SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Concrete formwork.

B. Floors and slabs on grade.

C. Concrete footings.

D. Concrete reinforcement.

E. Joint devices associated with concrete work.

F. Miscellaneous concrete elements, including equipment pads.

G. Post-installed anchors

H. Concrete curing.

1.02 RELATED REQUIREMENTS

A. Section 01 45 33 - Special Inspections: Code required special tests and inspections.

B. Section 07 92 00 - Joint Sealants: Products and installation for sealants and joint fillers for saw cut joints and isolation joints in slabs.

C. Section 09 05 61 - Common Work Results for Flooring Preparation: Remediation of slabs with excessive moisture or pH.

1.03 REFERENCE STANDARDS

A. ACI CODE-318 - Building Code Requirements for Structural Concrete and Commentary; 2019 (Reapproved 2022).

B. ACI PRC-211.1 - Selecting Proportions for Normal-Density and High Density-Concrete - Guide; 2022.

C. ACI PRC-302.1 - Guide to Concrete Floor and Slab Construction; 2015.

D. ACI PRC-304 - Guide for Measuring, Mixing, Transporting, and Placing Concrete; 2000 (Reapproved 2009).

E. ACI PRC-305 - Guide to Hot Weather Concreting; 2020.

F. ACI PRC-306 - Guide to Cold Weather Concreting; 2016.

G. ACI PRC-308 - Guide to External Curing of Concrete; 2016.

H. ACI PRC-347 - Guide to Formwork for Concrete; 2014 (Reapproved 2021).

I. ACI SPEC-117 - Specification for Tolerances for Concrete Construction and Materials; 2010 (Reapproved 2015).

J. ACI SPEC-301 - Specifications for Concrete Construction; 2020.

K. ACI 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary; American Concrete Institute; 2019

L. ACI 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary; American Concrete Institute; 2019

M. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement; 2022.

N. ASTM A1064/A1064M - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete; 2022.

O. ASTM C138/C138M - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete; 2023.

P. ASTM C172/C172M - Standard Practice for Sampling Freshly Mixed Concrete; 2017.

Q. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field; 2024.

R. ASTM C33/C33M - Standard Specification for Concrete Aggregates; 2023.

S. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; 2023.

T. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete; 2024.

U. ASTM C138/C138M - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete; 2017.

V. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic-Cement Concrete; 2020.

W. ASTM C150/C150M - Standard Specification for Portland Cement; 2022.

X. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete; 2020.

Y. ASTM C172/C172M - Standard Practice for Sampling Freshly Mixed Concrete; 2017.

Z. ASTM C231/C231M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; 2014.

AA. ASTM C260/C260M - Standard Specification for Air-Entraining Admixtures for Concrete; 2010a (Reapproved 2016).

AB. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete; 2019, with Editorial Revision (2022).

AC. ASTM C618 - Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete; 2023, with Editorial Revision.

AD. ASTM C881/C881M - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete; 2020a.

AE. ASTM C1059/C1059M - Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete; 2021.

AF. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete; 2012.

AG. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink); 2020.

AH. ASTM C1315 - Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete; 2019.

AI. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Asphalt Types); 2023.

AJ. ASTM E154/E154M - Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover; 2008a (Reapproved 2019).

AK. ASTM C 1602/C1602M - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete; 2012

AL. ASTM E1643 - Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs; 2018a.

AM. ASTM E1745 - Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs; 2017 (Reapproved 2023).

1.04 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Convene one week before starting work of this section. At least the following shall be in attendance at the meeting: Contractor's superintendent, testing agency responsible for concrete mix design, ready mix concrete manufacturer, concrete subcontractor, floor finishing subcontractor, independent testing agency, special inspector, architect engineer construction administrator, and the structural engineer of record.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Product Data: Submit manufacturers' data on manufactured products showing compliance with specified requirements and installation instructions.
   1. For curing compounds, provide data on method of removal in the event of incompatibility with floor covering adhesives.

C. Mix Design: Submit proposed concrete mix designs.
   1. Indicate proposed mix designs complies with requirements of ACI 301, Section 4 - Concrete Mixtures.
   2. Submit mix design for each concrete mix including test results documenting average compressive strength in accordance with ACI 301. Submit alternate design mixtures when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments. Include manufacturer's data for admixtures included in the mix. Include suppliers data and tests for aggregates and cementitious materials including portland cement, fly ash, and ground granulated blast-furnace slag as applicable.
      a. Indicate amounts of mixing water to be withheld for later addition at Project site.

