

Reinforced Concrete

1. SCOPE

The work shall consist of furnishing, forming, placing, finishing and curing portland cement concrete and furnishing and placing steel reinforcement as required to build the structures as shown on the drawings.

2. MATERIALS

Steel Reinforcement

Steel bars for concrete reinforcement shall be grade 40, 50, or 60 deformed bars conforming to one of the following specifications:

- Deformed and plain billet-steel bars for concrete reinforcement—ASTM A-615
- Rail-steel deformed bars for concrete reinforcement—ASTM A-996
- Axle-steel deformed bars for concrete reinforcement—ASTM A-996

Dowels shall be plain round bars conforming to the same specifications listed above for steel bars.

Fabricated deformed steel bar mats for concrete reinforcement shall conform to the requirements of ASTM A 184.

Plain steel welded wire reinforcement for concrete reinforcement shall conform to the requirements of ASTM A 185.

Deformed steel welded wire reinforcement for concrete reinforcement shall conform to the requirements of ASTM A 497.

Epoxy-coated steel bars for concrete reinforcement shall conform to the requirements of ASTM A 775.

Gauges, diameters, spacing, and arrangement of wires for welded steel wire

fabric shall be as defined for the specified style designations.

Portland Cement – Portland cement shall conform to the requirements of ASTM Specification C-150 for the specified type. If a type is not specified, Type I, Type II low alkali, or Type III high early strength shall be used.

Air-Entraining Admixtures – Air-entraining admixtures shall conform to the requirements of ASTM C-260.

Aggregates – Concrete aggregates shall conform to the requirements of ASTM C-33. Where aggregates conforming to these specifications are not obtainable, aggregates that have been shown by tests or by actual service to produce concrete of the required strength, durability, watertightness, and abrasion resistance may be used if authorized by the Engineer.

Concrete aggregates approved for use by the Montana Highway Department are acceptable.

Water – Water shall be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter, or other deleterious substances.

Storage of Materials – Steel reinforcement stored at the site of the work shall be stored above the ground surface on platforms, skids, or other supports and shall be protected from mechanical injury and corrosion.

Cement and aggregate shall be stored at the site in such a manner as to prevent deterioration or intrusion of foreign matter. Damaged materials will be rejected and not permitted to be used in the work.

3. BENDING BAR REINFORCEMENT

Reinforcing bars may not be field milled or field bent unless specifically authorized by the Engineer. All bends shall be made in accordance with standard approved practice and by approved machine methods. All bends shall be made without heating. Bars with kinks, cracks, or improper bends will be rejected.

4. SPLICING BAR REINFORCEMENT

The length of splices of reinforcing bars shall be as shown on the drawings. When not shown on the drawings, the length of splices shall provide an overlap equal to at least 36 diameters of the smaller bar being spliced.

5. SPLICING WELDED WIRE REINFORCEMENT

Unless otherwise specified, welded wire fabric shall be spliced in the following manner:

Adjacent sections shall be spliced end to end (longitudinal lap) by overlapping a minimum of one full mesh plus 2 inches plus the length of the two end overhangs. The splice length is measured from the end of the longitudinal wires in one piece of fabric to the end of the longitudinal wires in the lapped piece of fabric.

Adjacent sections shall be spliced side to side (transverse lap) a minimum of one full mesh plus 2 inches. The splice length shall be measured from the centerline of the first longitudinal wire in one piece of fabric to the centerline of the first longitudinal wire in the lapped piece of fabric.

6. SUPPORTING REINFORCEMENT

Reinforcement shall be accurately placed and secured in position in a manner that will prevent its displacement during the placement of concrete. Tack welding of bars will not be permitted.

Metal chairs, metal hangers, metal spacers and concrete chairs may be used to support the reinforcement. Metal hangers, spacers and ties shall be placed in such a manner that they will not be exposed in the finished concrete surface. The legs of metal chairs or side form spacers that may be exposed on any face of slabs, walls, beams or other concrete surfaces shall have a protective coating or finish by means of hot dip galvanizing, epoxy coating, plastic coating, or be stainless steel. Metal chairs and spacers not fully covered by a protective coating or finish shall have a minimum cover of 3/4-inch of concrete over the unprotected metal portion except for those with plastic coatings may have a minimum cover of 1/2-inch of concrete over the unprotected metal portion.

