

CAST-IN-PLACE CONCRETE

STANDARDS & SPECIFICATIONS MANUAL



MOORE COUNTY PUBLIC WORKS DEPARTMENT

AMENDED: June 2017

PREFACE

This Manual is for the Moore County Public Utilities and the East Moore Water District water and sewer systems, all of which are operated by the Moore County Public Works Department (MCPW).

These standards are for design and construction of utilities, which will come under the jurisdiction of Moore County Public Works (MCPW). **These standards alone do not constitute a complete set of construction documents. The owner's or developer's Professional Engineer is responsible for design and computation of complete construction and contract documents.** These standards are set forth as the minimal requirements to achieve a suitable quality level for utilities which will become the property of MCPW.

The standards do not include a complete commentary on methods of installation and detailed information of quality of workmanship in place. The owner's or developer's Professional Engineer must include detailed information on methods of construction and should expand on the testing and any of the special requirements to the engineer's satisfaction, subject to the approval of MCPW.

From time to time, these standards will be amended and/or expanded at the request of the MCPW Engineering Department and with approval of the Director. It will be the responsibility of the owner or developer to contact the MCPW to obtain updated standards.

There may be circumstances whereby the design engineer may wish to propose changes or modifications to these standards, when this occurs permission from the County Engineer shall be obtained prior to submission to NCDEQ.

Disclaimer

To the best of their ability, the authors have insured that material presented in this manual is accurate and reliable. The design of engineered facilities, however, requires considerable judgment on the part of designer. It is the responsibility of the design professional to insure that techniques utilized are appropriate for a given situation. Therefore, neither Moore County Public Works, nor any author or other individual, group, etc., associated with production of this manual, accepts any responsibility for improper design, any loss, damage, or injury as a result of the use of this manual.

TABLE OF CONTENTS

1.0	SUBMITTALS.....	1
	A. Product Data	
	B. Design Mixtures	
	C. Steel Reinforcement Shop Drawings	
	D. Material Certifications	
	E. Records	
	F. Chemical and Physical Analysis	
2.0	QUALITY ASSURANCE.....	1
	A. Manufacturer Qualifications	
	B. Source Limitations	
	C. Welding Qualifications	
	D. Concrete Testing Services	
	E. General	
3.0	DELEVERY, STORAGE AND HANDLING.....	2
4.0	FORM FACING MATERIALS.....	3
	A. Smooth- Formed Finished Concrete	
	B. Rough-Formed Finished Concrete	
	C. Forms for Cylindrical Columns, Pedestals and Supports	
	D. Chamfer Strips	
	E. Form Ties	
5.0	STEEL REINFORCEMENT.....	3
	A. Minimum Standard	
	B. Steel Bar Mats	
	C. Plain-Steel Wire	
	D. Plain-Steel Welded Wire Reinforcement	
	E. Bars	
	F. Installation	
6.0	REINFORCEMENT ACCESSORIES.....	6
	A. Joint Dowel Bars	
	B. Bar Supports	
7.0	CONCRETE MATERIALS.....	6
	A. Cementitious Material	
	B. Concrete Aggregates	
	C. Fine Aggregates	
8.0	ADMIXTURES.....	7
	A. General	

	B. Air-Entraining Admixture	
	C. Chemical Admixtures	
9.0	WATER STOPS.....	7
10.0	VAPOR RETARDS.....	8
11.0	CRUSHED STONE FILL.....	8
12.0	CURING AMTERIALS.....	8
13.0	RELATED MATERIALS.....	8
	A. Pre-Molded Expansion and Isolation Joint Filler Strips	
	B. Joint Sealing Compound	
	C. Surface Coating	
14.0	CONCRETE MIXING.....	8
	A. Plants	
	B. Batch Tickets	
	C. Equipment	
	D. Slump	
	E. Concrete Types and Strengths	
15.0	FORMWORK DESIGN.....	10
16.0	FORMWORK TOLORENCES.....	10
17.0	EMBEDED ITEMS.....	10
18.0	JOINTS.....	10
	A. General	
	B. Construction Joints	
	C. Contraction Joints in Slabs-on-Grade	
	D. Isolation Joints in Slabs-on-Grade	
	E. Doweled Joints	
19.0	SLABS ON GRADE.....	11
	A. Preparation of Subgrade	
	B. Joints	
20.0	CONCRETE PLACEMENT.....	12
21.0	FINISHING FORMED SURFACES.....	15
	A. Standard Rough Form Finish	
	B. Standard Finish for Exposed Surfaces	
	C. Smooth Form Finish	

22.0	FINISHING FLOORS AND SLABS.....	16
	A. General	
	B. Scratched Finish	
	C. Floated Finish	
	D. Troweled Finish	
	E. Broom Finish	
23.0	FINISHING TOLERANCES.....	16
24.0	CONCRETE ITEMS.....	17
	A. Filling In	
	B. Equipment Bases and Foundations	
25.0	CONCRETE PROTECTING AND CURING.....	17
26.0	JOINT FILLING.....	18
27.0	CONCRETE SURFACE REPAIRS.....	18
28.0	FIELD QUALITY CONTROL.....	19
	A. Testing and Inspecting	
	B. Logs	
29.0	EVALUATION AND ACCEPTANCE.....	21

