
CONSTRUCTION SPECIFICATION
CS-OR-220 REINFORCED CONCRETE

220.1 SCOPE

The work shall consist of furnishing, forming, placing, finishing, and curing Portland cement concrete. The structures shall be constructed at the location and to the line and grades as shown on the drawings.

220.2 MATERIALS

The materials required for reinforced concrete are detailed in the following material specifications:

Aggregates shall conform to the requirements of Section 220.24 of this specification and MS-OR-522, Aggregates for Portland Cement Concrete, unless otherwise specified.

Portland cement shall conform to the requirements of MS-OR-531, Portland Cement, for the specified type. One brand only of any type of cement shall be used in any single structure as defined in Section 220.24 of this specification.

Blast-furnace slag used as a partial substitution of Portland cement in concrete shall conform to the requirements of MS-OR-532, Supplementary Cementitious Materials.

Fly ash shall conform to the requirements of MS-OR-532, Supplementary Cementitious Materials.

All admixtures (plasticizers, water-reducing, accelerating, retarding, etc) shall conform to the requirements of MS-OR-533, Chemical Admixtures for Concrete. If air-entraining cement is used, any additional air-entraining admixture shall be of the same type as that in the cement.

Curing compound shall conform to the requirements of MS-OR-534, Concrete Curing Compound.

Preformed expansion joint filler shall conform to the requirements of MS-OR-535, Preformed Expansion Joint Filler.

Sealing compound for joints shall conform to the requirements of MS-OR-536, Sealing Compound for Joints in Concrete and Concrete Pipe.

Waterstops shall conform to the requirements of MS-OR-537, Nonmetallic Waterstops, and MS-OR-538, Metal Waterstops, for the specified kinds.

Dowels shall be a plain, round steel bar conforming to the requirements of MS-OR-539, Steel Reinforcement (for Concrete).

Water used in mixing and curing concrete shall be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter, or other deleterious substances.

220.2.1 CONCRETE MIX DESIGN

a. Responsibilities—The contractor is responsible for the design and proportioning of the concrete. Job mixes shall be prepared to meet the quality, consistency, and strength of concrete specified as below.

b. Design Criteria

Specified compressive strength

Class of Concrete	Specified Compressive Strength (f'c) at 28 Days (lb/in²)
5000	5,000
4000	4,000
3000	3,000
2500	2,500

Water-Cement Ratio – Maximum water-cement ratio shall be 0.50, unless otherwise specified.

Air Content – Unless otherwise specified the air content (by volume) of the concrete at the time of placement shall be:

Maximum size aggregate	Air content (%)
3/8 inch to 1 inch	5 to 7
Over 1 inch	4 to 6

Slump – The consistency of all concrete shall allow it to be placed without segregation or excessive laitance. Unless otherwise specified, the slump shall be:

Type of Structural Section	Slump (inches)
Massive sections, pavements, footings	2 ± 1
Heavy beams, thick slabs, thick walls (>12 inches)	3 ± 1
Columns, light beams, thin slabs, thin walls (12 inches or less)	4 ± 1

Admixtures

Superplasticizers. Superplasticized concrete shall be a concrete mix containing either a water-reducing, high range admixture (ASTM C 494, Type F or G) or a plasticizing admixture (ASTM C 1017) at a dosage rate that: (1) reduces the quantity of water required to produce a concrete mix within the above slump range by 12 percent or more, or (2) produces an increase in the slump of at least 2 inches above the slump of the design mix containing no water reducer or plasticizing admixture.

Water Reducing Admixture. A water-reducing admixture (ASTM C 494, Type F or G) and/or a plasticizing admixture (ASTM C 1017) may be added to an approved job mix without resubmittal and reapproval of the job mix if the following requirements are met:

- a. The admixture shall be introduced into the concrete mix as specified by the manufacturer and be compatible with other admixtures in the job mix.
- b. The water content shall be equal to or less than that required in the job mix without the admixture.
- c. The cement content shall be the same as that required in the job mix without the admixture.
- d. The air content shall be within the specified range.
- e. The slump shall not exceed 7.5 inches unless the contractor can demonstrate before placement that the job mix can be placed without segregation or excessive laitance at a slump greater than 7.5 inches. The concrete shall retain the increased slump for not less than 30 minutes.
- f. If the admixture is added at the job site, the slump of the concrete before the addition of the admixture shall not exceed the slump specified above for concrete that does not contain the admixture.

