

DIVISION 3

CONCRETE



SECTION 03100
CONCRETE FORMWORK

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Formwork for cast-in-place concrete, with shoring, bracing, and anchorage.
- B. Openings for other affected work.
- C. Form accessories.
- D. Stripping forms.

1.02 RELATED WORK

- A. Section 03210 - Reinforcing Steel
- B. Section 03310 - Structural Concrete.

1.03 REFERENCES

- A. ACI 301 - Specifications for Structural Concrete for Buildings.
- B. ACI 347 - Recommended Practice for Concrete Formwork.
- C. PS 1 - Construction and Industrial Plywood.
- D. ACI 318 - Building Code Requirements for Reinforced Concrete.
- E. Field Reference Manual, ACI Publication SP-15.

1.04 SYSTEM DESCRIPTION

Design, engineer and construct formwork, shoring, bracing to meet design and code requirements, so that resultant concrete conforms to required shapes, lines, dimensions and tolerances.

1.05 QUALITY ASSURANCE

Construct and erect concrete formwork in accordance with ACI 301 and 347, latest revisions. Contractor shall maintain a copy of these standards, or Publication SP-15 in the field at all times.

PART 2 - PRODUCTS

2.01 FORM MATERIALS

- A. Plywood; Douglas Fir species; medium density overlaid one side grade; sound, undamaged sheets with straight edges.
- B. Forms shall be sufficiently rigid to prevent displacement or sagging between supports, and so constructed that the concrete will not be damaged by their removal. The Contractor shall be entirely responsible for their adequacy.

C. For surfaces to be given rubbed finish, the form in contact with the concrete shall be made of plywood, metal, metal framed plywood faced, or other acceptable panel-type materials, to provide continuous straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize the number of joints. Forms shall not be pieced out by use of material different from those in the adjacent form or in such manner as will detract from the uniformity of the finished surface.

D. For surfaces other than those to be given rubbed finish forms shall be made of wood, metal, or other acceptable material. Wooden forms shall be constructed of sound lumber or plywood of suitable dimensions, free from knotholes and loose knots. Plywood shall be in reasonably good, condition. Metal forms shall be of an acceptable type for the work involved.

2.02 FORMWORK ACCESSORIES

A. Form ties to be encased in concrete shall not be made of through bolts or common wire, but shall be of a well established type, so made and installed as to embody the following features:

1. After removal of the protruding part of the tie, there shall be no metal nearer than 1-1/2" to the face of the concrete.
2. That part of the tie which is to be removed shall be at least 1/2" in diameter, or if smaller, it shall be provided with a wood, metal, or plastic cone 1" long placed against the inside of the forms. Cones shall be carefully removed from the concrete after the forms have been stripped.

B. Form Release Agent: Colorless material which will not stain concrete, absorb moisture or impair natural bonding or color characteristics of coating intended for use on concrete. Acceptable products include Nox-Crete Form Coating Release Agent, Debond Form Coating by L&M Construction Chemicals Inc., or approved equal.

C. Fillets for Chamfered Corners: Wood strip type to the size and shape as shown on the Drawings.

D. Nails, spikes, lag bolts, through bolts, anchorages: Sized as required of strength and character to maintain formwork in place while placing concrete.

PART 3 - EXECUTION

3.01 INSPECTION

Verify lines, levels and measurements before proceeding with formwork.

3.02 PREPARATION

Earth or rock forms not permitted except at footings.

3.03 ERECTION

A. Provide bracing to ensure stability of formwork. Strengthen formwork liable to be overstressed by construction loads.

B. Forms for walls, columns, or piers shall have removable panels at bottom for cleaning, and inspection. Forms for thin sections (such as walls or columns) of considerable height shall be arranged with suitable openings so that the concrete can be placed in a manner that will prevent segregation and accumulations

of hardened concrete on the forms or reinforcement above the fresh concrete, unless special spouts are used to place concrete, and so that construction joints can be properly keyed and treated.

D. Forms for exposed surfaces shall be built with 3/4" chamfer strips attached to produce smooth, straight chamfers at all sharp edges of concrete.

E. Before form material is reused, all surfaces that are in contact with the concrete shall be thoroughly cleaned, all damaged places repaired, and all projecting nails withdrawn.

3.04 TOLERANCES

Table 4.3.1 of ACI 301 shall be followed for forming tolerance limits.

3.05 APPLICATION OF RELEASE AGENT

Apply form release agent on formwork in accordance with manufacturer's instructions. Apply prior to placing reinforcing steel, anchoring devices, and embedded items.

3.06 INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Provide formed openings where required for work embedded in or passing through concrete.

B. Coordinate work of other sections in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchors, and other inserts.

C. Install accessories in accordance with manufacturer's instructions, level and plumb. Ensure items are not disturbed during concrete placement.

3.07 FORM REMOVAL

A. Do not remove forms and bracing until concrete has sufficient strength to support its own weight, and construction and design loads which may be imposed upon it.

