0.3 m] of a stockpile placed on an unprepared surface in concrete batches is allowed only under the Engineer's direct supervision and if the material meets all requirements of 3126, "Fine Aggregate for Portland Cement Concrete," and 3137, "Coarse Aggregate for Portland Cement Concrete."

Provide aggregates in accordance with the specified gradation requirements.

The Engineer will consider aggregates unacceptable if the variation in moisture content carried by any of the aggregates causes a marked variation in the consistency of successive batches of the mixed concrete, and will suspend operations until corrected.

C.2 Concrete Temperature Control

Produce concrete at temperatures from 50 °F to 90 °F [10 °C to 30 °C] and maintain temperatures until deposited in the work.

If necessary to maintain placement temperature, uniformly heat or cool the water, aggregates, or both, before introduction into the mixer. Control the temperature of the mixing water during heating or cooling.

Use aggregate at temperatures from 32 °F to 130 °F [0 °C to 55 °C]. Do not allow cementitious material to contact other batch material when the aggregate temperature exceeds 130 °F [55 °C].

Do not heat the cement, add salt, or add chemical admixtures to the concrete mix to prevent freezing.

Use a heating system to heat batch materials as approved by the Engineer. Do not use steam jets to spot heat the material as the work progresses.

Do not place mixer heaters intended for heating the batch materials in the mixer drum.

D Batching Requirements

Calibrate weighing equipment in accordance with 1901, “Measurement of Quantities.” Inspect and calibrate the scales in accordance with the Concrete Manual.

D.1 Batching by Weight

D.1.a Proportioning Methods

Proportion concrete batch materials by weight in a central plant or by volume as directed by the Engineer, in conjunction with the Concrete Engineer.

D.1.b Weighing Equipment and Tolerances

Weigh or measure concrete mixture ingredients using load cells or meters for ready-mix and paving concrete to within the targeted batch weight in accordance with the following:

- (1) Water – 1 percent,
- (2) Cement – 1 percent,
- (3) Other cementitious materials – 3 percent,
- (4) Aggregates – 2 percent, and
- (5) Admixtures – 3 percent.

D.1.c Batching of Mixing Water

Measure the mixing water on scales or water metering devices containing the following:

- (1) A discharge indicator capable of being set to within 1 gal [5 L] of a predetermined quantity,
- (2) A positive automatic shutoff valve, and
- (3) An approved inspection seal on the scale or water metering device dating the time of the previous calibration and adjustment

An authorized service agency will calibrate the water meter every 6 months and make adjustments as necessary before use meeting the requirements of the weighing procedure in the Concrete Manual.

Check the water meter for accuracy at least once each month as the work progresses.

D.1.d Batching of Cementitious Materials

Weigh the cementitious material independently of the aggregates in separate compartments or on separate scales.

If the Contractor weighs the cement first and then separately records the weights of each individual cementitious material, the Contractor may weigh the cementitious materials cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.e Batching of Aggregates

If the Contractor records each individual fraction weight of aggregates separately, the Contractor may weigh aggregates cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.f Admixture Proportioning

If using two or more admixtures in a single concrete batch, add each admixture separately to prevent interaction of the different admixtures before mixing with other batch materials. Agitate admixtures to ensure homogeneous concentrations in accordance with the manufacturers recommendations.

Incorporate admixtures to the batch mix in liquid form. Maintain admixture solutions at a uniform concentration at all times. Use the solution concentration and proportions designated by the manufacturer.

If using a mechanical dispenser for proportioning Class I or Class II admixtures, provide a site gauge or meter. Have the admixture manufacturer check admixture dispensers yearly to determine accuracy and ensure unobstructed flow.

D.2 Batching by Volume

Proportion concrete for bridge deck overlays by volume or as required by the Contract.

If the Contractor calibrates the mixer for the specific batch materials in use, the Contractor may proportion concrete on other items of work by volume as approved by the Engineer in writing.

The Engineer will approve all methods and equipment used in volumetric proportioning.

Determine all material proportions and calibration settings on the basis of 100 lb [100 kg] of cementitious material.

Provide and use only sacked cement in the original mill containers unless the Contractor calibrates the mixer for the specific materials in use. Do not use fractional sacks.