Precast concrete chairs shall be manufactured of the same class of concrete as that specified for the structure and shall have tie wires securely anchored in the chair or a V-shaped groove at least 3/4-inch in depth molded into the upper surface to receive the steel bar at the point of support. Precast concrete chairs shall be clean and moist at the time concrete is placed.

7. PLACING REINFORCEMENT

The following tolerances will be permitted in the placement of bars as shown on the drawings:

TABLE 1

Class of Concrete	Maximum Net Water Content (gallons/bag)		Minimum Cement Content (bags/cubic yard)	
	Without Air Entrainment	With Air Entrainment	Without Strength Test	With Strength Test
3000	7	6	6	5
4000	6	5	6.5	6

Note: A bag of cement weighs 94 pounds.

7. PLACING REINFORCEMENT (continued)

Variation in protective cover:

1/4 inch for 2-inch cover

1/2 inch for 3-inch cover

Variation of spacing:

1/12 of indicated spacing

Before reinforcement is placed, the surfaces of the bars and fabric and any metal supports shall be cleaned to remove any loose, flaky rust, mill scale, oil, grease or other coatings or foreign substances. After placement, the reinforcement shall be maintained in a clean condition until it is completely embedded in the concrete. On structures exceeding 2 cubic yards in concrete volume, the subgrade and placement of the reinforcing material shall be inspected by the Technician prior to placing the concrete.

8. DESIGN OF CONCRETE MIX

Concrete shall be classified as shown in Table 1.

Concrete shall be composed of portland cement, fine and coarse aggregates, water, and unless otherwise specified, an air-entraining admixture mixed in such proportions so as to produce the specified minimum compressive strength at the end of 28 days.

Calcium chloride or other corrosive accelerators shall not be used unless otherwise specified.

The maximum gallons of water per bag of cement and the minimum number of bags of cement per cubic yard of concrete for the specified class of concrete shall be as tabulated in Table 1.

Concrete mixtures shall be designed to use a maximum size of coarse aggregate of 1-1/2 inches. The proportioning of cement, sand, and coarse aggregate shall produce a concrete mixture, neither too sandy nor too harsh, that will work readily into the corners and angles of the forms and around reinforcement when consolidated, but will not segregate or exude free water during consolidation.

Unless otherwise specified, the slump at the time of placement shall be 3 to 5 inches. Air content by volume shall be 5-7% of the volume of the concrete.

9. QUALITY OF CONCRETE

Control – Prior to placement of any concrete, the Contractor shall furnish a statement to the Technician giving the proportions by dry weight of cement, aggregates, water and admixtures that they intend to use. If requested by the Technician, the Contractor shall furnish evidence satisfactory to the Technician that the proportions selected will produce concrete of the quality specified. The materials and

proportions so stated shall constitute the "job mix."

After a job mix has been approved, neither the source, character, grading of the aggregates nor the type or brand of cement or admixture shall be changed without prior notice to the Technician. If such changes are necessary, no concrete containing such new or altered materials shall be placed until the Technician has approved a revised job mix.

10. INSPECTION AND TESTING

The Technician shall have free entry to the plant and equipment furnishing concrete. Proper facilities shall be provided for the Technician to inspect materials, equipment, and processes and to obtain samples of the concrete. All tests and inspections will be conducted so as not to interfere unnecessarily with manufacture and delivery of the concrete.

If specified in the special provisions, standard tests of the compressive strength of the concrete will be made by the Contractor from concrete test cylinders cast by the Technician in conformance with ASTM C-31. The Contractor shall provide cylinder molds and shall have the cylinders tested by an approved laboratory (the Contractor bearing the costs of such testing).

One strength test shall consist of three standard cylinders made from a composite sample secured from a single load of concrete in accordance with ASTM C-172 and tested at 28 days. The test results at 28 days shall be the average of the strength of three specimens determined in accordance with ASTM C-39, except that if one specimen shows manifest evidence of improper sampling, molding, or testing, it shall be discarded and the strengths of the remaining two specimens shall be averaged. Should more than one specimen representing a test show such defects, the entire test shall be discarded.

One strength test, consisting of three test cylinders, shall be made for (1) each day's run or (2) for each 25 cubic yards of concrete placed, or fraction thereof.

A record shall be made of the particular load of concrete tested, and the exact location in the work at which each load represented by a strength test is deposited.

In the event that concrete tested in accordance with the requirements stated above fails to meet the strength requirements of these specifications, the contractor shall provide an acceptable new or adjusted mix.