STANDARD & SPECIFICATIONS MANUAL - CAST-IN-PLACE CONCRETE

1.0 SUBMITTALS

- A. Product Data:** For each type of product indicated.
- B. Design Mixtures:** For each concrete mixture. Submit alternate design mixtures when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
- C. Steel Reinforcement Shop Drawings:** Drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing and supports for concrete reinforcement.
- D. Material Certificates:** For each of the following, signed by manufacturers:
1. Cementitious Materials
 2. Admixtures
 3. Steel Reinforcement and Accessories
 4. Fiber Reinforcement
 5. Waterstops
 6. Curing Compounds
 7. Bonding Agents
 8. Adhesives
 9. Vapor Retarders
 10. Semi rigid Joint Filler
 11. Joint Filler Strips
- E. Records:** Contractor shall submit records of all concrete pours showing exact location of pour, date of pour, quantity of pour, and class of concrete poured to the County Engineer each month. Temperature at time of pour should also be recorded.
- F. Chemical and Physical Analysis:** Contractor shall also submit to the County Engineer chemical and physical analysis of all cement and fly ash delivered to the batch plant seven (7) days prior to use of the cement or fly ash.

2.0 QUALITY ASSURANCE

- A. Manufacturer Qualifications:** A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94 requirements for production facilities and equipment. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

- B. Source Limitations:** Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.
- C. Welding Qualifications:** Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code - Reinforcing Steel."
- D. Concrete Testing Service:** Owner shall engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

E. General

If the average strength of the laboratory control cylinders shows the concrete to be below the specified design strength, the aggregate proportions and water content may be changed by the County Engineer, who, in addition to such changes, may require core tests. Tests confirming concrete strengths on hardened concrete which was poured without testing shall be paid for by the Contractor.

Prepare design mixes for each class of concrete used in accordance with ACI 311.1. The Contractor shall pay for all design mix costs. Submit written reports to the Engineer for each proposed mix for each class of concrete prior to start of work. Do not begin concrete production until mixes have been approved by the Engineer.

Strength data for establishing standard deviation and required over strength factor will be considered suitable if the concrete production facility has certified records consisting of at least 30 consecutive tests in one group or the statistical average for two groups totaling 30 or more tests representing similar materials and project conditions. Records of these tests shall be submitted with the proposed design mix.

If standard deviation exceeds 800 psi or if no suitable records are available, selected proportions to produce an average strength of at least 1200 psi greater than the required compressive strength of concrete. If standard deviations are less than 600 psi, the minimum over strength factor required in the design mix shall be in accordance with ACI 318, Section 4.3.1.

Design mixes shall be proportioned using the maximum specified slump and temperature. Laboratory test date for revised mix designs and strength results must be submitted to and accepted by the Engineer before using in the work. Admixtures shall be used in strict accordance with the manufacturer's written instructions. Design mix shall be proportioned using the proposed admixtures at optimum recommended dosages. The manufacturer of the mixture shall prepare and submit test date used to determine the optimum dosage.

3.0 DELIVERY, STORAGE AND HANDLING

Reinforcing Steel shall be delivered to the Project Site properly tagged, bundled, and ready to place. Reinforcing steel delivered to the Project Site, and not immediately

placed in forms, shall be protected from mud, excessive rust producing conditions, oil, grease, or distortion. Reinforcing steel shall be stored off the ground. Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

4.0 FORM FACING MATERIALS

- A. Smooth-Formed Finished Concrete:** Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints. Plywood, metal, or other approved panel materials shall be high quality and standard for the industry.
- B. Rough-Formed Finished Concrete:** Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Forms for Cylindrical Columns, Pedestals, and Supports:** Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
- D. Chamfer Strips:** Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.
- E. Form Ties:** Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
 - 1. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.
 - 2. Furnish ties that, when removed, will leave holes no larger than 1 inch in diameter in concrete surface.
 - 3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

5.0 STEEL REINFORCEMENT

- A. Minimum Standard:** Unless otherwise indicated, all reinforcing steel shall conform to one of the following ASTM Standards, latest edition:
 - ASTM A 615, Grade 60
 - ASTM A 996, Grade 60
- B. Steel Bar Mats:** ASTM A 184, fabricated from ASTM A 615, Grade 60, deformed bars, assembled with clips.
- C. Plain-Steel Wire:** ASTM A 82.

D. Plain-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from steel wire into flat sheets.

E. Bars: Bars used for concrete reinforcement shall meet the following requirements for fabrication tolerance.

Sheared Length	+1"
Overall Dimension of Stirrups	+1/2"
All Other Bends	+1"

Bars shall be placed to the following tolerances:

Concrete Cover to Formed Surfaces	+1/4"
Top Bars in Slabs	+1/4"
Top Bars in Beams	+1/2"
Horizontal Tolerance from Vertical Surfaces	+1/4"
Vertical Bars in Columns	+1/4"
Vertical and Horizontal Bars in Walls	+1/2"
Lengthwise in Member	+2"
Wire Fabric	+1/2" from center of slab or location called for on drawings

Bars may be moved one bar diameter as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If the bars are moved more than one bar diameter, the resulting arrangement of bars shall be subject to approval.