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

Fly Ash. Fly ash may be used as a partial substitution for Portland cement in an amount not greater than 25 percent (by weight) of cement in the concrete mix unless otherwise specified.

Blast-furnace Slag. Ground granulated blast-furnace slag may be used as a partial substitution for Portland cement in amounts between 25 to 70 percent (by weight) of cement in the concrete mix unless otherwise specified.

220.3 INSPECTION AND TESTING

During the course of the work, the engineer performs quality assurance testing as required to assure the concrete meets the contract requirements. The NRCS shall have free entry to the plant to review the equipment used for mixing, dispersing, weighing, agitating and delivering concrete. Proper facilities shall be provided for inspecting materials, equipment and processes and to obtain samples of the ingredients and concrete. All tests and inspections will be conducted so as not to unnecessarily interfere with the manufacture and delivery of the concrete.

The manufacturer shall provide delivery tickets for each concrete delivery. Delivery/batch tickets shall be verified by the Quality Control personnel for meeting the specification requirements and acceptance of the delivered concrete mix. See section 041.23 for additional information on delivery/batch tickets.

Any portion of a batch may be tested by the engineer for any of the purposes shown below. Samples taken for testing shall be representative of that part of the batch.

- a. Determining uniformity of the batch.
- b. Checking compliance with requirements for slump and air content when the batch is discharged over an extended period.
- c. Checking compliance of the concrete with the specifications when the whole amount is being placed in a small structure, or a distinct part of a larger structure, is less than full batch.

If concrete is conveyed to the placement location by pumping or conveyor belts, the samples shall be collected at the discharge end.

When a plasticizing admixture is added to the concrete mix at the job site, slump tests are made both before the addition of the admixture to the concrete mix and after the admixture has been incorporated into the concrete mix.

The tests on concrete are performed by the following methods unless otherwise specified:

Type of Test	Test Method (ASTM designation)
Sampling	C 172
Slump test	C 143
Air content	C 231 or C 173
Compression test specimens	C 31 or C 42

Compressive strength testing	C 39
Unit weight	C 138
Temperature	C 1064

220.4 HANDLING AND STORAGE

Aggregates shall be stored or stockpiled in such a manner that separation of coarse and fine particles of each size is avoided and that various sizes do not become intermixed before proportioning. Methods of handling and transporting aggregates shall avoid contamination, excessive breakage, segregation, degradation, or intermingling of various sizes.

220.5 MIXERS AND MIXING

All concrete shall be properly mixed as specified per this Section 220.5 of this specification unless specified otherwise by a NRCS engineer.

Mixers shall be capable of thoroughly mixing the concrete ingredients into a uniform mass within the specified mixing time and of discharging the mix without segregation. Concrete shall be uniform and thoroughly mixed when delivered to the forms in a freshly mixed and unhardened state. Variations in slump of more than 1 inch within a batch is considered evidence of inadequate mixing and shall be corrected by changing batching procedures, increasing mixing time, changing mixers, or other means. Mixing time shall be within the limits specified below unless the contractor demonstrates by mixer performance tests that adequate uniformity is obtained by different times of mixing.

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. Water to compensate for up to a 1-inch loss in slump may be added, not to exceed the design maximum water cement ratio.

Withholding some of the mixing water until the concrete arrives on the job, then adding the remaining water and turning the mixer 30 revolutions at mixing speed is allowed to overcome transporting conditions.

Concrete may be furnished by ready-mix methods, by volumetric batching and continuous mixing at the site, or by batch mixing at the site and shall be in compliance with ASTM C 94.

220.6 FORMS

Forms shall be of good quality wood, plywood, steel, or other approved material and shall be mortar tight. The forms and associated falsework shall be substantial and unyielding and shall be constructed so that the finished concrete conforms to the specified dimensions and contours.