11. HANDLING AND MEASUREMENT OF MATERIALS

Materials shall be stockpiled and batched by methods that will prevent segregation or contamination of aggregates and insure accurate proportioning of the ingredients of the mix.

Cement shall be measured by weight or in bags of 94 pounds each. When cement is measured in bags, no fraction of a bag shall be used unless weighed.

Aggregates shall be measured by weight. Mix proportions shall be based on saturated, surface-dry weights. The batch weight of each aggregate shall be the required saturated, surface-dry weight plus the weight of surface moisture it contains.

Water shall be measured, by volume or by weight, to accuracy within 1% of the total quantity of water required for the batch.

Admixtures shall be measured within a limit of accuracy of 3%.

12. MIXERS AND MIXING

Concrete may be furnished by batch mixing at the site of the work or by ready-mix methods.

Mixers shall be capable of thoroughly mixing the concrete ingredients into a uniform mass and of discharging the mix without segregation.

Concrete shall be uniform and thoroughly mixed when delivered to the work site. Variations in slump of more than 1 inch within a batch will be considered evidence of inadequate mixing and shall be corrected by changing batching procedures, increasing mixing time, changing mixers, or other means.

For stationary mixers, the mixing time after all cement and aggregates are in the mixer drum shall be not less than 1-1/2 minutes. When concrete is mixed in a truck mixer, the number of revolutions of the drum or blades at mixing speed shall be not less than 70 nor more than 100.

Unless otherwise specified, volumetric batching and continuous mixing at the construction site will be permitted. The batching and mixing equipment shall conform to the requirements of ASTM Specification C-685 and shall be demonstrated prior to placement of concrete, by tests with the job mix, to produce concrete meeting the specified proportioning and uniformity requirements. Concrete made by this method shall be produced, inspected, and certified in conformance with Sections 6, 7, 8, 13, and 14 of ASTM Specification C-685.

No mixing water in excess of the amount called for by the job mix shall be added to the concrete during mixing or hauling or after arrival at the delivery point.

When truck ready-mixed or truck-mixed concrete is used, the Contractor shall submit to the Technician, with each mixer load, a certified delivery ticket giving the quantities of cement, fine aggregate, coarse aggregate, water, and admixtures, if any, contained in

the batch and the time the cement was introduced to the aggregates.

13. FORMS

Forms shall be of wood, plywood, steel, or other approved material and shall be mortar tight. The forms and associated false-work shall be substantial, unyielding and shall be constructed so that the finished concrete will conform to the specified dimensions and contours. Form surfaces shall be smooth and free from holes, dents, sags or other irregularities. Forms shall be coated with a non-staining form release agent before being set into place.

Metal ties or anchorages within the forms shall be equipped with cones, she-bolts or other devices that permit their removal to a depth of at least 1 inch without injury to the concrete. Ties designed to break off below the surface of the concrete shall not be used without cones.

All edges that will be exposed to view when the structure is completed shall be chamfered, unless finished with molding tools.

14. PREPARATION OF FORMS AND SUBGRADE

Prior to placement of concrete the forms and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings. The temperature of all surfaces to be in contact with the new concrete shall be no colder than 40 degrees Fahrenheit. Any oil on the reinforcing steel or other surfaces required to be bonded to the concrete shall be removed. Rock surfaces shall be cleaned by air-water cutting, wet sandblasting or wire brush scrubbing, as necessary, and shall be wetted immediately prior to placement of concrete. Earth surfaces shall be firm and damp. Placement of concrete on mud, dried

earth or un-compacted fill or frozen subgrade will not be permitted.

Items to be embedded in the concrete shall be positioned accurately and anchored firmly.

Weep holes in walls or slabs shall be formed with non-ferrous materials.

15. CONVEYING

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. In hot weather or under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85 degrees Fahrenheit or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed 45 minutes.

The Technician may allow a longer time, provided the setting time of the concrete is increased a corresponding amount by the addition of an approved set-retarding admixture. In any case, concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods that will prevent segregation of the aggregates or loss of mortar.

16. PLACING

Concrete shall not be placed until the subgrade; forms and steel reinforcement have been inspected and approved by the Technician. The Contractor shall give reasonable notice to the Technician each time he or she intends to place concrete.

The 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 or excessive laitance. Formed concrete shall be placed in

horizontal layers not more than 20 inches thick. Concrete shall not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation. Hoppers and chutes, pipes or "elephant trunks" shall be used as necessary to prevent segregation and the splashing of mortar on the forms and reinforcing steel above the layer being placed.