D. Samples: Submit samples of underslab vapor retarder to be used.

E. Test Reports: Submit report for each test or series of tests specified.

F. Manufacturer's Installation Instructions: For concrete accessories, indicate installation procedures and interface required with adjacent construction.

G. Project Record Documents: Accurately record actual locations of embedded utilities and components that will be concealed from view upon completion of concrete work.

H. Concrete Delivery Ticket: Submit a sample concrete delivery ticket in accordance with the requirements of ANSI/ASTM C94-03a "Standard Specification for Ready-Mix Concrete."

I. Concrete Test Results: Submit copies of all concrete test results signed by the testing laboratory.

J. Concrete Installers and Finishers Qualifications: Submit documentation for ACI certification for concrete flatwork finishers.

K. Testing Agency Qualifications: Submit qualifications for testing laboratory including certification for field testing technicians and laboratory testing technicians.

1.06 QUALITY ASSURANCE

A. Perform work of this section in accordance with ACI SPEC-301 and ACI CODE-318.
   1. Maintain at least one copy of each document on site.

B. Follow recommendations of ACI PRC-305 when concreting during hot weather.

C. Follow recommendations of ACI PRC-306 when concreting during cold weather.

D. Testing Agency Qualifications: an independent testing and inspection lab, acceptable to the Architect/Engineer, shall perform specified tests and inspections. The testing lab shall be qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
   2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

E. Concrete Manufacturer: Furnish concrete from a plant complying with the requirements of ASTM C94, Sections 8 & 9 with a current certificate from the National Ready Mixed Concrete Association.

F. Mix Design Engineer: Licensed to practice engineering in the state where the project is located with a minimum of 3 years experience in preparing concrete mix designs.

G. Cooperate with the Testing Agency and any special inspectors and provide them with free access to the work.

H. The testing agency shall verify the correct concrete mix design is being provided at the ready mix plant prior to going to the job site.

I. For floor slabs, verify concrete admixtures and sealants used are compatible with the applicable designated floor coverings and adhesives.

1.07 WARRANTY

A. See Section 01 78 00 - Closeout Submittals for additional warranty requirements.

PART 2 PRODUCTS

2.01 FORMWORK

A. Formwork Design and Construction: Comply with guidelines of ACI PRC-347 to provide formwork that will produce concrete complying with tolerances of ACI SPEC-117.

B. Form Materials: Contractor's choice of standard products with sufficient strength to withstand hydrostatic head without distortion in excess of permitted tolerances.
   1. Form Facing for Exposed Finish Concrete: Contractor's choice of materials that will provide smooth, stain-free final appearance.
   2. Earth Cuts: Do not use earth cuts as forms for vertical surfaces. Natural rock formations that maintain a stable vertical edge may be used as side forms.
   3. Form Coating: Release agent that will not adversely affect concrete or interfere with application of coatings.

2.02 REINFORCEMENT MATERIALS

A. Reinforcing Steel: ASTM A615/A615M, Grade 60 (60,000 psi) (420 MPa).
   1. Type: Deformed billet-steel bars.
   2. Finish: Unfinished, unless otherwise indicated.

B. Steel Welded Wire Reinforcement (WWR): Galvanized, plain type, ASTM A1064/A1064M.
   1. Form: Coiled Rolls.
   2. WWR Style: As indicated on drawings.

C. Reinforcement Accessories:
   1. Tie Wire: Annealed, minimum 16 gauge, 0.0508 inch (1.29 mm).
   2. Chairs, Bolsters, Bar Supports, Spacers: Sized and shaped for adequate support of reinforcement during concrete placement.

2.03 CONCRETE MATERIALS

A. Cement: ASTM C150/C150M, Type I - Normal Portland type.
   1. Acquire cement for entire project from same source.

B. Fine and Coarse Aggregates: ASTM C 33, Class 3M.
   1. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials. Stockpile aggregates in a manner that will prevent segregation or contamination with other materials or other size aggregates. Alkali-Silica Reactive (ASR) aggregates are not allowed.

C. Fly Ash: ASTM C618, Class C or F.

D. Water: Potable, clean and not detrimental to concrete, conforming to ASTM C 1602/C1602M.

2.04 ADMIXTURES

A. Chemical Admixture:
   1. Manufacturers:

a. Euclid.
b. Sika.
c. WR Grace.
d. BASF Masterbuilders.
e. Substitutions: See Section 01 60 00 - Product Requirements.