Form surfaces shall be smooth and free from holes, dents, sags, or other irregularities and shall be maintained in this condition throughout the work. Forms shall be coated with a non-staining form release agent before being set into place. All re-used form work shall be cleaned and inspected. Forms may be re-used a maximum of three times after proper cleaning and inspection. Formwork

showing damage (cracks, breaks, chips, de-lamination, etc) shall not be used or repaired for re-use.

When a superplasticized concrete mix is used, forms shall be coated according to the manufacturer's recommendations with a form release agent that is specifically formulated for plasticized concrete. The contractor shall be responsible in insuring that the forms are designed to withstand the increased pressures of the superplasticized concrete and the increased impact forces resulting from larger drop heights used in placing the superplasticized concrete.

Metal ties or anchorages that will be embedded in the concrete 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. If approved fiberglass or plastic form ties are used, the tie ends shall be cut flush with the finished concrete and ground smooth.

All edges that will be exposed shall be chamfered as specified on the drawings.

220.7 STEEL REINFORCEMENT

The steel reinforcement shall be as specified on the drawings. The steel shall be securely tied and positioned to prevent movement during the placement of concrete. The reinforcing steel in slabs on grade shall be supported on blocks or chairs. All blocks shall have a strength equal to or greater than the 28-day compressive strength of the concrete.

The length of splices shall be 30 diameters of the steel bar unless otherwise specified on the drawings. Welded splices are not permitted.

The bends shall be standard bends with the length and radius as specified by the Concrete Reinforcing Steel Institute, CRSI, and/or the Portland Cement Association, PCA.

220.8 PREPARATION OF FORMS AND SUBGRADE

The foundation area shall be cleared of all vegetation, organic material and rocks with a dimension greater than 2 inches. If fill material is required, it shall be placed in horizontal layers with a maximum lift of 4 inches before compaction. The moisture content of the earth fill material shall be controlled so that a firm dense foundation can be achieved. Earth fill sections with a height of 2 feet or greater will be constructed using the compaction requirements of NRCS CS-OR-205, Earthfill Class A or CS-OR-206, Earthfill Class S.

Before placement of concrete, the forms, embedments, and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings. Any form release agent on the reinforcing steel or other surfaces required to be bonded to the concrete shall be removed.

Rock surfaces shall be cleaned by high pressure air-water cutting, sandblasting, or wire brush scrubbing, as necessary, and shall be wetted immediately before placement of concrete. The earth surface shall be firm and damp. Placement of concrete on mud, dried earth, noncompacted fill, or frozen subgrade is not permitted. All ice, snow, and frost shall be removed, and the temperature

of all surfaces, including the reinforcing steel and other steel inclusions, to be in contact with the new concrete shall be no colder than 40 degrees Fahrenheit.

Items to be embedded in the concrete shall be positioned accurately and anchored firmly. Weepholes in walls or slabs shall be formed with nonferrous material.

220.9 CONVEYING

Concrete shall be delivered to the site and discharged completely into the forms within 1.5 hours or before the drum of truck has revolved a total of 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or 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.

Superplasticized concrete can be conveyed and placed when the temperature of the concrete is below 95 degrees Fahrenheit and the slump of the concrete remains within the allowable slump range.

The engineer can allow an appropriate extension of time when the setting time of the concrete is increased a corresponding amount by the addition of an approved admixture. In any case concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods that prevent segregation of the aggregates or loss of mortar.

220.10 PLACING

Concrete shall not be placed until the subgrade, forms, steel reinforcement, and other embedments are inspected and approved by the engineer. For walls and columns, subsequent higher placements of concrete shall not be placed until the concrete below the new placement has gained sufficient strength to support the concrete dead load and any superimposed loads without distress. Placement sequences and timing shall consider form removal timing covered in Section 220.17 of this specification.

The contractor shall have all equipment and material required for curing available at the site ready for use before placement of concrete begins.

