

## SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section specifies cast-in place concrete, including, but not limited to, concrete materials, mixture design, placement procedures, joints, joint fillers and finishes, for the following:

1. Footings.
2. Grade beams.
3. Foundation walls.
4. Retaining walls.
5. Slabs-on-grade.
6. Elevated slabs.
7. Concrete toppings.
8. Columns and pilasters.
9. Granular base and vapor barrier beneath slab-on-grade.
10. Grout for baseplates and bearing plates.
11. Fill for steel pan stairs.
12. Equipment bases and curbs.

- B. Related Work Specified in Other Sections:

- |                                    |                  |
|------------------------------------|------------------|
| 1. Submittals                      | Division 01      |
| 2. Quality Control                 | Division 01      |
| 3. Sustainability                  | Division 01      |
| 4. Concrete Formwork               | Section 03 10 00 |
| 5. Concrete Reinforcing            | Section 03 20 00 |
| 6. Post-Installed Anchors          | Section 05 05 19 |
| 7. Steel Decking                   | Section 05 31 00 |
| 8. Thermal and moisture protection | Division 07      |
| 9. Concrete Paving                 | Item P-501       |

#### 1.2 UNIT PRICES

- A. Work of this Section is affected by unit prices for concrete specified in Division 01 Section "Unit Prices."

#### 1.3 REFERENCES

- A. Definitions:

1. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.
2. Carbon dioxide mineralization: Active carbonation treatment of concrete during mixing such that the recycled carbon dioxide (CO<sub>2</sub>) that is injected during mixing is mineralized (i.e. chemically converted into a mineral) within the concrete.

3. Carbonation treatment: Active introduction of CO<sub>2</sub> into the concrete pore fluid which reacts with calcium from calcium hydroxide and calcium silicate hydrate to form calcite (CaCO<sub>3</sub>).
  4. Exposed to View: Readily apparent to the public in normal use of the structure. A view distance of 20 feet (6 m) is consistent with the intent of this definition.
  5. SER: Structural Engineer of Record.
  6. Structural Drawings: "S" series drawings of the Contract Documents.
  7. NWC: Normal weight concrete.
  8. LWC: Lightweight concrete.
- B. Building Code: Concrete work shall conform to the requirements of the Building Code identified on the Structural General Notes, and OSHA requirements, except where more stringent conditions or criteria occur in the standards referenced below and the Contract Documents.
- C. Standards: Where the applicable year of adoption or revision is not listed below, nor listed in the Building Code chapter, "Referenced Standards", the latest edition applies, including supplements and addenda.
1. American Concrete Institute, "ACI Manual of Concrete Practice," various committee reports as referenced herein.
  2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
  3. ACI 301, "Specifications for Structural Concrete."
  4. ACI 318, "Building Code Requirements for Structural Concrete."
  5. ACI SP-66, "ACI Detailing Manual."
  6. Concrete Reinforcing Steel Institute, CRSI MSP, "Manual of Standard Practice."
  7. American Society for Testing and Materials, ASTM, various standards as referenced.
  8. American Association of State Highway and Transportation Officials, AASHTO T259, "Method of Test for Resistance of Concrete to Chloride Ion Penetration."
  9. AASHTO T277, "Standard Method of Test for Rapid Determination of the Chloride Permeability of Concrete."
  10. AASHTO T318, "Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying."
  11. Evaluation Reports: Where designated in this Section, products shall have an active Evaluation Report evidencing compliance with provisions of the Building Code. Reports by ICC-ES Evaluation Service, Inc. or IAPMO-UES are acceptable.

#### **1.4 COORDINATION**

- A. Coordinate the Work of this Section with the Work of other Sections.

#### **1.5 ADMINISTRATIVE REQUIREMENTS**

- A. Pre-installation Meeting: Conduct meeting at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."
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. Installer.
    - d. Manufacturer (Ready-mix concrete producer).
    - e. Owner's Testing and Inspecting Agency.

2. Before submitting concrete design mixtures, review concrete design mixtures and examine procedures for ensuring quality of concrete materials.
3. Review methods and procedures related to cast-in-place including, but not limited to, the following:
  - a. Vapor barrier installation.
  - b. Concrete placement.
  - c. Cold- and hot-weather concreting procedures.
  - d. Concrete finishes and finishing.
  - e. Curing procedures.
  - f. Thermal control plan for mass concrete.
  - g. Construction, contraction, and isolation joints.
  - h. Joint-filler strips and semirigid joint fillers.
  - i. Concrete protection.
  - j. Review special inspection and testing and inspecting agency procedures.
  - k. Location of concrete sampling.
  - l. Storage of compression test specimens at site and transportation to laboratory.
  - m. Floor and slab flatness and levelness measurement.
- B. Minutes of the meeting shall be recorded, typed and distributed by the Contractor to all parties listed above within 5 working days of the meeting. Distribute additional copies to the following:
  1. Owner's Representative.
  2. Architect.

## **1.6 CONTRACTOR QUALIFICATIONS**

- A. Manufacturer: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
  1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
  2. Individual with responsibility for concrete mixtures certified as an NRMCA Concrete Technologist Level 2.
- B. Installer: An Installer with five years of experience performing concrete Work of similar size, complexity, and schedule.
  1. Personnel performing finishing of flatwork shall be minimally certified as ACI Concrete Flatwork Technician.
  2. Personnel serving as supervisors for finishing of flatwork shall be minimally certified as ACI Specialty Commercial/Industrial Flatwork Technician.
  3. Size shall be measured as the contract value of the cast-in-place concrete Work.
  4. If Installer's average yearly project size over the past five years is less than 80 percent of the contract value of the cast-in-place concrete Work for this Project, Installer shall submit a plan demonstrating, to the satisfaction of the Owner, Installer's capability to complete the cast-in-place concrete Work within the Project schedule.

## **1.7 SUBMITTALS**

- A. Required Submittals – Where/If the SUBMITTALS section of this Specification is in conflict with Division 1 Submittals, the more stringent requirements for the Contractor apply. Required submittal items are listed here; see below for detailed requirements. Do not submit items not requested.

B. Action Submittals

- 1) Mix Designs
  - 2) Product Data
  - 3) Samples
  - 4) Concrete Joint Locations
1. Mix Designs: Submit concrete mix designs for each type and strength of concrete required for this Project at least thirty (30) days before placing concrete.
  - a. Mix designs shall be prepared or reviewed by an approved independent Testing Agency retained by the Contractor in accordance with requirements of ACI 301 and ACI 318, and shall be coordinated with design requirements and Contract Documents.
  - b. Before submitting to Owner's Testing Agency, submit complete mix design data for each separate mix to be used on the Project in a single submittal.
  - c. Data shall be from the same production facility that will be used for this Project.
  - d. Mix Design data shall include but not be limited to the following:
    - 1) Locations on the Project where each mix design is to be used corresponding to Structural General Notes on the Drawings.
    - 2) Design Compressive Strength: As indicated on the Drawings.
    - 3) Proportions: ACI 301 and ACI 318.
    - 4) Gradation and quality of each type of ingredient including fresh (wet) unit weight, aggregates sieve analysis.
    - 5) Water/cementitious material ratio.
    - 6) Evaluate and classify fly ash in accordance with ASTM C 618.
    - 7) Report chemical analysis of fly ash in accordance with ASTM C 311.
    - 8) Classify blast furnace slag in accordance with ASTM C 989.
    - 9) Slump: Test according to ASTM C 143. This shall be the nominal slump as defined by ASTM C94.
    - 10) Certification and test results of the total water-soluble chloride ion content of the design mix - AASHTO T260 or ASTM C 1218.
    - 11) Air content of freshly mixed concrete by the pressure method, ASTM C 231, or the volumetric method, ASTM C 173.
    - 12) Unit Weight of Concrete: ASTM C 138.
    - 13) Carbon dioxide mineralization: Provide concrete producers certificate verifying mineralization of recycled carbon dioxide. Include quantity, location, and supplier of injected CO<sub>2</sub>.
    - 14) Design strength at 28, 56 or 90 days, as indicated on Structural General Notes: ASTM C 39.
      - a) Document strength based on basis of previous field experience or trial mixtures per ACI 301. Proportioning by Water-Cement Ratio is not permitted.
      - b) Submit strength test records, mix design materials, conditions, and proportions for concrete used for record of tests, standard deviation calculation, and determination of required average compressive strength.
      - c) If early concrete strengths are required, contractor shall submit trial mixture results as required.
    - 15) Test records to support proposed mixtures shall be no more than 12 months old and use current cement and aggregate sources.
    - 16) Manufacturer's product data for each type of admixture.
    - 17) Manufacturer's certification that all admixtures used are compatible with each other.