Minimum concrete protective covering for reinforcement except for extremely corrosive atmosphere or other severe exposures shall be as follows:

Concrete deposited Against the Ground	3"
Formed Surfaces Exposed to Weather or in Contact With the Ground	2"
Interior Surfaces:	1-1/2" for Beams and Column Ties; 3/4" for Slabs and Walls; Beam and Column Bars Shall be Anchored Against the Ties.

F. Installation:

Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

All reinforcement, at the time concrete is placed, shall be free of mud, oil, or other materials that may adversely affect or reduce the bond. Reinforcement with rust, mill scale or tooth will be accepted as being satisfactory without cleaning or brushing

provided the dimensions and weights, including heights of deformations, of a cleaned sample shall not be less than required by applicable ASTM Standards.

Accurately position, support, and secure reinforcement against displacement from construction loads, the placement of concrete or other anticipated loads. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

The Contractor shall securely maintain the steel reinforcement accurately in place until the concrete is placed. Any and all disturbances of reinforcing from any cause whatsoever shall be fully corrected prior to placing of concrete, and all damaged bar supports and spaces shall be repaired or removed and replaced. All bars shall be extended beyond stress points the development length of the bar or be provided with an equivalent development length with a hook.

Welding shall not be permitted except as authorized or directed by the County Engineer.

Over formwork, metal, plastic or other approved bar chairs and spacers shall be furnished. When the concrete surface will be exposed to weather in the finished structure or where rust would impair architectural finishes, the portions of all accessories in contact with the formwork shall be stainless steel or plastic.

Unless otherwise shown on the plans and details, the following accessories shall be provided for supports for all reinforcement:

1. Reinforced slabs-on-grade shall have plain precast concrete blocks sufficient to support bars within prescribed tolerances, or individual high chairs with runners to rest on soil.
2. Slab bars shall have continuous slab bolsters for bottom bars spaced a maximum distance of 48 inches on center, and for individual high chairs spaced 48 inches with a no.6 continuous support bar for top bars. Top bar supports shall be spaced a maximum distance apart of 48 inches and no greater than 18 inches from the overhanging ends of bars.
3. Box out all slots, chases, recesses or openings as shown on the drawings and specifications and as required by the work of other trades. Box out for all temporary openings such as slots, pipe spaces, etc., and build forms to seal up when and as required. Inserts, anchors, ties, hangers, etc. shall be built into concrete as required to secure the work of the various subcontractors. Collars, sleeves, thimbles, anchors, sockets, etc., shall be furnished to the General Contractor by the other subcontractors for installation in the formwork. Sleeves shall not displace the reinforcing steel from its designated location by more than one bar diameter unless approved by the Engineer. The Contractor shall be responsible for the design, engineering, construction and the coordination of the placement of items affecting each trade in the formwork.

Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least 1/2 mesh plus end extension of wires but not less than 6 inches. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire. Wire mesh shall be so placed as to positively secure its position 1/3 of the slab thickness below the top of the slab for slabs on grade.

Splices and offsets in reinforcements at points of maximum stress shall not be made. All splices shall be approved, and shall provide sufficient lap to transfer the stress between the bars by the required development length of the bars. The character and design of each splice shall conform to the requirements of the ACI 318. Bars shall not be bent after being embedded in hardened concrete, unless otherwise noted on the drawings. Bars with kinks or bends not shown on the drawings shall not be placed. The heating of reinforcement for bending or straightening will be permitted only if the entire operation is approved by the Engineer.

6.0 REINFORCEMENT ACCESSORIES

- A. Joint Dowel Bars:** ASTM A 615, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.
- B. Bar Supports:** Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from stainless steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports

7.0 CONCRETE MATERIALS

- A. Cementitious Material:** Use the following cementitious materials, of the same type, brand, and source, throughout Project:
 - 1. Portland Cement shall be fresh stock of an approved standard brand meeting the requirements of ASTM C 150, of Type II, white.
 - 2. Fly Ash shall have a high fineness and low carbon content and shall exceed the requirements of ASTM C 618, Class 7, except that the loss of ignition shall be less than 3 percent, and all fly ash shall be a classified processed material.
- B. Concrete Aggregates:** Unless otherwise specified all aggregate shall be normal weight aggregate in accordance with ASTM C 33. Aggregate for concrete shall consist of clean crushed stone or gravel having hard, strong, uncoated particles free

from injurious amounts of soft, thin, elongated or laminated pieces, alkali, organic or other deleterious matter. Maximum aggregate size shall be ¾-inch. The maximum permissible percentage of elongated particles shall not exceed 5 percent by weight. Provide aggregates from a single source.

- C. Fine Aggregate:** shall consist of sand, stone screening, or other inert materials with similar characteristics having clean, strong, durable, uncoated grains and free from lumps, soft or flaky particles, clay, shale, alkali, organic matter or other deleterious substances with reactivity to alkali in cement. Water shall be potable water in accordance with ASTM C 94.