Concrete shall be placed only in the presence of the engineer. The contractor shall give reasonable notice to the engineer before each placement. Such notice shall be far enough in advance to give the engineer adequate time to assure that the subgrade, forms, steel reinforcement, and other preparations comply with specifications. Other preparations include, but are not limited to, the concrete batching plant, mixing and delivery equipment and system, placing and finishing equipment and system, schedule of work, workforce, and heating or cooling facilities, as applicable. All deficiencies are to be corrected before concrete is delivered for placing.

Concrete shall be placed and consolidated to prevent segregation of the mix components. The concrete shall be deposited as closely as possible to its final position in the forms. It shall be worked into the corners and angles of the forms and around all reinforcement and embedded

items to prevent segregation of aggregates or excessive laitance. The depositing of concrete shall be regulated so that the concrete can be consolidated with a minimum of lateral movement. Concrete placed against a sloping surface shall start at the lowest elevation and work upwards to the highest elevation.

Concrete shall not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation. When a superplasticized concrete mix is used, concrete shall not be dropped more than 12 feet vertically unless suitable equipment is used to prevent segregation.

220.11 LAYERS

Slab concrete shall be placed to design thickness in one continuous layer unless otherwise specified. Formed concrete shall be placed in horizontal layers not more than 20 inches deep. Where a superplasticized concrete mix is used, formed concrete may be placed in horizontal layers not more than 5 feet deep.

Successive layers of fresh concrete between construction joints shall be placed at a rate fast enough that the preceding layer is still plastic and can be easily mixed with the fresh concrete such that seams (cold joints) or plane of weakness do not occur. If the surface of a previously placed layer of concrete has taken a set to the degree that it will not flow and mix with the succeeding layer when vibrated, the contractor shall discontinue placing concrete and shall make a construction joint according to the procedure specified in Section 220.13 of this specification. If placing is discontinued when a layer is incomplete, the ends of the incomplete layer shall be formed by a vertical bulkhead.

220.12 CONSOLIDATING

All concrete shall be consolidated with internal type mechanical vibrators capable of transmitting vibration to the concrete at frequencies not less than 8,000 impulses per minute, unless otherwise specified or approved before placement. Vibration shall be supplemented by spading, rodding, and hand tamping as necessary to ensure smooth and dense concrete along the form surface, in corners, and around embedded items. The contractor shall provide a sufficient number of vibrators to properly consolidate the concrete immediately after it is placed. A sufficient number of standby vibrators shall be kept onsite during the placement of concrete.

Vibration shall compact the concrete and bring it into intimate contact with the forms, reinforcing steel, and other embedded items while removing voids and pockets of entrapped air. The location, insertion, duration, and removal of the vibrators shall be such that maximum consolidation of the concrete is achieved without causing segregation of the mortar and coarse aggregate or causing water or cement paste to flush to the surface. Vibration shall be applied to the freshly deposited concrete by rapidly inserting the vibrator and slowly, in an up and down motion, removing the vibrator at points uniformly spaced at not more than 1.5 times the radius of the area visibly effected by vibration. Generally, this is at 5 to 10 seconds per foot on 14-inch spacings or less.

The area visibly affected by the vibrator shall overlap the adjacent, just vibrated area. The vibrator shall extend vertically into the previously placed layer of fresh concrete by at least 6 inches at all points. This ensures effective bond between layers. In thin slabs (6 inches or less) the vibrator(s) should be sloped toward the horizontal to allow operations in a fully embedded position.

Vibration shall not be applied directly to the reinforcement steel, the forms, or other embedded items unless otherwise specified. Vibration shall not be applied to concrete that has hardened to the degree that it does not become plastic when vibrated. If surface vibrators are used, they may contact forms when consolidating thin slabs.

The use of vibrators to transport concrete in the forms or conveying equipment is not permitted. Surface vibrators may be used to consolidate slabs 8 inches and less in thickness. Slabs more than 8 inches thick shall be consolidated with internal vibration and may be augmented through use of surface vibrator, such as vibrating screeds, plate or grid vibratory tampers, or vibratory roller screeds. If concrete is to be consolidated using surface vibration methods, the contractor shall detail how this work is to be performed in writing to the engineer for review and approval. This report must be submitted no less than 30 calendar days before placing concrete by this method. It includes equipment selection and specifications.