- 18) All information indicating compliance with Contract Documents including method of placement and method of curing.
  - 19) Normal Weight Concrete: Density per ASTM C 138. Design the mix to produce the strength, modulus of elasticity and density as indicated on the Contract Documents.
  - 20) Certification from a qualified testing agency indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity in accordance with ASTM C 33.
  - 21) Shrinkage tests in accordance with ASTM C 157.
    - a) Required for elements with shrinkage performance criteria indicated in the Cast-in-Place Concrete Table in the Structural General Notes.
  - 22) Additional requirements for mass concrete:
    - a) Submit mix design for mass concrete elements in conformance with requirements of ACI 301, Section 8 and ACI 211.1-Appendix 5. Mix designs shall be proportioned to achieve specified compressive strength at 56 days.
    - b) Submit calorimeter test results for all mass concrete mix designs.
    - c) Submit proposed methods of temperature control, including cementitious material content control in mix design to reduce heat-generating potential of concrete, precooling of ingredients to lower concrete temperature as placed, and methods to protect mass concrete elements from excessive temperature differentials.
    - d) Submit analysis of anticipated thermal developments within mass concrete elements with the proposed mix design for these elements. Results of the analysis, using methods such as the Schmidt model referenced in ACI 207.1R and site-specific data, shall address the maximum differential temperature and the maximum temperature during curing.
    - e) Submit proposed number and locations of temperature monitoring devices to record temperature development between the interior and the exterior of mass concrete elements.]
  - 23) Environmental Product Declaration (EPD):
    - a) Submit an EPD, in compliance with ISO 14025 type III, third party verified eco-label, for each concrete mix, see Structural General Notes. GWP shall be less than the maximum value listed in the Structural general Notes.
    - b) Impact Categories:
    - c) Global Warming Potential (GWP): All GWP information submitted shall be in the form of kgCO<sub>2</sub>e/kg.
    - d) Ozone Depletion Potential (ODP): All ODP information submitted shall be in the form of kgCFC11e/kg.
    - e) Acidification Potential (AP): All AP information submitted shall be in the form of kgSO<sub>2</sub>e/kg.
    - f) Eutrophication Potential (EP): All EP information submitted shall be in the form of kgNe/kg.
    - g) Smog Formation Potential (SFP): All SFP information submitted shall be in the form of kgO<sub>3</sub>e/kg.
    - h) Non-Renewable Energy Consumption (NREC): All NREC information submitted shall be in the form of MJ/kg.
2. Product Data: Submit product data clearly marked to indicate all technical information which specifies full compliance with this section and Contract Documents, including published application instructions, product characteristics, compatibility and limitations for each of the following:

- a. Bonding agents.
  - b. Curing compound and liquid sealer densifier. Submit for record to Architect a written statement guaranteeing that the compound will not leave discoloration on concrete to be left exposed or affect the bond for paint or other applied finishes. Include provision in written statement that in the event of failure of applied finishes to bond to membrane cured concrete, to remove the curing compound and leave suitable surfaces for bonding such finishes.
  - c. Absorptive covers and moisture retaining covers.
  - d. Vapor Barrier: See Division 7, Thermal and Moisture Protection.
  - e. Self-leveling concrete topping.
  - f. Grout: Submittal of Grout not by manufacturers listed herein must be accompanied by independent certification of ASTM C 1107 compliance without modification of standard methods.
  - g. Other products proposed by contractor, including admixtures used in concrete mix designs.
3. Samples: Samples shall be provided as requested by the Owner's Testing Agency or Owner's Representative.
- a. Distribute all test reports of acceptance testing to the licensed design professional, contractor, and ready-mixed producer per ACI 318 26.12.1.1.e.
4. Concrete Joint Locations: Submit plans indicating locations and details of construction joints, contraction joints, waterstops, sleeves, embedments, etc. that interact with the joints. Contractor to coordinate joint location with reinforcement shop drawings. Reinforcement shop drawings shall indicate additional reinforcement bars where required at construction joints.
- a. Joint locations for concrete slabs to receive a terrazzo or similar finish subject to reflective cracking must be coordinated with layout of finish drawings.

C. Informational Submittals

- 1) Contractor Qualification
  - 2) Hot and Cold Weather Procedures
  - 3) Preconstruction Survey
  - 4) Survey of Flat Plate or Flat Slab Concrete Floors during construction
  - 5) Survey of As-built Floor Conditions
  - 6) Survey of As-built Column and Wall Conditions
  - 7) Patching Defective Concrete Finishes
  - 8) Hazardous Materials Notification
  - 9) Whole Building Life Cycle Assessment Information
  - 10) Moisture Mitigation Procedure
    - a) Contractor to propose moisture mitigation strategy to measure, mitigate, and remediate (if necessary) floors to receive finishes.
1. Contractor Qualifications: Submit qualification data (personnel, firm resume, and project list with references) for each of the following:
- a. Concrete Manufacturer
  - b. Concrete Installer
2. Hot and Cold Weather Procedures: Submit to Architect written procedures for placement of concrete in hot and cold weather conditions. Hot and Cold weather are as defined in the Concrete Placement section of this Specification.
3. Preconstruction Survey: Where interface with existing construction occurs, before related shop drawings are prepared survey the existing construction and submit the survey prepared by a professional surveyor employed by the Contractor to the Architect.

4. Survey of Flat Plate or Flat Slab Concrete Floors during construction: Survey requirements are described on Contact Documents. Based on survey results, SER may propose adjustments to formwork and camber.
5. Survey of As-built Floor Conditions: Survey and report flatness (FF), levelness (FL), and final elevations of finished floors prior to shoring removal. For slabs that include camber, do not test for levelness (FL). Perform FF/FL testing in accordance with ASTM E 1155 requirements.
6. Patching Defective Concrete Finishes: Submit procedures and product information.
7. Hazardous Materials Notification: In the event no product or material is available that does not contain hazardous materials as determined by the Owner, a "Material Safety Data Sheet" (MSDS) equivalent to OSHA Form 20 shall be submitted for that proposed product or material prior to installation.
8. Whole Building Life Cycle Assessment Information:
  - a. Environmental Product Declaration (EPD):
    - 1) Submit an EPD, in compliance with ISO 14025 type III, third party verified eco-label, for each concrete mix used in the project, see Structural General Notes. It is acceptable to omit EPD for individual mixes comprising less than 2% of the total volume of concrete in the project, provided that EPDs are provided for at least 90% of total volume of all concrete used in the project.
    - 2) Impact Categories:
      - a) Global Warming Potential (GWP): All GWP information submitted shall be in the form of kgCO<sub>2</sub>e/kg.
      - b) Ozone Depletion Potential (ODP): All ODP information submitted shall be in the form of kgCFC11e/kg.
      - c) Acidification Potential (AP): All AP information submitted shall be in the form of kgSO<sub>2</sub>e/kg.
      - d) Eutrophication Potential (EP): All EP information submitted shall be in the form of kgNe/kg.
      - e) Smog Formation Potential (SFP): All SFP information submitted shall be in the form of kgO<sub>3</sub>e/kg.
      - f) Non-Renewable Energy Consumption (NREC): All NREC information submitted shall be in the form of MJ/kg.
  - b. Bill of Materials: for each mix design, report total concrete used in the project in cubic yards, broken out into the following categories:
    - a) Total Concrete Volume
    - b) Concrete Volume used in foundations
    - c) Concrete Volume used in Horizontal Applications, e.g. Slabs/Beams
    - d) Concrete Volume used in Vertical Applications, e.g. Walls/Columns
9. LEED Submittals:
  - a. IEQ Credit 4: VOC
    - 1) Submit Product Data and material safety data sheets stating compliance with VOC limits for Curing and Sealing Compounds. Refer to Division 1 for additional LEED requirements
  - b. MR Credit 5: Regional Materials – aggregates:
    - 1) Submit statement of sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - 2) Submit statement of manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.