8.0 ADMIXTURES

- A. General:** When required or permitted, admixtures shall conform to the appropriate specification indicated. Do not use admixtures which have not been incorporated and tested in the accepted mixes unless otherwise authorized in writing by the County Engineer.
- B. Air-Entraining Admixture:** shall be in accordance with ASTM C 260. Air-entraining admixtures shall be used for all concrete exposed to freezing and thawing or subjected to hydraulic pressure. Entrained air shall conform to the air control limits of Table 3.4.1 of ACI 301. The water-cement ratio for all air-entrained concrete exposed to freezing and thawing shall not exceed 0.53.
- C. Chemical Admixtures:** Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. Water-Reducing Admixtures shall be hydroxolated polymer type in accordance with ASTM C 494, Type A.
 2. Retarding Admixture: ASTM C 494, Type B.
 3. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.
 4. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494, Type G.
 6. Plasticizing and Retarding Admixture: ASTM C 1017, Type II.

9.0 WATERSTOPS

Flexible PVC Waterstops shall be in accordance with CE CRD-C 572 for embedding in concrete to prevent passage of fluids through joints with factory-fabricate corners, intersections, and directional changes. Provide PVC Waterstops in all construction joints in concrete walls and in concrete beams and slabs. PVC waterstops shall also be provided between concrete beams and slabs at all expansion joints to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

1. Manufacturers: Provide products by one of the following:
 - a. W. R. Meadows
 - b. Greenstreak.
 - c. Vinylex Corp.
2. Profile: Flat, dumbbell with center bulb
3. Dimensions: 6 inches by 3/8 inch thick; nontapered.

10.0 VAPOR RETARDERS

Sheet Vapor Barrier shall be minimum 10 mil polyethylene film that complies with ASTM C171 and meets or exceeds test for water retention, ASTM C 156. Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions. Lap joints 6 inches and seal with manufacturers recommended tape.

11.0 CRUSHED STONE FILL

Crushed Stone Fill shall be uniform 1-inch stone, no fines, in conformance to ASTM C 33.

12.0 CURING MATERIALS

Liquid curing material for concrete shall exceed the requirements of ASTM C 309, Type I. Products acceptable shall provide water retention not exceeding a loss of 0.020 grams per sq. cm. when tested at coverage of 200 sq. ft. per gallon and tested in accordance with ASTM C 156.

13.0 RELATED MATERIALS

- A. **Pre-molded Expansion and Isolation Joint Filler Strips:** shall be asphalt-saturated cellulosic fiber or in accordance with ASTM D 1751.
- B. **Joint Sealing Compound:** shall be a two-part mineral filled epoxy polyurethane, and shall be used for all exposed joints in exterior paving slabs, sidewalks, where concrete slabs abut concrete walls, and in exposed joints in slabs on grade.
- C. **Surface Coating:** for all exposed concrete except where otherwise shown shall be "Thoroseal" as manufactured by the Standard Dry Wall Co., or an approved equal.

14.0 CONCRETE MIXING

- A. **Plants:** Concrete shall be mixed at batch plants or it may be transit mixed as specified herein. Concrete batch plants must comply with the requirements of ASTM C 94 and ACI-304 with sufficient capacity of producing concrete of the quantity and quality as specified herein. During hot weather or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 will be required as follows:

1. When air temperatures are between 80 degrees F. and 90 degrees F., reduce the mixing and delivery time from 1-1/2 hours to 1 hour
2. When outside air temperatures are above 90 degrees F, reduce the mixing and delivery time from 1-1/2 hours to 45 minutes.

B. Batch tickets: Tickets for each load of concrete shall be submitted to the County Engineer. The following information shall be provided on each batch ticket:

1. Design mix designation
2. Exact time cement, water and aggregate were discharged into the mix
3. Compressive strength of mix
4. Amount of water added to the mix

C. Equipment: Maintain equipment in proper operating condition, with drums cleaned before charging of each batch. Schedule delivery of trucks in order to prevent delay of placing after mixing.

D. Slump: All concrete shall be proportioned and produced to have a maximum slump of 4 inches and a minimum slump of 2 inches. A tolerance of up to, but not exceeding, 1 inch above the indicated maximum shall be allowed for individual batches in any one day's pour provided the average of the most recent ten batches within the same pour does not exceed the maximum limits. No tolerance will be permitted for individual batches when less than ten (10) batches are delivered for one day's pour. Addition of water at the site for concrete mix with insufficient slumps, slumps less than the maximum specified herein, will not be permitted. Concrete delivered to the project with slump less than the minimum or greater than the maximum specified shall be rejected and discarded off site at no additional cost to the County.

E. Concrete Type and Strengths:

Location	Maximum Size Aggregate	*28 Day Compressive Strength
Slabs on Grade	3/4"	3,000 psi
Walls	3/4"	4,000 psi
Columns	3/4"	See Notes on Plan
Beams, Supported Slabs & Joists	3/4"	4,000 psi

Twenty-eight day strength shall be as determined from concrete sampled in accordance with ASTM C 172 and 4-inch diameter x 8-inch cylinders tested in accordance with ASTM C 31 and C 39.

15.0 FORMWORK DESIGN

The Contractor shall be responsible for the design of all concrete formwork. Formwork shall be designed in accordance with ACI 347 unless otherwise noted. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation and position indicated, within tolerance limits of ACI 117.

16.0 FORMWORK TOLERANCES

Unless otherwise specified by the County Engineer, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed in Table 4.3.1 of ACI 301. The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and bench marks to be used for reference purposes to check tolerances.

17.0 EMBEDDED ITEMS

Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
2. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
3. Install dovetail anchor slots in concrete structures as indicated.