B. Do not use chemicals that will result in soluble chloride ions in excess of 0.1 percent by weight of cement.

C. Air Entrainment Admixture: ASTM C260/C260M.

D. High Range Water Reducing and Retarding Admixture: ASTM C494/C494M Type G.

E. High Range Water Reducing Admixture: ASTM C494/C494M Type F.

F. Water Reducing and Accelerating Admixture: ASTM C494/C494M Type E.

G. Water Reducing and Retarding Admixture: ASTM C494/C494M Type D.

H. Accelerating Admixture: ASTM C494/C494M Type C.

I. Retarding Admixture: ASTM C494/C494M Type B.

J. Water Reducing Admixture: ASTM C494/C494M Type A.

K. Store admixtures to avoid contamination, evaporation, or damage. Protect liquids from freezing or other adverse temperatures. Agitate all admixtures used in form of suspension or non stable solutions prior to use. Follow manufacturer's directions.

2.05 ACCESSORY MATERIALS

A. Underslab Vapor Retarder: Complying with ASTM E1745, Class A; with a water vapor permeance ratings of 0.01 perms or less when tested in accordance with ASTM E 154 and stated by manufacturer as suitable for installation in contact with soil or granular fill under concrete slabs. The use of single ply polyethylene is prohibited.

B.
1. Accessory Products: Vapor retarder manufacturer's recommended tape, adhesive, mastic, prefabricated boots, etc., for sealing seams and penetrations.
   a. Where void forms are used, use tape which also mechanically bonds the vapor retarder to the bottom of the concrete slab, per the manufacturer's instructions.
2. Products:
   a. Henry Company; Moistop Ultra 15: www.henry.com/#sle.
   b. ISI Building Products; Viper VaporCheck II 15-mil (Class A): www.isibp.com/#sle.
   c. Poly-America; Husky Yellow Guard Class A 15-mil Vapor Barrier: www.yellowguard.com/#sle.
   d. Stego Industries, LLC; Stego Wrap Vapor Barrier (15-mil): www.stegoindustries.com.
   e. W. R. Meadows, Inc; PERMINATOR Class A - 15 mils (0.38 mm): www.wrmeadows.com/#sle.
   f. Viaflex; VaporBlock VB15: www.viaflex.com
   g. Substitutions: See Section 01 60 00 - Product Requirements.

C. Capillary Water Barrier/Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 1-1/2 inch sieve and 0 to 5 percent passing a No. 8 sieve.

D. Post-Installed Anchors
1. Mechanical Anchors: Tested and qualified for use in accordance with ACI 355.2 and ICC-ES AC193 for cracked and uncracked concrete recognition. Acceptable products include:
   a. SIMPSON STRONG-TIE "TITEN-HD" and "TITEN HD ROD HANGER" (ICC-ES ESR-2713)
   b. SIMPSON STRONG-TIE "STAINLESS STEEL TITEN-HD" (IAPMO UES ER-493)
   c. SIMPSON STRONG-TIE "STRONG-BOLT 2" (ICC-ES ESR-3037)

d. HILTI "KWIK HUS-EZ" and "KWIK HUS-EZ I" SCREW ANCHOR (ICC-ES ESR-3027)
e. HILTI "KWIK BOLT-TZ" EXPANSION ANCHOR (ICC-ES ESR 1917)
f. HILTI "HDA UNDERCUT" (ICC-ES ESR-1546)
g. HILTI "HSL-3" EXPANSION ANCHOR (ICC-ES ESR-1545)
h. DEWALT "POWER-STUD+ SD1" (ICC-ES ESR-2818)
i. DEWALT "POWER-STUD+ SD2, SD4 or SD6" (ICC-ES ESR-2502)
j. DEWALT "SCREW-BOLT+" (ICC-ES ESR-3989)
k. DEWALT CCU+ (ICC-ES ESR 4810)
l. DEWALT SNAKE+ (ICC-ES ESR 2272)
m. DEWALT MINI UNDERCUT+ (ICC-ES ESR 3912)
n. DEWALT HANGER-MATE+(ICC-ES ESR 3889)

2. Adhesive Anchors: Tested and qualified for use in accordance with ACI 355.4 and ICC-ES AC308 for cracked and uncracked concrete recognition. Acceptable products include:
a. SIMPSON STRONG-TIE "SET-3G" (ICC-ES ESR-4057)
b. SIMPSON STRONG-TIE "AT-3G" (ICC-ES ESR-5026)
c. HILTI "HIT-HY 200 SAFESET FAST CURE" (ICC-ES ESR-3187)
d. HILTI "HIT-RE 500-SD SLOW CURE" (ICC-ES ESR-2322)
e. DEWALT "AC200+" (ICC-ES ESR-4027)
f. DEWALT "PURE 110+" (ICC-ES ESR-3928)
g. Steel anchor element shall be Hilti HAS-E, ASTM F1554 Grade 36, or ASTM A193, Grade B6, B8, or B8M continuously threaded rod.