220.13 CONSTRUCTION JOINTS

Construction joints shall be made at the locations shown on the drawings unless otherwise specified or approved by the engineer. If construction joints are needed that are not shown on the drawings, they shall be placed in locations approved by the engineer.

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 twice the maximum aggregate diameter used in the concrete mix.

Nonvertical construction joints in structural elements, such as walls and columns, shall be consolidated and screeded to grade unless otherwise specified. Construction joints shall be covered and wet cured for 7 days or until concrete placement resumes unless otherwise specified. Steel tying and form construction next 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.

[DESIGNER SHALL SELECT THE APPROPRIATE METHOD BASED ON TYPE OF PROJECT, JOB CLASS, AND TYPE AND LOCATION OF HORIZONTAL JOINT]

Method 1—The surface of construction joints shall be cleaned of all unsatisfactory concrete, laitance, coatings, stains, or debris by sandblasting or high-pressure air-water cutting, or both. Sandblasting can be used after the concrete has gained sufficient strength to resist excessive cutting, and high-pressure air-water cutting can be used as soon as the concrete has hardened sufficiently to prevent the jet from displacing the coarse aggregates. The surface of the concrete in place shall be cut to expose clean, sound aggregate, but not so deep as to undercut the edges of larger particles of the aggregate. After cutting, the surface shall be thoroughly washed to remove all loose material. If the surface is congested by reinforcing steel, is relatively inaccessible, has cured beyond the ability to cut with air-water blasting, or disturbing the concrete before it is hardened is considered undesirable, cleaning of the joint by air or water jets is not permitted. The sandblasting method is required after the concrete has hardened.

Immediately before new concrete is placed, all construction joints shall be wetted and standing water removed.

Method 2—The surface of construction joints shall be cleaned of all unsatisfactory concrete, laitance, coatings, stains, or debris by washing and scrubbing with a wire brush or wire broom, or by other means approved by the engineer. Immediately before new concrete is placed, all construction joints shall be wetted and standing water removed.

220.14 EXPANSION AND CONTRACTION JOINTS

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 fully exposed for its entire length with clean and true edges.

Where open joints or weakened plane "dummy" joints are specified, joints formed in fresh concrete shall be constructed by the insertion and subsequent removal of a wood strip, metal plate, or other suitable template. This will be done so that the corners of the concrete do not chip or break. The edges of the fresh concrete at the joints shall be finished with an edging tool before the joint strips are removed. Open joints or weakened plane dummy joints may also be sawcut joints conforming to the depth and extent specified.

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

220.15 WATERSTOPS

Waterstops shall be held firmly in the correct position as the concrete is placed. Joints in metal waterstops shall be brazed or welded. Joints in rubber or plastic waterstops shall be cemented, welded, or vulcanized as recommended by the manufacturer. Joints shall be watertight and of a strength equivalent to that specified in MS-OR-537, Nonmetallic Waterstops. Intersecting waterstop joints shall be prefabricated and supplied by the same manufacturer providing the waterstop.

220.16 REMOVAL OF FORMS, SUPPORTS, AND PROTECTIVE COVERINGS

Forms, supports, and protective coverings shall be removed as soon as practical after the concrete has gained sufficient strength to support its own weight and superimposed loads. Removal shall be done so that the concrete surface is not damaged and sudden or excessive stresses are not induced. The minimum period from completion of the concrete placement to the removal of the forms shall be based on either strength tests or cumulative times.

Strength tests—The strength of the in place concrete is determined by testing concrete cylinders specifically cast for this purpose and cured adjacent to the member in accordance with the ASTM C 31 method for determining removal time. Unless otherwise specified, forms supporting the weight of the concrete member may be removed after the concrete strength is 70 percent of that specified for the class of concrete. Forms not supporting the weight of the concrete member or other superimposed loads may be removed after the concrete strength has reached the strength specified in Section 220.24 of this specification.