B. Remove formwork progressively so that no unbalanced loads are imposed on structure.

C. Do not damage concrete surfaces during form removal.

3.08 CLEANING

A. Clean forms to remove foreign matter as erection proceeds.

B. Ensure that water and debris drain to exterior through clean out ports.

C. During cold weather, remove ice and snow from forms. Do not use deicing salts. Do not use water to clean out completed forms, unless formwork and construction proceed within heated enclosure. Use compressed air to remove foreign matter.

- END OF SECTION -

SECTION 03210**REINFORCING****PART 1 - GENERAL****1.01 WORK INCLUDED**

- A. Reinforcing steel.
- B. Shop Drawings.

1.02 RELATED WORK

- A. Section 03100 - Concrete Formwork.
- B. Section 03310 - Structural Concrete.

1.03 REFERENCES

- A. ASTM A-615 - Deformed and Plain Billet - Steel Bars for Concrete Reinforcement.
- B. ACI 315-80 (86) - Details and Detailing of Concrete Reinforcement.
- C. ACI 315R-80 (88) - Manual of Engineering and Placing Drawings for Reinforced Concrete Structures.
- D. ASTM A-185 - Welded Steel Wire Fabric For Concrete Reinforcement.
- E. ACI 301-89 - Specifications For Structural Concrete For Buildings.

1.04 SUBMITTALS

Shop Drawings: The Contractor shall submit a complete set of shop drawings including schedules and bending drawings for all reinforcement used in the work in accordance with ACI 315, and ACI 315R. Review of drawings by the Contractor and the Engineer is required before shipment can be made.

PART 2 - PRODUCTS**2.01 MATERIALS**

- A. The minimum yield strength of the reinforcement shall be 60,000 pounds per square inch. Bar reinforcement shall conform to the requirements of ASTM A-615. All bar reinforcement shall be deformed.
- B. Welded wire fabric shall conform to ASTM A-185, welded steel wire fabric for concrete reinforcement.
- C. Reinforcement supports and other accessories in contact with the forms for members which will be exposed to view in the finished work shall have approved high density polyethylene tips so that the metal portion shall be at least one quarter of an inch from the form or surface. Supports for reinforcement, when in contact with the ground or stone fill, shall be precast stone concrete blocks.

2.02 FABRICATION

A. Reinforcement shall be bent cold. It shall be bent accurately to the dimensions and shapes shown on the plans and to within tolerances specified in the CRSI Manual of Standard Practice.

B. Reinforcement shall be shipped with bars of the same size and shape, fastened securely with wire and with metal identification tags using size and mark.

PART 3 - EXECUTION

3.01 PLACING AND FASTENING

A. Before being placed in position, reinforcement shall be cleaned of loose mill and rust scale, dirt and other coatings that will interfere with development of proper bond.

B. Reinforcement shall be accurately placed in positions shown on the drawings and firmly held in place during placement and hardening of concrete by using annealed wire ties. Bars shall be tied as required to prevent displacement under foot traffic and during casting operations, and shall be placed within tolerances allowed in Section 5.6.2 of ACI 301.

C. Distance from the forms shall be maintained by means of stays, blocks, ties, hangers or other approved supports. (See paragraph 2.01 C) If fabric reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

D. Before any concrete is placed, the Engineer shall have inspected the placing of the steel reinforcement and given permission to deposit the concrete. Concrete placed in violation of this provision will be rejected and thereupon shall be removed.

E. Unless otherwise specified, reinforcement shall be furnished in the full lengths indicated on the plans. Splicing of bars, except where shown on the plans, will not be permitted without the approval of the Engineer. Where splices are made, they shall be staggered insofar as possible.

F. Wire mesh reinforcement shall be continuous between joints. Laps shall be at least one full mesh plus 2", staggered to avoid continuous lap in either direction and securely wired or clipped with standard clips.

G. Dowels shall be installed at right angles to construction joints and expansion joints. Dowels shall be accurately aligned parallel to the finished surface, and shall be rigidly held in place and supported during placing of the concrete. At expansion joints only polyethylene with a minimum thickness of 14 mils.

- END OF SECTION -

SECTION 03251**EXPANSION AND CONTRACTION JOINTS****PART 1 - GENERAL****1.01 WORK INCLUDED**

- A. Forming integral contraction and control joints in concrete.
- B. Visually concealing expansion joints in concrete.

1.02 RELATED WORK

- A. Section 03100 - Concrete Formwork.
- B. Section 03310 - Structural Concrete.

PART 2 - PRODUCTS**2.01 INTEGRAL JOINT MATERIAL**

A. Waterstop for Construction and Control Joints: Unless otherwise shown, waterstops shall be 6" wide, 3/16" minimum thickness, flat-ribbed, or dumbbell polyvinyl chloride (PVC), in accordance with Corps of Engineers Specifications CRD-C-572, latest revision, as manufactured by Vinylex Corp, W. R. Grace Company, Greenstreak, or equal. Split-ribbed waterstops may be used where appropriate.