3. Substitution requests for products other than those specified shall be submitted by the Contractor to the Architect Engineer along with calculations that are prepared and sealed by a registered professional engineer licensed in the State in which the project is located. The calculations shall demonstrate that the substituted product is capable of achieving the pertinent equivalent performance values (minimum) of the specified product using the appropriate design procedures and/or standard(s) as required by the building code.

E. Steel-Reinforced Plastic Trowel Blades for use at Decorative Exposed Surfaces.
1. Manufacturers:
a. Wagman Metal Products; Poly Pro reinforced trowel blades; www.wagmanmetal.com/#sle.
b. Substitutions: See Section 01 60 00 - Product Requirements.

2.06 BONDING AND JOINTING PRODUCTS

A. Latex Bonding Agent: Non-redispersable acrylic latex, complying with ASTM C1059/C1059M, Type II.

B. Epoxy Bonding System:
1. Complying with ASTM C881/C881M and of Type required for specific application.

C. Slab Isolation Joint Filler: 1/2-inch (13 mm) thick, height equal to slab thickness, with removable top section forming 1/2-inch (13 mm) deep sealant pocket after removal.
1. Material: ASTM D1751, cellulose fiber.

D. Slab Construction Joint Devices: Combination keyed joint form and screed, galvanized steel, with rectangular or round knockout holes for conduit or rebar to pass through joint form at 6 inches (150 mm) on center; ribbed steel stakes for setting.
1. Provide removable or non-removable plastic cap based on slab exposure, floor finish and manufacturer's recommendations. Removable plastic caps shall form a minimum 3/8" wide by 1/2" deep void for sealant.
2. Height: To suit slab thickness.

E. Sealant and Primer: As specified in Section 07 92 00 - Joint Sealants.

F. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 or aromatic polyurea with a Type A shore durometer hardness range of 90 to 95, according to ASTM D 2240.

2.07 CURING MATERIALS

A. Evaporation Reducer: Liquid thin-film-forming compound that reduces rapid moisture loss caused by high temperature, low humidity, and high winds; intended for application immediately after concrete placement.
   1. Products:
      a. Dayton Superior Corporation; AquaFilm: www.daytonsuperior.com/#sle.
      b. Euclid Chemical Company ; EUCOBAR: www.euclidchemical.com/#sle.
      c. SpecChem, LLC; SpecFilm Concentrate or SpecFilm: www.specchemllc.com/#sle.
      d. W. R. Meadows, Inc; Evapre or Evapre-RTU: www.wrmeadows.com/#sle.
      e. Substitutions: See Section 01 60 00 - Product Requirements.

B. Curing and Sealing Compound, High Gloss: Liquid, membrane-forming, clear, nonyellowing acrylic; complying with ASTM C1315 Type 1 Class A.
   1. Application: Use at concrete slabs exposed in final construction.
   2. A minimum of 2 coats are required. The first coat for curing and the second coat for sealing after all construction debris is removed.
   3. Vehicle: Solvent-based.
   4. Solids by Mass: 25 percent, minimum.
   5. VOC Content: Ozone Transport Commission (OTC) compliant.

C. Moisture-Retaining Sheet: ASTM C171.
   1. Regular curing paper, white curing paper, clear polyethylene, white polyethylene, or white burlap-polyethylene sheet.

D. Water: Potable, not detrimental to concrete.

2.08 CONCRETE MIX DESIGN

A. Proportioning Normal Weight Concrete: Comply with ACI PRC-211.1 recommendations.

B. Concrete Strength: Establish required average strength for each type of concrete on the basis of field experience or trial mixtures, as specified in ACI SPEC-301.
   1. For trial mixtures method, employ independent testing agency acceptable to Architect Engineer for preparing and reporting proposed mix designs.
   2. Test reports verifying the concrete strength must be submitted with mix designs for approval.

C. Admixtures: Add acceptable admixtures as recommended in ACI PRC-211.1 and at rates recommended or required by manufacturer.