Increase the cementitious content by 10 percent in the computation of volume proportions unless the Contractor calibrates the mixer for the specific materials in use.

E Mixing Requirements

The Engineer may check the water measuring equipment for accuracy before mixing operations begin and at any other time the Engineer considers necessary.

Mix concrete by one of the following methods:

- (1) A central plant (stationary plant),
- (2) Entirely or in part in truck mixers, or
- (3) At the construction site.

Do not allow the mixing batch to merge or intermix with the subsequent dry batch during mixing.

Discharge water remaining in the drums before batching.

Mix concrete to provide a mixture that is homogeneous and uniform in color. The Engineer will reject concrete batches that show a marked variation in consistency or evidence of improper mixing as unacceptable work in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

After completely mixing the concrete, either in a central plant mixer or truck mixer, continuously agitate while in transit to the point of placement until the concrete is discharged from the unit, unless otherwise allowed by the Engineer, in conjunction with the Concrete Engineer.

If the mixing does not appear uniform, perform slump tests at the 15 percentage point and the 85 percentage points during unloading. If the results show a slump variation greater than 1½ in [38 mm], stop work and correct the mixing unit.

Produce concrete in such quantity and at such a rate as proper placement and finishing will permit. Do not re-temper partially set concrete.

Do not hand mix concrete.

E.1 Mixing In Truck Mixer

Charge the materials into the truck mixer drum by introducing sufficient water before adding solid materials. Perform charging operations without losing materials.

Leave the truck mixer at the plant site for a minimum of 5 min or 50 revolutions during the mixing period. Transport the concrete at agitating speed to the point of placement.

F Certified Ready-Mix Concrete

F.1 Definitions

The Department defines ready-mix concrete as one of the following:

- (1) Central-mixed concrete proportioned and mixed in a stationary plant and hauled to the point of placement in revolving drum agitator trucks or a truck mixer, or
- (2) Truck-mixed concrete proportioned in a stationary plant and fully mixed in truck mixers.

Table 2461-7 defines commonly used certified ready-mix terms.

**Table 2461-7
Certified Ready-Mix Terminology**

Term	Definition
Mix design water	The maximum allowable water content for 1 cu. yd [1 cu. m] of concrete in accordance with MnDOT Form TP 02406, <i>Estimated Composition of Concrete Mixes</i> .
Total moisture factor	Factor used to determine total amount of water carried by a given wet aggregate.
Absorption factor	Factor used to determine the water contained within the pores of the aggregate and is held within the particles by capillary force.
Free moisture	The water that is carried on the surface of the aggregate that becomes part of the total water.
Batch water	Water actually batched into the truck by the batcher.
Total water	Batch water added to free moisture. Total water may also include the water used in diluting admixture solutions.
Temper water	Water added in mixer to adjust slump.
Total actual water	The water in the concrete mixture at the time of placement from any source other than the amount absorbed by the aggregate. It includes all batch water placed in the mixer, free moisture on the aggregate and any water added to the ready mix truck prior to placement.
Ready-Mix Producer or "Producer"	Party that is producing the concrete for the Contract. It is understood that the Ready-Mix Producer is the agent of the Contractor.

F.2 General Requirements

Supply ready-mix concrete in accordance with 2461.3.F.3, "Certified Ready-Mix Plant Program."

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

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

F.3 Certified Ready-Mix Plant Program

Provide ready-mix concrete produced by a certified ready-mix plant. Perform quality control of concrete production under a certification program for ready-mix concrete plants.

Complete all concrete plant documentation utilizing the Concrete Ready-mix Plant QC Workbook available from the MnDOT Concrete Engineering website. Electronically submit the QC Workbook to the Engineer by the Tuesday immediately following the previous week's production.

F.3.a Plant Certification

Before concrete production each season, ensure the producer performs the following:

- (1) Performs an on-site inspection at the concrete plant with the Engineer and completes a MnDOT Form 2163, *Concrete Plant Contact Report*.
- (2) Signs the report certifying compliance with the Certified Ready Mix requirements and continual maintenance of the plant. The Engineer will also sign MnDOT Form 2163, *Concrete Plant Contact Report*.
- (3) Provides a copy of the current Concrete Manual and retains it on-site.
- (4) Equips the Certified Ready-Mix Plant with a working facsimile machine or an email address.
- (5) Keeps plant reports, charts ,and supporting documentation on file at the plant site for 5 calendar years.
- (6) Provides electronic scales for weighing all materials.

