

# Chapter 6. Concrete Specifications and Installation

## Wisconsin Construction Specification for Secondary Containment and Mixing and Loading Areas

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## Part I. Installing Concrete

### 1. Scope

The work shall consist of forming, placing, finishing, and curing Portland cement concrete and the furnishing and placing of steel reinforcement and waterstops as required on the construction drawings.

Failure to meet any requirements contained in this specification shall be cause for rejection of the concrete installed.

### 2. Materials

*Portland cement* shall meet the requirements of ASTM C 150.

*Reinforcing steel* shall be free from loose rust, oil, grease, paint, or other deleterious matter. Steel bars for concrete reinforcement shall meet the requirements of ASTM A 615. The steel shall be deformed, Grade-60, billet-steel bars as noted on the plans.

*Waterstops* shall be made of rubber (natural or synthetic) for pesticide mixing and loading pads and secondary containment, or vinyl chloride polymer or copolymer having a minimum width of 6 inches and a minimum web thickness of 3/16 inches. Waterstops shall be one of the following types: those intended for placement entirely within the concrete cross section or those anchored to the subgrade or subbase prior to pouring concrete over them. Those placed within the concrete shall have ribbed or bulb-type anchor flanges and a hollow tubular center bulb. All waterstops shall be placed or installed per the manufacturer's recommendations.

*Curing compound* shall be a liquid, membrane-forming compound suitable for spraying on the concrete surface. The curing compound shall meet the requirements of ASTM C 309 Type 2 (white pigmented).

### 3. Preparing the subgrade and forms

The site shall be graded to the dimensions and elevations as specified in the construction plans.

The subgrade shall be:

- Of uniform material and density (without abrupt changes from hard to soft).
- Prepared to adequately support reinforcement chairs.
- Prepared so as to prevent significant displacement or deforming by foot traffic during construction.
- Free of organic matter and frost.
- Free of standing or puddled water while the concrete is placed.
- Either undisturbed or compacted to almost maximum density and moistened with water before concrete is placed.

When needed, the subbase must be a minimum of 4-inch thick granular material compacted to near maximum density. If the subbase required is thicker, it must be placed in maximum thickness layers of 4- to 6-inch thick and compacted lifts. Granular material for the subbase may be sand, sand-gravel, crushed stone, or combinations of these materials that meets the following requirements:

- Maximum particle size: Not more than 1/8 subbase thickness.
- Passing No. 200 sieve: 15 percent maximum.
- Plasticity index: 6 maximum.
- Liquid Limit: 25 maximum.

Concrete shall not be placed on mud, dried earth, uncompacted fill, frozen soil, or in standing water.

Concrete shall not be placed directly on a vapor retarder. If a vapor retarder is used, place a 6- to 8-inch layer of compacted, self-draining granular fill subbase over the vapor retarder before placing the concrete.

Prior to placement of concrete, the forms shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings. Rock surfaces shall be cleaned by air-water cutting, wet sandblasting, or wire brush scrubbing as necessary.

The forms shall be substantial and unyielding and shall be constructed so that the finished concrete will conform to the specified dimensions and contours. Forms shall be mortar tight. Forms with torn surfaces, worn edges, dents, or other defects shall not be used. Forms shall be coated with a form release agent before being set into place. Excess form coating material shall not come in contact with the steel reinforcement or with hardened concrete against which fresh concrete is to be placed.

#### **4. Placing reinforcing steel**

Any oil on the reinforcing steel or other surfaces required to be bonded to the concrete shall be removed. Reinforcement shall be accurately placed as shown on the drawings and secured in position in a manner that will prevent its displacement during the placement of concrete. Metal chairs, metal hangers, metal spacers, plastic chairs, or concrete chairs shall be used to support the reinforcement.

Reinforcement for sloped slabs or flatwork shall be supported by a minimum of one support chair every third bar or every 4 feet in each direction, whichever spacing is smaller. Support chairs shall have a minimum basal area of 4 square inches in contact with the subgrade.