D. For floor slabs, verify components of mix design are compatible with the flooring materials and adhesives.

E. Normal Weight Concrete:
   1. Water-Cement Ratio: As indicated in Concrete Mixture Schedule.
   2. Air Content, when determined in accordance with ASTM C231: As indicated in Concrete Mixture Schedule for mixes where Air-entrainment is required.
   3. Maximum Slump: As indicated in Concrete Mixture Schedule before the addition of any water reducing admixture, but no more than 8 inches after the addition of any water reducing admixture. Higher slumps may be acceptable in self consolidating concrete or flowing concrete applications with the approval of the Architect Engineer.
   4. Maximum Aggregate Size: As indicated in Concrete Mixture Schedule.
   5. Fly Ash Content: Fly Ash shall not be used in concrete for slabs. Maximum 25 percent of cementitious materials by weight for other concrete.
   6. Water-Cement Ratio: As indicated in Concrete Mixture Schedule.
   7. Maximum Aggregate Size: As indicated in Concrete Mixture Schedule.

2.09 MIXING

A. Transit Mixers: Comply with ASTM C94/C94M.

B. Adding Water: If concrete arrives on-site with slump less than suitable for placement, do not add water that exceeds the maximum water-cement ratio or exceeds the maximum permissible slump.

C. Mixing Time: Mix and place concrete within 1 1/2 hours of initial batching of the concrete. When the air temperature is between 85 and 90 degrees F reduce the maximum time between batching and placing the concrete to 75 minutes. When the air temperature is above 90 degrees F reduce the batching and placing time to 60 minutes. Longer mix times may be possible with the use of appropriate admixtures but only with written approval of admixture manufacturer(s) and Architect/Engineer.

D. Addition of Water at Job Site: Unless the delivery ticket states the amount of water that can be added without exceeding the design water cement ratio and the slump of the mix, water cannot be added at the job site. Addition of water above the design water/cement ratio shall be cause for rejection of the concrete.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify lines, levels, and dimensions before proceeding with work of this section.

3.02 PREPARATION

A. Formwork: Comply with requirements of ACI SPEC-301. Design and fabricate forms to support all applied loads until concrete is cured and for easy removal without damage to concrete.

B. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete. Chamfer exterior corners and edges of permanently exposed concrete. Comply with Division 1 requirements for certified wood used for formwork and disposal of construction waste.

C. Coordinate placement of embedded items with erection of concrete formwork and placement of form accessories.

D. Where new concrete is to be bonded to previously placed concrete, prepare existing surface by cleaning and applying bonding agent in according to bonding agent manufacturer's instructions.
   1. Use epoxy bonding system for bonding to damp surfaces, for structural load-bearing applications, and where curing under humid conditions is required.
   2. Use latex bonding agent only for non-load-bearing applications.

E. Interior Slabs: Install vapor retarder under interior slabs per ASTM E 1643 and the manufacturer's written instructions. Lap joints minimum 6 inches (150 mm). Seal joints, seams and penetrations watertight with manufacturer's recommended products and follow manufacturer's written instructions. Use manufacturer's recommended pipe boot and tape to seal vapor retarder to all pipes, conduits, and other elements that penetrate slabs-on-grade. Repair damaged vapor retarder before covering per manufacturer's instructions. Where slab is poured over void forms, mechanically bond the vapor retarder to the underside of the slab with textured tape per manufacturer's instructions.
   1. Extend vapor retarder over footings and seal to foundation wall, grade beam, or slab at an elevation consistent with the top of the slab or terminate at impediments such as water stops or dowels. Seal around penetrations such as utilities and columns in order to create a monolithic membrane between the surface of the slab and moisture sources below the slab as well as at the slab perimeter.
   2. Vapor Retarder Over Granular Fill: Install compactible granular fill before placing vapor retarder as indicated on drawings. Do not use sand.

3.03 INSTALLING REINFORCEMENT AND OTHER EMBEDDED ITEMS

A. Comply with requirements of ACI SPEC-301. Clean reinforcement of loose rust and mill scale, and accurately position, support, and secure in place to achieve not less than minimum concrete coverage required for protection.

B. Install welded wire reinforcement in maximum possible lengths, and offset end laps in both directions. Splice laps with tie wire.

C. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not interfere with concrete placement.

3.04 PLACING CONCRETE

A. Do not add water to concrete during delivery at Project site unless amount that can be added without exceeding the water/cement ratio is stated on the delivery ticket. If water is allowed to be added it must be introduced and mixed inside the transit mixer drum for 5 minutes or 70 revolutions before the concrete leaves the truck.

B. Place concrete in accordance with ACI PRC-304.
   1. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301. Do not use vibrators to transport concrete inside of forms.

C. Place concrete for floor slabs in accordance with ACI PRC-302.1.
   1. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel of section is complete. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.