B. Self Expanding Waterstops:

- 1. When approved by the Engineer, the Contractor may install self-expanding waterstop impregnated with sodium bentonite similar to Volclay Waterstop-RX. The manufacturer's recommended installation procedures shall be followed.
- 2. Self Expanding Waterstops shall not be used at expansion joints.

C. Joint Filler: ANSI/ASTM D994, bituminous impregnated fiberboard; closed cell polyethylene; self-expanding cork; of the sizes detailed and in the locations indicated on the Drawings. Bituminous impregnated fiberboard shall not be used to fill joints in liquid retaining structures. Where the application requires cementing the joint filler into place, a pressure sensitive adhesive recommended by the manufacturer shall be used.

2.02 SEALANTS

Sealant and Caulking: Specified in Section 07900.

PART 3 - EXECUTION**3.01 INSTALLATION**

- A. Locate and form expansion control and contraction joints.

B. Waterstops shall be provided at all joints where indicated on the drawings. Waterstops shall also be provided in all joints, vertical and horizontal, in water containment and subterranean structures. Install waterstops continuous without displacing reinforcement. All joints between adjacent continuing and intersecting sections of waterstop including butt joints, tee joints, and other angled joints shall be heat fused to form a watertight seal. Waterstops shall not be lapped. Waterstops shall be securely wired in place to maintain proper position during placement of concrete.

C. Place formed construction joints in slabs or walls as detailed on the Drawings or as directed by Engineer. Set top screed to required elevations. Secure to resist movement of wet concrete.

D. Install joint fillers and sealants in accordance with manufacturer's instructions. Use primers of type recommended by joint filler and sealant manufacturer.

E. Apply sealants in accordance with Section 07900.

-- END OF SECTION --

SECTION 03310
STRUCTURAL CONCRETE

PART 1 - GENERAL

1.01 WORK INCLUDED

The work in this section shall include all formwork, shoring, bracing, anchorage, concrete reinforcement and accessories for cast-in-place concrete.

1.02 GENERAL REQUIREMENT

All concrete construction shall conform to all applicable requirements of ACI 301, Specifications for Structural Concrete for Buildings, except as modified by the supplemental requirements specified herein.

1.03 RELATED WORK

- A. Section 02200 - Earthwork
- B. Section 03100 - Concrete Formwork
- C. Section 03210 - Reinforcing Steel

1.04 REFERENCES

A. The Contractor shall obtain and have available in the field office at all times the following references:

- 1. Specifications for Structural Concrete for Building ACI 301 (latest revision).
- 2. Manual of Standard Practice - CRSI (latest revision).
- 4. Placing Reinforcing Bars - CRSI (latest revisions).
- 5. Building Code Requirements for Reinforced Concrete ACI 318 and ACI 350 (latest revision).

B. The following standard shall also apply to this work:

- 1. ASTM C-143 - Test Method for Slump of Hydraulic Cement Concrete
- 2. ASTM C-150 - Specification for Portland Cement
- 3. ASTM C-33 - Specification for Concrete Aggregates
- 4. ASTM C-260 - Specification for Air Entraining Admixtures for Concrete
- 5. ASTM C-494 - Specification for Chemical Admixtures for Concrete
- 6. ASTM A-615 - Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcement
- 7. ASTM C-94 - Specification for Ready-Mixed Concrete

8. ASTM C-31 - Practice for Making and Curing Concrete Test Specimens in the Field
9. ASTM C39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens
10. ASTM C42 - Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

1.05 SUBMITTALS

- A. The Contractor shall submit the following data established per Section 3.9 of ACI 301.
 1. Concrete mix designs, test results and curves plotted to establish water cement ratio if paragraph 3.9.3.3 of ACI 301 is used.
 2. Proposed mix designs and all necessary substantiating data used to establish proposed mix designs if paragraph 3.9.1.1 or 3.9.1.2 of ACI 301 is used.
 3. Mix designs for all mixes proposed or required to be used, including all mixes containing admixtures.
 4. A certified copy of the control records of the proposed production facility establishing the standard deviation as defined in paragraph 3.9.1.1 of ACI 301.
- B. Certification attesting that admixtures equal or exceeds the physical requirements of ASTM C-494 for Type A (water reducing) Type D (water reducing and retarding), and Type E (water reducing and accelerating) admixtures.
- C. Drawings showing locations of all proposed construction joints.
- D. Certification that the concrete aggregates comply with the provisions of ASTM C33.
- E. Certification that the air-entraining admixture complies with ASTM C-260.

1.06 QUALITY ASSURANCE (Special Inspection)

- A. Consistency: Concrete shall be of such consistency that it can be worked readily into all parts of the forms and around embedded work, without permitting the materials to segregate, or free water to collect on the surface.
- B. Compression Tests:
 1. During the progress of the work, at least one set of four compression test cylinders shall be made for each 50 cubic yards of structural concrete or major fraction thereof, and not less than one such set for each type of concrete for each days pouring. Cylinders made in the field shall be made and cured in accordance with the ASTM Standard Method of Making and Curing Concrete Test Specimens in the Field, designation C31, except that wherever possible molds shall be left on cylinders until they reach the laboratory.
 2. One cylinder of each set shall be broken in accordance with ASTM C-39 at seven days and the other three at twenty-eight days. Two copies of these test results shall be submitted to the Engineer on the same day of the tests.