Tying steel to protruding steel or form construction in contact with new concrete shall not be started until the concrete has cured a minimum of 12 hours.

#### **5. Placing waterstops**

Waterstops shall be located as shown on the drawings and secured in position so that displacement does not occur during concrete placement. Waterstops placed within the concrete will normally need to be installed using multiple concrete pours and should be secured to reinforcement bars using wire or "hog ring" type fasteners. Contractors must install waterstops following the waterstop manufacturer's recommendations.

Factory fabricated waterstop corners and transitions shall be provided, leaving only straight butt joint splices for field fabrication. Splices in waterstops shall be welded as recommended by the manufacturer.

#### **6. Placing and finishing concrete**

Concrete shall not be placed until the subgrade, forms, and steel reinforcement and waterstops have been inspected and approved by the Technician. Any deficiencies are to be corrected before the concrete is delivered for placement.

The contractor shall furnish the Technician a delivery ticket as specified in Part II for each load of concrete delivered to the site.

Concrete shall be delivered to the site and discharged into the forms within 1-1/2 hours after the introduction of the cement to the aggregates. When a water-reducing agent or superplasticizer is used, the manufacturer's recommended time limit for discharge after addition shall apply. In hot weather, as defined

in Section 9, or under conditions contributing to quick stiffening of the concrete, discharge of the concrete shall not exceed 45 minutes unless a set-retarding admixture is used or the mix is remaining workable.

Upon the concrete's arrival at the job site, addition of water will be allowed to adjust the slump, provided such addition does not exceed the specified limits of the slump or maximum water content contained in the design mix. A small amount of concrete may be discharged prior to the addition of water. Final placement of the batch shall begin immediately after mixing of the added water is completed. No additional water shall be added to the mix after placement has begun.

Concrete shall be deposited as closely as possible to its final position in the forms and shall be worked into the corners and angles of the forms and around all reinforcement and embedded items in a manner to prevent segregation of aggregates. Placement of concrete for sloped slabs may also be achieved by gravity flow. All placement shall be done in a manner that prevents incorporation of subgrade material into the concrete.

The Technician shall obtain adequate documentation of the constructed slab thickness to ensure concrete placement as shown in the construction plan.

If the concrete sets during placement to the degree that it will not flow and merge with the succeeding pour when tamped or vibrated, the contractor shall discontinue placing concrete and install a formed construction joint. The contractor shall be prepared to install unplanned construction joints in the event that there is an interruption of the pour, equipment breakdown, or other problem that makes unplanned stopping the placement of concrete necessary. Prior to commencement of concreting operations at the construction joint, the joint surface shall be cleaned to remove all laitance, exposed sand, and surface mortar by one of the following methods:

1. The joint surface shall be cleaned to expose coarse aggregate by sandblasting or air-water cutting after the concrete has gained sufficient strength to prevent displacement of the coarse aggregate or cement fines. The surface of the concrete shall not be cut so deep as to undercut the coarse aggregate. The joint surface shall be washed to remove all loose material after cutting.
2. According to methods specified by the approver of the construction plan.

The surfaces of all construction joints shall be wetted and standing water removed immediately prior to placement of the new concrete. The new concrete shall be placed directly on the cleaned and washed surface. New concrete shall not be placed until the hardened concrete has cured at least 12 hours. The newly placed concrete shall be consolidated to achieve a good bond with the previously hardened concrete.

Concrete mixes not containing superplasticizer shall not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation. Concrete mixes containing superplasticizer shall not be dropped more than 12 feet vertically and shall be placed in lifts not exceeding 5 feet in depth.