F.3.b Sampling and Testing

Provide a MnDOT Certified Concrete Plant Level 2 Technician to oversee testing and plant operations and to remain on-site during concrete production or have cellular phone availability.

Provide facilities in accordance with 1604, "Plant Inspection – Commercial Facility," for the use of the plant technician in performing tests.

Ensure the producer provides technicians with certification at least meeting MnDOT Concrete Plant Level 1 to perform all of the duties in accordance with the Concrete Manual. The Engineer will provide technicians with certification at least meeting MnDOT Concrete Plant Level 1 to perform all of the duties in accordance with the Concrete Manual.

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

Take samples randomly using ASTM D 3665, Section 5.

Perform testing at the certified ready-mix plant site. Perform additional testing as directed by the Engineer. The Engineer may oversee the quality control sampling process.

Provide equipment and perform calibrations meeting the requirements of the following:

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

F.3.c Gradations

Determine the gradation of the fine aggregates and the coarse aggregates as required by the Contract. Use mechanical shakers for sieve analysis of fine and coarse aggregates.

Identify quality control companion samples with the following information:

- (1) Date,
- (2) Test number,
- (3) Time,
- (4) Type of material,
- (5) Plant, and
- (6) Sampling location.

Document gradation results on MnDOT Form 2449, *Weekly Concrete Aggregate Report*.

Chart all producer gradation results and Department verification gradation results of the coarse aggregate and the No. 8 [2.36 mm], No. 30 [600 μ m], and No. 50 [300 μ m] sieves of the fine aggregate.

The producer may request a reduction in testing rates as approved by the Engineer, in conjunction with the Concrete Engineer.

If the gradation tests on split samples from quality control or verification samples result in a variation between the producer and the Department greater than that set forth in Table 2461-8, the parties shall follow the procedures for test

result dispute resolution available from the MnDOT Concrete Engineering website.

Table 2461-8	
Allowable Variations on Percent Passing Sieves	
Sieve Size	Allowed Percentage
2 in – 3/8 in [50 mm – 9.5 mm]	± 6
No. 4 – No. 30 [4.75 mm – 600 µm]	± 4
No. 50 [300 µm]	± 3
No. 100 [150 µm]	± 2
No. 200 [75 µm]	± 0.6

F.3.c.(1) Non-conforming Material

Only place concrete meeting the gradation requirements in the work. If the Contractor places concrete not meeting the gradation requirements into the work, the Engineer will not accept nonconforming concrete at the Contract unit price.

For concrete not meeting the required gradation, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the Contract unit price for the concrete Contract item in accordance with Table 2461-9 and Table 2461-10. When there is not a separate *Structural Concrete* Contract unit price for an item of work or the concrete is a minor component of the Contract unit price, the Department will reduce payment based on a concrete price of \$100.00 per cu. yd [\$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-9	
General Concrete for Individual Aggregate Fractions	
Fine and Coarse Aggregate Specification Sieves other than	
Fine Aggregate No. 200 [75 µm]	
Outside of Specification, %	Adjusted Contract Unit Price
≤ 3	The Department will pay 98 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.
4 – 6	The Department will pay 95 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.
7 – 10	The Department will pay 90 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.
> 10	The Department will pay 75 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.

Table 2461-10 General Concrete for No. 200 [75 µm] Sieve of Fine Aggregate	
Outside of Specification, %	Adjusted Contract Unit Price
< 0.3	The Department will pay 98 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.
0.4 – 0.6	The Department will pay 95 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.
0.7 – 1.0	The Department will pay 90 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.
> 1.0	The Department will pay for 75 percent of the relevant Contract unit price for concrete placed as approved by the Engineer.

If failure occurs on the fine aggregate No. 200 [75 µm] sieve and on other sieves concurrently, the Department will only reduce the price based on the larger percentage deduction.

