SECTION 031000
CONCRETE FORMING AND ACCESSORIES

PART 1. GENERAL

1.01 SUMMARY

A. Furnish all labor, materials, equipment and incidentals required to design, install and remove formwork for cast-in-place concrete as shown on the drawings and as specified herein.
B. Secure to forms or set for embedment all miscellaneous metal items, sleeves, reglets, anchor bolts, inserts, waterstops, fiberglass reinforced plastic components and other items furnished under other Sections and required to be cast into concrete.
C. The General Contractor shall coordinate with other contractors as to inserting sleeves that are necessary to complete construction. The General Contractor shall be responsible for placement of such items for the other contractors.

1.02 SUBMITTALS AND TESTING

A. Submit in accordance with Section 013300, shop drawings and product data showing materials of construction and details of installation for:
    1. Form release agent
    2. Form ties
    3. Form liners (if shown on drawings)

1.03 REFERENCE STANDARDS (Most Current Edition)

A. American Concrete Institute (ACI)
    1. ACI 301 - Specifications for Structural Concrete for Buildings
    2. ACI 318 - Building Code Requirements for Reinforced Concrete
    3. ACI 347R - Guide to Formwork for Concrete
B. American Plywood Association (APA)
    1. Material grades and designations as specified

1.04 DESIGN OF FORMS

A. Structural design responsibility: Contractor shall provide all forms and shoring designed by a professional engineer registered in the State of New York. Design and erect formwork in accordance with the requirements of ACI 301 and ACI 318 and as recommended in ACI 347R. Comply with all applicable regulations and codes. Consider special requirements due to the use of plasticized and/or retarded set concrete.
B. Review of the submitted materials will not relieve the Contractor of responsibility for the strength, safety, or correctness of methods used.
C. Demonstrate to the Engineer on a designated area of the concrete substructure exterior surface that the form release agent will not impair the bond of paint, sealant, waterproofing, or other coatings and will not affect the forming materials.

PART 2. PRODUCTS

2.01 MATERIALS

A. Make forms for cast-in-place concrete of wood or steel, except as specified in Paragraphs 2.1B. Construct wood forms of sound lumber or plywood free from knotholes and loose knots.

Construct steel forms to produce surfaces equivalent in smoothness and appearance to those produced by new plywood panels. Design and construct all forms to provide a flat, uniform concrete surface requiring no grinding, repairs, or finishing except as specified in Section 03345.

B. Make forms for exposed (non-submerged) exterior and interior concrete of new and unused Plyform exterior grade plywood panels manufactured in compliance with the APA and bearing the APA trademark. Provide B grade or better veneer on all faces to be in contact with concrete.

C. Provide rigid forms that will not deflect, move, or leak. Design forms to withstand the high hydraulic pressures resulting from rapid filling of the forms and heavy high frequency vibrations of the concrete. Limit deflection to 1/400 of each component span.

D. Column forms shall have a ¾" chamfer on all corners unless otherwise indicated.

E. Form release agent shall be applied to all form surfaces that come in contact with concrete. The form agent shall be non-staining, non-residual, water based, and bond breaking. The form release agent shall not impair the bond of paint, sealant, waterproofing or other coatings.

F. Form ties shall be as follows:

1. Flat bar ties for panel forms shall have plastic or rubber inserts with a minimum depth of 1.5" and manufactured to permit patching of the tie hole.
2. Wire ties shall be manufactured so that after removal of the projecting part, no metal remains within 1.5" of the face of the concrete. The part of the tie to be removed shall be provided with a plastic or wooden cone at least ½" diameter and 1.5" long. Provide cone washer type ties in concrete exposed to view or sewage.
3. Provide ties for liquid containment structures and exterior below grade basement walls that have a neoprene rubber washer waterstop.

PART 3. EXECUTION

3.01 GENERAL

A. Clean, fill and seal form tie holes with non-shrink cement grout.

B. Provide forms for all cast-in-place concrete including the sides of footings. Construct and place forms to provide concrete of the shape, lines, dimensions and appearances indicated.

C. Provide removable panels at the bottom of the forms for walls and columns to allow cleaning, inspection, and joint surface preparation. Provide closable intermediate inspection ports in forms for walls. Provide tremies, flexible hose, and hoppers for placement of concrete to prevent drops of greater than 5'-0" and to prevent accumulation of hardened concrete on forms and reinforcing above the freshly placed concrete.

D. Place molding, bevels or other types of chamfer strips securely in forms.

E. Provide rigid forms to withstand construction loads and vibration and remain within tolerance of deflection limits.

3.02 FORM PREPARATION

A. Clean, repair, remove projecting nails and fill holes, and smooth protrusions on all form surfaces to be in contact with concrete before reuse.

B. Coat wood forms in contact with concrete using a form releasing agent prior to form installation.

C. Clean steel forms by sandblasting or other means to remove mill scale and other ferrous deposits from the contact surface. Coat steel forms in contact with concrete form releasing agent prior to form installation.

3.03 FORM INSPECTION

A. Notify Engineer when forms are complete and at least 2 working days before the placement of concrete.

3.04 REMOVAL OF FORMS

A. The Contractor is responsible for all damage resulting from the removal of forms and shall repair at no cost to the Owner.

END OF SECTION

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SECTION 032000
CONCRETE REINFORCING

PART 1. GENERAL

1.01 SUMMARY

A. Furnish all labor, materials, equipment and incidentals required to design, install reinforcement for cast-in-place concrete as shown on the drawings and as specified herein.
B. Dowels embedded into concrete and reinforcing of lintels for masonry units.

1.02 REQUIREMENTS OF REGULATORY AGENCIES

A. All steel used on the project must meet the requirements of the American Iron and Steel Act. Submit certification with shop drawings.

1.03 SUBMITTALS AND TESTING

A. Submit in accordance with Section 013300, shop drawings and product data showing materials of construction and details of installation for:
    1. Reinforcing steel in accordance with ACI 315
B. Review of the submitted materials will not relieve the Contractor of responsibility for the strength, safety, or correctness of methods used.

1.04 REFERENCE STANDARDS (Most Current Edition)

A. American Concrete Institute (ACI)
    1. ACI 301 - Specifications for Structural Concrete for Buildings
    2. ACI 318 - Building Code Requirements for Reinforced Concrete
    3. ACI 315 (SP-66) - Details and Detailing of Concrete Reinforcement
B. American Society for Testing and Materials
    1. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
    2. ASTM A185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
    3. ASTM A496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
    4. ASTM A497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
    5. ASTM A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
    6. ASTM A706 - Standard Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement
C. American Welding Society (AWS)
    1. AWS D1.4 Structural Welding Code - Reinforcing Steel
D. Concrete Reinforcing Steel Institute (CRSI)
    1. Manual of Standard Practice

1.05 DELIVERY, HANDLING AND STORAGE

A. Reinforcing steel shall be free of mill scale, rust, dirt, grease and other foreign matter.

B. Ship and store reinforcing steel with bars of the same size / shape / grade and tag with a waterproof mark designation that is the same as those on the submitted shop drawings.
C. Store reinforcing steel off of the ground and protect against dirt and moisture.

PART 2. PRODUCTS

2.01 MATERIALS

A. Deformed Concrete Reinforcing Bars are to be Grade 60, ASTM A615
B. Deformed Concrete Reinforcing Bars required to be field bent or welded are ASTM A706
C. Welded Steel Wire Fabric to be ASTM A185
D. Welded Deformed Steel Wire Fabric to be ASTM A497
E. Reinforcing Steel Accessories
    1. Plastic Protected Wire Bar Supports: CRSI Bar Supports, Class 1 - Maximum Protection.
    2. Stainless Steel Protected Wire Bar Supports: CRSI Bar Supports, Class 2 - Moderate Protection with legs made wholly from stainless steel wire
    3. Precast Concrete Bar supports: CRSI Bar Supports, Precast Concrete Bar Supports. Precast concrete blocks that have equal or greater strength than the surrounding concrete.
F. Tie Wire for reinforcing shall be 16-gauge or heavier black annealed wire

2.02 FABRICATION

A. Comply with the CRSI Manual of Standard Practices
B. Bend bars cold. Do not straighten or re-bend or heat bars
C. Bend bars around a revolving collar having a diameter not less than that recommended by The CRSI manual
D. Saw cut bar ends that are to be butt spliced, placed through limited diameter holes in metal or threaded.

PART 3. EXECUTION

3.01 INSTALLATION

A. Comply with the CRSI Manual of Standard Practice for surface condition, bending, spacing, and tolerances of placement for reinforcement. Provide the amount of reinforcing indicated at the spacing and clearances shown on the drawings.
B. Determine clear concrete cover based on exposure. Unless noted otherwise on the drawings, provide the following minimum concrete cover:

1.	Concrete cast against and permanently exposed to earth	3"
2.	Concrete exposed to soil, water, sewage, sludge and/or weather:	
	a. Slabs and walls (both faces)	3"
	b. Beams and columns (ties, spirals, stirrups)	3"
3.	Concrete not exposed to soil, water, sewage, sludge and/or weather:	
	a. Slabs and walls (both faces)	1"
	b. Beams and columns (ties, spirals, stirrups)	1.5"

C. Coat placed reinforcement that will be exposed for 60 + days with a heavy coat of neat cement slurry.

D. Do not weld reinforcing either during fabrication or erection unless indicated on the drawings or as specified herein or prior written approval by the engineer. Remove all bars that have been welded (including tack welds) without such approvals or directions. Comply with AWS D1.4 when authorized or instructed to weld reinforcement.
E. Reinforcement bars interfering with the location of the other reinforcing steel, conduits or embedded items may be moved within the specific tolerances or one bar diameter, whichever is greater. Obtain engineers approval should a greater displacement be required to avoid the interference. Do not cut reinforcement to install inserts, conduits, sleeves, etc.
F. Secure, support and tie reinforcing steel to prevent movement during concrete placement. Secure dowels in place before placing concrete.
G. Closely inspect the reinforcing steel for breaks. Replace and repair by cutting out damaged bar(s) and splicing new bars.