Immediately after the concrete is placed in the forms, it shall be consolidated by vibration or hand tamping as necessary to ensure dense concrete. Walls 4 feet high and higher shall be vibrated. Concrete supplied with superplasticizer shall be placed with a minimum amount of vibrating and finishing effort. Vibration shall not be applied directly to the reinforcement steel or the forms nor to concrete that has hardened to the degree that it does not become plastic when vibrated. Each pour shall be consolidated to ensure a monolithic bond with the preceding pour. The use of vibrators to transport concrete in the forms, slabs, or conveying equipment will not be permitted.

Vibration is required at all joints that contain integral waterstops.

All flatwork shall be screeded to grade and then bull-floated. Vibratory screeding may be used instead of bull-floating. An additional finish may be specified. All flatwork surfaces shall be true and even and shall be free from open or rough spaces, depressions, or projections.

Sloped slabs shall be worked to a uniform grade, maintaining the specified thickness, and finished in a manner to ensure dense concrete. All sloped slab surfaces shall be smooth and shall be free from open or rough spaces, depressions, or projections.

## **7. Removing forms**

Forms shall be removed in such a way as to prevent damage to the concrete. Supports shall be removed in a manner that will permit the concrete to take the stresses due to its own weight uniformly and gradually. Wall forms and forms for joints with waterstops shall not be removed for 24 hours after the concrete is placed. Other forms may be removed when the concrete is sufficiently cured so that the concrete will not be damaged.

Immediately after the forms are removed, concrete that is honeycombed, damaged, or otherwise defective shall be repaired or replaced as directed by the Technician. Repairs are to be made according to American Concrete Institute (ACI) 301, Specifications for Structural Concrete. The procedure is in the section for repair of surface defects other than tie holes. All repaired areas shall be cured as specified in Section 8.

For structures that are not required to be liquid tight, form ties shall be removed flush with or below the concrete surface. For structures that are to be liquid tight, form ties shall be removed to a minimum depth of 1/2 inch. All cavities or depressions resulting from removing the form ties shall be patched with commercially available patching products including:

- Portland cement mortar modified with a latex bonding agent conforming to ASTM C 1059, Type II.
- Epoxy mortars and epoxy compounds that are moisture-insensitive during application and after curing and that embody an epoxy binder conforming to ASTM C 881, Type III.
- Nonshrink Portland cement grout conforming to ASTM C 1107.
- Packaged dry concrete repair materials conforming to ASTM C 928.

The age of stripped concrete or slabs shall be at least 7 days before any load (including backfill) is applied other than the weight of the wall, forms, scaffolds for succeeding lifts, or light equipment.

## **8. Curing**

Concrete shall be cured for a period of at least 7 days after it is placed except as stated in Section 10. Exposed concrete surfaces shall be kept continually wet during the entire curing period or until curing compound is applied.

Curing compound shall be applied at the rate recommended by the manufacturer, as a minimum. It shall form a uniform, continuous, adherent film that shall not check, crack, or peel and shall be free from pinholes or other imperfections.

Curing compound shall not be used at construction joints or other areas that are to be bonded to additional concrete. These areas shall be wet cured. Surfaces subjected to heavy rainfall or running water within 3 hours after the application of curing compound or surfaces damaged by subsequent construction operations during the curing period shall be recoated in the same manner as the original application.

## **9. Placing concrete during hot weather**

For the purpose of this specification, hot weather is defined as any combination of high temperature, (generally above 80 degrees F), low relative humidity, and wind velocity tending to impair the quality of fresh or hardened concrete or otherwise resulting in abnormal properties.

Special provisions shall be made to immediately protect and cure the concrete due to rapid drying conditions. Concrete surfaces shall not be allowed to dry after placement and during the curing period. Wood form surfaces shall be kept continually moist.

In extreme conditions, it may be necessary to (1) restrict placement to late afternoon or evening, (2) restrict the depth of layers to assure coverage of the previous layer while it will still respond readily to vibration, (3) suspend placement until conditions improve.