3. Additional tests of the in-place concrete shall be made when test results indicate specified concrete strengths and other characteristics have not been attained in the structure. Cored cylinders used to test concrete adequacy shall comply with ASTM C42. All test procedures and results shall be subject to the review and approval of the Engineer. The Contractor shall pay for such tests when unacceptable concrete is verified. On evidence of these tests, any concrete that fails to meet the specified strength requirements shall be strengthened or replaced as directed by the Engineer at the Contractor's expense.

C. Inserts in Concrete Other Trades:

1. All trades shall be notified, at the proper time, to install items to be embedded in concrete.
2. All castings, inserts, conduits, and other metalwork shall be accurately built into or encased in the concrete by the Contractor as directed and all necessary precautions shall be taken to prevent the metalwork from being displaced or deformed. The installation shall be inspected before concrete is placed.
3. Anchor bolts shall be set by means of substantial templates.

D. Testing:

1. The necessary testing (Special Inspection) service of this section shall be performed by an independent Inspection agency hired by the Owner.
2. The testing agency shall perform the following tests on the sampled concrete:
 - a. Slump
 - b. Air Content
 - c. Concrete Temperature
 - d. Compression test of cylinders made under paragraph B.
3. If, in the opinion of the Engineer, there is reasonable doubt that the concrete aggregates comply with ASTM C33. The testing agency shall, test the fine aggregate and course aggregate for compliance with these specifications.
4. Written reports shall be submitted to the Engineer.

E. Hot Weather Requirements: Placing of concrete under conditions of high temperatures, low humidity or wind shall be done in accordance with the American Concrete Institute "Hot Weather Concreting" (ACI 305R-89).

F. Cold Weather Requirements: Cold weather concreting procedures and precautions shall conform with American Concrete Institute "Cold Weather Concreting" (ACI 306 R-88).

PART 2 - PRODUCTS

2.01 CONCRETE MIX

- A. Structural concrete shall be proportioned by Section 3.9 of ACI 301.

- B. Selection of Proportions for Structural Concrete:
1. 4,000 psi compressive for strength at 28 days.
 2. Type I cement plus water reducing dispersing agent and air.
 3. Maximum (water)/(cement and water reducing dispersing agent) ratio = 0.45.
 4. Minimum cement content = 564 lbs. (6.0 bags)/cu. yd. concrete.
 5. Nominal maximum size coarse aggregate = No. 67 (3/4" maximum) or No. 57 (1" maximum).
 6. Air content = 6% plus or minus 1% by volume.
 7. Slump = 4" (+/- 1") in accordance with ASTM C-143.

2.02 OPTIONAL CONCRETE MIX USING FLY ASH

Selection of Proportions for Structural Concrete:

- A. 4,000 psi compressive for strength at 28 days.
- B. Type I cement plus water reducing dispersing agent and air.
- C. Maximum (water)/(cement plus water reducing dispersing agent) ratio - 0.45.
- D. Minimum cement content - 517 lbs. (5.5 bags)/cu. yd. concrete.
- E. Maximum Fly Ash Content - 71 lbs./cu. yd.
- F. Nominal maximum size coarse aggregate - No. 67 (3/4" maximum) or No. 57 (1" maximum).
- G. Air content - 6% plus or minus 2% by volume.
- H. Slump = 4" (+/- 1") in accordance with ASTM C-143.

2.03 FLY ASH CONCRETE

A. In the absence of a verified and acceptable history of fly ash concrete mixes, the following procedure is required to establish the quality of the concrete mix.

B. Trial batches must be made starting 30 days ahead of initial concrete pour. Three (3) mixes shall be designed and produced at no cost to the Owner or the Engineer as follows:

1. Mix using Type I cement with water reducing admixture for normal temperatures (Class A).
2. Mix using Type I cement with water reducing admixture for cold weather temperatures (Class A).
3. Mix using Type I cement with water reducing admixture for hot temperatures (Class A).

C. Four (4) test cylinders shall be cast for each of the (3) mixes. Two (2) cylinders shall be broken at 7 days, and two (2) cylinders shall be broken at 28 days, for each of the (3) mixes. The trial batch design report shall include strength breaks at 7-days and 28-days, air content, etc.

D. The water-reducing, cement dispersing admixture used in fly ash concrete, shall be a normal, accelerated, or retarded hardening admixture. The admixture shall be used at optimum dosage to offset the slow strength development and setting characteristics of the fly ash. Only those brands of admixture that can provide readily available field service on short notice to provide field services, inspection, and assistance, will be acceptable.

E. Prior to the use of fly ash concrete, recent mill reports shall be submitted on a regular basis during the project. Maximum loss of ignition (LOI) shall be 6%.