Cumulative time—The total accumulated time, not necessarily continuous, that the air adjacent to the concrete is above 50 degrees Fahrenheit and the specified concrete curing has occurred concurrently will be determined. Forms may be removed after the total accumulated time shown:

Accumulated Form Removal Times		
Forms	Time ^{1/}	
Sides of slabs or beams		12 hours
Undersides of slabs or beams	Clear span	^{2/}
	< 10 ft	4 days
	10 - 20 ft	7 days
	> 20 ft	14 days
Sides of walls or columns	Height above form	^{3/ 4/}
	< 10 ft	12 hours
	< 20 ft	24 hours
	> 20 ft	72 hours

1/ Table values apply to normal concrete. Values for concrete that contains cements or admixtures that significantly retard or accelerate strength gain will be determined by the engineer and based on actual design mix data.

2/ Values apply to members designed to support significant superimposed loads. Values for members designed for only self weight when placed in service shall be 50 percent greater.

3/ Values apply to members not subject to significant horizontal loads. Additional time or rebracing is needed

for members subject to significant wind or other horizontal loads.

4/ Subsequent higher lifts may be placed after 12 hours.

220.17 FINISHING FORMED SURFACES

All formed concrete surfaces shall be true and even, and shall be free from overtolerance depressions, holes, projections, bulges, or other defects in the specified surface finish or alignment, unless otherwise specified. Depressions are measured as the distance from the bottom of a 5-foot-long template or straight edge.

A surface to be backfilled or otherwise concealed when construction is completed shall have the following surface treatment unless otherwise specified:

- a. Repair defective concrete.
- b. Fill all form tie holes.

- c. Correct surface depressions deeper than 1 inch.
- d. Remove or smooth fins and abrupt projections that exceed 0.75 inch.

A surface to be permanently exposed, where other finishes are not specified, shall have the following treatment:

- a. Repair defective concrete.
- b. Fill all form tie holes.
- c. Remove or smooth all abrupt irregularities greater than 0.25 inch in depth or projection.
- d. Treat all depressions and irregularities so that they do not exceed 0.5 inch in depth.

Form bolt and tie holes and other holes of similar size and depth shall be repaired and filled as specified in Section 220.22 of this specification.

220.18 FINISHING UNFORMED SURFACES

All exposed surfaces of the concrete shall be accurately screeded to grade and then float finished unless otherwise specified. The float finish shall result in a surface that has no irregularities of more than 0.25 inch when checked with a template or straight edge that is 10 feet long.

All exposed surfaces of concrete shall be accurately struck off to grade after placement and consolidation are completed. Following strikeoff, the surface shall be immediately smoothed by darbying or bull floating before any free water has bled to the surface. The concrete shall then be allowed to rest until the bleed water and water sheen have left the surface and the concrete has stiffened to where it will sustain foot pressure with only about 0.25-inch indentation. At this time all joints and edges that are exposed to view and are not chamfered shall be finished with edging tools. After edging and hand jointing is complete, all exposed surfaces shall be floated with wood or magnesium floats. The floating should work the concrete no more than necessary to remove screed, edger, and jointer marks and to produce a compact surface uniform in texture.

Water shall not be sprinkled or added to the surface of the concrete during the darbying, bull floating, floating, or other finishing operations to facilitate finishing.

220.19 CURING

Freshly placed concrete shall be cured a minimum of 7 days. A curing process shall be started as soon as the concrete has hardened sufficiently to prevent surface damage. Curing concrete, including exposed surfaces of formed concrete and concrete in forms, shall be maintained at a satisfactory moisture content for at least 7 days following placement. If forms are removed before the end of the 7-day curing period, the interrupted curing process shall be reestablished and maintained until a full 7-day curing period is achieved. A satisfactory moisture condition is:

- a. Continuous or frequent application of water or use of a saturated cover material, such as canvas, cloth, burlap, earth, or sand.

- b. Prevention of excessive water loss from the concrete by use of an impermeable coating (curing compound) or covering (plastic, paper).

The application of water or covering shall not erode, mar, or otherwise damage the concrete. Plastic film or paper shall meet the requirements of ASTM C 171. Black covering shall not be used when concreting in hot weather.