- 3) Submit statement of Product Value: Indicate dollar value of product containing regional materials; include materials cost only.
  - 4) Submit statement of Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
- c. MR Credit 5: Regional Materials – water:
- 1) Submit statement of sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
  - 2) Submit statement of manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
  - 3) Submit statement of Product Value: Indicate dollar value of product containing regional materials; include materials cost only.
- d. MR Credit 5: Regional Materials – cement:
- 1) Submit statement of sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
  - 2) Submit statement of manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
  - 3) Submit statement of Product Value: Indicate dollar value of product containing regional materials; include materials cost only.
- e. MR Credit 5: Regional Materials – supplementary cementitious materials (SCM).
- 1) Submit statement of sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
  - 2) Submit statement of manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
  - 3) Submit statement of Product Value: Contractor to indicate dollar value of product containing regional materials; include materials cost only.
- f. MR Credit 4: Fly ash – recycled content:
- 1) Submit statement of recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
  - 2) Submit statement of relative dollar value of recycled content product to total dollar value of product included in project.
- g. MR Credit 4: Ground Granulated Blast-furnace Slag:
- 1) Submit statement of recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
  - 2) Submit statement of relative dollar value of recycled content product to total dollar value of product included in project.
- h. MR Credit 4: Recycled Concrete Aggregates:
- 1) Submit statement of recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
  - 2) Submit statement of relative dollar value of recycled content product to total dollar value of product included in project.



D. Submittal Process

1. Submittal of shop drawings and other submittals by the Contractor shall constitute Contractor's representation that the Contractor has verified all quantities, dimensions, specified performance criteria, installation requirements, materials, catalog numbers and similar data with respect thereto and reviewed or coordinated each drawing with other Drawings and other trades. The Contractor shall place their shop drawing stamp on all submittals confirming the above.
2. Shop drawings: Submit in complete packages so that individual parts and the assembled unit may be reviewed together. This Specification Section and the applicable drawings used in the development of the shop drawings shall be referenced on each shop drawing to facilitate checking.
3. Format:
  - a. All Submittals, except Samples and mockups, shall be submitted in PDF format with each file being uniquely named.
  - b. All Submittals, except Samples and mockups, will be returned in Adobe PDF format with each file being uniquely named.
4. The Contractor shall allow at least ten (10) working days between receipt and release by the SER for the review of shop drawings and submittals.
5. All modifications or revisions to submittals and shop drawings must be clouded, with an appropriate revision number clearly indicated. The following shall automatically be considered cause for rejection of the modification or revision whether or not the drawing has been approved by the Architect:
  - a. Failure to specifically cloud modifications
  - b. Unapproved revisions to previous submittals
  - c. Unapproved departure from Contract Documents
6. Resubmittals: Completely address previous comments prior to resubmitting a drawing. Resubmit only those drawings that require resubmittal.
7. Resubmittals Compensation: The Contractor shall compensate the Architect for submittals that must be reviewed more than twice due to contractors' errors. The Contractor shall compensate the Architect at the standard billing rates plus out-of-pocket expenses incurred at cost + 10%.
8. The Contractor shall deliver to the Architect at the completion of the job an electronic version of the final as-built shop drawings.

E. Submittal Review

1. The review and approval of shop and other submittals by the Architect shall be for general conformance with the design intent of the work and with the information given in the Contract Documents only and will not in any way relieve the Contractor or the Contractor's Engineer from:
  - a. Responsibility for all required detailing and proper fitting of construction work.
  - b. The necessity of furnishing material and workmanship required by contract Drawings and Specifications which may not be indicated on the shop drawings.
  - c. Conforming to the Contract Documents.
  - d. Coordination with other trades.
  - e. Control or charge of construction means, methods, techniques, sequences or procedures, for safety precautions and programs in connection with the work.

## **1.8 QUALITY ASSURANCE BY OWNER'S TESTING AGENCY**

- A. Quality assurance is testing and special inspection to assist the Owner in evaluating the Contractor's performance. Special inspection is in addition to the testing and inspection performed by the Building Official. It is not a substitute for the testing and inspection which is required as part of the Contractor's quality control program.
- B. Testing Agency: Owner will engage and pay a qualified testing and inspecting agency to perform tests and special inspections and prepare test reports.
- C. Correct deficiencies in Work, at Contractor's expense, that test reports and inspections indicate does not comply with the Contract Documents. Re-inspection and re-testing shall be at Contractor's expense.
- D. Coordination with Owner's Testing Agency: The Contractor shall have sole responsibility for coordinating their work with the testing agency to assure that all test and inspection procedures required by the Contract Documents and Public Agencies are provided. The Contractor shall cooperate fully with the Owners testing agencies in the performance of their work and shall provide the following:
  - 1. Information as to time and place of starting field construction and concrete placement schedule, one week prior to the beginning of the work.
  - 2. Site File: At least one copy of each approved shop drawing shall be kept available in the contractor's field office. Drawings not bearing evidence of approval and release for construction by the Architect shall not be kept on the job. Provide drawings for the work to be performed one week prior to the start of work.
  - 3. Representative sample pieces requested by the inspection agency for testing, if necessary.
  - 4. Full and ample means of assistance for testing and inspection of material.
  - 5. Proper facilities, including scaffolding, temporary work platforms, safety equipment etc., for inspection of the work in shop and field.
- E. Where testing is required for less than 100% of locations, select test locations at random and throughout the project.
- F. Duties of the Owner's Testing Agencies:
  - 1. Reports: Inspection results shall be reported in Adobe PDF format, with each file being uniquely named, to authorities having jurisdiction, Architect, Contractor, and Fabricator within 48 hours of inspection. Specifically indicate items that are in non-compliance with the requirements of the Contract Documents.
  - 2. Rejection: The Owner's Testing Agency has the right to reject any material, at any time, when it is determined that the material or workmanship does not conform to the Contract Documents. The Testing Agency shall report deficiencies to Owner, Architect and Contractor immediately.
  - 3. Remedial Work: The Testing Agency shall indicate to the Contractor where remedial work must be performed and will maintain a current list of work not in compliance with the Contract Documents. This list shall be submitted to the Architect and Owner on a weekly basis.
- G. Required Special Inspections:
  - 1. Inspect concrete materials and operations as Work progresses.
    - a. Verify use of required mix design at intended location
    - b. Record location of point of concrete discharge of each batch truck tested, cross referenced to grid lines.