F. Tests for air content shall be made twice a day at the jobsite prior to pouring, for all mixes containing fly ash.

2.04 ADMIXTURES

A. An air entraining admixture shall be used on all concrete and shall be the Master Builders MB-VR, or MicroAir, Euclid Chemical Company AIR-MIX, W. R. Graces Darex, or equal. The admixture shall meet the requirements of ASTM C-260. Certification attesting to the percent of effective solids and compliance of the material with ASTM C-260 shall be furnished.

B. A water-reducing, admixture for concrete shall conform to ASTM C-494 for type A (water-reducing and normal setting admixtures) and shall be Master Builders Pozzolith 344N, Nox-Crete Plastiflow, or Plastocrete 161 by Sika, or an approved equal.

C. The water-reducing, set retarding admixture for concrete shall conform to ASTM C494 for Type D (water reducing and retarding admixtures) and shall be Master Builders, Pozzolith 100-XR, Daratard-17 by W. R. Grace, or an approved equal.

D. Certification shall be furnished attesting that the admixture exceeds the physical requirements of ASTM C-494, Type A, water reducing and normal setting admixture, and when required, for ASTM C-494, Type D, water reducing and retarding admixture when used with local materials with which the subject concrete is composed.

E. The admixture manufacturer shall provide a qualified concrete technician employed by the manufacturer to assist in proportioning concrete for optimum use. He also will be available to advise on proper addition of the admixture to the concrete and on adjustment of the concrete mix proportions to meet changing job conditions.

F. When more than one admixture is used, all admixtures shall be by the same manufacturer.

G. Calcium chloride will not be permitted as an admixture in any concrete.

H. Water-reducing, non chloride, accelerators shall conform to ASTM C494 Type E and shall be Accelguard 80 by the Euclid Chemical Company or Pozzolith High Early by Master Builders or an approved equal.

I. High-Range Water-Reducing Admixture:

1. High-Range Water-Reducing Admixture (Super Plasticizer) shall conform to ASTM C 494, Type F or Type G and containing not more than 0.1 percent chloride ions.
2. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

- a. "WRDA 19" or "Daracem"; W. R. Grace.
- b. "Sikament"; Sika Chemical Corp.
- c. "Rheobuild"; Master Builders.

2.05 WATER

The water for concrete shall be clean, fresh, and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances. No water shall be added to the concrete at the site unless approved in writing by the concrete provider.

2.06 AGGREGATES

A. Fine aggregates shall be natural and having clean, hard, uncoated grains, and shall be free from injurious amounts of clay, dust, organic matter or other deleterious substances, and shall conform to ASTM C-33. Sand shall be graded as follows:

| | Percent |
|------------------------|---------|
| Passing 3/8 Inch Sieve | 100 |
| Passing No. 4 Sieve | 45-80 |
| Passing No. 50 Sieve | 5-25 |
| Passing No. 100 Sieve | 0-8 |

B. Coarse aggregate shall be crushed stone having clean, hard, uncoated particles, and shall be free from injurious amounts of soft, friable, thin, elongated or laminated pieces. Coarse aggregates shall conform to ASTM C-33 and shall be graded in accordance with the following:

| | Percent by Weight | |
|---------------------------------|-------------------|---------------|
| | <u>No. 57</u> | <u>No. 67</u> |
| Passing 1-1/2-Inch Square Sieve | 100 | --- |
| Passing 1-Inch Square Sieve | 5-100 | |
| Passing 3/4-Inch Square Sieve | — | 90-100 |
| Passing 1/2-Inch Square Sieve | 25-60 | --- |
| Passing 3/8-Inch Square Sieve | — | 20-55 |
| Passing No. 4 Square Sieve | 0-10 | 0-10 |
| Passing No. 8 Square Sieve | 0-5 | 0-5 |

Refer to Section 3.6 of ACI 301-84 for maximum size of coarse aggregate.

2.07 AGGREGATES AND DETERMINING PROPORTIONS

A. No concrete shall be used in the work until the materials and mix designs have been tested by the testing laboratory and accepted by the Engineer.

B. The Engineer shall have the right to order changes as may be necessary to meet the specified requirements.

C. If concrete of the required characteristics is not being produced as the work progresses, the Engineer may order such changes in proportions or materials, or both, as may be necessary to secure concrete of the specified quality. The Contractor shall make such changes at his own expense and no extra compensation will be allowed because of such changes.

2.08 MIXING

All central plant and rolling stock equipment and methods shall conform to the Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers' Bureau of the National Ready Mixed Concrete Assn., as well as the ACI Standards for Measuring, Mixing, Transporting, and Placing Concrete ACI 304R-89, and with the ASTM specification for Ready Mixed Concrete, Designation C94-89b.

PART 3 - EXECUTION

3.01 PLACING AND COMPACTING CONCRETE

A. At least 20 hours before the Contractor proposed to make any placement of concrete, he shall notify the Engineer of his intention and planned procedure. Unless otherwise planned, the work shall be so executed that a section begun on any day shall be completed during daylight of the same day.