Curing compound may be used for exposed surfaces or formed surfaces after patching and repair are completed. Curing compounds shall not be used on a surface that is to receive additional concrete, paint, tile, or other coatings unless the contractor demonstrates that the membrane can be satisfactorily removed or can serve as a base for the later application.

Curing compound shall be thoroughly mixed before applying and be agitated during application. The compound shall be applied at a pressure of 75 to 100 pounds per square inch. A continuously agitating pressure sprayer is used for application at a uniform rate of not less than 1 gallon per 175 square feet of surface. Manual hand pump sprayers shall not be used unless otherwise specified. For individual concrete placements or repairs having a surface area of 400 square feet or less, curing compound may be applied with a soft-bristled brush, paint roller, or hand sprayer. The compound shall form a uniform, continuous, adherent film that shall not check, crack, or peel and shall be free from pinholes or other imperfections.

All surfaces covered with curing compound shall be continuously protected from damage to the protective film during the required curing period.

A surface subjected to heavy rainfall or running water within 3 hours after the compound has been applied or that is damaged by subsequent construction operations during the curing period shall be resprayed in the same manner as for the original application.

Water for curing shall be clean and free from any substances that cause discoloration of the concrete.

220.20 CONCRETING IN COLD WEATHER

Methods for concreting in cold weather shall be performed when, for more than 3 consecutive days, the following conditions exist:

- a. The average daily air temperature at the job site is less than 40 degrees Fahrenheit. (The average daily air temperature is the average of the highest and lowest temperatures occurring during the period from midnight to midnight.)
- b. The air temperature at the job site is not more than 50 degrees Fahrenheit for more than half of any 24-hour period.

Concrete shall be protected against freezing during the first 24 hours after placement whether or not the average weather conditions specified above for cold weather concreting exist. The following provisions also shall apply unless otherwise specified:

- a. When the cement is added to the mix, the temperature of the mixing water shall not exceed 140 degrees Fahrenheit nor shall the temperature of the aggregate exceed 150 F.

- b. The temperature of the concrete at the time of placing shall be within the placement temperature range shown below, unless otherwise specified.

Least Dimension of Section, Inches	Placement Temperature, °F
Less than 12	55 – 75
12 to 36	50 – 70
36 to 72	45 – 65
Greater than 72	40 – 60

- c. The minimum temperature of the concrete for the first 72 hours after placement shall not be less than the minimum temperature shown above. Concrete structures shall be immediately protected after concrete placement by covering, housing, insulating, or heating concrete structures sufficiently to maintain the minimum temperature adjacent to the concrete surface. If the minimum temperature requirements are not met and the concrete did not freeze, the protection time will be extended a period equal to twice the number of hours the temperature was below the minimum temperature.
- d. Exhaust flue gases from combustion heaters shall be vented to the outside of the enclosure. The heat from heaters and ducts shall be directed in such a manner as to not overheat or dry the concrete in localized areas or to dry the exposed concrete surface.
- e. At the end of the protection period, the concrete shall be allowed to cool gradually. The maximum decrease at the concrete surface in a 24-hour period shall not exceed 40 degrees Fahrenheit.

220.21 CONCRETING IN HOT WEATHER

Methods for concreting in hot weather shall be in accordance with the requirements set forth below.

For the purpose of this specification, hot weather is defined as any combination of the following conditions that impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise resulting in detrimental results:

- a. High ambient temperature
- b. High concrete temperature
- c. Low relative humidity
- d. Wind velocity
- e. Solar radiation

Whenever the above conditions exist or when climatic conditions are such that the temperature of the concrete may reasonably be expected to exceed 90 degrees Fahrenheit at the time of delivery to the worksite or during the placement operations, the following provisions shall apply:

- a. The contractor shall maintain the temperature of the concrete below 90 degrees Fahrenheit during mixing, conveying, and placing.
- b. Exposed concrete surfaces that tend to dry or set too rapidly shall be continuously moistened using fog sprays or other means to maintain adequate moisture during the time between placement and finishing. Water shall not be sprinkled or added directly to the surface of the concrete before finishing.
- c. Finishing of slabs and other exposed surfaces shall be started as soon as the condition of the concrete allows and shall be completed without delay. Water shall not be sprinkled or added to the surface of the concrete during the darbying, bull floating, floating, or other finishing operations to facilitate finishing.
- d. Formed surfaces shall be kept completely and continuously wet from the time the concrete takes initial set to when the forms are removed. After the forms are removed, the concrete surfaces shall be kept completely and continuously wet for the duration of the curing period or until curing compound is applied in accordance to Section 220.19 of this specification.
- e. Exposed and unformed concrete surfaces, especially flat work placed with large areas of surface, shall be kept completely and continuously wet for the duration of the curing period or until curing compound is applied in accordance to Section 220.19 of this specification. The concrete shall be protected against thermal shock from rapid cooling (5 °F per hour or more than 40 °F per 24-hour period) of the concrete by application of curing water or temperature changes during the first 24 hours of the curing period.
- f. When any single or combination of conditions may result in very rapid setting or drying of the concrete, extreme conditions exist. For flat work and slab construction, extreme conditions exist when the evaporation rate¹ exceeds 0.2 pound per square foot per hour. The engineer may:
 1. Restrict placement to the most favorable time of the day.
 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.
 4. Restrict the removal of forms, repair, and patching to small areas that can be protected with curing compound immediately.

¹ *The evaporation rate for flat work and slab construction may be determined by calculating the evaporation rate from a shallow cake pan having a surface area of at least 1 square foot or by other methods approved by the engineer or designated in section 25.*

220.22 CONCRETE PATCHING, REPAIR OR REPLACEMENT

Patching. All form bolts, metal ties, and similar forming restraints shall be removed to a depth of 1 inch below the surface of the concrete and their cavities repaired unless otherwise specifically permitted or specified. Small cavities, large air holes, minor honeycombed areas, and other superficial imperfections that require patching to meet the specified finish requirements shall be thoroughly cleaned and filled. Holes left by bolts or straps that pass through the concrete section shall be filled solid with a dense, well-bonded, nonshrink patching material. Dry-pack mortar and replacement concrete shall follow the appropriate procedure detailed in the Repair and Maintenance chapter of the Concrete Manual, Bureau of Reclamation, U.S. Department of the Interior. Proprietary patching material shall be appropriate for the type of repair, used within the manufacturer's recommended limits, and applied according to the manufacturer's recommendations.

Repair or replacement —The contractor shall repair or replace concrete that does not meet the requirements of this specification. Before starting any repair or replacement work, the contractor shall prepare a written plan for the repair or replacement. The primary reference for material and repair methods for the plan shall be the appropriate sections of the Repair and Maintenance chapter of the Concrete Manual, Bureau of Reclamation, U.S. Department of the Interior. The repair plan shall be submitted to the engineer for review at least 10 days before any repair or replacement work. Approval of the plan will be authorized in writing by the contracting officer. When proprietary patching material is proposed, the manufacturer's data sheets and written recommendations shall be submitted to NRCS for approval prior to repair work.

Repair material or replacement concrete shall have properties, color, and texture similar to and compatible with the concrete being repaired or replaced. Repair or replacement concrete work shall be performed only when the engineer is present.

Curing of repaired or replaced concrete shall be started immediately after finish work is completed and as specified by the manufacturer of proprietary compounds.

220.23 DELIVERY TICKETS

The contractor shall furnish to the NRCS technician/engineer a delivery ticket for each batch of concrete prior to the unloading at the site. The delivery ticket may be printed, stamped, or written and shall provide the following information for each batch of concrete:

- a. Name of the ready-mix company and batch plan, or batch plan number
- b. Serial number or ticket
- c. Date
- d. Truck number
- e. Name of purchaser/contractor
- f. Specific designation of job (Name and location)
- g. Specific Class or designation of the concrete in conformance with that employed in job specifications

- h. Amount of concrete in cubic yards (or cubic meters)
- i. Time loaded or of first mixing of cement and aggregates

Delivery Tickets for each load of Ready-Mix concrete shall be furnished to the NRCS technician at the time of placement.

220.24 ITEMS OF WORK AND CONSTRUCTION DETAILS