3.02 REINFORCEMENT AROUND OPENINGS

A. Provide additional reinforcing steel on each side of the opening equivalent to one half of the cross-sectional area of the reinforcing steel interrupted by the opening unless indicated otherwise. Extend each end of each bar beyond the edge of the opening or penetration by the tension development length for that bar size.

3.03 SPLICING OF REINFORCEMENT

A. Compression splices - provide lap splice of 30 bar diameters, but not less than 12" unless indicated on the Drawings. Base the lap splice length for column vertical bars on the bar size in the column above.
B. Tension lap splices shall be in accordance with ACI 318. Stagger splices in adjacent bars. Provide Class B tension lap splices at all locations unless otherwise indicated.
C. Lap splices in welded wire fabric in accordance with the requirements of ACI 318 but not less than 12". Tie the spliced fabrics together with wire ties spaced not more than 24" on center and lace with wire of the same diameter as the welded wire fabric. Offset splices in adjacent widths to prevent continuous splices.

3.04 ACCESSORIES

A. Provide and install accessories such as chairs, chair bars and the like to support the reinforcement at the spacings and clearances indicated on the Drawings. Secure accessories to prevent the displacement of such items during erection and concrete placement.
B. Use precast concrete blocks where reinforcing is to be supported over soil.
C. Provide #5 support bars (minimum). Do not reposition upper bars in a bar mat for use as support bars.

3.05 INSPECTION

A. Notify engineer when the reinforcing is complete and ready for inspection at least two working days prior to placement of concrete. Do not cover the reinforcing steel with concrete until the engineer has inspected and approved the reinforcement for size, spacing, splice lengths and positions.
B. Forms are to be kept open for the engineer to perform the inspection.

END OF SECTION

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SECTION 033000
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place concrete, including concrete materials, mixture design, placement procedures, testing, and finishes.

2. These Specifications shall apply to all concrete installed by any Contractor on the project.

B. Related Requirements:

1. Section 03100 "Concrete Forming and Accessories" for form-facing materials, form liners, insulating concrete forms, and waterstops.
2. Section 03200 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.

B. Water/Cement Ratio (w/cm): The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:

a. Contractor's superintendent.
b. Independent testing agency responsible for concrete design mixtures.
c. Ready-mix concrete manufacturer.
d. Concrete Subcontractor.

2. Review the following:

a. Special inspection and testing and inspecting agency procedures for field quality control.
b. Construction joints, control joints, isolation joints, and joint-filler strips.
c. Semirigid joint fillers.
d. Vapor-retarder installation.

e. Anchor rod and anchorage device installation tolerances.
f. Cold and hot weather concreting procedures.
g. Concrete finishes and finishing.
h. Curing procedures.
i. Forms and form-removal limitations.
j. Shoring and reshoring procedures.
k. Methods for achieving specified floor and slab flatness and levelness.
l. Floor and slab flatness and levelness measurements.
m. Concrete repair procedures.
n. Concrete protection.
o. Initial curing of field test cylinders (ASTM C31/C31M.)

1.4 REFERENCES

A. The American Concrete Building Code Requirements for Reinforced Concrete ACI 318, ACI 350 and all standards cited in this code shall apply to all work. These include but are not limited to the following:

1. American Concrete Institute (ACI)
   a. ACI 117M - Standard Specifications for Tolerances for Concrete Construction and Materials
   b. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight and
   c. Mass Concrete
   d. ACI 212.3R-04 - Chemical Admixtures for Concrete
   e. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete
   f. ACI 305R - Hot Weather Concreting
   g. ACI 306R - Cold Weather Concreting
   h. ACI 318 - Building Code Requirements for Reinforced Concrete
   i. ACI 350 - Environmental Engineering Concrete Structures

2. American Society for Testing and Materials
   a. ASTM C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   b. ASTM C33 - Standard Specification for Concrete Aggregates
   c. ASTM C39 - Standard Test Method for Compressive Strength of Cylinder Concrete Specimens
   d. ASTM C42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   e. ASTM C94 - Standard Specification for Ready-Mixed Concrete
   f. ASTM C143 - Standard Test Method for Slump of Hydraulic Cement Concrete
   g. ASTM C150 - Standard Specification for Portland Cement
   h. ASTM C171 - Standard Specification for Sheet Materials for curing Concrete
   i. ASTM C173 - Standard Test Method for Air content of Freshly Mixed Concrete by the Volumetric Method.
   j. ASTM C231 - Standard Test Method for Air content of Freshly Mixed Concrete by the Pressure Method.
   k. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete

l. ASTM C311 - Standard Test Method for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete.
m. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete
n. ASTM C618 - Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete
o. ASTM C1077 - Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for use in Construction and Criteria for Laboratory Evaluation
p. ASTM C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates
q. ASTM E329 - Standard Practice for Use in the Evaluation of Testing and Inspection Agencies as Used in Construction

3. National Ready Mixed Concrete Association (NRMCA)
   a. Quality Control Manual

4. Truck Mixer Manufacturers Bureau (TMMB)
   a. TMMB 100 - Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards

1.5 SUBMITTALS

A. Concrete Mix Submittals

1. Submit concrete mix design for each formulation of concrete proposed for use. Include sources of cement, fly ash, aggregates, air-entraining admixture, water reducing admixture, water / cement ratio and concrete slump.

2. Include in the concrete mix submittal concrete test reports to substantiate concrete suppliers standard deviation and concrete mix design. The concrete supplier shall certify that all concrete mix designs meet all requirements of ASTM C33, including all provisions regarding alkali silica reaction (ASR).

B. Reinforcement Shop Drawings

1. The Contractor shall furnish shop drawings detailing all reinforcement indicated on the contract drawings. No reinforcement shall be fabricated prior to the approval of these drawings.

2. The Contractor shall submit mix designs for all types of concrete to be used in the work, and the name and location of concrete material suppliers.

3. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.

   a. Location of construction joints is subject to approval of the Engineer.

C. Qualifications of the testing laboratory shall be submitted and contain the following:

1. Name and address

2. List of technical services to be provided

3. Name and qualifications of the employees taking the samples and performing the tests

D. Material certifications for the following shall be submitted, all material certifications shall be signed by the supplier.

1. Portland cement.
2. Fly ash.
3. Slag cement.
4. Aggregates.
5. Admixtures:

    a. Include limitations of use, including restrictions on cementitious materials, supplementary cementitious materials, air entrainment, aggregates, temperature at time of concrete placement, relative humidity at time of concrete placement, curing conditions, and use of other admixtures.
6. Vapor retarders.
7. Curing materials.

8. Joint fillers.
9. Repair materials.

E. Design Mixtures: For each concrete mixture, include the following:

1. Mixture identification.
2. Minimum 28-day compressive strength.
3. Durability exposure class.
4. Maximum w/cm.
5. Calculated equilibrium unit weight, for lightweight concrete.
6. Slump limit.
7. Air content.
8. Nominal maximum aggregate size.
9. Steel-fiber reinforcement content.
10. Synthetic micro-fiber content.
11. Indicate amounts of mixing water to be withheld for later addition at Project site if permitted.
12. Include manufacturer's certification that permeability-reducing admixture is compatible with mix design.
13. Include certification that dosage rate for permeability-reducing admixture matches dosage rate used in performance compliance test.
14. Intended placement method.
15. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

F. Concrete Schedule: For each location of each Class of concrete indicated in "Concrete Mixtures" Article, including the following:

1. Concrete Class designation.
2. Location within Project.
3. Exposure Class designation.
4. Formed Surface Finish designation and final finish.
5. Final finish for floors.
6. Curing process.
7. Floor treatment if any.

G. Informational Submittals

1. Qualification Data: For the following:

    a. Installer: Include copies of applicable ACI certificates.
    b. Ready-mixed concrete manufacturer.

2. Material Certificates: For each of the following, signed by manufacturers:

    a. Cementitious materials.
    b. Admixtures.
    c. Curing compounds.
    d. Bonding agents.
    e. Adhesives.
    f. Vapor retarders.
    g. Semirigid joint filler.
    h. Joint-filler strips.
    i. Repair materials.

3. Material Test Reports: For the following, from a qualified testing agency:

    a. Portland cement.
    b. Fly ash.
    c. Slag cement.
    d. Aggregates.
    e. Admixtures:
        1) Permeability-Reducing Admixture: Include independent test reports, indicating compliance with specified requirements, including dosage rate used in test.

4. Floor surface flatness and levelness measurements report, indicating compliance with specified tolerances.

5. Research Reports:

    a. For concrete admixtures in accordance with ICC's Acceptance Criteria AC198.
    b. For sheet vapor retarder/termite barrier, showing compliance with ICC AC380.

6. Preconstruction Test Reports: For each mix design.

7. Field quality-control reports.

8. Minutes of preinstallation conference.

H. All submittals shall include a certification of full compliance with ARRA Buy American requirements

I. Other Items

1. The Contractor shall provide copies of all concrete batch plant truck slips at the time of delivery and prior to placement of concrete.

1.6 DELIVERING, HANDLING AND STORAGE

A. Cement: Store in weather tight container to protect against contamination

B. Aggregate: Do not use frozen or partially frozen aggregate

C. Sand: Allow sand to drain to uniform moisture content before using. Do not use partially frozen sand.

D. Admixtures: Store in weather tight container to protect against contamination, do not allow to freeze and allow provide agitating equipment for uniform dispersion in concrete mix.

1.7 QUALITY ASSURANCE

A. Comply with American Concrete Building Code Requirements for Reinforced Concrete ACI 318, 350R and all standards cited (most recent edition) in this code shall apply to all work.

B. Installer Qualifications: A qualified installer who employs Project personnel qualified as an ACI-certified Flatwork Technician and Finisher and a supervisor who is a certified ACI Flatwork Concrete Finisher/Technician or an ACI Concrete Flatwork Technician with experience installing and finishing concrete, incorporating permeability-reducing admixtures.

1. Post-Installed Concrete Anchors Installers: ACI-certified Adhesive Anchor Installer.

C. Ready-Mixed Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1. Manufacturer certified in accordance with NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

D. Laboratory Testing Agency Qualifications: A testing agency qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated and employing an ACI-certified Concrete Quality Control Technical Manager.