B. Ready mixed concrete shall be transported to the site in watertight agitator or mixer trucks. The quantity of concrete to be mixed or delivered in any one batch shall not exceed the rated capacity of the mixer or agitator for the respective conditions as stated on the nameplates.

C. Information necessary to calculate the total mixing water shall be recorded on the delivery slip for the Engineer's information. Total mixing water includes free water on the aggregates, water and ice batched at the plant, and water added by the truck operator. The Contractor may request permission to add water at the job site, and when the addition of water is permitted by the Engineer, the quantity added shall be the responsibility of the Contractor and in no case shall the total water per bag of cement exceed that determined by the designed mix. Mixing and discharge time shall be as recommended in ACI-304.

D. Concrete which has become compacted or segregated during transportation to or on the site of the work shall be satisfactorily remixed just prior to being placed in the forms.

E. Partially hardened concrete shall not be deposited in the forms. The retempering of concrete which has partially hardened (that is, the remixing of concrete with or without additional cement, aggregate, or water) will not be permitted.

F. The concrete shall be mixed only in the quantity required for immediate use. Concrete that has developed an initial set shall not be used. The Contractor shall have sufficient plant capacity and transporting apparatus to insure continuous delivery at the rate required.

G. The temperature of the concrete mixture immediately before placement shall be between 50 degrees F and 90 degrees F.

H. Concrete that is truck mixed or transported in truck mixers or truck agitators shall be delivered to the site of the work and discharge completed in the forms within 1-1/2 hours or before the drum has revolved 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. When the concrete temperature exceeds 85 degrees F, the time shall be reduced to 45 minutes. Concrete shall be placed in the forms within 15 minutes after discharge from the mixer at the job site.

I. If concrete is placed by pumping, no aluminum shall be used in any parts of the pumping system which contact or might contaminate the concrete. Aluminum chutes and conveyors shall not be used.

J. No concrete shall be placed on frozen subgrade or in water, or until the subgrade, forms, and preliminary work have been accepted. No concrete shall be placed until all materials to be built into the concrete have been set and have been accepted by the various trades and by the Engineer. All such materials shall be thoroughly clean and free from rust, scale, oil, or any other foreign matter.

K. Forms and excavations shall be free from water and all dirt, debris, and foreign matter when concrete is placed. Except as otherwise directed, wood forms and embedded wood called for or allowed shall be thoroughly wetted just prior to placement of concrete.

L. Chutes for conveying concrete shall be metal or metal lined and of such size, design and slope as to ensure a continuous flow of concrete without segregation. The slope of chutes shall have approximately the same slope. The discharge end of the chute shall be provided with a baffle, or if required, a spout and the end of the chute or spout shall be kept as close as practicable to, but in no event more than 5 ft. above the surface of the fresh concrete. When the operation is intermittent, the chute shall discharge into a hopper.

M. In thin sections of considerable height (such as walls and columns), concrete shall be placed in such manner as will prevent segregation and accumulations of hardened concrete on the forms or reinforcement above the mass of concrete being placed. To achieve this end, suitable hoppers spouts with restricted outlets, etc. shall be used as required or permitted unless the forms are provided with suitable openings.

N. Chutes, hoppers, spouts, etc. shall be thoroughly cleaned before and after each run and the water and debris shall not be discharged inside the form.

O. For any one placement, concrete shall be deposited continuously in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams and planes of weakness within the section, and so as to maintain until the completion of the unit, an approximately horizontal plastic surface.

P. No wooden spreaders shall be left in the concrete.

Q. During and immediately after being deposited, concrete shall be thoroughly compacted by means of suitable tools and methods, such as internal type mechanical vibrators operating at not less than 5,000 rpm. or other tool spading to produce the required density and quality of finish. Vibration shall be done only by experienced operators under close supervision and shall be carried in such manner and only long to produce homogeneity and optimum consolidation without permitting segregation of the solid constituents, "pumping" of air, or other objectionable results. All vibrators shall be supplemented by proper spade puddling approximately 2 to 3 in. away from forms to remove included bubbles and honeycomb. Excessive spading against the forms, causing the deposition of weak mortar at the surface shall be avoided.

R. The concrete shall be thoroughly rodded and tamped about embedded materials so as to secure perfect adhesion and prevent leakage. Care shall be taken to prevent the displacement of such materials during concreting.

S. All subgrades shall be covered with a 6 mil minimum thickness polyethylene sheet with joints lapped a minimum of 12 inches unless otherwise required or permitted.

3.02 BONDING CONCRETE AT CONSTRUCTION JOINTS

A. In order to secure full bond at construction joints, the surface of the concrete previously placed (including vertical, inclined, and substantially horizontal areas) shall be thoroughly cleaned of foreign materials and laitance, if any.

B. The previously placed concrete at the joint shall be damp but free of standing water. The surface shall be prepared as per ACI 301. The referenced cement grout shall be between 1 to 2 inches thick on all wall pours.