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted Contract unit prices for coarse aggregate quality failures in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

F.3.d Moisture Content

Ensure the producer performs the following:

- (1) Determines the moisture content using the oven-dry method in all fractions of the aggregate.
- (2) Documents moisture tests on MnDOT Form 2152, *Concrete Batching Report*.
- (3) Charts the moisture content of each aggregate.

In addition to the oven-dry moisture test, the producer may obtain the moisture content in the fine aggregate using a moisture probe.

To obtain approval for the use of a moisture probe, ensure the producer calibrates the moisture probe before each construction season meeting the requirements of the Concrete Manual. Ensure the producer verifies and charts both the probe moisture content and the oven-dry verification moisture test.

F.3.e Plant Diaries

Provide daily plant diaries in accordance with the Concrete Manual using an approved form from the MnDOT’s Concrete Engineering website.

F.3.f Batch Weight Verification

The Engineer will observe the batching process to verify weights shown on the Certificate of Compliance.

The Engineer will observe the actual water batched during each collection of verification gradations in accordance with the following:

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

The Engineer will document the actual water batched on MnDOT Form 24143, *Weekly Certified Ready-Mix Plant Report* and submit a copy to the Engineer to provide to the Concrete Engineer.

The Engineer will provide plant diaries in accordance with the Concrete Manual.

F.3.g Certificate of Compliance

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

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

Provide a computerized Certificate of Compliance from the producer for each item of information, including the following:

- (1) Name of the ready-mix concrete plant.
- (2) Name of the Contractor.
- (3) Date.
- (4) State Project Number (SP) or (SAP).
- (5) Bridge Number (if applicable).
- (6) Time concrete was batched.
- (7) Truck number.
- (8) Quantity of concrete in this load.

- (9) Running total of each type of concrete, each day for each project.
- (10) Type of concrete (MnDOT Mix Designation Number).
- (11) Cementitious materials using MnDOT Standard Abbreviations.
- (12) Admixtures using MnDOT Standard Abbreviations.
- (13) Aggregate sources using 5 digit State Pit Numbers.
- (14) Admixture quantity in fluid ounces per 100 lb [milliliters per kilogram] or ounces per cubic yard [milliliters per cubic meter].
- (15) Batch information for materials using MnDOT standardized labels to represent each column in Table 2461-11. Present the information in the order listed across the page (a through k) or print the information using two lines provided that the materials are identified in each line of information.

Table 2461-11			
Standardized Certificate of Compliance Labels			
	Formula Letter	Formul a	Standard Label
a	Ingredients (aggregate, cementitious, water, admixtures)	—	Ingredient
b	Product Source (MnDOT Standard Abbreviation) ^b	—	Source
c	Total Moisture Factor (in decimals to 3 places)	—	MCFac
d	Absorption Factor (in decimals to 3 places)	—	AbsFac
e	MnDOT mix design oven dry (OD) weights, <i>lb/cu. yd [kg/cu. m]</i>	—	OD
f	Absorbed moisture in the aggregates, <i>lb/cu. yd [kg/cu. m]</i>	$(e \times d)$	Abs
g	Saturated surface dry (SSD) weights for aggregates, <i>lb/cu. yd [kg/cu. m]</i>	$(e + f)$	SSD
h	Free moisture, <i>lb/cu. yd [kg/cu. m]</i>	$(c - d) \times e$	Free Mst
i	Target weights for one cubic yard [cubic meter] of concrete, <i>lb/cu. yd [kg/cu. m]</i>	$(g + h)$	CY Targ [CM Targ]
j	Target batch weights, <i>lb [kg]</i>	$(cu. yd \times i)$ $[cu. m \times i]$	Target
k	Actual batch weights, <i>lb [kg]</i>	—	Actual
NOTE: Actual cubic yards [cubic meters] batched may vary due to differences in air content, weight tolerances, specific gravities of aggregates, and other variables.			