## **10. Placing concrete during cold weather**

When the minimum daily atmospheric temperature is less than 40 degrees F, concrete shall be insulated or housed and heated immediately after placement. Concrete admixtures other than those banned can be used to adjust the concrete mix to compensate for concrete placement during cold weather. The temperature of the concrete and air adjacent to the concrete shall be maintained at not less than 50 degrees F or more than 90 degrees F for the duration of the curing period.

The curing period may be reduced to 3 days when Type III cement is used. An additional 100 pounds of Type I cement and a maximum of 6 gallons of added water per cubic yard may be used in lieu of Type III cement.

Combustion heaters shall have exhaust flue gases vented out of the concrete protection enclosure and shall not be permitted to dry the concrete.

The contractor shall furnish the Technician a record of daily maximum and minimum outside air and concrete surface air temperatures during the curing period. The record shall include temperatures at several points along the concrete.

## **11. Joints**

Concrete joints shall be of the type and at locations shown on the construction drawings. Joints containing waterstops shall be inspected before concrete placement.

Sawn or hand tooled joints with integral waterstops shall be placed within 12-24 hours (maximum) after concrete placement.

## Part II. Furnishing Concrete

### 1. Scope

The work shall consist of furnishing Portland cement concrete as required on the construction drawings. All materials, test procedures, and admixtures shall meet the requirements of the latest edition of the applicable ASTM designation.

The mix proportion in this specification is required to yield a 28-day compressive strength of 4,500 psi or more. The contractor shall provide a concrete mix design and laboratory testing that verifies the concrete supplied will produce compressive strengths that equal or exceed 4,500 psi.

Failure to meet any requirement in this specification shall be cause for rejecting the concrete.

### 2. Materials

The contractor shall provide the Technician with test data, independent laboratory reports, or other evidence from the concrete supplier showing that all materials meet the requirements of this specification.

The use of any admixtures in the concrete mix shall be in strict compliance with the manufacturer's recommendations.

- A. Portland cement shall conform to ASTM C 150 and shall be Type I, or IA, II, or IIA, III or IIIA.
- B. Fine aggregate shall conform to ASTM C 33 and be composed of clean, uncoated grains of material.
- C. Coarse aggregate shall be gravel or crushed stone conforming to ASTM C 33 and be clean, hard, durable, and free from clay or coating of any character. The maximum size coarse aggregate shall be 1-1/2 inches.
- D. Water shall be clean at a pH = 5.0-7.0 and free from injurious amounts of oil, salt, acid, alkali, organic matter, or other deleterious substances.
- E. The water-cement ratio shall be no greater than 0.45 (4,500 psi).
- F. Air entraining agent shall conform to ASTM C 260 and shall be between 5-7.5 percent.
- G. Pozzolan (fly ash) shall be in strict compliance with ASTM C 618, Class F or C. The loss of ignition shall not exceed 6 percent.
- H. Ground Granulated Blast Furnace (GGBF) Slag shall conform to ASTM C 989.
- I. Water-reducing admixtures shall conform to ASTM C 494, and superplasticizers shall conform to ASTM C 1017 and may be the following types:
  1. Type A - Water-reducing admixture.
  2. Type D - Water-reducing and retarding admixture.
  3. Type F - Water-reducing, high range admixture (superplasticizer).
  4. Type G - Water-reducing, high range, and retarding admixture (superplasticizer). Type D or G admixture may be used at the option of the contractor/supplier when the air temperature is more than 80 degrees F at the time of mixing and/or placement.
- J. Calcium chloride or other antifreeze compounds or accelerators will not be allowed.

### 3. Concrete Mix Design

To help ensure the concrete is impermeable and watertight DATCP requires the concrete meet the following specifications:

- Have a compressive strength of 4,500 psi at 28 days
- Have a W/C ratio minimum of 0.45

- Have a maximum slump of 3 inches and minimum slump of 1 inch
- Have 5 to 7.5 percent air entrainment

Follow the procedures listed below to ensure a proper design

1. Use a water-reducing admixture for easier workability at placement and improved water tightness and strength of low-slump concrete.
2. Use clean, drinkable mixing water at a pH = 5.0-7.0.
3. Use large (1 to 1.5 inch), clean, impervious aggregate.