3.03 CURING AND PROTECTION

A. All concrete, particularly slabs and including finished surfaces, shall be treated immediately after concreting or cement finishing is completed, to provide continuous moist curing for at least seven days, regardless

of the adjacent air temperature. Walls and vertical surfaces may be covered with continuously saturated burlap, or kept moist by other acceptable means. Horizontal surfaces, slabs, etc., shall be ponded to a depth of 1/2" wherever practicable, or kept continuously wet by the use of lawn sprinklers, a complete covering of continuously saturated burlap, or by other acceptable means.

B. For at least seven days after having been placed, all concrete shall be so protected that the temperature at the surface will not fall below 45 degrees F.

C. No manure, salt, or other chemicals shall be used for protection.

D. The above mentioned 7 day periods may be reduced if compression tests, in accordance with ASTM C-39, on field cured cylinders indicate that expected 7 day strength gain has been achieved, and approval is granted by the Engineer.

E. Wherever practicable, finished slabs shall be protected from the direct rays of the sun to prevent checking and crazing.

F. Curing compounds may be used.

3.04 TRIMMING AND REPAIR OF SURFACE DEFECTS

A. The Contractor shall use suitable forms, mixture of concrete, and workmanship so that concrete surfaces, when exposed, will require no patching. Concrete which, in the opinion of the Engineer has excessive honeycomb, aggregate pockets, or depressions will be rejected and the Contractor shall, at his own expense remove the entire section containing such defects and replace it with acceptable concrete.

B. As soon as the forms have been stripped and the concrete surfaces exposed, fins and other projections shall be removed, recesses left by the removal of form ties shall be filled and surface defects which do not impair structural strength shall be repaired.

C. Defective concrete shall be cut perpendicular to the surface until sound concrete is reached, but not less than 1" deep. The remaining concrete shall be thoroughly roughed and cleaned. Concrete in an area at least 6" wide surrounding the area to be patched shall be dampened. A bonding grout shall be prepared using a mix of approximately 1 part cement to 1 part fine passing a No. 30 mesh sieve, mixed to the consistency of thick cream, and then well brushed into the surface.

D. The patching mixture shall be made of the same materials and approximately the same proportions as used for the concrete except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 2-1/2 parts sand by damp loose volume. White portland cement shall be substituted for a portion of the gray portland cement on exposed concrete in order to produce a color matching the color of the surrounding concrete. The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.

E. After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least 1 hour before being finally finished. The patched area shall be kept damp for 7 days. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.

F. After being cleaned and thoroughly dampened, the tie holes shall be filled solid with patching mortar.

G. The use of mortar patching as above specified shall be confined to the repair of small defects in relatively green concrete. If substantial repairs are required, the defective portions shall be cut out to sound concrete and the defective concrete replaced by means of gunite, or the structure shall be taken down and rebuilt, all as the Engineer may decide or direct.

3.05 FINISHES

- A. Exposed to View Concrete Surfaces:
1. All concrete exposed to view in the completed structures shall be produced using materials and workmanship to such quality that only nominal finishing will be required. The provisions of paragraphs 13.3, 13.4, and 13.6 of ACI 301 shall apply to all exterior exposed to view concrete surfaces.
 2. All formed, exterior, exposed to view, concrete shall be prepared as paragraph 3.04 B, then rubbed. Exterior vertical surfaces shall be rubbed to one foot below grade.
- B. All smooth form concrete vertical surfaces shall be true plane within 1/4" in 10 feet as determined by a 10 foot straight edge placed anywhere on the surface in any direction. Abrupt irregularities shall not exceed 1/8".
- C. Exterior platforms, steps and landings shall be given a broom finish. Broom finish shall be applied to surfaces which have been steel troweled to an even smooth finish. The troweled surface shall then be broomed with a fiber bristle brush in the direction transverse so that of the main traffic.
- D. Walking surfaces of slabs shall have a steel troweled finish unless shown otherwise on Drawings.

- END OF SECTION -

SECTION 03600**PRECISION GROUTING****PART 1 - GENERAL****1.01 WORK INCLUDED**

A. Provide all labor, material, equipment and services required for grouting of equipment, machinery, structural steel, handrails, anchor bolts and other items of work for which grouting is specified or required. All unnecessary holes, openings and cracks in existing concrete shall be filled and patched.

B. The object of these Specifications is to obtain grout which can be mixed to a flowable consistency (i.e., thinner than plastic consistency), placed in leakproof forms, with a minimum of strapping, without bleed water exceeding specification requirements. The requirement of 24 hour presoak of existing concrete is of prime importance and must be adhered to.

1.02 DESCRIPTION OF WORK

A. High strength, precision support of machine bases and soleplates, setting anchor bolts, and bearing plates.

B. Work includes providing a non-shrink, ready-to-use, fluid precision grout material; proportioned, pre-mixed and packaged at the factory; delivered to the job site to place with only the addition of water; forming, placing and curing as specified in this section.

1.03 RELATED WORK

A. Section 03310 - Structural Concrete.

B. Review all divisions and sections for equipment, machinery and other items to be grouted.

1.04 QUALITY ASSURANCE

Comply with the following codes, standard, test and recommended practices for foundation concrete as apply to precision grouting.