D. Notify Architect not less than 24 hours prior to commencement of placement operations.

E. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

F. Ensure reinforcement, inserts, waterstops, embedded parts, and formed construction joint devices will not be disturbed during concrete placement.

G. Place concrete continuously without construction (cold) joints wherever possible; where construction joints are necessary, before next placement prepare joint surface by removing laitance and exposing the sand and sound surface mortar, by sandblasting or high-pressure water jetting.

H. Finish floors level and flat, unless otherwise indicated, within the tolerances specified below.

I. Cold Weather: When the temperature is below 40 degrees F maintain concrete temperature between 50 and 70 degrees F for the required curing period. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials. Do not use calcium chloride, salt, or other materials containing antifreeze agents. Do not use chemical accelerators unless approved by the Architect/Engineer and included in the mix designs. Follow recommendations of ACI 306R.

J. Hot Weather: When the temperature is over 85 degrees F, maintain the concrete below 90 degrees F at the time of placement. Make arrangements for installation of windbreaks, shading, fog spraying, sprinkling, ponding, or other protective measures to protect the concrete. Fog spray forms, steel reinforcement, and subgrade just before placing concrete. Keep the subgrade uniformly moist without standing water, soft spots, or dry areas. Follow recommendations of ACI 305R.

3.05 SLAB JOINTING

A. Locate joints as indicated on drawings.

B. Anchor joint fillers and devices to prevent movement during concrete placement.

C. Isolation Joints: Use preformed joint filler with removable top section for joint sealant, total height equal to thickness of slab, set flush with top of slab.

1. Install wherever necessary to separate slab from other building members, including columns, walls, equipment foundations, footings, stairs, manholes, sumps, and drains.

D. Load Transfer Construction and Contraction Joints: Install load transfer devices as indicated; saw cut joint at surface as indicated for contraction joints.
   1. Form weakened-plane contraction joints in layout indicated. Provide keyed joints at construction joints and where indicated. Other joints may be keyed joints or sawn joints.

E. Saw Cut Contraction Joints: Saw cut joints before concrete begins to cool, within 4 to 12 hours after placing; use 3/16 inch (5 mm) thick blade and cut at least 1 inch (25 mm) deep but not less than one quarter (1/4) the depth of the slab.
   1. Saw joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints in concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

F. Construction Joints: Where not otherwise indicated, use metal combination screed and key form, with removable top section for joint sealant. Install per manufacturer's recommendations.

3.06 FLOOR FLATNESS AND LEVELNESS TOLERANCES

A. An independent testing agency, as specified in Section 01 40 00 - Quality Requirements, will inspect finished slabs for conformance to specified tolerances.

B. Maximum Variation of Surface Flatness:
   1. Exposed Concrete Floors: 1/8 inch (3 mm) in 10 feet (3 m).
   2. Under Seamless Resilient Flooring: 1/8 inch (3 mm) in 10 feet (3 m).

C. Correct the slab surface if tolerances are less than specified.

D. Correct defects by grinding or by removal and replacement of the defective work. Areas requiring corrective work will be identified. Re-measure corrected areas by the same process.

3.07 JOINTS - OTHER THAN SLABS

A. General: Construction joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect/Engineer.
   1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
   2. Form keyed joints as indicated.
   3. Locate joints for beams, slabs, joists, and girders in the middle third of spans.
   4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
   5. Space vertical joints in walls as indicated or at 20 foot maximum on center if not indicated.
   6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

3.08 WATERSTOPS

A. Flexible Waterstops: Install in construction joints and at other joints where indicated to form a continuous diaphragm. Install in longest lengths practical. Support and protect waterstops during progress of the work. Field fabricate joints in waterstops according to manufacturer's written instructions.

B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's instructions, adhesive bonding, mechanically fastening, and firmly pressing into place. Install in longest lengths practical.

3.09 CONCRETE FINISHING

A. Repair surface defects, including tie holes, immediately after removing formwork.

B. Unexposed Form Finish: Rub down or chip off fins or other raised areas 1/4 inch (6 mm) or more in height.

C. Concrete Slabs: Finish to requirements of ACI PRC-302.1 and as follows:
   1. Surfaces to Receive Thin Floor Coverings: "Light steel-troweled" as described in ACI 302.1R; thin floor coverings include carpeting, resilient flooring, seamless flooring, thin set quarry tile, and thin set ceramic tile.
   2. Other Surfaces to Be Left Exposed: Trowel as described in ACI PRC-302.1, minimizing burnish marks and other appearance defects.

3.10 CURING AND PROTECTION

A. Comply with requirements of ACI PRC-308. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.

B. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
   1. Normal concrete: Not less than seven days.