Immediately after the concrete is placed in the forms, it shall be consolidated by spading, hand tamping or vibration as necessary to insure smooth surfaces and dense concrete. Each layer shall be consolidated to insure a monolithic bond with the preceding layer. If the surface of a layer of concrete in place sets to the degree that it will not flow and merge with the succeeding layer when spaded or vibrated, the Contractor shall discontinue placing concrete and shall make a construction joint according to the procedure specified herein.

If placing is discontinued when an incomplete horizontal layer is in place, the unfinished end of the layer shall be formed by a vertical bulkhead.

17. CONSTRUCTION JOINTS

Construction joints shall be made at the locations shown on the drawings. If construction joints are needed which are not shown on the drawings, they shall be placed in locations approved by the Technician.

Where a feather edge would be produced at a construction joint, as in the top surface of a sloping wall, an insert form shall be used so that the resulting edge thickness on either side of the joint is not less than 3 inches.

In walls and columns, as each lift is completed, the top surfaces shall be immediately and carefully protected from any condition that might adversely affect the hardening of the concrete.

Steel tying and form construction adjacent to concrete in-place shall not be started until the concrete has cured at least 12 hours. Before new concrete is deposited on or against concrete that has hardened, the forms shall be retightened. New concrete shall not be placed until the hardened concrete has cured at least 12 hours.

Surfaces of construction joints shall be cleaned of all unsatisfactory concrete, laitance, coatings or debris by washing and scrubbing with a wire brush or wire broom or by other means approved by the Technician. The surfaces shall be kept moist for at least 1 hour prior to placement of the new concrete.

18. EXPANSION AND CONTRACTION

Expansion and contraction joints shall be made only at locations shown on the drawings.

Exposed concrete edges at expansion and contraction joints shall be carefully tooled or chamfered, and the joints shall be free of mortar and concrete. Joint filler shall be left exposed for its full length with clean and true edges.

Preformed expansion joint filler shall be held firmly in the correct position as the concrete is placed.

When open joints are specified, they shall be constructed by the insertion and subsequent removal of a wooden strip, metal plate or other suitable template in such a manner that the corners of the concrete will not be chipped or broken. The edges of open joints shall be finished with an edging tool prior to removal of the joint strips.

19. WATERSTOPS

Waterstops shall be held firmly in the correct position as the concrete is placed. Joints in metal waterstops shall be soldered,

brazed or welded. Joints in rubber or plastic waterstops shall be cemented, welded or vulcanized as recommended by the manufacturer.

20. REMOVAL OF 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.

Forms shall not be removed sooner than the following minimum times after the concrete is placed. These periods represent cumulative number of days and fractions of days, not necessarily consecutive, during which the temperature of the air adjacent to the concrete is above 50 degrees Fahrenheit.

<u>Element</u>	<u>Time</u>
Beams, arches--supporting forms and shoring	14 days
Conduits, deck slabs--supporting (inside) forms and shoring	7 days
Conduits, (outside forms), sides of beams, small structures	24 hours
Columns, walls, spillway risers--with side or vertical load	7 days
Columns, walls, spillway risers --with no side or vertical load:	
Concrete supporting more than 30 feet of wall in place above it	7 days
Concrete supporting 20 to 30 feet of wall in place above it	3 days

<u>Element</u> (continued)	<u>Time</u>
Concrete supporting not more than 20 feet of wall in place above it ¹	24 hours

¹Age of stripped concrete shall be at least 7 days before any load is applied other than the weight of the column or wall itself and the forms and scaffolds for succeeding lifts.

22. FINISHING FORMED SURFACES

All concrete surfaces shall be true and even and shall be free from open or rough spaces, depressions or projections.

Immediately after the removal of the forms:

- a. All fins and irregular projections shall be removed from exposed surfaces.
- b. The holes produced on all surfaces by the removal of form ties, cone-bolts, and she-bolts shall be cleaned, wetted and filled with a dry-pack mortar consisting of one part portland cement, three parts sand that will pass a No. 16 sieve, and just sufficient water to produce a consistency such that the filling is at the point of becoming rubbery when the material is solidly packed.

22. FINISHING UNFORMED SURFACES

All exposed surfaces of the concrete shall be accurately screeded to grade and then wood or magnesium float finished, unless specified otherwise.