A. ACI 304 - Guide for Measuring, Mixing, Transporting and Placing Concrete.

B. ACI 305 - Hot Weather Concreting.

C. ACI 306 - Cold Weather Concreting.

D. ACI 347 - Guide to Formwork for Concrete.

E. ASTM C191 - Standard Test Method for Time of Set of Hydraulic Cement by Vicat Needle.

F. ASTM C827 - Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.

G. Manufacturer's Information on Use of Grout.

H. Corps of Engineers - CRD C-621 Corps of Engineers Specification for Nonshrink Grout.

- I. ASTM C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.

1.05 SUBMITTALS

A. The Contractor shall submit to the Engineer prior to installation, manufacturer's literature and certified test data that material complies with the requirements of these specifications.

PART 2 - PRODUCTS

2.01 GROUT

Cement-based grouts must have a minimum 15 year history of use and meet the following performance requirements at maximum water. They must not contain expansive cement or metallic particles such as aluminum powder or iron fillings.

A. Plastic Volume Change: The grout shall show no shrinkage (0.0%) and a maximum 4.0% expansion from time of placement until final set when tested according to ASTM C 827.

B. Hardened Volume Change: The grout shall show no shrinkage (0.0%) and a maximum 0.2% expansion in the hardened state when tested according to CRD C-621.

C. Compressive Strength: The grout shall show a minimum of 28-day compressive strength of 5,000 psi when tested according to ASTM C 109, restrained.

D. Creep: The grout shall show creep equal to or less than $.6 \text{ in./in.} \times 10^{-3}$ at 70°F for a minimum of one year when tested according to CPR Creep Test (extrapolated data is not acceptable).

E. Working Time: The grout shall show a consistency greater than 125% for a minimum 45 minutes when tested according to applicable consistency sections of ASTM C 827 at 15 minutes intervals.

F. Tests: Upon Request of the Engineer, the Cylinder Plate Test shall be run on any field shipments.

2.02 WATER

Water shall be suitable for drinking.

PART 3 - EXECUTION

3.01 INSPECTION

A. Inspect concrete surfaces to receive grout and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints impregnations and all loose material or foreign matter likely to affect the bond or performance of the grout.

B. Newly placed concrete shall have been placed and cured sufficiently to attain its design strength.

C. Inspect baseplates for rust, oil, and other deleterious substances.

3.02 PREPARATION

A. In order to ensure proper bond to the baseplate and the concrete, all grease, oil, dirt, curing compounds, laitance and other deleterious materials must be completely removed from the concrete and bottom of baseplate.

B. Roughen the surfaces by chipping, sandblasting or other mechanical means to assure bond of the grout to the existing concrete. Loose or broken concrete shall be removed.

C. After concrete surfaces have been washed clean, they shall then be saturated with water for 24 hours prior to placement of cement-based grout.

D. Upon completion of saturation period excess water shall be removed with clean compressed air prior to grouting.

E. Formwork shall be compatible with proposed method of placing grout. Design for rapid, continuous and complete filling of space to be grouted.

1. Build strong, tight forms braced so they will not leak or buckle under weight of fluid grout. On placing side, slant form at 45 degrees angle and pour grout directly on slanted face. On other sides, place form and pour grout directly on slanted face. On other sides, place form 1/2" or more from base of bedplate and 1" or more higher than underside of the plate.
2. Caulk forms with grouting material being used on inside or a sand-cement mortar outside to prevent leakage and loss of "head". Use expanded polystyrene or other means to caulk between foundation and portions of the bedplate and equipment to seal off areas where grout is not desired.

3.03 INSTALLATION

A. Preparation of grout shall be in paddle-type mortar mixer suitable mechanical mixer. DO NOT MIX BY HAND. Mix according to the manufacturer's recommendations.

B. Mix grout adjacent to area being grouted, have sufficient manpower and equipment available for rapid and continuous mixing and placing. Do not add cement, sand or pea gravel, additives.

C. Avoid a consistency that produces bleeding. Mix materials for a minimum of 3 minutes and not more than 5 minutes and place immediately. Do not retemper. Do not use mixing water above 80 degrees F (27 degrees C).

D. Grout shall be placed under environmental conditions acceptable to manufacturer's standards for the product.

E. Placing: Grout may be drypacked, flowed, vibrated or pumped into place. All grouting shall take place from one side of the plate to the other to avoid trapping air.

F. Cutback: Just before the grout has reached its final set, the grout shall be cut back to the lower edge of the plate. A 45 degree angle or vertical cutback shall be used.

G. Curing: The grout shall be kept moist for a minimum of three days. The method needed to protect the grout will depend on temperature, humidity and wind. Wet burlap, a soaker hose, sun shading, ponding and in extreme conditions a combination of methods shall be employed.

H. Field service representative of the manufacturer shall be available during initial planning for installation to suggest recommended procedures and at start of placement for further suggestions.

I. A minimum of three (3) days notice shall be given by the Contractor to the manufacturer prior to use of the product.

- END OF SECTION -