- c. Record temperature of concrete at time of placement.
  - d. Record weather conditions at time of placement, including temperature, wind speed, relative humidity, and precipitation.
  - e. Record types and amounts of admixtures added to concrete batches, including that added after departure of concrete trucks from batch plant at the project site.
  - f. Record amounts of and monitor dosing of high-range water-reducing admixtures added at site for site-added admixtures and redosing for plant-added admixtures.
  - g. Record amount of water added at the site and verify that total water content does not exceed amount specified in the mix design. Addition of water at the site is subject to prior approval by the Architect.
  - h. Monitor consistency and uniformity of concrete.
  - i. Monitor preparation for concreting operations, placement of vapor barrier, placement of concrete, and subsequent curing period for conformance with Specifications for following procedures:
    - 1) Concrete curing.
    - 2) Hot weather concreting operations.
    - 3) Cold weather concreting operations.
2. Sample and test concrete mixes:
- a. Minimum sampling frequency:
    - 1) One sample set for each truckload for concrete used for columns.
    - 2) One sample set for each concrete design mix.
    - 3) One sample set per day.
    - 4) One sample set for each 150 cubic yards (75 cubic meter).
    - 5) One sample set for each 5000 sq. ft. (450 sq. meter) area of slabs or walls.
    - 6) Additional samples if deemed necessary by the Owner's Testing Agency.
  - b. Obtain each test sample from different batches selected on a strictly random basis before commencement of concrete placement. Record location in structure of sampled concrete.
  - c. Determine air content of normal weight concrete in accordance with either ASTM C 231 or ASTM C 138. Determine air content of lightweight concrete in accordance with ASTM C 173.
  - d. Determine unit weight of normal weight concrete in accordance with ASTM C 138 and lightweight concrete in accordance with ASTM C 567.
  - e. Test water content of freshly mixed concrete in accordance with AASHTO T 318 for the following concrete types:
    - 1) Architecturally exposed hard troweled slabs
    - 2) Slab to receive a bonded finish floor material
    - 3) Slabs with specified concrete compressive strength exceeding 6000 psi (42 MPa).
  - f. Conduct slump tests in accordance with ASTM C 143. For Self-Consolidating Concrete, conduct slump flow test per ASTM C 1611/C 1611M.
  - g. Conduct slump tests for concrete enhanced with high-range water-reducing admixtures as follows:
    - 1) Concrete with plant added high-range water-reducing admixtures shall be sampled immediately upon arrival at job site. Batches delivered to site with slumps in excess of the range defined in the mix design submittal or with excessive segregation as defined in the ACI Manual of Standard Practice Part I shall be rejected.
    - 2) Concrete with site added high-range water-reducing admixtures shall be sampled immediately upon arrival at job site and after addition of high-range

- water-reducing admixtures for conformance to initial water slump and final slump requirements.
- 3) Concrete shall also be sampled at point of initial discharge for conformance to slump and/or slump-flow requirements. Visually observe slump-flow at point of concrete placement. If slump loss is visually observed to exceed the range specified for mix design, perform additional slump test at point of discharge from concrete pump hose.
- h. Conduct strength tests of laboratory-cured concrete as follows:
- 1) Secure sample sets in accordance with ASTM C 172.
  - 2) Mold cylinders in accordance with ASTM C 31 and cure under standard moisture and temperature conditions in accordance with ASTM C 31, Section 7 (a). Quantity of cylinders listed below is based on a cylinder size of 4 inches (100 mm) diameter x 8 inches (200 mm) long. If 6 inches (150 mm) diameter by 12 inches (300 mm) long cylinders are used, the total quantity of cylinders may be reduced by one with two cylinders instead of three tested at the age designated for determination of f'c.
  - 3) Test cylinders in accordance with ASTM C 39. For specified concrete strength of 10,000 psi (70 MPa) and above, cylinders shall be ground and not capped.
  - 4) For 28-day mixes mold six cylinders. Test two cylinders at seven days and three cylinders at 28 days. The 28-day strength shall be the average of the three 28 day cylinders. One cylinder shall be retained in reserve for later testing if required.
  - 5) For 56-day mixes mold seven cylinders. Test one cylinder at seven days, two cylinders at 28 days, and three cylinders at 56 days. The 56-day strength shall be the average of the three 56 day cylinders. One cylinder shall be retained in reserve for later testing if required.
  - 6) For 90-day mixes mold eight cylinders. Test one cylinder at seven days, one at cylinder at 28 days, two cylinders at 56 days, and three cylinders at 90 days. The 90-day strength shall be the average of the three 90-day cylinders. One cylinder shall be retained in reserve for later testing if required.
  - 7) When high early strength concrete is required by contractor, additional cylinders shall be made and tested as required at Contractor's expense.
  - 8) If one cylinder in a test manifests evidence of improper sampling, molding or other damage, discard cylinder and base test results on that of remaining cylinders.
- i. Conduct strength tests of field-cured concrete as follows:
- 1) Testing of field-cured specimens are required for loading of composite metal deck.
  - 2) Testing is in addition to the laboratory-cured specimens.
  - 3) Secure sample sets in accordance with ASTM C 172.
  - 4) Mold cylinders in accordance with ASTM C 31 and cure in field. Quantity of cylinders listed below is based on a cylinder size of 4 inches (100 mm) diameter x 8 inches (200 mm) long. If 6 inches (150 mm) diameter by 12 inches (300 mm) long cylinders are used, the total quantity of cylinders may be reduced by one with two cylinders instead of three tested at the age designated for determination of f'c.
  - 5) Mold five cylinders: Test two cylinders at seven days and three cylinders at the age designated for determination of f'c. The strength shall be the average of the sample set tested that day.

- 6) When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
3. Inspect base plate grouting
    - a. Inspect mixing and placement of non-shrink grout.
    - b. Test for compressive strength in accordance with ASTM C 109. Make one sample for each 2 hours of grout placement.
  4. Floor flatness and levelness tolerance compliance testing is to be performed within 24 hours of concrete placement by Owner's Testing Agency, and prior to the removal of shores and forms.
  5. Failure to detect any defective work or material shall not in any way prevent later rejection when such defect is discovered, nor shall it obligate the Architect for final acceptance.
- H. Certifications: When all work has been approved by the Testing Agency, the Testing Agency shall certify in a letter to the Architect and Owner that the installation is in accordance with the design and Specification requirements including applicable codes.

#### **1.9 CONTRACTOR QUALITY ASSURANCE AND QUALITY CONTROL**

- A. The Contractor shall provide a program of quality control to ensure that the minimum standards specified herein are attained.
- B. The Contractor shall immediately report to the Architect any deficiencies in the work which are departures from the Contract Documents which may occur during construction. The Contractor shall propose corrective actions and their recommendations in writing and submit them for review by the Architect. After proposed corrective action is accepted by the Architect and Owner, the Contractor shall correct the deficiency at no cost to the Owner.
- C. The Owner's general review during construction and activities of the Owner's Testing Agency are undertaken to inform the Owner of performance by the Contractor but shall in no way replace or augment the Contractor's quality control program or relieve the Contractor of total responsibility for quality control.

#### **1.10 OBSERVATIONS BY DESIGN PROFESSIONAL**

- A. Review: The Design Professionals will observe the construction for general compliance with the provisions of the Contract Documents during various phases of construction.
- B. Compensation for Additional Services: Should additional work by Design Professionals such as design, drafting, meetings and/or visits be required which are necessitated by failure of the Contractor to perform the work in accordance with the Contract Documents, the Contractor is responsible for paying for additional work performed by the Design Professionals at their standard firm-wide billing rates plus out-of-pocket expenses incurred at cost + 10%. Additional costs for testing and inspection by the Owner shall also be compensated by the Contractor

#### **1.11 DELIVERY AND ACCEPTANCE REQUIREMENTS**

- A. Deliver materials to Project in such quantities and at such times to ensure continuity of installation.

- B. Do not deliver concrete until vapor barrier, forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement and all inspections have been completed.
- C. Field Acceptance of Concrete:
  - 1. Concrete not within slump or slump flow tolerance of the approved concrete design mixture at the point of discharge shall not be used in the Work.
    - a. Slump tolerance:
      - 1) For slump 2 inches (50 mm) and less: +/- 1/2 inch (13 mm).
      - 2) For slump more than 2 inches (50 mm) through 4 inches (100 mm): +/- 1 inch (25 mm).
      - 3) For slump greater than 4 inches (100 mm): +/- 1.5 inches (40 mm).
    - b. Slump flow tolerance: +/- 3 inches (75 mm).
  - 2. Concrete not within +/- 1.5 percent of the air content of the approved concrete design mixture at the point of placement shall not be used in the Work.
  - 3. Concrete not within temperature limits at the point of discharge shall not be used in the Work.
  - 4. Concrete not within +/- 3 lb./cu. ft. (48.1 kg/cu. m) of the unit weight of the approved concrete design mixture at the point of discharge shall not be used in the Work.