18.0 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete. Clean joint surface of laitance, coatings, loose particles, and foreign matter to expose aggregate. Prepare for bonding of fresh concrete to new concrete that has hardened; at joints between foundation systems and walls dampen, but do not saturate, the roughened and cleaned surface of set concrete immediately before placing fresh concrete. In lieu of neat cement grout, bonding grout may be a commercial bonding agent. Apply to cleaned concrete surfaces in accordance with the printed instruction of this bonding material manufacturer.

B. Construction Joints: Install so strength and appearance of concrete will be least impaired, at locations indicated or as approved by Engineer.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.

2. Provide keyways at least 1-1/2 inches deep in all construction joints in walls, slabs, and between walls, and foundation systems.
 3. Locate joints for beams, slabs, joists, and girders near the middle of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
 6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Contraction Joints in Slabs-on-Grade:** Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:
1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
- D. Isolation Joints in Slabs-on-Grade:** After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
1. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants are indicated.
 2. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
- E. Doweled Joints:** Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

19.0 SLABS ON GRADE

- A. Preparation of Subgrade:** The subgrade shall be well drained and of adequate and uniform loadbearing nature. The in-place density of the subgrade soils shall be at least the minimum required in the specifications. The bottom of an undrained granular base course shall not be lower than the adjacent finished grade. The subgrade shall be free of frost before concrete placing begins. If the temperature inside a building where concrete is to be placed is below freezing, it shall be raised and maintained above 50 degrees F. long enough to remove all frost from the

subgrade. The subgrade shall be moist at the time of concreting. If necessary, it shall be dampened with water in advance of concreting, but there shall be no free water standing on the subgrade nor any muddy or soft spots when the concrete is placed.

- B. Joints:** Joints in slabs on grade shall be located as to divide the slab in areas not in excess of 800 sq. ft. The maximum distance between joints in slabs on grade at all points of contact between slabs on grade and vertical surfaces such as foundation walls and elsewhere as indicated. At exposed joints, recess the premolded fill on a minimum of ½-inch, and fill the remaining section with a joint seal and as specified herein. All exposed construction joints in the slabs on grade shall have the edges tooled and the crack and groove formed by the edging tool filled with a polyurethane joint sealant. No Form-A-Key or similar metal form joints will be permitted.

20.0 CONCRETE PLACEMENT

Before placing concrete, the formwork installation, reinforcing steel, and items to be embedded or cast-in must be complete. Notify other crafts involved in ample time to permit the installation of their work; co-operate with other trades in setting such work, as required. Notify Engineer upon completion of installation of all reinforcing and other items in ample time to permit inspection of the work. Soil bottoms at foundation systems are subject to testing laboratory as directed by the Engineer. Place concrete immediately after approval of foundation excavations.

Before placing concrete, all equipment for mixing and transporting and placing concrete shall be cleaned, all debris and ice removed from spaces to be occupied by the concrete, forms thoroughly cleaned of soil, ice, or other coatings which will prevent proper bond, reinforcement shall be securely tied in place and expansion joint material, anchors, and other embedded items shall be securely positioned. Hardened concrete and foreign materials shall be removed from the conveying equipment.

Do not add water to concrete during delivery, at Project site, or during placement unless approved by Engineer. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

Place concrete in compliance with the practices and recommendations of ACI 304 or as herein specified. Concrete shall be handled from the mixer to the place of final deposit as rapidly as practical by methods which will prevent separation or loss of ingredients and in a manner which will assure that the required quality concrete is obtained. Conveying equipment shall be of size and design to insure a continuous flow of concrete at the delivery point.

Concrete placed by pumping shall conform to the recommendations of ACI Publication, "Placing Concrete by Pumping Methods."

Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, construction joints shall be located at points as provided for in the drawings or as approved. Deposit concrete as nearly as possible to its final location to avoid segregation due to rehandling or flowing. Do not subject concrete to any procedure which will cause segregation.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
3. Do not use concrete which has become non-plastic and unworkable or does not meet the required quality control limits, or which has become contaminated by foreign material. Remove rejected concrete from the project site and dispose of in an acceptable location. Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand-spading, rodding, and tamping. Vibration of forms and reinforcing steel will not be permitted.
4. Screed concrete which is to receive other construction to the proper level to avoid excessive skimming or grouting.

Do not use concrete which has become non-plastic and unworkable or does not meet the required quality control limits, or which has become contaminated by foreign material. Remove rejected concrete from the project site and dispose of in an acceptable location. Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand-spading, rodding, and tamping. Vibration of forms and reinforcing steel will not be permitted.

Concrete shall not be allowed to "freefall" a distance greater than 36 inches. All concrete placed in columns and walls shall be placed through a tremie with the bottom or outlet of the tremie being held at maximum of 36 inches above the surface where concrete is being placed.

Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.
3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Slope surfaces uniformly to drains where required.
5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, free of lumps and hollows before excess bleedwater appears on the surface. Do not sprinkle water on the plastic surface. Do not further disturb slab surfaces before starting finishing operations.

Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. All concrete placed in temperatures 40 degrees F. or below or exposed to temperatures 40 degrees F. or below within five (5) days after the concrete is placed, shall conform to the requirements of ACI 306.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

The following protection requirements for concrete placed, protected, and cured in temperature 40 degrees F. or less shall be considered the minimum acceptable standards.