1. Personnel performing laboratory tests to be an ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I. Testing agency

laboratory supervisor to be an ACI-certified Concrete Laboratory Testing Technician, Grade II.

2. Independent testing laboratory shall meet the requirements of ASTM E329 and ASTM C1077 and be acceptable to the Engineer. There shall be no relationship / co-ownership between the Contractor or concrete manufacturer and the Testing Laboratory that would cause a conflict of interest.

E. Any concrete that fails to meet the specified requirements shall be removed and replaced with approved materials at the Contractor's expense, when and as directed by the Engineer.

F. The Engineer must approve all mixes to be used prior to construction. No mix or concrete may be used without approval by the Engineer.

1.8 QUALITY CONTROL - PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on each concrete mixture.

1. Include the following information in each test report:

a. Admixture dosage rates.
b. Slump.
c. Temperature
d. Air content.
e. Seven-day compressive strength.
f. 28-day compressive strength.
g. Permeability.

B. Provide concrete composed of Portland cement, fly ash, fine aggregate, coarse aggregate, water and admixtures as specified and produced by a plant complying with ACI 318 and ASTM C94. Batch all constituents, including admixtures, at the plant.

C. Measure materials for batching concrete by weighing in conformity with and within the tolerances stated in ASTM C94. Scales must be certified by Sealer of Weights and Measures within one year of use. Weigh cement and fly ash in individual weigh batches that are separate and distinct from those used for other materials.

D. Measure the amount of free water in fine aggregates within 0.3% with a moisture meter. Adjust for moisture content of fine aggregates. Record the number of gallons of water as-batched on printed batch tickets.

E. The batch plant and the Contractor shall conform to all batch times and time limits specified by NYSDOT. Loads exceeding those times will be rejected.

F. Test aggregates for potential alkali reactivity in accordance with ASTM C1260.

Test the fly ash and/or the fly ash and concrete mixture to provide test data confirming that the fly ash in combination with the cement to be used meets all strength requirements and is compatible with the other concrete additives.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Comply with ASTM C94/C94M and ACI 301 (ACI 301M).

1.10 FIELD CONDITIONS

A. Cold-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 306.1 and as follows.

1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
2. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301 (ACI 301M).
3. Do not use frozen materials or materials containing ice or snow.
4. Do not place concrete in contact with surfaces less than 35 deg F (1.7 deg C), other than reinforcing steel.
5. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

B. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M), and as follows:

1. Maintain concrete temperature at time of discharge to not exceed 95 deg F (35 deg C).
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement sheet vapor retarder/termite barrier material and accessories for sheet vapor retarder/ termite barrier and accessories that do not comply with requirements or that fail to resist penetration by termites within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 (ACI 301M) unless modified by requirements in the Contract Documents.

B. Source Limitations:

1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.
2. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant.
3. Obtain aggregate from single source.
4. Obtain each type of admixture from single source from single manufacturer.

2.2 MATERIALS

A. Delivery, Storage and Handling:

1. All materials shall be so delivered, stored and handled as to prevent the inclusion of foreign materials and damage of material by water. All materials shall be of the respective type specified herein.

B. Water: Water shall be clean and free from deleterious materials. ASTM C94/C94M, potable.

C. Cementitious Materials:

1. Portland Cement: ASTM C150/C150M, Type I/II, gray with low alkali (less than 0.7% NaOH).
2. Fly Ash: ASTM C618, Class F with maximum carbon content of 4%.
3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.

D. Normal-Weight Aggregates: ASTM C33/C33M, Class 4S coarse aggregate or better, graded. Provide aggregates from a single source.

1. Alkali-Silica Reaction: Comply with one of the following:

   a. Expansion Result of Aggregate: Not more than 0.04 percent at one-year when tested in accordance with ASTM C1293.
   b. Expansion Results of Aggregate and Cementitious Materials in Combination: Not more than 0.10 percent at an age of 16 days when tested in accordance with ASTM C1567.
   c. Alkali Content in Concrete: Not more than 4 lb./cu. yd. (2.37 kg/cu. m) for moderately reactive aggregate or 3 lb./cu. yd. (1.78 kg/cu. m) for highly reactive aggregate, when tested in accordance with ASTM C1293 and categorized in accordance with ASTM C1778, based on alkali content being calculated in accordance with ACI 301 (ACI 301M).

2. Maximum Coarse-Aggregate Size: 3/4 inch (19 mm) nominal.
3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

E. Air-Entraining Admixture: ASTM C260/C260M.

F. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures that do 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 Admixture: ASTM C494/C494M, Type A. Water reducing admixtures shall be added to the mix at the point of delivery. Proportion and mix are to be in accordance with the manufacturer's recommendations.

2. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.

3. Permeability-Reducing Admixture: ASTM C494/C494M, Type S, hydrophilic, permeability-reducing crystalline admixture, capable of reducing water absorption of concrete exposed to hydrostatic pressure (PRAH).

a. Basis of Design: Xypex Concentrate Admix C-2000 / C-1000 or Penetron Admix
b. Permeability: No leakage when tested in accordance with U.S. Army Corps of Engineers CRD C48 at a hydraulic pressure of 150 psi for 14 days.

G. Vapor Retarders: Sheet Vapor Retarder, Class A: ASTM E1745, Class A; not less than 10 mils (0.25 mm) thick. Include manufacturer's recommended adhesive or pressure-sensitive tape.

2.3 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.

B. Moisture-Retaining Cover: ASTM C171, polyethylene film burlap-polyethylene sheet.

1. Color:

a. Ambient Temperature Below 50 deg F (10 deg C): Black.
b. Ambient Temperature between 50 deg F (10 deg C) and 85 deg F (29 deg C): Any color.
c. Ambient Temperature Above 85 deg F (29 deg C): White.

C. Curing Paper: 8-feet- (2438-mm-) wide paper, consisting of two layers of fibered kraft paper laminated with double coating of asphalt.

D. Water: Potable or complying with ASTM C1602/C1602M.

E. Clear, Solvent-Borne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A.

F. Clear, Waterborne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A.

2.4 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork.

B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 in accordance with ASTM D2240.

C. Bonding Agent: ASTM C1059/C1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

D. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade and class to suit requirements, and as follows:

1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.5 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3 mm) and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3 to 6 mm) or coarse sand, as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 4100 psi (29 MPa) at 28 days when tested in accordance with ASTM C109/C109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch (6 mm) and that can be filled in over a scarified surface to match adjacent floor elevations.

1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by topping manufacturer.
4. Compressive Strength: Not less than 5000 psi (34.5 MPa) at 28 days when tested in accordance with ASTM C109/C109M.

2.6 EMBEDDED MATERIALS

A. Reinforcing Bars: All reinforcement, used in this work, shall be of clean, new stock free from defects and free from bends not required by the drawings. The reinforcement shall be delivered, at the site of the work, free of mill or rust scales. The reinforcement shall be sorted for mesh and size and/or for size and length, properly identified and stored in racks suitably protected from the weather.

Reinforcing Bars shall conform to specifications for Deformed Billet Steel Bars for Concrete Reinforcement (ASTM A615). The yield strength of all bars (fy) shall be 60,000 psi, unless noted otherwise on the contract plans.

All reinforcement shall be tied in accordance with ACI recommendations for allowable movement during construction.

B. Mesh: Reinforcement shall be welded mesh fabric of the respective weights and sizes called for on the drawings, or as may be hereinafter specified. Wire mesh shall conform in all respects to the ASTM Standard Specifications for "Cold Drawn Steel Wire for Concrete Reinforcement" - Serial Designation A185-37.

C. Waterstops:

1. Flexible PVC Waterstops: CE CRD-C 572, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes. Profile shall be ribbed without center bulb and dimensions shall be 6 inches by 3/8” thickness

2. Self-Expanding Waterstops: Manufactured rectangular or trapezoidal strip, with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete, 3/4 by 1 inch.

3. Injection Waterstops: Flexible tubular strip reinforced with spiral wire and covered with woven membrane and injected with a polyurethane hydrophobic polymer grout.

2.7 WATERPROOFING

A. Waterproofing: Xypex Concentrate Admix C-2000 / C-1000 concrete waterproofing or Penetron® Admix concrete waterproofing as manufactured by Penetron®. The admixture shall be used in all concrete tank walls and slabs that contain liquids.

B. Liquid Water-Repellant: All exposed exterior concrete which does not contain the waterproofing admixture shall have a water repellant applied to 1’ below scheduled finish grade and 1’ below the normal water surface level. Additionally, all existing exterior concrete not scheduled to have other sealants applied shall be coated with liquid water repellant. The repellant shall be a non-toxic, breathable, clear water repellent intended for single-coat application that, after cure, leaves no visible surface residue, color or gloss. Silicone or acrylic based materials will not be accepted. Repellant shall be Hydrozo Clear 600 as manufactured by Hydrozo Coatings Co., Barrier B-28 percent as manufactured by Barrier Chemical Corp. or approved equal.

C. Sealant: All interior concrete slabs not receiving the water proof admixture shall be sealed with an aqueous, urethane fortified, thermoplastic resin. Sealant shall be Sikafloor® WP-31 Concrete Sealer as manufactured by the Sika Corporation or approved equal.

2.8 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301 (ACI 301M).

1. Use a qualified testing agency for preparing and reporting proposed mixture designs, based on laboratory trial mixtures at the expense of the Contractor.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash or Other Pozzolans: 25 percent by mass.
2. Slag Cement: 50 percent by mass.

C. Admixtures: Use admixtures in accordance with manufacturer's written instructions.

1. Use water-reducing or high-range water-reducing admixture in concrete, as required, for placement and workability.
2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
3. Use water-reducing admixture in pumped concrete and concrete with a w/cm below 0.50.
4. Use permeability-reducing admixture in concrete mixtures where indicated.

2.9 CONCRETE MIXTURES

A. Normal-weight concrete used for footings.

1. Exposure Class: ACI 318 (ACI 318M) F0, S1, W0, C1.
2. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
3. Maximum w/cm: 0.50.
4. Air Content:

    a. Exposure Class F0: 2.0 percent, plus or minus 1.0 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size.

5. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

B. Normal-weight concrete used for foundation & building walls.

1. Exposure Class: ACI 318 (ACI 318M) F2, S0, W0, C1.
2. Minimum Compressive Strength: 4500 psi (31 MPa) at 28 days.
3. Maximum w/cm: 0.45.
4. Air Content:

a. Exposure Class F2: 6.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size.

5. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

C. Normal-weight concrete used for mat slab & tank walls.

1. Exposure Class: ACI 318 (ACI 318M) F2, S1, W1, C2.
2. Minimum Compressive Strength: 5000 psi at 28 days.
3. Maximum w/cm: 0.40.
4. Air Content:

a. Exposure Class F2: 6.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size.

5. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent by weight of cement.

D. Normal-weight concrete used for interior slabs-on-ground & concrete topping slabs.

1. Exposure Class: ACI 318 (ACI 318M) F0, S0, W0, C0.
2. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
3. Maximum w/cm: 0.50.
4. Minimum Cementitious Materials Content: 540 lb/cu. yd. (320 kg/cu. m).
5. Air Content:

a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished floors.

6. Limit water-soluble, chloride-ion content in hardened concrete to 1.00 percent by weight of cement.

E. Base concrete mixes on standard deviation data of prior mixes with essentially the same proportions of the same materials or develop concrete mixes by laboratory tests using the materials proposed for the work. For concrete mixes developed by laboratory testing, base cement content of the concrete on curves showing the relationship between water: cement ratio and 7 and 28-day compressive strengths of concrete made using the proposed materials. Determine curves by four or more points, each representing an average value of at least three test specimens and one water: cement ratio at each age. Provide curves with a range of values sufficient to yield the desired data, including the compressive strengths specified, without extrapolation. The cement content of the concrete mixes to be used, as determined from the curve, shall correspond to the required average compressive strength in Table 5.3.2.2 of ACI 318. The resulting mix shall not conflict with the limiting values for maximum water: cement ratio and net minimum cement content specified in Table A of this section.

F. Proportion admixtures according to the manufacturer's recommendations. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of the other admixture(s). The aggregates shall be proportioned so as to produce a conglomerate

aggregate of the minimum void content, plus the necessary excess of fines as may be required to give the desired workability. The mixed concrete shall contain a sufficient quantity of cement paste to slightly overfill the void.

PART 3 - EXECUTION

3.1 WORKMANSHIP

A. Workmanship shall be of the highest quality and only competent and experienced workmen, skilled in their trade, shall be employed on this work.

3.2 EXAMINATION

A. Verification of Conditions:

1. Before placing concrete, verify that installation of concrete forms, accessories, and reinforcement, and embedded items is complete and that the Engineer’s inspection has been performed.
2. Do not proceed until unsatisfactory conditions have been corrected and approval has been obtained by the Engineer.

3.3 MIXING AND TRANSPORTING

A. Comply with ACI 304R, ACI 318 and ASTM C94 for all central plant and transport methods.

B. Provide ready-mixed concrete produced by equipment complying with ACI 318 and ASTM C94 and produced by a plant certified by the NRMCA. All truck mixers shall carry a rating plate conforming to TMMB 100. Clean each mix truck drum and reverse drum rotation before truck proceeds under the batching plant. Each transit-mix truck must have a continuous, nonreversible, revolution counter showing the number of revolutions at mixing speeds.

C. The entire contents of the drum shall be discharged before recharging. The mixer shall be cleaned whenever mixing is suspended and at frequent intervals when in use.

D. The volume of the mixed material per batch shall not exceed the manufacturer's rated capacity of the mixer.

E. Concrete shall be mixed in such quantities and at such time that any batch can be placed in the work within thirty (30) minutes after the time of mixing. No concrete shall be placed in the work after its initial set has occurred and re-tempered concrete shall not be used under any conditions.

F. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete in accordance with ASTM C94/C94M, and furnish batch ticket information.

G. The mix truck, used in transporting the concrete shall have its drum rotating from the time it is charged until it is discharged.

H. The concrete shall be on the job site and placed within a period of ninety (90) minutes after being loaded at the ready-mixed plant and any concrete enroute in excess of this time limit may, at the discretion of the Engineer, be rejected.

I. No concrete shall be placed in the work after its initial set has occurred and re-tempered concrete shall not be used under any conditions.

J. Contractor is to provide equipment of size and type to provide continuous flow of concrete at the delivery end.

K. Weigh-tickets shall be prepared and delivered, in duplicate, with each truck showing the actual batch size; quantity delivered; the actual weights of cement, fine and coarse aggregate, fly ash and water; moisture content of fine and coarse aggregate at time of batching; type, brand and quantity of each admixture; time of loading at the ready-mix plant; the time and quantity of any additional water. A blank shall also be provided on the weigh-ticket for the time of arrival at the site; this space is to be filled in and initialed by the Contractor's superintendent or foreman. A copy of the weigh-ticket shall be delivered to the Engineer for each batch of concrete delivered to the site.

L. The Engineer or representative, shall have access to the batch plant, from which the ready-mixed concrete is supplied, for the purpose of inspecting materials used in the mix and for checking and reporting the time of departure of each truck from the mixing plant to the job site.

M. The mix truck, used in transporting the concrete shall have its drum rotating from the time it is charged until it is discharged.

N. Temperature and Mixing Time Control

1. In cold weather, if water or aggregate has been heated, combine water with aggregate in the mixer before cement is added. Do not add cement to mixtures of water and aggregate when the mixture temperature is greater than 90o F.

2. In hot weather, cool ingredients before mixing to maintain temperature of the concrete below 90° F.

3. Maximum time interval from the addition of mixing water and/or cement to the batch and the final placement in the forms shall not exceed:

Temperature of Air or Concrete	Maximum Time
80º F to 90º F.	45 minutes
70º F to 79º F	60 minutes
40º F to 69º F	90 minutes

3.4 INSTALLATION OF VAPOR RETARDER

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder in accordance with ASTM E1643 and manufacturer's written instructions.

1. Install vapor retarder with longest dimension parallel with direction of concrete pour.
2. Face laps away from exposed direction of concrete pour.
3. Lap vapor retarder over footings and grade beams not less than 6 inches (150 mm), sealing vapor retarder to concrete.
4. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape.
5. Terminate vapor retarder at the top of floor slabs, grade beams, and pile caps, sealing entire perimeter to floor slabs, grade beams, foundation walls, or pile caps.
6. Seal penetrations in accordance with vapor retarder manufacturer's instructions.
7. Protect vapor retarder during placement of reinforcement and concrete.

    a. Repair damaged areas by patching with vapor retarder material, overlapping damages area by 6 inches (150 mm) on all sides, and sealing to vapor retarder.

B. Bituminous Vapor Retarders: Place, protect, and repair bituminous vapor retarder in accordance with manufacturer's written instructions.

3.5 JOINTS

A. Construct joints true to line, with faces perpendicular to surface plane of concrete.

B. Construction Joints: Coordinate with floor slab pattern and concrete placement sequence.

1. Install so strength and appearance of concrete are not impaired, at locations indicated on Drawings or as approved by Engineer.
2. Place joints perpendicular to main reinforcement.

    a. Continue reinforcement across construction joints unless otherwise indicated.
    b. Do not continue reinforcement through sides of strip placements of floors and slabs.

3. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
4. Locate joints for beams, slabs, joists, and girders at third points of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
5. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
6. Space vertical joints in walls as indicated on Drawings. Unless otherwise indicated on Drawings, locate vertical joints beside piers integral with walls, near corners, and in concealed locations where possible.
7. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
8. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Control Joints in Slabs-on-Ground: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of concrete thickness as follows:
   1. Sawed Joints: Form control joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3.2-mm-) wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random cracks.

D. Isolation Joints in Slabs-on-Ground: 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 (13 mm) or more than 1 inch (25 mm) below finished concrete surface, where Sika 51SL joint sealant is indicated.
   2. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

3.6 Dowel Plates: Install dowel plates at joints where indicated on Drawings.

3.7 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items, and vapor retarder is complete and that required inspections are completed.

   1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.
   2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.
   3. Before placing concrete, the forms shall be thoroughly cleaned of all chips, shavings and other debris.

B. Notify Engineer and testing and inspection agencies 72 hours prior to commencement of concrete placement.

C. Contractor shall not place concrete prior to field testing and approval of results by the site Inspector/Engineer.

D. Place concrete, except as modified herein, in accordance with ACI 304R, Chapter V

E. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect in writing, but not to exceed the amount indicated on the concrete delivery ticket.

   1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

F. The concrete shall be placed before it has had time to attain the initial set and under no conditions shall it be re-tempered and used. Any concrete which may have become compacted shall be satisfactorily re-mixed just before placed in the forms.

G. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness.
   1. Place concrete in forms using tremie tubes taking care to prevent segregation. Keep end of tremie tubes in contact with the concrete already in place. Do not drop concrete freely more than 4 feet.
   2. If a section cannot be placed continuously, provide construction joints as indicated.
   3. Concrete shall be deposited as near its final position as is possible to prevent segregation.
   4. In placing concrete, care shall be taken to avoid disturbing the steel reinforcing extending into the concrete that has partially set.
   5. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
   6. Concreting shall proceed at such a rate that the previously placed concrete is integrated with fresh plastic cement. Concrete shall at all times be plastic and flow readily into the space between the bars.
   7. Concrete shall not be deposited in freestanding water, loose dirt, rubbish or other foreign matter, nor shall water be permitted to rise on or flow over freshly placed concrete until the concrete has set for at least twenty-four (24) hours.
   8. Place each batch into the edge of the previously placed concrete to avoid stone pockets, segregation and cold joints.
   9. Consolidate placed concrete with mechanical vibrating equipment in accordance with ACI 301 (ACI 301M).

      a. Do not use vibrators to transport concrete inside forms.

      b. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer.

      c. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.

      d. At each insertion, limit duration of vibration to time necessary to consolidate concrete, and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

      e. During and after placing concrete, it shall be continuously and sufficiently forked or, if so approved, vibrated to expel entrapped air. All large stones shall be kept away from the faces by means of a spading fork.