#### **1.12 STORAGE AND HANDLING REQUIREMENTS**

- A. Store materials in accordance with ACI 304R.
- B. Store cement in weather-tight buildings, bins or silos that will exclude moisture and contaminants.
- C. Store admixtures to avoid contamination, evaporation, damage, and in accordance with manufacturer's temperature and other recommendations.
- D. Keep packaged material in original containers with seals unbroken and labels intact until time of use.
- E. Handle fine and coarse aggregates as separate ingredients.
- F. Arrange aggregate stockpiles to avoid excessive segregation and prevent contamination with other materials or with other sizes of like aggregates.
- G. Do not use frozen or partially frozen aggregates.
- H. Allow sand to drain until it has reached relatively uniform moisture content before use.
- I. Protect liquid admixtures from freezing and temperature changes that would adversely affect characteristics, and in accordance with manufacturer's recommendations
- J. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Availability: Confirm availability of all products and notify Architect of any that cannot be provided.

### **2.2 MANUFACTURERS**

- A. In other Part 2 Articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
  - 2. Products: Subject to compliance with requirements, provide one of the products specified.
  - 3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
  - 4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

### **2.3 CONCRETE MIX DESIGN**

- A. Contractor, Installer, and Manufacturer shall coordinate to provide concrete mixtures that meet the minimum requirements indicated in this Article and in the Structural General Notes.
- B. Prepare mix designs for each type of concrete, proportioned on the basis of laboratory trial mixture or field test data according to ACI 301, to meet requirements herein and to meet durability requirements based on exposure classes according to chapter 19 of ACI 318 (ACI 318M).
  - 1. Use a qualified independent testing agency or qualified ready-mix concrete laboratory for preparing and reporting proposed mixture designs based on laboratory trial mixtures.
  - 2. Each combination of material proposed for use shall have separate backup documentation, except accelerating admixture or retarding admixture can be provided without separate backup documentation.
  - 3. Slump, air content, and maximum allowable chloride-ion content limits of ACI 301 do not apply.
  - 4. Conform to additional requirements of ACI 211.2 for lightweight concrete.
- C. Contractor, Installer, and Manufacturer shall coordinate to establish properties of fresh concrete to facilitate placement and finishing with minimal segregation and bleeding. Factors shall include, but are not limited to, slump or slump flow, set time, method of placement, rate of placement, hot and cold weather placement, curing, and concrete temperature.
- D. Cementitious Materials: Use fly ash, pozzolan, and/or ground granulated blast-furnace slag, and/or silica fume, and/or carbon dioxide mineralization as needed to reduce the total amount of Portland cement, which would otherwise be used to the maximum content identified in the Structural General Notes per mix design.
  - 1. Minimum cementitious materials content requirements for floors from ACI 301 do not apply.

2. Limit percentage, by weight, fly ash cementitious material in concrete for slabs-on-grade and elevated slabs to 25 percent.
  3. Limit percentage, by weight, of cementitious materials other than Portland cement in concrete subject to exposure class F3 according to chapter 19 of ACI 318 (ACI 318M).
  4. Add alternate: provide a minimum of 30% supplementary cementitious material (SCM) for all concrete mixes.
- E. Water-Cementitious Material (W/C) Ratio:
1. All concrete exposed to deicing salts, brackish water seawater or spray from these sources shall have a maximum W/C ratio of 0.40
  2. Weight of fly ash or pozzolanic admixtures shall be included with the weight of cementitious materials used to determine the W/C ratio.
  3. For all concrete, use normal weight concrete with a maximum w/c ratio of 0.45 and a maximum slump of 5 inches (plus or minus 1 inch) prior to adding high-range water reducer, if applicable. Provide air entrainment for all F1 exposure of 5% minimum.
- F. Admixtures: Use admixtures as needed according to manufacturer's written instructions and the following:
1. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
  2. Use polycarboxylate high-range water-reducing admixture and viscosity modifying admixture in self-consolidating concrete.
  3. Consult with manufacturer for dosage rate based on cement content of actual concrete design mixtures proposed.
  4. Use corrosion-inhibiting admixture in concrete for elevated slabs subject to exposure class C2. Dosage to be determined based on target service life.
- G. The minimum compressive strength at the age indicated shall be the higher of:
1. The value for strength indicated.
  2. The value required for durability based on exposure classes according to chapter 19 of ACI 318 (ACI 318M).
- H. Concrete shall have, at the point of placement, a consistent slump or slump flow that enables the concrete to be placed without segregation, to be well and thoroughly consolidated into forms and around steel reinforcement, prestressing tendons, and other embedments, and allows for controlled bleeding and setting time leading to an acceptable finished surface as defined by flatness, texture, and surface hardness requirements.
1. Slump for concrete with high range water-reducing admixture shall not exceed 9 inches (225 mm) after addition of water-reducing admixture.
  2. Slump/flow diameter for self-consolidating Concrete shall be of 20 inches (500 mm) minimum or as required by the successful test placement onsite, which shall verify proper workability, finish, and setting time.
- I. Concrete for elevated slabs on steel deck shall, shall have air content that meets limits for durability based on exposure classes according to chapter 19 of ACI 318 (ACI 318M) and the limits of the applicable Fire-Resistance Rating.
- J. Concrete designated as mass concrete shall meet, in addition to temperature limits of ACI 301, the following temperature limits at the point of placement:
- a. Minimum: 35 deg F (2 deg C) at the point of placement.
  - b. Maximum: 70 deg F (21 deg C) at the point of placement.



- K. Lightweight concrete shall have the following unit weights:
  - 1. Maximum unit weight while concrete is plastic: 117 lb./cu. ft. (1874 kg/cu. m) as determined by ASTM C 138.
  - 2. Maximum air-dry unit weight: 110 lb./cu. ft. (1762 kg/cu. m).
- L. Concrete shall meet the maximum drying shrinkage limit as indicated in the Drawings. Specimens shall be cured in water storage for 7 days followed by 28 days of air storage according to ASTM C 157/C 157M, section 11.1. Shrinkage shall be measured after 28 days of air storage.

## 2.4 CONCRETE MATERIALS

- A. Provide documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.
- B. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
  - 1. Portland Cement: ASTM C 150, Type as required for durability based on exposure classes according to chapter 19 of ACI 318 (ACI 318M0). Supplement with the following 'Supplementary Cementitious Materials.'
  - 2. For mass concrete, use of ASTM C 150 Type III cement is prohibited.
- C. Supplementary Cementitious Material:
  - 1. Fly Ash: ASTM C 618, Class C or F. Class F shall be used at mass concrete elements.
  - 2. Ground Granulated Blast-Furnace Slag (GGBFS): ASTM C 989, Grade 100 or 120.
  - 3. No fly ash or GGBFS from plant co-fired with hazardous or medical waste or tire derived fuel.
  - 4. Silica Fume: ASTM C 1240, amorphous silica.
  - 5. Natural Pozzolans: ASTM C 618, Class N.
  - 6. Limit the maximum content of supplementary cementitious materials for concrete exposed to deicing chemicals to values shown in ACI 318, Table 26.4.2.2(b)
  - 7. The exact percentages used shall be based on successful test placement on site. Resubmit mix design if percentages change based on test placement.
  - 8. The fly ash or natural pozzolan supplier shall have an effective quality control program in place to guard against contamination of the fly ash and assure compliance with Specifications.
  - 9. Fly ash and GGBFS used shall be from one source throughout the project. Substitution of sources will be acceptable only if testing of concrete mixes containing the substituted material show similar test results and if the color of concrete produced with the substituted material matches the color of previously poured concrete to the satisfaction of the Architect.
- D. Blended Hydraulic Cement: ASTM C 595, excluding Type IS ( $\geq 70$ ).
- E. Carbon dioxide mineralization: Carbon dioxide in the mixture must be post-industrial CO<sub>2</sub> sourced from an emitter within 50 miles from the injection site.
- F. Normal weight Aggregates: ASTM C 33, Class 3S coarse aggregate or better, graded.
  - 1. Provide aggregates from a single source.
  - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement and free of deleterious materials that may cause pop outs.