The air content (by volume) shall be 5 to 7.5 percent of the volume of the concrete at the time of placement. This requirement shall be met by using Type IA, IIA, or IIIA Portland cement or the manufacturer's recommended quantity of an air-entraining agent.

The slump shall be 1 to 3 inches (flatwork) 1 to 4 inches (wall) except when a water-reducing agent or superplasticizer is used in the concrete mix. When a water-reducing agent or superplasticizer is used, the slump shall be 3 inches or less before the addition of the admixture and shall not exceed 8 inches following addition and mixing. Additional water-reducing agents or superplasticizer shall not be added to the concrete mix after discharge of the concrete at the job site has commenced.

The oven dry weight of the fine aggregates shall be 30 to 45 percent of the total oven dry weight of the combined aggregates.

The contractor/supplier may use the following mix proportions per cubic yard to produce concrete with a minimum compressive strength of 4,500 psi. Other mix proportions proposed by the contractor/supplier may be submitted to the Technician for approval prior to use.

Portland cement*, lbs/yd <sup>3</sup>	Maximum water,** lbs/yd <sup>3</sup>	Nominal minimum aggregate size, in.	Fine aggregate, fineness module = 2.50, lbs/yd <sup>3</sup>	Coarse aggregate, lbs/yd <sup>3</sup>
665	300	3/4	1,040	1,800
590	265	1½	930	2,110

Reference page 171 of *Design and Control of Concrete Mixtures* for W/C ratio of 0.45.

\* Water-reducing agent or superplasticizer may be added to the mix.

\*\*Total of aggregate moisture, mixing water added at the plant, and mixing water added at the job site.

#### 4. Mixtures and Mixing

Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C 94.

Concrete shall be uniform and thoroughly mixed when delivered to the forms.

No mixing water in excess of the amount shown for the design mix or in an amount that would cause the maximum slump to be exceeded shall be added to the concrete during mixing or hauling or after arrival at the delivery point.

The concrete shall be batched and mixed such that the temperature of the concrete at time of placing shall not be less than 50 degrees F nor more than 90 degrees F.

Allow no more than 30 minutes between truckloads of concrete during placement.

Mix 70 to 100 revolutions at mixing speed, then an additional 200 to 230 revolutions (maximum of 300 total revolutions) at agitating speed.

Discharge load within 1.5 hours.

Minimize discharge drop distance by using a discharge chute.

When possible, concrete shall be placed in a continuous pour in one day, with no cold joints.

Use vibration during placement; vibrate at 5,000 to 15,000 rpm frequency for minimum aggregate segregation.

## **5. Batch Ticket Information**

The contractor shall obtain from the supplier a delivery ticket for each load of concrete before unloading at the site. The following minimum information shall be included on the load ticket:

- A. Name of concrete supplier and batch plant.
- B. Name of purchaser and job location.
- C. Date of delivery.
- D. Truck number.
- E. Amount of concrete delivered.
- F. Time loaded or time of first mixing of cement and aggregates.
- G. Mixing water in the load added as free water.
- H. Type and amount of cement.
- I. Type and amount of admixtures.
- J. Weights of fine and coarse aggregate.
- K. Percent moisture content or weight of free water contained in the aggregates.

The contractor or inspector shall also include the following additional information on the load ticket:

- A. Water added by the receiver of the concrete.
- B. Time the concrete arrived at the site.
- C. Time the concrete was completely unloaded.

Upon completion of the concrete placement, copies of all load tickets shall be provided to the Technician. Materials information that will remain constant throughout the job may be provided by the supplier and approved by the Technician prior to placing concrete. This materials information may be omitted from the load ticket.