C. Formed Surfaces: Cure by moist curing with forms in place for full curing period.

D. Slabs scheduled to receive Adhesive-Applied Flooring or other moisture sensitive flooring: Slab shall be cured by being covered with moisture retaining sheets (curing paper, polyethylene, or a combination of the two) for 3 to 7 days. Slabs shall not be cured by adding water. Curing compounds are not allowed.
   1. Floor slabs shall meet the requirements of Section 090561 prior to installation of floor coverings.

E. Slabs on grade exposed in final construction, not subject to wheel traffic (such as forklifts or pallet jacks) and not scheduled to receive stain: Curing shall be by a curing and sealing compound.
   1. Curing and sealing compound: Apply uniformly to floors and slabs in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during the curing period. Clean the top of the slab and provide a final coat to seal the slab before the final acceptance by the owner.

F. Protection of work: Protect all work from damage from concreting operations. Protect completed concrete as follows:
   1. Finished Surfaces: Protect from damage from rain. Keep surfaces clean and free from oil, grease, dirt, or other foreign matter and protect from damage by construction equipment, materials, etc. Do not permit heavy traffic on finished floor for a minimum of 7 days after it is placed. Install barriers and if necessary maintain a watchman to enforce this requirement. Do not cut pipe on slabs to be exposed in final construction. Diaper all equipment working over slabs to receive stain to prevent oil leakage.
   2. Protection of Footings Against Freezing: Cover completed work at footing level with sufficient temporary or permanent cover as required to protect footings and adjacent subgrade against possibility of freezing; maintain cover for time period as necessary.

3.11 REMOVAL AND REUSING FORMS

A. Removal of forms:
   1. Formwork not supporting the weight of the concrete, such as sides of beams, walls, column, and other similar part of the work, may be removed after cumulatively curing at not less than 50 degrees F for 24 hours after placing concrete provided the concrete is sufficiently hard to not be damaged by form removal operations, and provided curing and protection operations are maintained.
   2. Formwork supporting the weight of the concrete, such as beam, soffits, and slabs, may not be removed in less than 14 days after the concrete is placed and until concrete has attained 80 percent of its minimum compressive strength at 28 days.

B. Reusing forms:

1. Clean and repair surfaces of forms to be reused in work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable for exposed surfaces. Apply new form release agent.
2. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by the Architect/Engineer.

3.12 MISCELLANEOUS CONCRETE ITEMS

A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as here-in specified, to blend with in-place construction.

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

C. Equipment Bases And Foundations: Provide machine and equipment bases and foundations as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnished machines and equipment.

D. Post-installed anchors:
1. Shall only be used where specified on the construction documents. The contractor shall obtain approval from the Architect/Engineer prior to installing post-installed anchors in place of missing or misplaced cast-in-place anchors.
2. Care shall be taken in placing post-installed anchors to avoid conflicts with existing rebar.
3. Hole shall be drilled and cleaned in accordance with the manufacturer's written instructions.
4. Provide continuous or periodic inspection for all adhesive and mechanical anchors per the product's applicable ICC-ES Evaluation Report (ICC-ES ESR) OR IAPMO UES EVALUATION REPORT (IAPMO UES ER).
5. Contact manufacturer's representative for the initial training for installation of and for product related questions and availability. Call SIMPSON STRONG-TIE at (800) 999-5099. Call HILTI at (800) 423-6587. Call DEWALT at (800) 524-3244.
6. The contractor shall arrange an anchor manufacturer's representative to provide on-site installation training for all of their anchoring products specified. The Architect Engineer must receive documented confirmation that all of the contractor's personnel who install anchors are trained prior to the commencement of installing anchors.

3.13 JOINT FILLER

A. Slab on Grade Control Joint Filler: At keyed construction joints, sawn joints, and tooled joints fill the control joint as follows:
1. Slabs exposed to view in final construction: Remove the cap at keyed control joints, clean the joint and fill the void with semi-rigid joint filler. Install in accordance with manufacturer's written instructions.
2. Slabs to be covered with tile: Remove the cap at keyed control joints, clean the joint, and fill the joint and any spalls or other slab imperfections with non-shrink grout or a concrete patching material a minimum of 56 days after the slab has been poured.
3. Slabs to be covered with carpet: Leave the cap at keyed control joints. Do not fill the joint except where the joint is greater than 1/8" in width and as required to fill spalls and other imperfections in the slab that may damage or show through the carpet. Clean the spall and joint in those areas and fill with non-shrink grout or a concrete patching material.