- (16) Total Water (Batch Water + Free Moisture) in pounds [kilograms].
- (17) Water available to add $[(\text{Mix Design Water}) \times (\text{Target CY (CM)}) - \text{Total water}]$ in gallons [liters].
- (18) Space to note the water adjustment information, including:
 - (18.1) Water in gallons [liters] added to truck at plant (filled in by producer, enter zero if no water is added).
 - (18.2) Water in gallons [liters] added to truck at the jobsite (filled in by producer or Engineer, enter zero if no water is added), and
 - (18.3) Total actual water in pounds [kilogram] (Total Water from Certificate of Compliance plus any additions).
- (19) The following information printed with enough room beside each item to allow the Engineer to record the test results:
 - (19.1) Air content,
 - (19.2) Air temperature,
 - (19.3) Concrete temperature,
 - (19.4) Slump,
 - (19.5) Cylinder number,
 - (19.6) Location or part of structure,
 - (19.7) Time discharge, and
 - (19.8) Signature of Inspector.
- (20) Location for the signature of the MnDOT Certified Plant 1 Technician representing the producer. The technician will review the first Certificate of Compliance for each mix type, each day, for accuracy and hand sign the Certificate of Compliance at a location designated for signature signifying agreement to the terms of this policy and to certify that the materials itemized in the shipment comply requirements of the Contract.

F.3.h Decertification

If the Contractor provides concrete from a plant that cannot produce concrete, fails to perform testing, fails to report accurate results, or fails to complete the required documentation, the Engineer may reject the concrete as unacceptable in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

The Concrete Engineer, with coordination from the Engineer, may decertify the plant and halt production of concrete if the producer performs the following:

- (1) Procedural changes made after the completion of the Concrete Plant Contact Report and after starting the work that cause non-compliance with the program,
- (2) Continually produces concrete in non-compliance with this section,
- (3) Completely disregards the requirements of this section, and

If decertifying the plant, the Concrete Engineer may perform the following:

- (1) Revoke plant certification.
- (2) Revoke technician certification for individuals involved,
- (3) Revoke bidding privileges as determined by the Construction Engineer, and
- (4) Criminal prosecution for fraud as determined by the Attorney General.

G Concrete Placement

Do not produce concrete earlier than 60 min before the National Weather Service official sunrise, unless the Engineer approves otherwise.

Place concrete after the Engineer inspects and approves the foundation preparations, forms and falsework erection, placement of reinforcement steel, materials, equipment condition, and cold weather protection.

Do not place concrete if portions of the base, subbase, or subgrade layer are frozen, or if the excessive moisture levels make the grade unstable. Maintain the surface temperature above freezing for forms, steel, and adjacent concrete that will come in contact with the poured concrete before concrete placement.

Protect the concrete from freezing.

Protect the concrete against damage from construction operations or traffic.

Assume full responsibility for the acceptable production, placement, finishing, and curing of all concrete under the conditions prevailing, regardless of the restrictions imposed. Provide any artificial lighting, rain or cold weather protection necessary at no additional cost to the Department. The Engineer may subject any defects in concrete or concrete surfaces resulting from weather conditions, inadequate lighting, or other causes to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.1 Notice of Inspection

Notify the Engineer at least 24 h before beginning concrete production to allow the Engineer time to provide inspection forces needed for the work and to approve preparations for concrete placement. If the Contractor fails to provide 24 h notice, the Engineer may delay concrete placement in accordance with 1503, "Conformity with Contract Documents" and 1512, "Unacceptable and Unauthorized Work."

If the producer needs to change plants during placement, notify the Engineer and obtain approval before changing the plant.

G.2 Placement Temperatures

Do not place concrete when the air temperature at the point of placement is below 36 °F [2 °C] or is expected to fall below 36 °F [2 °C] within the following 24 h period unless approved cold-weather provisions are in-place. Discontinue concrete placement if the air temperature falls below 36 °F [2 °C].

Maintain concrete at a temperature from 50 °F to 90 °F [10 °C to 30 °C] until placement.

G.3 Delivery Requirements

Place concrete into the work in accordance with the following:

- (1) Type 1 Concrete—within 90 min of batching, and
- (2) 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. If the haul time does not facilitate mixing and placing the concrete within 90 minutes, test the concrete in accordance with 2461.3E1a.

The Contractor may transport Type 3 concrete in non-agitating equipment if the concrete is discharged within 45 min of batching.

Batch time starts when the batch plant or the transit mix truck adds the cement to the other batch materials.