H. 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. Do not place concrete floors and slabs in a checkerboard sequence.
   2. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
   3. Maintain reinforcement in position on chairs during concrete placement.
   4. Screed slab surfaces with a straightedge and strike off to correct elevations.
   5. Level concrete, cut high areas, and fill low areas.
   6. Slope surfaces uniformly to drains where required.
   7. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface.

8. Do not further disturb slab surfaces before starting finishing operations.

3.8 COMPACTING

A. Consolidate concrete by vibration and puddling, spading, rodding or forking so that concrete is completely worked around reinforcement, embedded items, openings and into corners. Continuously perform puddling, spading, rodding and forking along with vibration of the placement of concrete to eliminate air or stone pockets.

B. Compact all concrete with mechanical vibrators. Keep standby vibrators on site during placing of concrete

C. Use vibrators having a minimum frequency of 7000 revolutions per minute. Insert vibrators and withdraw at points from 18" to 30" apart. Vibrate sufficiently at each insertion to consolidate concrete, generally 5 to 15 seconds. Do not over vibrate so as to segregate.

D. All laborers are to be trained in the correct use of mechanical vibrators in concrete consolidation.

E. Compactive effort will be limited to the degree necessary to keep concrete from separating as a result of compaction.

F. Insert vibrator so area visibly affected by vibrator overlaps adjacent just-vibrated area by few inches.

G. Beams: Vibrate beams separately before slab placement. Place slab concrete after vibrating beam, but before beam concrete reaches initial set.

H. Slabs: Insert vibrators for full depth of slab. Allow vibrator to penetrate slab into previously placed beams.

I. Walls: Insert vibrators along each face (i.e., just behind reinforcing) and allow vibrator to sink into previous lifts as deep as will easily penetrate.

J. Along Waterstop: Insert vibrators along full length of waterstop alternating on each side at 12 in. maximum centers.

3.9 FINISHING FORMED SURFACES

A. As-Cast Surface Finishes:

1. ACI 301 (ACI 301M) Surface Finish SF-2.0: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams.

    a. Patch voids larger than 3/4 inch (19 mm) wide or 1/2 inch (13 mm) deep.
    b. Remove projections larger than 1/4 inch (6 mm).
    c. Patch tie holes.

d. Surface Tolerance: ACI 117 (ACI 117M) Class B.
e. Locations: Apply to all concrete surfaces.

B. Related Unformed Surfaces:

1. At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a color and texture matching adjacent formed surfaces.
2. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.10 FINISHING FLOORS AND SLABS

A. Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Float Finish:

1. When bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
2. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 (ACI A117M) tolerances for conventional concrete.
3. Apply float finish to surfaces to receive trowel finish and to be covered with built-up or membrane roofing.

C. Trowel Finish:

1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.
2. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance.
3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
4. Do not add water to concrete surface.
5. Do not apply hard-troweled finish to concrete, which has a total air content greater than 3 percent.
6. Apply a trowel finish to surfaces exposed to view.
7. Finish surfaces to the following tolerances, in accordance with ASTM E1155 (ASTM E1155M), for a randomly trafficked floor surface:

a. Slabs on Ground:

1) Finish and measure surface so gap at any point between concrete surface and an unleveled, freestanding, 10-ft.- (3.05-m-) long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/4 inch (6 mm).

D. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and locations indicated on Drawings.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.
2. Coordinate required final finish with Engineer before application.

3.11 CURING

A. As soon as the exposed horizontal concrete surfaces have been finished and are sufficiently hardened (not easily scratched), they shall be cured to retain moisture and proper temperature. **All costs shall be borne by the Contractor, and no additional compensation shall be granted for cold weather conditions.**

B. All concrete shall be adequately protected from mechanical injury or by actions of the elements until such time as the concrete is thoroughly set.

C. The concrete shall not be loaded in any way or capacity until the seventh (7th) day concrete compression and flexure test results are reviewed by, and accepted by, the Engineer.

D. The Contractor shall not remove the concrete forms, shores, or weather protection until authorized by the Engineer.

E. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

1. Comply with ACI 301 (ACI 301M) and ACI 306.1 for cold weather protection during curing.
2. Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M) for hot-weather protection during curing.
3. Maintain moisture loss no more than 0.2 lb/sq. ft. x h (1 kg/sq. m x h), calculated in accordance with ACI 305.1, before and during finishing operations.

F. Curing Formed Surfaces: Comply with ACI 308.1 (ACI 308.1M) as follows:

1. Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces.
2. Cure concrete containing color pigments in accordance with color pigment manufacturer's instructions.
3. If forms remain during curing period, moist cure after loosening forms.
4. If removing forms before end of curing period, continue curing for remainder of curing period, as follows:

    a. Continuous Fogging: Maintain standing water on concrete surface until final setting of concrete.
    b. Continuous Sprinkling: Maintain concrete surface continuously wet.
    c. Absorptive Cover: Pre-dampen absorptive material before application; apply additional water to absorptive material to maintain concrete surface continuously wet.

d. Water-Retention Sheeting Materials: Cover exposed concrete surfaces with sheeting material, taping, or lapping seams.
e. Membrane-Forming Curing Compound: Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions.

1) Recoat areas subject to heavy rainfall within three hours after initial application.
2) Maintain continuity of coating and repair damage during curing period.

G. Curing Unformed Surfaces: Comply with ACI 308.1 (ACI 308.1M) as follows:

1. Begin curing immediately after finishing concrete.
2. Interior Concrete Floors:

a. Floors to Receive Floor Coverings Specified in Other Sections: Contractor has option of the following:

1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.

a) Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.

2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive.

a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
b) Cure for not less than seven days.

3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:

a) Water.
b) Continuous water-fog spray.

b. Floors to Receive Penetrating Liquid Floor Treatments: Contractor has option of the following:

1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.

a) Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.

2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive.

a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
b) Cure for not less than seven days.

3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:

a) Water.
b) Continuous water-fog spray.

c. Floors to Receive Polished Finish: Contractor has option of the following:

1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.

a) Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.

2) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:

a) Water.
b) Continuous water-fog spray.

d. Floors to Receive Chemical Stain:

1) As soon as concrete has sufficient set to permit application without marring concrete surface, install curing paper over entire area of floor.
2) Install curing paper square to building lines, without wrinkles, and in a single length without end joints.
3) Butt sides of curing paper tight; do not overlap sides of curing paper.
4) Leave curing paper in place for duration of curing period, but not less than 28 days.

e. Floors to Receive Urethane Flooring:

1) As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
2) Rewet absorptive cover, and cover immediately with polyethylene moisture-retaining cover with edges lapped 6 inches (150 mm) and sealed in place.
3) Secure polyethylene moisture-retaining cover in place to prohibit air from circulating under polyethylene moisture-retaining cover.
4) Leave absorptive cover and polyethylene moisture-retaining cover in place for duration of curing period, but not less than 28 days.

f. Floors to Receive Curing and Sealing Compound:

1) Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller in accordance with manufacturer's written instructions.
2) Recoat areas subjected to heavy rainfall within three hours after initial application.
3) Repeat process 24 hours later, and apply a second coat. Maintain continuity of coating, and repair damage during curing period.

3.12 TEMPERATURE OF CONCRETE

A. Concrete, when deposited, shall have a temperature ranging between a minimum of fifty (50) degrees F. and a maximum of ninety (90) degrees F.

1. The minimum temperature of concrete immediately after placement and during the protection period shall be:
   < 12" thick section = 55° F (Max Temp. 75° F)
   12" to 36" = 50° F (Max Temp. 70° F)

2. Protect concrete during cold weather by providing continuous warm, moist curing for a total of 350 degree-days of curing. Degree-days are defined as the daily average temperature of the air at the concrete surface over a 24-hour period. Temperature is to be taken in the shade.

3. Protect the concrete surface from direct exposure to temperatures 40° F and below.

B. Cold Weather Placement

1. Cold weather shall be defined as a period of 3-successive days having an average outdoor temperature of 40o F or lower.

2. Concrete placement, curing, protection, delivery, and batch formula (admixtures, heating) shall comply with ACI 306R

3. Preparation before concrete is placed requires a temperature increase of the formwork, reinforcement, and other surfaces that will contact fresh concrete so the temperature of the freshly placed concrete will not decrease below the minimums as placed and maintained (Table below).

Recommended concrete temperatures

		Section size, minimum dimension			
		< 12 in. (300 mm)	12 to 36 in. (300 to 900 mm)	36 to 72 in. (900 to 1800 mm)	> 72 in. (1800 mm)
Line	**Air temperature**	**Minimum concrete temperature as placed and maintained**			
1	—	55 F (13 C)	50 F (10 C)	45 F (7 C)	40 F (5 C)
		Minimum concrete temperature as mixed for indicated air temperature*			
2	Above 30°F (–1°C)	60°F (16°C)	55°F (13°C)	50°F (10°C)	45°F (7°C)
3	0 to 30°F (–18 to –1°C)	65°F (18°C)	60°F (16°C)	55°F (13°C)	50°F (10°C)
4	Below 0 F (–18 C)	70 F (21 C)	65 F (18 C)	60 F (16 C)	55 F (13 C)
5	—	**Maximum allowable gradual temperature drop in first 24 hours after end of protection**			
		50°F (28 C)	40° (22 C)	30°F (17 C)	20°F (11 C)

*For colder weather, a greater margin in temperature is provided between concrete as mixed and required minimum temperature of fresh concrete in place.

4. Contractor shall provide a cold weather concreting plan outlining methods and procedures for batch formula changes, transportation, placement, protection, curing, concrete temperature monitoring, standby equipment, etc.

5. Concrete shall not be placed during inclement or freezing weather without the explicit permission of the Engineer. For concrete placed in freezing weather, Contractor shall insulate, enclose, and heat as required to maintain temperatures specified below. **All costs for such protection shall be borne by the Contractor.**

6. Temperature of reinforcement, forms, fillers, and other materials in contact with concrete at time of placement shall not be less than 40ºF. Preheat if temperature below 40ºF.