3.14 FIELD QUALITY CONTROL

A. An independent testing agency shall perform field quality control tests, as specified in Section 014533 - Special Inspections.

B. Provide free access to concrete operations at project site and cooperate with appointed firm.

C. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of concrete operations.

D. The testing agency shall verify the correct concrete mix design is being provided at the ready mix plant prior to going to the job site.

E. Tests of concrete and concrete materials may be performed at any time to ensure compliance with specified requirements.

F. Concrete Test Samples: Samples for acceptance tests on concrete shall be obtained in accordance with ASTM C172C172M.

G. Compressive Strength Tests: ASTM C39/C39M.
   1. Make and cure test specimen in accordance with ASTM C31/C31M.
   2. Samples for strength tests of each class of concrete placed each day shall be taken not less than once a day, nor less than once for each 150 cu yd of concrete, nor less than once for each 5000 sq ft of surface area for slabs or walls
   3. A strength test shall be the average of the strengths of at least two 6 by 12 in. cylinders or at least three 4 by 8 in. cylinders made from the same sample of concrete and tested at 7 and 28 days. Test additional cylinders at 56 days if the average 28 day strength is less than the specified design strength.
   4. Take one additional test cylinder set during cold weather concreting, cured on job site under same conditions as concrete it represents.

H. Perform one slump test for each set of test cylinders taken, following procedures of ASTM C143/C143M.

I. Perform one air content test in accordance with ASTM C231C231M for each strength test of concrete.

J. Determine temperature of concrete sample for each strength test in accordance with ASTM C1064/C1064M.

K. Determine density (unit weight) and yield of concrete sample for each strength test in accordance with ASTM C138/C138M.

3.15 DEFECTIVE CONCRETE

A. Test Results: The testing agency shall report test results in writing to Architect and Contractor within 24 hours of test.

B. Defective Concrete: Concrete not complying with required lines, details, dimensions, tolerances or specified requirements.

C. Repair or replacement of defective concrete will be determined by the Architect. The cost of additional testing shall be borne by Contractor when defective concrete is identified.

D. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Architect for each individual area.

E. Repair of Formed Surfaces: Surface defects include color and texture irregularities, crack, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. Cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension in solid concrete. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush coat holes and voids with bonding agent. Fill and compact with patching mortar before the bonding agent has dried. Remove and replace concrete defective surfaces if defects cannot be repaired to satisfaction of Architect/Engineer.

F. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surfaced plan to tolerances specified for each surface and finish. Correct high areas by grinding after concrete has cured at least 14 days. Correct low areas immediately after completion of surface finishing operations by cutting out low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete.

3.16 PROTECTION

A. Do not permit traffic over unprotected concrete floor surface until fully cured.

3.17 CONCRETE MIXTURE SCHEDULE

A. Use: Footings
   1. Compressive Strength (fc) Minimum at 28 Days, PSI: 3500
   2. Aggregate Size Maximum, inches (Note: 1): 1-1/2
   3. Slump Limit, inches: 4
   4. Water to Cement (w/c) Ratio Maximum: 0.48
   5. Air Content, percent: None

B. Use: Interior Slab-on-Grade
   1. Compressive Strength (fc) Minimum at 28 Days, PSI: 3500
   2. Aggregate Size Maximum, inches (Note: 1): 1
   3. Slump Limit, inches: 4
   4. Water to Cement (w/c) Ratio Maximum: 0.45 (0.40 at slabs with floor coverings)
   5. Air Content, percent: None

C. Use: Exterior Slabs and Pads
   1. Compressive Strength (fc) Minimum at 28 Days, PSI: 4500
   2. Aggregate Size Maximum, inches (Note: 1): 1
   3. Slump Limit, inches: 4
   4. Water to Cement (w/c) Ratio Maximum: 0.45
   5. Air Content, percent: 6
   6. Floor/Slab Finish: Broom finish

D. Notes:
   1. Maximum size of coarse aggregates: Comply with ACI 301 for minimum clearance between reinforcing bars, sides of forms, and slab or topping thickness (except in unbonded topping maximum aggregate size shall not exceed one-quarter topping thickness).
   2. Air Content, when determined in accordance with ASTM C231: As indicated in Concrete Mixture Schedule for mixes where Air-entrainment is required.
   3. Maximum Slump: As indicated in Concrete Mixture Schedule before the addition of any water reducing admixture, but no more than 8 inches after the addition of any water reducing admixture. Higher slumps may be acceptable in self consolidating concrete or flowing concrete applications with the approval of the Architect Engineer.

END OF SECTION