G.4 Field Adjustments

Do not add additional mixing water once the concrete is 60 min old.

Mix the load a minimum of 5 minutes or 50 revolutions at mixing speed after addition of any admixture.

For concrete with slumps of greater than 1 inch (25 mm) do not make water adjustments after approximately 1 cubic yard (1 m^3) is discharged.

For concrete with slumps of 1 inch (25 mm) or less, the Engineer will allow water adjustments as necessary to facilitate placement.

The Engineer will test the concrete for compliance with 2461.3.G.6, “Consistency,” and 2461.3.G.7, “Air Content,” in accordance with the following:

- (1) If the test taken by the Engineer passes, the Engineer will continue verification testing in accordance with the Schedule of Materials Control.
- (2) If the test taken by the Engineer fails, make adjustments and perform any quality control testing before the Engineer performs a final test. Acceptance or rejection of the truck is based on the Engineer's final test result.
- (3) The Engineer will test up to two additional trucks in accordance with items (1) and (2) above.
- (4) If the concrete does not meet the specification after those three trucks, the Engineer will reduce their verification testing rate to once per truck for acceptance for the remainder of the pour.

G.5 Test Methods and Specimens

The Engineer will furnish molds based on the maximum size aggregate for the test specimens in accordance with the following:

- (1) 4 in × 8 in [100 mm × 200 mm] cylinder molds,
- (2) 6 in × 12 in [150 in × 300 mm] cylinder molds for maximum aggregate sizes greater than 1¼ in [31.5 mm], and
- (3) 6 in × 6 in × 20 in [150 in × 150 in × 500 mm] beam molds and use other beam mold sizes as approved by the Engineer.

Provide curing tanks of adequate size and number for curing all of the concrete test specimens in accordance with 2031.3.C, "Special Requirements." Supply the curing tanks with heaters to maintain a water temperature of 73 °F ± 3 °F [23 °C ± 2 °C].

If Contractor testing is required by the Contract, perform the following:

- (1) Determine the required testing rates in accordance with the Schedule of Materials Control,
- (2) Take samples after the first ¼ cu yd [cu. m] and before discharging the last ¼ cu. yd [cu. m] of the batch,
- (3) Perform concrete sampling and testing meeting the requirements of the Concrete Manual,
- (4) Measure slump and air content, and make strength specimens when placing the concrete,
- (5) Record field measurements, including strength specimen identifications on MnDOT Form 2448, *Weekly Concrete Report*, to provide to the Concrete Engineer.

The Engineer will transport the cylinders to the Department's Laboratory for testing.

G.5.a Standard Strength Cylinders

The Department will perform the following for standard strength cylinders:

- (1) Cast cylinders for testing at 28 days,
- (2) Mark cylinders for identification of the represented unit or section of concrete,
- (3) Cure the cylinders meeting the requirements of the Concrete Manual, and
- (4) Submit cylinders and a completed cylinder identification card to the Department's Laboratory.

The producer of precast units is responsible for casting standard strength cylinders.

G.5.b Control Strength Cylinders

The Engineer will use control cylinders to determine when the sequence of construction operations is dependent upon the rate of concrete strength development. The Engineer will cast control cylinders to determine when the concrete attains the required strength for all desired control limitations. The Contractor is responsible for any additional control cylinders beyond the requirements of 2461.3.G.5.b (1).

The Department will perform the following for control strength cylinders:

- (1) Cast up to three (3) control cylinders.
- (2) Cure the cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of the Concrete Manual,
- (3) Mark control cylinders for identification of the represented unit or section of concrete, and
- (4) Submit cylinders and a completed cylinder identification card to the Department's Laboratory.

If the Department is unavailable to test the control cylinders, the Contractor shall submit the control cylinders to an independent testing facility for testing or perform the testing on the control cylinders on a portable mechanical or hydraulic testing machine checked and calibrated with a standard proving ring as approved by the Engineer and in the presence of the Engineer.

The producer of precast units is responsible for casting control strength cylinders.

G.5.c Strength Specimens for Concrete Paving

Use flexural beams to determine strength or provide cylinders as allowed by the Contract or approved by the Engineer.

Cast standard beams or cylinders for testing at 28 days.