3. Maximum coarse aggregate size shall conform to the requirements as specified in ACI 301 but shall not exceed the following:
    - a. 1 inch (25 mm) for footings, drilled piers and caissons
    - b. 3/4 inch (20 mm) for all other locations
  4. Contractor shall furnish concrete with 3/8 inch (10 mm) maximum aggregate at no additional cost to the Owner if areas of high reinforcement density require it for placement and consolidation.
- G. Aggregates for alkali silica reactions comply with one of the following options:
1. Determined to be non-reactive – expansion  $\leq 0.04\%$  at 1 year in accordance with ASTM C1293
  2. Aggregates used with similar composition of cementitious materials shall have at least 2 years in similar exposure conditions with no evidence of deleterious cracking attributable to ASR
  3. Combination of cementitious materials and each aggregate shall be tested by ASTM C1567 to obtain expansion that does not exceed 0.10 at 16 days.
- H. Cementitious material used shall have at least 2 years of use with proposed aggregates without detrimental reaction based on testing to ASTM C1293. Length change shall not exceed 0.10% after 2 years per ASTM C1293.
- I. Lightweight Aggregate: ASTM C 330.
1. Provide aggregates from a single source.
  2. Aggregate shall contain the minimum absorbed moisture content recommended by the manufacturer for the project prior to batching.
  3. Maximum coarse aggregate size shall conform to the requirements as specified in ACI 301 but shall not exceed 3/4 inch (20 mm).
- J. Water and Ice: ASTM C 1602/C 1602M.
1. Clean and free from injurious amounts of oil, acids, alkali, salts, organic material, or other deleterious materials.

## 2.5 ADMIXTURES

- A. General: Provide admixtures certified by admixture manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
- B. Air-Entraining Admixture: ASTM C 260.
- C. Water Reducing, Accelerating, and/or Retarding Admixtures: ASTM C 494/C 494M.
- D. Plasticizing Admixtures: ASTM C 1017/C 1017M.
- E. Viscosity Modifying Admixture:
1. Available products:
    - a. Viscrol, EUCON ABS or EUCON WO by Euclid Chemical Company.
    - b. V-MAR3 by W. R. Grace & Co.
    - c. MasterMatrix VMA by Master Builders.
    - d. Sika Stabilizer Series by Sika Corporation.

- F. Shrinkage Reducing Admixture: Commercially formulated to reduce drying shrinkage.
1. Available Products:
    - a. Eucon SRA or Conex by Euclid Chemical Company.
    - b. Eclipse by W. R. Grace & Co.
    - c. MasterLife SRA by Master Builders.
    - d. Sika Control 40 by Sika Corporation.
- G. Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
1. Available Products:
    - a. MCI 20005 NS or 2006 NS by Cortec Corporation.
    - b. EUCON CIA by Euclid Chemical Company.
    - c. DCI or DCI-S by W. R. Grace & Co.
    - d. Rheocrete 222+ or Rheocrete CNI by BASF.
    - e. FerroGard or Sika CNI by Sika Corporation.
- H. Crystalline Waterproofing: Commercially formulated additive containing catalytic chemicals which migrate through the concrete using moisture present in the concrete as the migrating medium, and which cause the moisture and the natural chemical by-products of cement hydration in the concrete to react causing the growth of non-soluble crystals in the pores and capillary tracts of the concrete that allow passage of water, thereby rendering the concrete itself waterproof.
1. Available Products:
    - a. Xypex Admix C-500 by Xypex Chemical Company.
    - b. KIM HS by Kryton.

## **2.6 VAPOR BARRIERS**

- A. Plastic Barrier: ASTM E 1745, Class A, not less than 15 mils (0.38 mm) thick having a water-vapor transmission rate no greater than 0.008 gr./sq. ft./hr. (5.58 mg/sq. m/hr.) when tested in accordance with ASTM E 96. Include manufacturer's recommended adhesive or pressure-sensitive tape, mastic, and pipe boot.
1. Available Products:
    - a. Perminator by W. R. Meadows
    - b. Griffolyn Type-65G or -105 by Reef Industries, Inc.
    - c. Stego Wrap Vapor Barrier by Stego Industries LLC

## **2.7 JOINT FILLERS**

- A. Permanent Compressible Joint Filler:
1. Closed-cell expansion joint filler, ultraviolet stable, minimal moisture absorption, non-impregnated, nonstaining and nonbleeding, inert and compatible with cold-applied sealants.
  2. Available Products:
    - a. Ceramar by W. R. Meadows

- B. Temporary Compressible Joint Filler:
  - 1. White molded polystyrene beadboard.
- C. Semirigid Joint Filler: Two-component semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 per ASTM D 2240.
- D. Noncompressible Joint Filler:
  - 1. Rigid closed-cell extruded polystyrene board, square edges, 40 psi (275 MPa) compressive strength, ASTM C 578, Type IV.
  - 2. Available Products:
    - a. STYROFOAM 40 by Dow Chemical
- E. Asphalt-Impregnated Joint Filler:
  - 1. Preformed, ASTM D 994, 1/2 inches (13 mm) maximum.
  - 2. Available Products:
    - a. Asphalt Expansion Joint Filler by W.R. Meadows
- F. Asphalt-impregnated fiberboard expansion joint filler for interior work: ASTM D1751.
- G. Self-expanding cork board expansion joint filler for exterior work: ASTM D1752.

## 2.8 FLOOR AND SLAB TREATMENTS

- A. Slip-Resistive Emery Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive, crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials with 100 percent passing No. 4 (4.75-mm) sieve.
  - 1. Available Products:
    - a. Emery by Anti-Hydro International, Inc.
    - b. Emery Non-Slip by Dayton Superior Corporation
    - c. Grip It by L&M Construction Chemicals, Inc.
- B. Slip-Resistive Aluminum Granule Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of not less than 95 percent fused aluminum-oxide granules.
  - 1. Available Products:
    - a. A-H Aloxx by Anti-Hydro International, Inc.
    - b. Grip It AO by L&M Construction Chemicals, Inc.
    - c. Frictex NS by Sonneborn, Div. of ChemRex
- C. Emery Dry-Shake Floor Hardener: Unpigmented, factory-packaged, dry combination of portland cement, graded emery aggregate, and plasticizing admixture; with emery aggregate consisting of no less than 60 percent of total aggregate content.
- D. Metallic Dry-Shake Floor Hardener: Unpigmented, factory-packaged, dry combination of portland cement, graded metallic aggregate, rust inhibitors, and plasticizing admixture; with metallic aggregate consisting of no less than 65 percent of total aggregate content.
- E. Unpigmented Mineral Dry-Shake Floor Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, and plasticizing admixture.

1. Available Products:
  - a. Concolor by ChemMasters
  - b. Conshake 500 by Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company.
  - c. Surflex by Euclid Chemical Company
- F. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; colorless; that penetrates, hardens, and densifies concrete surfaces.
  1. Available Products:
    - a. Intraseal by Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company
    - b. Ashford Formula by Curecrete Distribution Inc.
    - c. Euco Diamond Hard by Euclid Chemical Company
    - d. Seal Hard by L&M Construction Chemicals, Inc.

## 2.9 CURING MATERIALS

- A. Interaction with Finishes:
  1. See architectural Drawings for finish material applied over concrete.
  2. Use only curing and sealer compounds that are compatible with finish material.
  3. Manufacturer's certification is required.
  4. Where finish material is liquid rubberized asphalt, use only strippable type curing compound
- B. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
  1. Available Products:
    - a. Eucobar by Euclid Chemical Company
    - b. Confilm by BASF
- C. 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.
- D. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- E. Water: Potable.
- F. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1D, Class B, dissipating.
  1. Available Products:
    - a. W.B. Resin Cure by Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company
    - b. Kurez DR VOX by Euclid Chemical Company
    - c. L&M Cure R by L&M Construction Chemicals, Inc.
- G. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.
  1. Available Products:

- a. Sealcure 1315 WB by Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company
  - b. Super Diamond Clear VOX by Euclid Chemical Company
  - c. Lumiseal WB Plus by L&M Construction Chemicals, Inc.
- H. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.
  - 1. Available Products:
    - a. Sealcure 1315 by Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company
    - b. Super Diamond Clear by Euclid Chemical Company
    - c. Lumiseal Plus by L&M Construction Chemicals, Inc.