Excessive floating or troweling of surfaces while the concrete is soft will not be permitted.

The addition of dry cement or water to the surface of the screeded concrete to expedite finishing will not be allowed.

Joints and edges on unformed surfaces that will be exposed to view shall be chamfered or finished with molding tools.

23. CURING

Concrete shall be prevented from drying for a curing period of at least 7 days after it is placed. Exposed surfaces shall be kept continuously moist for the entire period, or until curing compound is applied as specified below.

Moisture shall be maintained by sprinkling, flooding or fog spraying or by covering with continuously moistened canvas, cloth mats, straw, sand or other approved material. Wood forms left in place during the curing period shall be kept continuously wet. Formed surfaces shall be thoroughly wetted immediately after forms are removed and shall be kept wet until patching and repairs are completed. Water or covering shall be applied in such a way that the concrete surface is not eroded or otherwise damaged.

Concrete, except at construction joints, may be coated with an approved curing compound in lieu of continued application of moisture except as otherwise specified in the special provisions. The compound shall be sprayed on the moist concrete surfaces as soon as free water has disappeared, but shall not be applied to any surface until patching, repairs and finishing of that surface are completed. The compound shall be applied at a uniform rate of not less than 1 gallon per 150 square feet of surface and shall form a continuous adherent membrane over the entire surface. Curing compound shall be thoroughly mixed before applying and continuously agitated during application. Curing compound shall not be applied to surfaces requiring a bond to subsequently placed concrete, such as construction joints, shear plates, reinforcing steel and other embedded items. If the membrane is damaged during the curing period, the

damaged area shall be re-sprayed at the rate of application specified above. Surfaces covered by the membrane shall not be trafficked unless protected from wear.

24. REMOVAL AND REPLACEMENT OR REPAIR

When concrete is honeycombed, damaged or otherwise defective, the Contractor shall remove and replace the structure or structural member containing the defective concrete or, where feasible, correct or repair the defective parts. The Technician will determine the required extent of removal, replacement or repair.

25. CONCRETING IN COLD WEATHER

Concrete shall not be mixed nor placed when the daily minimum atmospheric temperature is less than 40 degrees Fahrenheit unless facilities are provided to prevent the concrete from freezing. The temperature of the concrete at the time of placing shall not be less than 50 degrees Fahrenheit nor more than 90 degrees Fahrenheit. Concrete shall not be deposited on frozen ground nor in forms containing ice or frost. The use of accelerators or antifreeze compounds will not be allowed.

The air and forms in contact with the concrete shall be maintained at temperatures greater than 50 degrees Fahrenheit but less than 90 degrees Fahrenheit for at least 5 days and at a temperature above freezing for the remainder of the specified curing period. Concrete permitted to be cured with curing compounds shall be provided the same protection against freezing and low temperatures as provided herein. No fire or excessive heat shall be permitted near or in direct contact with concrete at any time.

26. CONCRETING IN HOT WEATHER

The Contractor shall apply effective means to maintain the temperature of the concrete below 90 degrees Fahrenheit during mixing, conveying and placing.

Formed surfaces shall be kept completely and continuously wet for the duration of curing period (prior to, during and after form removal) or until curing compound is applied.

Concrete surfaces, especially flat work placed with large areas of surface, shall be covered as soon as the concrete has sufficiently hardened and shall be kept continuously wet for at least 24 hours of the curing period. This protective method may be continued for the required curing period or until curing compound is applied.

Moist curing may be discontinued before the end of the curing period if white pigmented curing compound is applied immediately, in accordance with the procedures specified in Section 23.

27. MEASUREMENT AND PAYMENT (Used only if applicable)

For items of work for which specific unit prices are established, reinforced concrete will be measured to the neat lines shown on the drawings and the volume of concrete will be computed to the nearest 0.1 cubic yard. Measurement of concrete placed against the sides of an excavation without the use of intervening forms will be made only to the neat lines or pay limits shown on the drawings. No deduction in volume will be made for chamfers, rounded or beveled edges or for any void or embedded item that is less than 3 cubic feet in volume.

Payment for each item of concrete will be made at the agreed-to unit price or the agreed-to lump sum, whichever is applicable, for that item. Such payment will

CONSTRUCTION SPECIFICATION

Reinforced Concrete MT-106-10

constitute full compensation for all labor, materials, including steel, equipment, transportation, tools, forms, falsework, bracing and all other items necessary and incidental to the completion of the work.