Cast a sufficient number of control beams or cylinders to determine when the concrete attains the required strength for all desired control limitations.

Cure the standard beams or cylinders meeting the requirements of the Concrete Manual.

Cure the control beams or cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of the Concrete Manual.

The Engineer will test the flexural beams and record the results on MnDOT Form 2162, *Concrete Test Beam Data*.

If using cylinders, the Engineer will submit cylinders and a completed identification card to the Department's Laboratory.

G.6 Consistency

The Engineer will test the concrete for consistency using the slump test during the progress of the work. The Department may reject concrete batches with consistencies outside of the slump range in accordance with Table 2461-10. If any test shows the slump in excess of the upper limit of the slump range, the Engineer will reject the concrete represented by that test unless the Contractor makes adjustments to the concrete before use.

Adjust the slump within the allowable range to optimize both placement and finishing.

If not using a Department approved Type A water reducer at the manufacturer's recommended dosage rates listed on the Approved/Qualified Products List, meet the slump values for the slump range without water reducer in accordance with Table 2461-12.

If using an Department approved Type A water reducer at the manufacturer's recommended dosage rates listed on the Approved/Qualified Products List, meet the slump values for the slump range with water reducer in accordance with Table 2461-12.

Table 2461-12 Slump Range Designation		
Slump Designation	Slump Range without Water Reducer, <i>in</i> [mm]	Slump Range with Water Reducer, <i>in</i> [mm]
1	½ – 1 [12 – 25]	½ – 1 [12 – 25]
2	1 – 2 [25 – 50]	1 – 3 [25 – 75]
3	1 – 3 [25 – 75]	1 – 4 [25 – 100]
4	2 – 4 [50 – 100]	2 – 5 [50 – 125]
5	2 – 5 [50 – 125]	2 – 6 [50 – 150]
6	3 – 6 [75 – 150]	3 – 7 [75 – 175]

Contact the Engineer if encountering unusual placement conditions that render the specified slump range unsuitable. The Department will provide mix composition modifications for Department designed mixes to provide the desired change in consistency while maintaining the other specified properties of the concrete mix. Do not add water solely to temporarily facilitate the placement of concrete.

G.6.a Concrete Placed by the Slip-Form Method

Place concrete that does not slough and is adequately consolidated at a slump value that optimizes placement for the designated mixture.

G.6.b Non-Conforming Material

Only place concrete meeting the slump requirements in the work. If the Contractor places concrete not meeting the slump requirements into the work, the Engineer will not accept non-conforming concrete at the Contract unit price.

For concrete not meeting the required slump, 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 Tables 2461-13, 2461-14, 2461-15 and 2461-16. When there is not a separate Contract unit price for *Structural Concrete* for an item of work or the concrete is a minor component of the Contract unit price, the Department will reduce payment based on a concrete price of \$100.00 per cu. yd [\$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-13 General Concrete*	
Outside of Slump Range	Adjusted Contract Unit Price
Below slump range*	The Department will pay 95 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
$\leq 1\frac{1}{2}$ in [40 mm] above slump range	The Department will pay 75 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
$1\frac{3}{4}$ in [45 mm] – $2\frac{1}{4}$ in [55 mm] above slump range	The Department will pay 50 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
$> 2\frac{1}{4}$ in [55 mm] above slump range	The Department will pay 25 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
* If the Contractor places piling or footing concrete below the slump range, the Department will deduct \$100 per cu. yd [\$130 per cu. m] or the Contractor-provided invoice amount to the relevant Contract unit price of the concrete represented by the slump test, whichever is less. The Department will not reduce Contract unit price for low slump concrete placed with the slip-form method as approved by the Engineer.	

Table 2461-14 Bridge Deck Concrete	
Outside of Slump Range	Adjusted Contract Unit Price
Below slump range	The Department will pay 95 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
$\leq 1\frac{1}{2}$ in [40 mm] above slump range	The Department will pay 75 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
$> 1\frac{1}{2}$ in [40 mm] above slump range	The Department will pay 25 percent of the relevant Contract unit price for materials placed as approved by the Engineer.