## 2.10 BONDING AGENTS

- A. Bonding Agent for Cured Concrete (existing concrete damp or dry, at least 28 days old, no surface water):
  - 1. ASTM C 881 Type I and IV, Grade 3, Class B and C.
  - 2. Available Products:
    - a. CONCRESE PASTE (LPL), Class C Only, by BASF
    - b. CONCRESE LIQUID (LPL)", Class C Only, by BASF, for bonding topping
    - c. EUCO #452 Epoxy System by Euclid Chemical Company
    - d. DURALCRETE Series by Euclid Chemical Company
    - e. FLEXOCRETE System by Euclid Chemical Company, for bonding topping
- B. Bonding Agent for Uncured Concrete: (existing concrete damp or dry, less than 28 days old, no surface water):
  - 1. ASTM C 881, Type II and V, Grade 2, Class B and C.
  - 2. Available Products:
    - a. DURALCRETE System by Euclid Chemical Company
    - b. Sikadur 32 Hi-Mod by Sika Corporation
- C. Anti-Corrosive Epoxy Cementitious Bonding Compound and Corrosion Protection of Reinforcement (bonding agent for existing concrete saturated surface dry, no surface water):
  - 1. This adhesive shall be a water-based epoxy/cementitious compound for adhesion and corrosion protection of reinforcing members (20 hour maximum open time).
  - 2. Available Products:
    - a. DURALPREP AC by Euclid Chemical Company
    - b. ARMATEC 110 by Sika Corporation
- D. Adhesive Between Cured Concrete Elements:
  - 1. ASTM C 881 Type I and IV, Grade 3, Class B and C
  - 2. Acceptable Product
    - a. Sikadur 31 Hi-Mod Gel (1:1 Mix Ratio) by Sika Corporation

## **2.11 RELATED MATERIALS**

- A. Waterstops: Provide waterstops at all construction joints and other joints in all foundation walls below grade, at exterior curbs, and where shown on the drawings. Size to suit joints. Provide flat, dumbbell type and coordinate with architectural information.
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Polyvinyl Chloride (PVC) waterstops: Corps of Engineers CRD-C 572.
      - 1) Sika Greenstreak
      - 2) JP Specialties, Inc
- B. Nonshrink Grout
1. Provide pre-packaged natural aggregate grout, high-precision, nonshrink, ready-to-use, complying with the following requirements:
    - a. 7000 psi (48 MPa) minimum compressive strength.
    - b. Grout shall conform to ASTM C 1107
  2. All material used including water, mixer and pre-packaged grout must be initially at the 45°F (7°C) and 90°F (32°C) limits when testing is initiated.
  3. Available Product:
    - a. MASTERFLOW 928 by BASF
    - b. HI-FLOW GROUT by Euclid Chemical Company
    - c. Five Star Grout by Five Star Products
    - d. Sikagrout 328 by Sika Corporation
- C. Self-Leveling Concrete Topping
1. Use cement-based, polymer modified self-leveling product, capable of being placed from feathered edge to 1 inch (25 mm) thickness without aggregate in one pour. If greater than 1 inch (25 mm) thickness is required, aggregate shall be used in accordance with manufacturer's requirements.
  2. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
  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. Used as underlayment beneath floor coverings:
    - a. Primer: Product of underlayment manufacturer recommended for floor covering, substrate, conditions, and application.
    - b. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C 109/C 109M.
  5. Used as overlayment, remaining exposed:
    - a. Primer: Product of overlayment manufacturer recommended for substrate, conditions, and application.
    - b. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C 109/C 109M.

## **2.12 CONCRETE REPAIR MATERIALS**

- A. Patching Mortar: Mix dry-pack patching mortar, consisting of one part portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing. For areas exposed to view, blend white portland cement and standard

portland cement as required such that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.

B. Polymer Repair Mortar

1. The following patching mortars may be used when color match of the adjacent concrete is not required.
2. Available Products:
  - a. Thin Top Supreme or Tammspatch II by Euclid Chemical Company (for 1/16 inch (2 mm) to 3/8 inch (10 mm) thickness, horizontal repairs).
  - b. Concrete Top Supreme" (for 3/8 inch (10 mm) to 2 inches (50 mm) thickness horizontal repairs).
  - c. Sikatop 121 Plus or Sikatop 122 Plus by Sika Corporation, for horizontal repairs.
  - d. Verticoat, Verticoat Supreme or Duraltop Gel by Euclid Chemical Company, for vertical and overhead repairs.
  - e. Sikatop 123 Plus by Sika Corporation, for vertical and overhead repairs.
  - f. EMACO R Series by BASF, for horizontal, vertical and overhead repairs.

C. High Strength Flowing Repair Mortar

1. Verify color match requirements with Architect.
2. For forming and pouring structural members, or large horizontal repairs, provide the flowable one-part, high strength microsilica modified repair mortar with 3/8 inch (10 mm).
3. The product shall achieve 9000 psi (62 MPa) @ 28-days at a 9 inches (225 mm) slump.
4. Prior approval by the Architect is required for cold weather applications
5. Available Product:
  - a. Eucocrete by Euclid Chemical Company
  - b. EMACO S Series by BASF
  - c. Sika Repair 211 SCC Plus by Sika Corporation

D. Repair Topping

1. Latex and microsilica modified cementitious mortar topping, which meets or exceeds the bond strength requirements of ASTM C 1059.
2. Resistance to wear: The finished topping shall show a depth of wear of 0.0079 inch (0.2 mm) or less when tested at 28 days with a Chaplin Abrasion Tester.
3. Available Products:
  - a. Thin-Top Supreme or Tammspatch II by Euclid Chemical Company
  - b. Sika Repair 211 SC Plus by Sika Corporation

E. Epoxy Injection:

1. ASTM C881, moisture insensitive maximum viscosity 350 cps at 77°F (25°C).
2. Available Product:
  - a. Concrecive 1380 by BASF
  - b. Eucopoxy Injection Resin by Euclid Chemical Company
  - c. Sikadur 35, LV, LPL by Sika Corporation

F. Pressure-Injected Foam Resin:

1. Available Product:
  - a. HA Sealform by DeNeef
  - b. ScotchSeal 5600 by 3M
  - c. SikaFix HH by Sika Corporation



- G. Semi Rigid Epoxy:
  - 1. Available Product:
    - a. MM-80 Semi Rigid Epoxy Joint Filler by METZGER/McGUIRE
- H. Methyl Methacrylate (MMA)
  - 1. Available Product:
    - a. T-78 Methyl Methacrylate Polymer Crack Healer/Sealer by Transpo Industries, Inc.
- I. Sealant:
  - 1. Silicone or Polyurethane Sealant (as selected based on project requirements such as loading, traffic, bond, coatings, etc.).
  - 2. Joint to be routed and cleaned per manufacturer's written directions

### **PART 3 - EXECUTION**

#### **3.1 PREPARATION**

- A. Notify the Architect and the Owner's Testing Agency 48 hours prior to starting concrete placement.
- B. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and inspected by Owner's Testing and Inspecting Agency.
  - 1. Formwork shall be clean and prepared per Section 03 10 00.
  - 2. Reinforcement and accessories shall be in proper locations, clean, free of loose scale, dirt or other foreign coatings that may reduce bond to concrete.
- C. Subgrade:
  - 1. Dampen subgrades not covered with membrane by sprinkling immediately before placing concrete.
    - a. Omit when subgrade is already damp.
  - 2. Do not place on water-saturated subgrade unless placing can be done without damage to subgrade (surface is stable) and loading the subgrade does not drive free water to the surface.
  - 3. Do not place concrete on frozen ground.
  - 4. Place granular base to thickness specified on drawings. Consolidate and smooth surface with a vibratory plate.
- D. Dewatering:
  - 1. Remove puddled water from concrete formwork.
  - 2. Divert any flowing water to sump and remove by pumping.
- E. Where indicated, place, protect, and repair vapor barriers according to ASTM E 1643 and manufacturer's written instructions.
  - 1. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape.
  - 2. Extend vapor barrier up face of walls at edges of slabs-on-grade and seal to wall with manufacturer's recommended tape.