1. Slabs, Beams: Enclose the entire perimeter of the floor below with a continuous sheet of reinforced polyethylene or canvas. The enclosure shall be securely fastened to the top of the outside edge of the forms of the area being protected and to the slab or floor level immediately below the concrete being protected. The top of the concrete surface shall be covered with either insulating blankets designed specifically for this use, or sheets of polystyrene covered with polyethylene. Sufficient heaters shall be placed in the enclosure below the slabs to maintain the air temperature within all sections of the enclosure between 60 degrees F. and 70 degrees F. for a minimum period of five (5) days. Salamanders will not be permitted.
2. Columns and Walls: Forms shall remain in place for a minimum of five days. When the outside temperature falls below 32 degrees F., an insulating blanket shall be dropped over and around the perimeter of the column or wall. These blankets shall remain in place for a minimum period of five days.
3. Slabs on Grade: Cover top with insulating blankets. Blankets shall remain in place for a minimum period of five days.
4. Temperature of concrete at placement shall not be less than 55 degrees F.
5. In addition to laboratory-cured test specimens, additional concrete test specimens shall be cured under the same field conditions that the concrete in the field represented by these cylinders is cured and high thermometers shall be placed on the surface of slab to record daily temperatures during curing period.

Hot-Weather Placement: Comply with ACI 305 and as follows:

1. An approved admixture designed to retard the rate of set shall be used for all concrete placed when temperatures exceed 75 degrees F. Set retarding admixtures shall conform to ASTM C 494, Type D, water reducing and retarding.
2. Wet forms thoroughly before placing. Cool reinforcing by wetting sufficiently so that steel temperatures will be nearly equal to the ambient air temperature.

3. Provide wind breaks around the perimeter of the area where concrete is being placed.
4. Fresh concrete with temperatures 90 degrees F. or above shall be discarded off site.
5. The amount of cement used in the job is computed for the temperature indicated on the approved design mix. For higher concrete mix temperature, the weight of the cement shall be increased at the rate of 12 lbs. per cubic yard for each 10 degrees F. above the concrete mix temperature.

21.0 FINISHING FORMED SURFACES

- A. Standard Rough Form Finish:** Provide a standard rough form finish to all concrete formed surfaces that are to be concealed in the finish work or other construction. **NOTE:** Interior faces of walls of water retaining structures are not considered to be concealed. Standard rough form finish shall consist of all defective areas repaired as specified and all holes or voids larger than 3/8 inch filled with cement grout.
- B. Standard Finish for Exposed Surfaces:** Provide an applied surface finish of "Thorseal" or an approved equal to all exposed interior and exterior concrete finishes unless otherwise noted. Interior faces of walls of water retaining structures, including areas which are normally submerged, are considered to be exposed surfaces and shall receive the specified standard finish for exposed surfaces. The surface finish shall consist of chopping and/or grinding down all high spots removing grinding of all burrs and/or other projections, filling all voids 3/8 inch and larger, and cutting out all unsound concrete and patching as specified herein. Before applying the finish, wet and clean the surface of all grease, oils, efflorescence, and other foreign material. Dampen surface immediately ahead of application. Apply the finish coat with a tampico fiber brush by laying the finish coat on the wall in a thick coat of a minimum of 2 lbs. per sq. yard, and brush to a uniform level surface. Do not apply in temperatures 40 degrees F or below, or when temperatures are likely to fall below 40 degrees F within 24 hours after application. The finish coat shall be mixed in strict accordance with the manufacturer's written instructions. After the finish coat has cured, apply a finish coat of "Quick Seal" at a minimum of 12 lb. per sq. yd. The Thorseal shall be applied by trained technicians.
- C. Smooth Form Finish:** Provide a smooth form finish for all exposed interior concrete walls inside buildings, in pipe gallery areas, or as noted on the Drawings. Standard form finish shall produce a smooth, hard, uniform texture on the concrete. The arrangement of the forms and the number of seams and joints shall be kept to a minimum. Immediately after forms are removed, cut out all unsound concrete and patch as specified herein, and fill all pinholes and other voids larger than 1/4 inch with a cement grout. Compress mortar into voids with a firm rubber trowel or float. After mortar dries, wipe off surface with burlap.

22.0 FINISHING FLOORS AND SLABS

- A. General:** Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Scratched Finish:** After the concrete has been placed, consolidated, struck off, and leveled to a Class C tolerance, but still plastic, the surface shall be roughened with stiff brushes or rakes before a final set. A scratched finish shall be applied to all surfaces which are to receive a bonded surface finish.
- C. Floated Finish:** After the concrete has been placed, consolidated, struck off, and leveled, the concrete shall not be worked further until ready for floating. Floating shall begin when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation. During or after the first floating, planeness of surface shall be checked with a 10'-0" straight edge applied at not less than two different angles. All high spots shall be cut down and all low spots filled during this procedure to produce a surface with Class B tolerance throughout. This slab shall then be floated immediately to a uniform sandy texture. A float finish shall be applied to all slab surfaces which are to receive a waterproofing membrane.
- D. Troweled Finish:** The surface shall first be float-finished as specified. It shall next be power troweled, and finally hand troweled. The first troweling after power floating shall produce a smooth surface which may still show some trowel marks. Additional troweling shall be done by hand after the surface has hardened sufficiently. The final troweling shall be done when a ringing sound is produced as the trowel is moved over the surface. The surface shall be thoroughly consolidated by the hand troweling operations. The finished surface shall be essentially free of trowel marks, uniform in texture, and appearance, and shall be planed to a Class tolerance. On surfaces intended to support floor coverings, any defects of sufficient magnitude to show through the floor covering shall be removed by grinding. A trowel finish shall be applied to all surfaces which are exposed to view or are to receive a floor covering of carpet, vinyl, asbestos, tiles, etc.
- E. Broom Finish:** Immediately after the concrete has received a float finish, it shall be given a coarse transverse scored texture by drawing a broom or burlap belt across the surface. A broom finish shall be applied to all parking surfaces, exterior concrete walks, and concrete paving slabs.