Table 2461-15 Low Slump Bridge Deck Concrete From ½ in to 1 in [12 mm to 25 mm]	
Outside of Slump Range	Adjusted Contract Unit Price
Below slump range	No deduction for materials placed as approved by the Engineer.
≤ ½ in [12 mm] above slump range	The Department will pay 50 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
> ½ in – ¾ in [12 mm – 20 mm] above slump range	The Department will not pay for concrete placed but will allow the concrete to remain in place as approved by the Engineer.
> ¾ in [20 mm] above slump range	The Department will not pay for concrete. Provide additional testing as directed by the Engineer to determine if the concrete can remain in place or is subject to removal and replacement.

Table 2461-16 Low Slump Concrete — Patching From ½ in to 1 in [12 mm to 25 mm]	
Outside of Slump Range	Adjusted Contract Unit Price
Below slump range	No deduction for materials placed as approved by the Engineer
≤ ½ in [12 mm] above slump range	The Department will pay 75 percent of the relevant Contract unit price for materials placed as approved by the Engineer.
≥ ¾ in [20 mm] above slump range	The Department will pay 25 percent of the relevant Contract unit price for materials placed as approved by the Engineer.

G.7 Air Content

Maintain the air content of Type 3 general concrete at the specified target of 6.5 percent ±1.5 percent of the measured volume of the plastic concrete in accordance with 1503, “Conformity with Contract Documents.”

Make any adjustments immediately to maintain the desired air content.

Measure the air content at the point of placement but before consolidation.

G.7.a Non-Conforming Material

Only place Type 3 concrete meeting the air content requirements in the work. If the Contractor places Type 3 concrete not meeting the air content

requirements into the work, the Engineer will not accept non-conforming concrete at the Contract unit price.

For concrete not meeting the required air content, 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 2461-17. When there is not a separate Contract unit price for *Structural Concrete* for an item of work or the concrete is a minor component of the Contract unit price, the Department will reduce payment based on a concrete price of \$100.00 per cu. yd [\$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-17	
General Concrete (Target Air Content 6.5%)	
Air Content, %	Adjusted Contract Unit Price
> 10.0	The Department will pay 75 percent of the Contract unit price for the concrete represented for material placed as approved by the Engineer.
>8.0 – 10.0	The Department will pay 95 percent of the Contract unit price for the concrete represented for material placed as approved by the Engineer.
5.0 – 8.0	The Department 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 Department will pay 75 percent of the Contract unit price for the concrete represented for material placed as approved by the Engineer.
>3.5 – 4.0	The Department will pay 25 percent of the Contract unit price for the concrete represented and placed as approved by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the surface is exposed to freeze-thaw cycling, coat the concrete with an approved epoxy penetrant sealer from the Approved/Qualified Products List.
≤ 3.5	Remove and replace concrete in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work,” as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in place, the Engineer will not pay for the concrete and if the Engineer determines the surface is exposed to salt-brine freeze-thaw cycling, coat with an approved epoxy penetrant sealer from the Approved/Qualified Products List.

G.8 Allowable Testing Tolerances

Allowable tolerances are based on the results from two different testers and two different pieces of equipment from the same sample. Perform the test within the allowable tolerances in accordance with Table 2461-18.

Table 2461-18	
Allowable Testing Tolerances	
Test	Allowable Tolerance
Air content, % volume of concrete	1.0
Average slump:	
≤ 4 in [100 mm]	1.0 in [25 mm]
4 in – 6 in [100 mm – 150 mm]	1.5 in [38 mm]
≥ 6 in [150 mm]	2.0 in [50 mm]
Unit weight, per cu. ft [cu. m], calculated to an air-free basis	1.0 lb/cu. ft [16 kg/cu. m]
Compressive strength 3,000 psi – 8,000 psi [20.6 MPa – 55.2 MPa], average of 3 tests	500 psi [3.4 MPa]

2461.4 METHOD OF MEASUREMENT

The Engineer will measure fresh concrete produced as required by the Contract by the theoretical volume. The Engineer will deduct accountable waste from the concrete measurement.

The Engineer will measure concrete mixtures on the basis of the dimensions of the structure shown on the plans. If the plans do not include a Contract item for concrete used in miscellaneous items, include the cost of the concrete with the relevant Contract items.