7. Protect concrete during cold weather by providing continuous warm, moist curing for a total of 350 degree-days of curing. Degree-days are defined as the daily average temperature of the air at the concrete surface over a 24-hour period. Temperature is to be taken in the shade.

8. Maintain air and forms at temperature above 50ºF for at least the first 3 days and at temperature above 32ºF for remainder of specified curing period.

9. Calcium chloride or other admixtures shall not be used to protect concrete from freezing, unless directed by the Engineer. Contractor shall employ protection methods specified above as an alternative to admixtures.

C. Hot Weather Placement

1. Hot weather concreting is defined in ACI 305R as a rate of evaporation exceeding 0.2 lb/sf/hr as a result of high temperatures, low humidity and wind velocity. The Contractor shall request the Engineer to make a determination of Hot Weather protection measures in accordance with ACI 305R should the climate dictate.

   a. Temperature of the concrete being placed shall not exceed 90º F.

   b. Contractor shall provide a hot weather concreting plan outlining methods and procedures for batch formula changes, transportation, placement, protection, curing, concrete temperature monitoring, standby equipment, etc.

3.13 INSTALLATION OF EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining Work that is attached to or supported by cast-in-place concrete.

1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of ANSI/AISC 303.
3. 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.
4. Do not place ducts, conduits, and pipes in slabs on grade. Place minimum 4 in. under bottom of slab

3.14 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

A. Filling In:

1. Fill in holes and openings left in concrete structures after Work of other trades is in place unless otherwise indicated.
2. Mix, place, and cure concrete, as specified, to blend with in-place construction.
3. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases as indicated on Drawings, and extend base not less than 6 inches (150 mm) in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated on Drawings, or unless required for seismic anchor support.
3. Minimum Compressive Strength: 4000 psi at 28 days.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
6. Prior to pouring concrete, place and secure anchorage devices.

    a. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    b. Cast anchor-bolt insert into bases.
    c. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.15 QUALITY CONTROL – FIELD TESTING

A. The Contractor shall provide field and laboratory concrete testing by the independent testing company listed on the approved respective submittal. **The cost of all concrete testing shall be borne by the Contractor.**

1. Testing Agency:

a. Testing agency to be responsible for providing curing container for composite samples on Site and verifying that field-cured composite samples are cured in accordance with ASTM C31/C31M.
b. Testing agency to immediately report to Engineer, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
c. Testing agency to report results of tests and inspections, in writing, to Owner, Engineer, Contractor, and concrete manufacturer within 48 hours of inspections and tests.

1) Test reports to include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:

a) Project name.
b) Name of testing agency.
c) Names and certification numbers of field and laboratory technicians performing inspections and testing.
d) Name of concrete manufacturer.
e) Date and time of inspection, sampling, and field testing.
f) Date and time of concrete placement.
g) Location in Work of concrete represented by samples.
h) Date and time sample was obtained.
i) Truck and batch ticket numbers.
j) Design compressive strength at 28 days.
k) Concrete mixture designation, proportions, and materials.
l) Field test results.
m) Information on storage and curing of samples before testing, including curing method and maximum and minimum temperatures during initial curing period.
n) Type of fracture and compressive break strengths at seven days and 28 days.

2. Preparation for Field Testing:

a. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:

1) Daily access to the Work.
2) Incidental labor and facilities necessary to facilitate tests and inspections.
3) Secure space for storage, initial curing, and field curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.

4) Security and protection for test samples and for testing and inspection equipment at Project site.

3. Field Testing:
   a. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.

   b. The following field tests shall be performed at the point of placement **for each load** of concrete to be placed. Tests shall be performed in accordance with ASTM C172-0 Standard Practice for Sampling Freshly Mixed Concrete

      1) Mix Design: All concrete batch plant truck slips shall be examined for verification of complete conformance with the approved design mix.

      2) Slump: Tests shall be made by the Testing Lab personnel immediately prior to placing the concrete. Such tests shall be made in accordance with ASTM C143.

      3) Air Content: Test for air content shall be made by the Testing Lab personnel on a fresh concrete sample. Such tests shall be made in accordance with ASTM C231 or ASTM C173 if the volumetric method is used due to high absorption aggregates.

   c. If the field test should conclude that the concrete mix delivered to the site does not comply with the approved design mix, the Engineer shall reject the concrete truck at no cost to the Owner and the field test shall be repeated for the next truck to arrive on-site.

   d. Post-placement concrete temperature monitoring shall be performed by the Engineer. Any documented temperature observations made outside of the approved range shall result in further concrete testing at the expense of the Contractor.

4. Compressive Strength Test

   a. All specimens shall be tested by a certified testing laboratory, approved by the Engineer, in accordance with the latest edition of the ASTM Standard Specifications entitled “Standard Method of Test for Compressive Strength of Molded Concrete Cylinders: Serial Designation: C39.

   b. A laboratory test consisting of **eight (8) concrete cylinders** shall be made of the concrete used in each placement. The concrete contractor shall perform one such test on each day that concrete is poured and **for each 50 cubic yards, or fraction thereof**, as a part of the Contract.

      1) For example, if the pour requires 110 cubic yards, three sets of cylinders are taken. A record shall be kept showing the time and location of the batch from which the test was made. Three (3) copies of the test reports shall be transmitted directly from the testing laboratory to the Engineer who, in turn,

will transmit one to the Owner. Tests results submitted by the Contractor shall not be accepted.

c. Test specimens shall consist of 6" by 12" cylinders, prepared in accordance with the latest edition of the ASTM Standard Specifications entitled "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field". All tests will be as follows:

1) 2 cyl - 7 days

2) 2 cyl - 14 days

3) 2 cyl - 28 days

4) 2 cyl - Extra

d. Any concrete that fails to meet the specified requirements shall be removed and replaced with approved materials at the Contractor’s expense, when and as directed by the Engineer.

5. Additional Tests:

a. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

b. Testing and inspecting agency to make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer.

c. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Architect.

1) Acceptance criteria for concrete strength to be in accordance with ACI 301 (ACI 301M), Section 1.6.6.3.

d. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

e. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

f. Measure floor and slab flatness and levelness in accordance with ASTM E1155 (ASTM E1155M) within 24 hours of completion of floor finishing and promptly report test results to Engineer.

3.16 DEFECTIVE WORK

A. Immediately after the removal of forms, the concrete surfaces shall be inspected for defective areas and the Contractor shall immediately replace and/or patch all imperfections in accordance

with these specifications. No corrective action shall be taken to address imperfections prior to the Engineer's inspection and subsequent approval.

B. All concrete work, not formed as shown on the drawings, out of alignment or level, or showing a defective surface, shall be removed and completely replaced in a manner meeting with the Engineer's approval. Slight imperfections, which may be patched without impairing the strength or appearance of the structure, may be patched, providing the Engineer's permission is obtained prior to the patching.

C. Permission to patch work shall not be considered as a waiver of the Owner’s right to require complete removal of such defective work if the patching done fails to satisfactorily restore the quality and appearance of the work. All defective concrete work shall be made good by patching or replacement, regardless of any previous permission that the Contractor may have received regarding procedure or methods of concrete operations.

D. Defective areas, which are to be replaced when so directed by the Engineer, shall be chipped away to a depth not less than two (2) inches clear inside of the reinforcement and the edges of the cut shall be perpendicular to the finished surface. The surfaces of the cut and a space at least six (6) inches wide, entirely surrounding the cut, shall be wetted thoroughly to prevent absorption of water from the patching mortar. The patch shall be made of the same materials and of the same proportions as were used for the original concrete except that the coarse aggregate shall be omitted and fine aggregate substituted therefore. In order for the patch to match the surrounding concrete, it may be necessary to substitute white cement for a part of the gray cement. The amount of water used in mixing shall be as little as is consistent with the requirements of handling and placing. The mortar shall be thoroughly compacted into place and shall be finished slightly higher than the surrounding surface. It shall then be left undisturbed from two (2) to three (3) hours to permit the initial shrinkage before being finished. The patch shall be finished to match the adjoining surface and shall be protected and cured as provided herein before.

E. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.

F. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension to solid concrete.

    a. Limit cut depth to 3/4 inch (19 mm).
    b. Make edges of cuts perpendicular to concrete surface.
    c. Clean, dampen with water, and brush-coat holes and voids with bonding agent.
    d. Fill and compact with patching mortar before bonding agent has dried.
    e. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.

2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement, so that, when dry, patching mortar matches surrounding color.

a. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.
b. Compact mortar in place and strike off slightly higher than surrounding surface.

3. Repair defects on concealed formed surfaces that will affect concrete's durability and structural performance as determined by Architect.

G. Repairing Unformed Surfaces:

1. Test unformed surfaces, such as floors and slabs, for finish, and verify surface tolerances specified for each surface.

a. Correct low and high areas.
b. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

2. Repair finished surfaces containing surface defects, including spalls, popouts, honeycombs, rock pockets, crazing, and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
3. After concrete has cured at least 14 days, correct high areas by grinding.
4. Correct localized low areas during, or immediately after, completing surface-finishing operations by cutting out low areas and replacing with patching mortar.

a. Finish repaired areas to blend into adjacent concrete.

5. Correct other low areas scheduled to receive floor coverings with a repair underlayment.

a. Prepare, mix, and apply repair underlayment and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
b. Feather edges to match adjacent floor elevations.

6. Correct other low areas scheduled to remain exposed with repair topping.

a. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations.
b. Prepare, mix, and apply repair topping and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.

7. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete.

a. Remove defective areas with clean, square cuts, and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around.
b. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
c. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate.

d. Place, compact, and finish to blend with adjacent finished concrete.
e. Cure in same manner as adjacent concrete.

8. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar.

a. Groove top of cracks and cut out holes to sound concrete, and clean off dust, dirt, and loose particles.
b. Dampen cleaned concrete surfaces and apply bonding agent.
c. Place patching mortar before bonding agent has dried.
d. Compact patching mortar and finish to match adjacent concrete.
e. Keep patched area continuously moist for at least 72 hours.

H. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

I. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.17 CLEANUP

A. Any and all work, of this and/or other trades, soiled or damaged in the execution of the work covered by this section of the specifications, shall be thoroughly cleaned, repaired and/or replaced, as directed by the Engineer, at this Contractor's expense.

B. Upon completion of his work this Contractor shall remove all his tools, equipment, surplus material, debris, etc., leaving the premises in an orderly and clean condition.

C. Drums of the mix truck shall be cleaned thoroughly with clear water after each batch.

D. The entire contents of the drum shall be discharged before recharging. The mixer shall be cleaned whenever mixing is suspended and at frequent intervals when in use.

3.18 PROTECTION

A. Protect concrete surfaces as follows:

1. Protect from petroleum stains.
2. Diaper hydraulic equipment used over concrete surfaces.
3. Prohibit vehicles from interior concrete slabs.
4. Prohibit use of pipe-cutting machinery over concrete surfaces.
5. Prohibit placement of steel items on concrete surfaces.
6. Prohibit use of acids or acidic detergents over concrete surfaces.
7. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

3.19 COORDINATION

A. The General Contractor shall coordinate with other contractors as to providing sleeves, anchors, and pads, and other requirements that are necessary to complete construction. The General Contractor shall be responsible for placement of such items for the other contractors.

END OF SECTION

SECTION 033450
CONCRETE JOINTS AND FINISHES

PART 1. GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, materials, equipment and incidentals required to install joints in concrete, sealants, waterstops, and accessories as shown on the Contract Drawings and specified herein. Concrete joints include construction, expansion, isolation and control joints and shall be of the type shown on the drawings and/or specified herein.

1.02 REFERENCE STANDARDS (Most Current Edition)

A. American Concrete Institute (ACI)
   1. ACI 301 - Specifications for Structural Concrete for Buildings
   2. ACI 318 - Building Code Requirements for Reinforced Concrete
   3. ACI 315 (SP-66) - Details and Detailing of Concrete Reinforcement
   4. ACI 224 - Joints in Concrete Construction

B. American Society for Testing and Materials
   1. ASTM C33 - Standard Specification for Concrete Aggregates
   2. ASTM A675 - Standard Specification for Steel Bars, Carbon, Hot Wrought, Special Quality, Mechanical Properties

1.03 DELIVERY, HANDLING AND STORAGE

A. Deliver products in original, unopened containers displaying the manufacturer's label with product identification and batch number.
B. Store products in accordance with manufacturer recommendations.

1.04 QUALITY ASSURANCE

A. For concrete that will receive additional finishes, the surface shall be prepared in accordance with the manufacturer's product requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. All materials used together in a given joint shall be compatible with one another. Coordinate material selection with suppliers and products to provide compatibility.

2.02 CONSTRUCTION JOINTS

A. Construction joints for interruptions in slabs on grade concrete placements shall be fabricated from 18 gauge galvanized steel shaped to form a tongue and groove mechanical key joint. Preformed knock-out holes shall be provided at 6" on center. The unit shall be the same depth as the concrete. The units shall be the "Vulco Screed Joint 11" (free flow) as made by Vulcan, the "Tongue Groove" joint #95 as made by Heckmann, the "Keyed Kold Joint" as made by Burke, or equal. Units shall be staked a minimum of 2'-0" on center or more often as required.

2.03 EXPANSION, CONTRACTION AND ISOLATION JOINT

A. Expansion, contraction and isolation joint filler shall be preformed, non-staining, and compatible with sealant and primer. Joint filler material shall be closed cell superior grade polyethylene or non-extruding PVC, such as Sonneborn "Vinylform", Servicised "Rodofoa 11" by W. R. Grace or equal.
B. If of a supporting type, (supporting concrete) joint filler material shall be closed cell rigid foam, cork, or non-impregnated fiber board, such as Sonneborn ("Sonoflex Cork", Servicised "Standard Cork" filler by W. R. Grace Co.) or equal. Where sealant is to be applied, the joint filler or backer shall be compatible as a back-up material, with regard to the sealant not bonding to or being stained by the backup. If the joint filler is a material that will bond to the sealant, the polyethylene tape shall be used to cover the back up. The polyethylene shall be a type that will not bond to the sealant. Note that joint fillers shall be held back for sealants where possible.
C. Sealant shall be in accordance with Section 03300

PART 3. EXECUTION

3.01 INSTALLATION OF ISOLATION JOINTS:

A. Isolation joints for slabs on grade: The floor shall be separated structurally from other building elements to accommodate differential horizontal and vertical movement. Isolation joints shall be used at junction with walls, columns, machine foundations, and footings, or other points of restraint, such as drain pipes, chimneys, sumps, stairways, etc. Joint material shall be removed to the depth required for installation of the sealant. Isolation joints are shown on Contract Drawings.

3.02 INSTALLATION OF CONTRACTION JOINTS IN SLABS ON GRADE:

A. Contraction joints shall be provided as shown on the drawings. In the event none are shown or are only partially shown, no slab larger than 20 feet shall be constructed without a control joint. All reinforcing steel shall be interrupted at the control joints with a 2" gap. Joints shall be formed either with a pre-molded joint insert or a sawcut. Cutting shall be done as early as possible and within 24 hours after the concrete has set. (Wait just long enough that the blade does not ravel the edges of the fresh concrete.) The saw shall be guided to insure straight cuts. The width of the cut shall be minimum of 1 1/4" and in depth 25% of the slab thickness. As an alternative to sawing, so called "Zip-Strips" may be used if they conform to the requirements for sawn joints. The joints shall be filled with a sealant as specified herein.

3.03 INSTALLATION OF EXPANSION JOINTS

A. Expansion joints shall be provided as shown on the Drawings. In the event none are shown or are only partially shown, no element longer than 80 feet shall be constructed without an expansion joint.
B. Reinforcement or other fixed items embedded or bonded into the concrete shall not be run through expansion joints. Provide appropriate expansion dowels as shown. Dress edges of concrete corners to provide a smooth, uniform edge. Thoroughly clean all expansion joints of dust, oil, grease, water, dirt, frost or other foreign materials immediately prior to sealing.
C. The joints shall be filled with sealant as specified herein.

3.04 SLAB, WALL AND FLOOR FINISHES

A. The finish of all floors, slabs, flow channels, and tops of walls shall be accomplished by the contractor as described below, by types, and in accordance with the schedule outlined in the project documents. When type of finish is not specified in the project documents, the following finishes shall be used as applicable:

1. Type 1 - Scratched Finish: For surfaces intended to receive bonded applied cementitious applications.
2. Type 2 - Floated Finish: For surfaces intended to receive roofing, water proofing or tile membranes, or sand bed terrazzo.
3. Type 3 - Troweled Finish: For floors intended as walking surfaces, for reception of floor coverings, flow channels, tankage and all areas where in contact with liquids. All walls to have Type 3 finish.
4. Type 4 - Broom or Belt Finish: For sidewalks and ramps.
5. Type 5 - Nonslip Finish: For exterior platforms, steps, and landings; and for exterior and interior pedestrian ramps.
6. Type 6 - Rubbed Finish: Vertical concrete above grade exposed to view, underside of concrete slab exposed to view, interior tank walls exposed to view + 2' below low water level (rough form finish on submerged walls).

B. FINISHING TOLERANCES

Finishes with Class A tolerances shall be true planes within 1/8 inch in 10 feet, as determined by a 10-foot straightedge placed anywhere on the slab in any direction. Where drains are to be provided, pitch concrete surface to drains such that there are no low spots.

C. FINISHES

1. Type 1 - Scratched Finish: After the first floating to a Class C tolerance, the surface shall be roughened with stiff brushes or rakes before final set. (The procedure is same as Type 2 up to first floating.
2. Type 2 - Floated Finish: After the concrete has been placed, consolidated, struck off, and leveled, the concrete shall not be worked further until ready for floating. Preferably a magnesium float will be used. 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-foot straightedge 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 within Class B tolerance throughout. The slab shall then be refloated immediately to a uniform sandy texture.
3. Type 3 - Troweled Finish: The surface shall first receive a Type 2 float finish. It shall next be power troweled, and finally hand troweled. The first troweling after power floating shall produce a smooth surface which is relatively free of defects but which may still show some trowel marks. Additional trowelings 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 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 A tolerance, except tolerance for concrete on metal deck shall be Class B. On surfaces

intended to support floor coverings, any defects of sufficient magnitude to show through the floor covering shall be removed by grinding. If the concrete surface contains excess alkaline, the Contractor shall acid etch the floor and wash same so that a proper bond can be achieved later between floor covering adhesive and the concrete.

4. Type 4 - Broom or Belt Finish: Immediately after the concrete has received a Type 2 float finish, it shall be given a course transverse scored texture by drawing a broom or burlap belt across the surface.
5. Type 5 - Nonslip Finish: Where the contract documents require a nonslip finish, the surface shall be given a "dry shave" application, as specified herein, of crushed ceramically bonded aluminum oxide. The rate of application of such material shall not be less than 50 pounds per 100 square feet.
6. Type 6 - Rubbed Finish: While the wall is still damp apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat within all pits, air holes or blemishes in parent concrete. Avoid coating large areas with slurry at one time. Before the slurry has dried or changed color, apply a dry (almost crumbly) grout proportioned by volume and consisting of 1-part cement to 1.5 parts of clean masonry sand having a fineness modulus of approximately 2.3 and complying with the gradation requirements of ASTM C33 for such materials. Grout shall be uniformly applied by means of damp pads of coarse burlap. Scrub grout into the pits and air holes to provide a dense mortar in all imperfections. Allow the mortar to partially harden for 1-2 hours (weather dependent). If the air is hot and dry, keep the wall damp during this period using a fine / fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the edge of a steel trowel without damaging the grout in the small pits and holes removed, cut off all that can be removed with a trowel. Rub dried surface vigorously with clean dry burlap to completely remove dried grout. On the day following the repair of pits air holes and blemishes, the walls shall again be rubbed with dry, used, pieces of burlap. The walls shall be washed and scrubbed with a stiff bristle brush. The walls shall be sprayed with a fine fog for 3-days following this wash down.