23.0 FINISHING TOLERANCES

Finishes with a Class C tolerance shall be true planes within $\frac{1}{4}$ inch in 24 inches as determined by a 24-inch straight edge placed elsewhere on the slab in any direction. Variation from level for Class A. tolerance shall not exceed $\frac{1}{4}$ inch in 10'-0" or $\frac{1}{2}$ inch maximum in any one bay between columns. Variation from level for a Class B and Class C finish shall not exceed $\frac{1}{4}$ inch in 10'-0" or $\frac{3}{4}$ inch in any one bay between columns.

24.0 CONCRETE ITEMS

- A. Filling In:** Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.
- B. Equipment Bases and Foundations:** Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.

25.0 CONCRETE PROTECTING AND CURING

Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 305 for hot-weather protection during curing.

Protect freshly placed concrete from premature drying and excessive cold or hot temperatures, and maintain without drying at a relatively constant temperature for the period of time necessary for hydration of the cement and proper hardening of the concrete.

Curing for all horizontal slab surfaces, except those to receive a bonded finish material, during periods when the outside air temperature does not exceed 60 degrees F. shall be provided by applying a membrane-forming curing compound to concrete surfaces as soon as the final troweling or floating operation has been completed. Apply uniformly with a roller brush at a rate not to exceed 200 sq. ft. per gallon. Maintain the continuity of the coating and repair damage to the coat during the entire curing period. Curing for surfaces to receive a bonded finish material shall be as noted below. Curing for all horizontal surfaces during period when the outside air temperature will exceed 60 degrees F. shall be provided by covering the entire surface with burlap. The burlap shall be lapped 1/2 width in order to provide a double thickness of burlap. Immediately following the placement of the burlap, the entire surface shall be maintained continuously wet for a period of 7 days. Do not permit surfaces to dry at any period during the required curing period.

Cure formed surfaces by moist curing with the forms in place for the full curing period, or until forms are removed. If forms are removed before the curing period is complete, apply a membrane-forming curing compound to damp surfaces as soon as the water film has disappeared. Apply uniformly in continuous operation by roller brushes in accordance with the manufacturer's directions.

Do not use membrane curing compounds on surfaces which are to be covered with a coating material applied directly to the concrete or with any other cover or finish material

which shall be bonded to the concrete. These surfaces must be watercured with a full coverage of burlap kept continuously moist for a period of 7 days.

During the curing period, protect concrete from damaging mechanical disturbances, including load stresses, shocks, excessive vibration and from change caused by subsequent construction operations.

26.0 JOINT FILLING

Prepare, clean, and install joint filler according to manufacturer's written instructions. Defer joint filling until concrete has aged at least one month. Do not fill joints until construction traffic has permanently ceased.

Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

27.0 CONCRETE SURFACE REPAIRS

Defective Concrete: Repair and patch defective areas when approved by Engineer. Remove and replace concrete that cannot be repaired and patched to Engineer's approval.

Repair and patch defective areas immediately after removal of forms as directed by the Engineer. Cut out honeycombs, rock pockets, voids over ½ inch in diameter and holes left by tie rods and bolts down to solid concrete, but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to the concrete surfaces. Expose reinforcing steel with at least ¾ inch clearance all around. Dampen all concrete surfaces in contact with patching concrete, and brush with a neat cement grout coating or concrete bonding agent. Place patching concrete before grout takes its initial set. Mix patching concrete of the same materials to provide concrete of the same type or class as the original adjacent concrete. Place, compact, and finish as required to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.

Fill holes extending through concrete by means of a plunger type gun or other suitable device from the least exposed face to insure complete filling. Remove stains and other discolorations that cannot be removed by cleaning for all exposed surfaces. Repair isolated random cracks and single holes not over 1 inch in diameter by the dry-pack method. Groove the top of cracks and cut out holes to sound concrete and clean of dust, dirt, and loose particles. Dampen all cleaned concrete surfaces and brush with a neat cement grout coating. Place dry-pack, consisting of 1 part Portland cement to 2-1/2 parts fine aggregate passing a no. 16 mesh sieve using only enough water as required for handling and placing. Compact dry-pack mixture in place and finish to match the existing surface.

Fill in holes and openings left in concrete structures for the passage of work by other trades, unless otherwise shown or directed, after the work of other trades is in place. Mix, place, and cure concrete as herein specified, to blend with in-place construction. Provide all other miscellaneous concrete filling shown or required to complete work.

Correct high areas in unformed surfaces by grinding, after the concrete has cured at least 14 days. Correct low areas in unformed surfaces during, or immediately after, completion of surface finishing operations by cutting out the low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. Proprietary patching compounds may be used when acceptable to the Engineer.

28.0 FIELD QUALITY CONTROL

A. Testing and Inspecting: The Owner shall employ a concrete testing laboratory to provide all laboratory testing services on the project and a concrete technician to perform all quality control tests on concrete and materials used to batch concrete. The testing agency employed shall meet the requirement of ASTM E 329.

Such tests will be provided and paid for by the Owner, except that tests which reveal non-conformance with the Specifications and all succeeding tests for the same area, until conformance with the Specifications is established shall be at the expense of the Contractor. The Owner will be responsible for paying for only the successful tests.

The Contractor shall provide and maintain adequate facilities on the project for the testing laboratory to locate the required testing equipment and for safe storage area for test cylinders. The general contractor shall provide at his own expense all casual labor needed to assist the concrete technician in obtaining samples of concrete and concrete materials and moving and transporting cylinders and materials which are being tested.

The following services shall be performed by the designated testing agency:

1. Review and/or check-test the Contractor's proposed materials for compliance with the specifications.
2. Review and/or check-test the Contractor's proposed mix design as required by the Engineer.
3. Secure production samples of materials at plants or stock piles during the course of the work and test for compliance with the specifications.
4. Conduct strength tests of the concrete during construction in accordance with the following procedures:
 - a. Secure composite samples in accordance with ASTM C 172. Each sample shall be obtained from a different batch of concrete on a random basis, avoiding any selection of the test batch other than by a number selected at random before commencement of concrete placement.

- b. Mold and cure three specimens from each sample in accordance with ASTM C 31. Any deviations from the requirements of this Standard shall be recorded in the test report.
 - c. Test specimens in accordance with ASTM C 39. Two specimens shall be tested at 28 days for acceptance and one shall be the average of the strengths of the two specimens tested at 28 days. If one specimen in a test manifests evidence of improper sampling, molding or testing, it shall be discarded and the strength of the remaining cylinder shall be considered the test result. Should both specimens in the test show any of the above defects, the entire test shall be discarded. When high early strength concrete is used, the specimens shall be tested at the ages indicated in the Contract Documents.
 - d. Make at least one strength test for each 50 cu. yd., or fraction thereof, of each mix design of concrete placed in any 1 day. When the total quantity of concrete with a given mix design is less than 50 cu. yd., the strength test may be waived by the Engineer if, in his judgment, adequate evidence of satisfactory strength is provided, such as strength test results for the same kind of concrete supplied on the same day and under comparable conditions to other work or other projects.
5. Determine slump of the concrete sample for each strength test and whenever consistency of concrete appears to vary, in accordance with ASTM C 143.
 6. Determine air content of normal weight concrete sample for each strength test in accordance with either ASTM C 231, ASTM C 173, or ASTM C 138 as appropriate.
 7. Determine unit weight of concrete sample for each strength test.
 8. Determine temperature of concrete sample for each strength test.
 9. Determine in-place strength of concrete by curing cylinders under the same field conditions that the concrete representing these field cylinders is cured and additionally by determining the degree/hours of curing required for the concrete to develop the required strength for form removal.
 10. Inspect concrete batching, mixing and delivery operations to the extent deemed necessary by the Engineer.
 11. Review the manufacturer's report for each shipment of cement.

B. Logs: The Contractor shall maintain an accurate log showing the following information:

1. Date of pour
2. Area poured
3. Temperature at time of pour
4. Average ambient temperature during curing period
5. Date forms scheduled for removal
6. Date form removal completed
7. Method of reshoring (number of floor, etc.)
8. Test cylinder serial numbers
9. Strength of test cylinders at 7 and 28 days.

29.0 EVALUATION AND ACCEPTANCE

The concrete quality control testing as specified will be evaluated by the following criteria:

1. Compressive strength tests for laboratory-cured cylinders will be considered satisfactory if the averages of all sets of three consecutive compressive strength test results equal or exceed the 28 day design compressive strength of the type of class of concrete; and, no individual strength test falls below the required compressive strength by more than 500 psi. If compressive strength tests fail to meet these requirements, the concrete represented by these tests will be considered deficient and subject to additional testing and/or removal.
2. Concrete work which does not conform to the specified requirements, including strength, tolerance and finishes, shall be corrected as directed at the Contractors expense, without extension of time therefor. The Contractor shall also be responsible for the cost of corrections to any other work affected by or resulting from correction to the concrete work. Core tests, if required, shall be evaluated in accordance with the requirements of ACI 318.
3. The testing agency shall further provide quality control inspection and testing of materials used in concrete. The following inspection and tests shall be on all equipment and materials on a random basis:
 - a. Fineness modulus and gradation of sand
 - b. Fineness modulus and gradation of coarse aggregate.
 - c. Colorimetric of sand.
 - d. Weight per cu. ft. and percent of voids on a dry rodded basis of the coarse aggregate.
 - e. Check of aggregate stock piles for contamination or intermingling of aggregates.
 - f. Check of mixing equipment and trucks for compliance with ASTM C 94.
 - g. Absorption of stone and sand.