END OF SECTION

SECTION 033600
PRECAST CONCRETE STRUCTURES

PART 1 GENERAL

1.01 This Section includes, but is not limited to:
A. Catch basins

1.02 REQUIREMENTS OF REGULATORY AGENCIES

B. All steel used in manufacturing precast structures must meet the requirements of the American Iron and Steel Act. Submit certification with shop drawings.

C. All frames and grates must meet the requirements of the American Iron and Steel Act. Submit certification with shop drawings.

1.03 SUBMITTALS

A. Shop Drawings: Show complete fabrication details and connections to adjacent Work. Indicate member dimensions and cross-section; location, size, and type of reinforcement; and lifting devices.
1. Indicate welded connections by AWS standard symbols. Detail inserts, connections, and joints, including accessories and construction at openings in pre-cast units.

B. Product Data: Manufacturer's catalog cuts, specifications, and installation instructions. Must include name of manufacturer, dimensional information, verification of concrete mix and reinforcement, design loading (i.e., traffic or non-traffic), and weight information.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver the amount of precast units needed in a timely manner to the Project site to ensure installation continuity.

B. Store and handle the units at the Project site to prevent cracking, distortion, staining, or other physical damage, and so that markings are visible. Lift and support units at designated lift points.

PART 2 PRODUCTS

2.01 GENERAL MATERIALS FOR PRECAST CONCRETE STRUCTURES

A. Acceptable precast manufacturers; The Fort Miller Company, Inc., or equal.

B. Design Case: AASHTO H20-44 Live Load traffic loading with ground water table at grade elevation (designed for buoyancy).

C. Concrete Reinforcement:
1. Steel Bars: ASTM A 615 – A497, Grade 60.
2. Welded Wire Fabric: ASTM A 185, Grade 65.

D. Pipe-to-Manhole/Drainage Structure Connections-One of the following:
1. A-Lok Flexible Connector by A-Lok Products, Inc., 697 Main St., Tullytown, PA 19007, (215) 547-3366.
2. Lockjoint Flexible Connector by Chardon Rubber Company, 373 Washington St., Chardon, OH 44024, (216) 285-2161.
3. Kor-N-Seal Flexible Connector by NPC, Inc., 250 Elm St., Milford, NH 03055, (601) 673-8680.
4. Link-Seal Flexible Connector by Thunderline Link-Seal, Inc., 6525 Goforth St., Houston, TX 77021, (713) 747-8819.
5. For manhole core bores, use Link Seal flexible connectors.

E. Mortar: ASTM C 270, Type M.

2.02 CATCH BASIN SPECIFIC MATERIALS

A. NYSDOT catch basins shall conform to NYSDOT requirements.

B. Precast sections to be interlocking and gasketed with precast knockouts on all sides

C. Opening dimensions shall be in accordance with the Contract Drawings Details.

D. Curb Inlet Frames, Grates and Curb Boxes:
1. Designed to meet AASHTO H20 wheel loading requirements. Manufacture, workmanship and certified proof-load tests shall conform to AASHTO M306-89-Standard Specification for Drainage Structure Castings.
2. Material:
   a. Cast iron: ASTM A 48, Class 30B or 35B.
   b. Delivered to the Site free of any coatings, unless otherwise specified.
3. Frames: Square top with round 36-inch OD base flange and integral stiffeners.
4. Grates:
   a. Opening dimensions shall be in accordance with the Contract Drawings Details.
   b. Bicycle safe.
5. Minimum total weight of curb inlet frame, grate and box: 340 lbs.
6. Acceptable Curb Inlets: Pattern R-3010 with Type A grate by Neenah Foundry Company, P. O. Box 729, Neenah, WI 54957, (414) 729-3661; Pattern 2640 by Syracuse Castings Sales Corp., P. O. Box 190, South Bay Rd., Cicero, NY 13039, (315) 699-2601.

E. Drop Inlet Frames and Grates:

1. Designed to meet AASHTO H20 wheel loading requirements. Manufacture, workmanship and certified proof-load tests shall conform to AASHTO M306-89-Standard Specification for Drainage Structure Castings.
2. Material:
   a. Cast iron: ASTM A 48, Class 30B or 35B.
   b. Delivered to Site free of any coatings, unless otherwise specified.
3. Frames: Opening dimensions shall be in accordance with the Contract Drawings Details.

4. Grates:
   a. Bicycle safe
   b. Opening dimensions shall be in accordance with the Contract Drawings Details.
5. Minimum total weight of frame and grate: 245 lbs.
6. Acceptable Drop Inlet Frames and Grates: Pattern R-3562 by Neenah Foundry Company, P. O. Box 729, Neenah, WI 54957, (414) 729-3661; Pattern 1396440 frame with Pattern 1396040 grate by Syracuse Castings Sales Corp., P. O. Box 190, South Bay Rd., Cicero, NY 13039, (315) 699-2601.

PART 3 EXECUTION

3.01 INSTALLATION

A. Construct structures circular in form with precast reinforced riser sections. Seal joints between precast riser sections with material specified. Install steps 12 inches oc from top to bottom and in a manner capable of withstanding a lateral pull of 1,000 lbs.
   1. Wall thickness for structures 12 feet deep or less: 5 inches.
   2. Wall thickness for structures greater than 12 feet deep: 6 inches.
   3. 8-inch minimum floor slab thickness.

B. Position new manholes such that the top surface of the manhole cover will be flush with finished pavement grade or 0.25” below ground finished grade, as applicable.

C. Form inverts in sanitary manholes on straight runs by the use of channel pipe. Form inverts in manholes at changes in direction or grade by making curved channels of concrete. Channels shall have a smooth surface free from irregularities. **Note: All invert elevations provided on the Contract Drawings are for the centerline of the channel at the center of the manhole. As detailed there is a ¼” pitch from inlet to outlet.

D. Cut sanitary laterals which will enter above the invert to correct length before installation. Do not chip off after installation. Use Ductile Iron piping for drops.

E. Construct drop inlets of concrete or precast units.

F. Install curb inlets where indicated.

G. Grouting Connections and Joints: After precast units have been placed, reset, raised, etc. and secured, grout all open spaces, including those at connections and joints as follows:
   1. For open joints with seepage, fill with Xypex patch plug hydraulic cement or approved equal. Fill other voids with cement grout.
   2. Shrinkage-resistant grout consisting of premixed compound and water to provide a flowable mixture without segregation or bleeding.
   3. Provide forms or other acceptable methods to retain grout in place until sufficiently hard to support itself. Pack spaces with stiff grout material, tamping until voids are completely filled. Place grout to finish smooth, plumb, and level with adjacent concrete surfaces. Keep grouted joints damp for not less than 24 hours after initial set. Promptly remove grout material from exposed surfaces before it hardens.

END OF SECTION

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SECTION 036000
GROUT

PART 1. GENERAL

1.01 SUMMARY

A. Furnish all labor, materials, equipment and incidentals required to supply and place grout.

1.02 SUBMITTALS

A. Submit product data showing materials of construction and details of installation for:
   1. Commercially manufactured non-shrink cementitious grout. Include catalog cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations and surface preparations.
   2. Cement grout. Include the type and brand of cement, the gradation of fine aggregate, product data on any proposed admixtures and proposed grout mix.

B. Qualifications:
   1. Submit documentation that grout manufacturers have at least 10 years experience in the production and use of the grouts proposed.

C. Review of the submitted materials will not relieve the Contractor of responsibility for the strength, safety, or correctness of methods used.

1.03 REFERENCE STANDARDS (Most Current Edition)

A. American Society for Testing and Materials (ASTM)
   1. ASTM C33 - Standard Specification for Concrete Aggregates
   2. ASTM C150 - Standard Specification for Portland Cement
   3. ASTM C827 - Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.
   4. ASTM C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

B. U.S. Army Corps of Engineers Standard (CRD)
   1. CRD-C621 - Corps of Engineers Specification for Non-shrink Grout

1.04 DELIVERY, HANDLING AND STORAGE

A. Deliver products in original, unopened containers displaying the manufacturer's label with product identification and batch number.

B. Store products in accordance with manufacturer recommendations.

PART 2. PRODUCTS

2.01 NON-SHRINK GROUT

A. Non-shrink cementitious grout shall conform to ASTM C1107, Grade B or C and CRD-C621. Acceptable products are as follows:

1. General purpose non-shrink cementitious grout: SikaGrout 212 by Sika Corp.; Set Grout by Master Builders, Inc.; Euco NS by The Euclid Chemical Co.; NBEC Grout by Five Star Products, Inc. or equal.
2. Flowable non-shrink cementitious grout: Masterflow 928 by Master Builders; Hi-Flow Grout by the Euclid Chemical Co.; SikaGrout 212 by Sika Copr.; Five Star Grout by Five Star Products, Inc. or equal

2.02 CEMENT GROUT

A. A mixture of one part Portland cement conforming to ASTM C150, Types I, II, or III and one to two parts sand conforming to ASTM C33 with sufficient water to place and work grout.

2.03 WATER

A. Potable water

2.04 CONCRETE GROUT

A. Concrete grout shall be concrete as specified in 033000 except with a maximum coarse aggregate size of 3/8".

PART 3. EXECUTION

3.01 PREPARATION

A. Place grout over cured concrete that has obtained full design strength.
B. Concrete surfaces to receive grout shall be clean, free of ice, frost, dirt, grease, oil, laitance, loose material and paint that could affect bonding.
C. Grout shall be applied to a roughen surface.
D. Wash concrete surface and keep moist for 24 hours prior to application of grout. Remove any excess water prior to placement of grout.

3.02 INSTALLATION

A. Mix, apply and cure the grout product in accordance with manufacturer's recommendations and as stated herein.
B. Take precautions to keep temperatures of the receiving concrete and the grout between 40^{o} and 90^{o} F for 24-hours after placement.
C. Place expansion, contraction and isolation joints in the grout when placing grout over such.
D. Add washed pea gravel to cement and non-shrink cementitious grout when depth exceeds 3".
E. Keep grout moist and within recommended temperatures for a minimum of 24-hours after placement. Provide shade if in direct sunlight and wind screens as necessary to prevent excessive evaporation.

END OF SECTION