3. Use manufacturer's recommended pipe boot and tape to seal vapor to all pipes, conduits, and other elements that penetrate slabs-on-grade.
4. Avoid use of stakes through vapor retarder. Stakes will not be permitted where vapor barrier cannot be repaired after removal of stake.
5. Where the use of stakes is required, leave in place plastic stakes shall be installed using manufacturer's approved mastic in accordance with vapor retarder manufacturer's instructions. Stakes shall be cut-off minimum 3/4 inch (20 mm) clear of slab surface and shall not be removed or driven down following initial installation

### 3.2 INSTALLATION OF EMBEDDED ITEMS

- A. General: Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions and directions provided by suppliers of items to be attached thereto unless directed otherwise by these specifications. Install reglets to receive top edge of foundation sheet waterproofing where specified by the Architect, and to receive thru-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, relieving angles and other conditions.
- B. Anchor Rods: Furnish anchor rods and other connectors required for securing structural steel to foundations and other in-place work as shown on the drawings. Furnish 1/8" minimum steel templates for presetting rods and other anchors to accurate locations as shown on the drawings in keeping with the tolerances noted in ACI 117 for embedded anchor rods. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of ANSI/AISC 303
- C. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure units sufficiently strong to support types of screed strips by use of strike-off templates or accepted compacting type screeds.
- D. Do not install sleeves in concrete slabs, pier caps, footings or walls except where shown on the structural drawings or approved by the Architect and Engineer.
- E. Securely fasten embedded plates, angles, anchor rods and other items to be built into the concrete to the formwork or hold in place with templates. Insertion of these items into concrete after casting is prohibited.
- F. Conduit:
  1. Embedded conduits (including pipes, tubes, wires, etc.) and boxes are not permitted to be installed in elevated slabs.
  2. Embedded conduits (including pipes, tubes, wires, etc.) and boxes are permitted to be installed in slabs-on-grade as follows:
    - a. Maximum nominal diameter of conduit shall not be greater than 1 inch. No more than two 3/4 inch nominal diameter conduit shall cross at a single point, and the crossing angle shall not be less than 60 degrees.
    - b. Spacing of conduits shall not be less than three times the actual outside diameter of the largest conduit.
    - c. Conduit and boxes shall not be fastened to parallel reinforcing.
    - d. Conduit shall be placed such that the concrete cover over the conduit is not less than 3/4 inch.
    - e. Conduit and boxes shall be placed such that no reinforcing is cut or displaced.

- f. Stagger conduit couplings so that couplings on adjacent conduits do not lie in the same transverse plane.
  - g. Thicken the slab as necessary to maintain at least 5 inches of concrete below the box.
- G. Aluminum: Do not embed aluminum items in concrete.
- H. Temperature Sensors:
  - 1. Embed sensors in the mat foundations that are mass concrete. Insert, for every 5,000 sq. ft. of plan area, at the following locations:
    - a. At mid-depth.
    - b. 2 inches below the top surface.
  - 2. Securely attach sensors to reinforcing to avoid displacement during concrete placement.

### 3.3 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.
  - 1. Discharge of the concrete shall be completed within 1-1/2 drihours after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates.
  - 2. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
  - 3. Time to discharge may be extended with retarder admixtures only if mix submittal clearly states the maximum time and maximum air temperature allowed before discharge, and approved by Architect.

### 3.4 CONCRETE PLACEMENT

- A. Do not add water beyond the water content of the mix design to concrete during delivery, at Project site, or during placement.
  - 1. Do not place concrete in the rain.
- B. Concrete slurry mix used to prime or clean concrete pump shall not be placed into the Work unless slurry design mixture has been submitted and approved.
- C. When the specified strength of the column concrete is greater than 1.2 times that of the floor system, concrete of the strength specified for the column shall be placed in the floor system at the column location. Top surface of the column concrete shall extend 2 feet (600 mm) into the floor system from the face of the column. Column concrete shall be well integrated with the floor system concrete.
- D. 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.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
  2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
  3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. 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.
  4. Do not vibrate self-consolidating concrete.
- E. Placing concrete in forms:
1. In depositing concrete in columns or walls, place concrete in a manner that will prevent segregation and accumulation of hardened concrete on the forms or metal reinforcement above the level of the concrete.
- F. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
  2. Maintain reinforcement in position on chairs during concrete placement.
  3. Screed slab surfaces with a straightedge and strike off to correct elevations.
  4. Slope surfaces uniformly to drains where required.
  5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.
- G. Pumping shall be done in strict accordance with ACI 304.2R
- H. Consolidating:
1. Use internal vibrators for thorough consolidation of all concrete.
  2. Use size and power recommended by ACI 309 for the element of work.
  3. Use consolidation techniques that minimize entrapped air.
  4. Do not place vibrators against reinforcement or forms.
- I. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
1. 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.
  2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
  3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
  4. Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures.
  5. Remove frost, snow and ice from forms, reinforcement and other embedments immediately prior to concrete placement.
- J. Hot-Weather Placement: Comply with ACI 305.1 and as follows:

1. Maintain concrete temperature below 95 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.
3. When concrete placement will occur late in the day and reinforcing steel will be heated by the sun, cover reinforcing steel with water-soaked burlap so that steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
4. When concrete operations must be performed in direct sun, wind, high temperatures, low relative humidity, or other adverse placing conditions, the specified evaporation retarder shall be applied one or more times during the finishing operation to prevent plastic cracking.

K. Floor slabs on steel framing:

1. Deposit concrete working outward from beam centers to avoid overloading metal deck.
2. Maintain specified concrete thickness over metal deck as a minimum. Increase thickness as required to compensate for deflection of metal deck.
3. Use screeding and strikeoff procedures that have proven successful in compensating for normal deflection of metal deck and steel framing. Increase concrete thickness as required to compensate for deflection of steel framing, except limit additional concrete thickness to tolerance maximum at any individual location.

### 3.5 JOINTS

- A. Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Coordinate location of construction and contraction joints with locations of joints in finish materials where they exist.
- C. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible. See drawings for additional requirements.
- D. Locate construction and contraction joint as indicated on approved Concrete Joint Location submittal.
- E. Construction Joints:
1. Locate construction joints within the central third of the span.
  2. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings, pile caps, or pier caps.
  3. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
  4. Use construction joint former or install joint by removing the forms in time to permit roughening of construction joints of structural members by chipping and wire brushing to remove all loose and foreign material and roughen to 1/4 inch (6 mm) amplitude. The existing concrete at joints shall either be (a) dampened to the point that the surface is saturated, but all standing water has been removed, promptly followed by placement and vibration of fresh concrete, or (b) not required to be dampened, with one of the specified bonding compounds applied as appropriate for the joint condition, following manufacturer recommendations, with placement and vibration of fresh concrete to follow while the epoxy bonding agent is still tacky. Joints without epoxy bonding agent require fresh concrete with slump 7 inches (180 mm) or greater at horizontal joints, and fresh concrete confined to maintain pressure against the joint at vertical joints. Where such conditions

- are not present, or where applying water to dampen the surface is impractical, use epoxy bonding agent suitable for dry surfaces
5. Waterstops: Provide waterstops in construction joints as indicated on the Architectural and Structural Drawings. Install waterstops to form continuous diaphragm in each joint. Make provisions to support and protect exposed waterstops during progress of work. Fabricate field joints in waterstops in accordance with manufacturer's printed instructions.
  6. Use epoxy bonding adhesive according to ACI 503.2 at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

F. Contraction Joints:

1. In Slabs-on-Grade, form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints as follows:
  - a. Maximum slab area controlled by jointing is 400 sq. ft. (35 sq. meters).
  - b. Located joints to conform to bay spacing wherever possible (at column centerlines, half bays, third bays).
  - c. Sawcuts shall be made as soon as possible after slab finishing as may be safely done without dislodging aggregate. The Soff-Cut saw shall be used immediately after final finishing. Conventional saw shall be used as soon as possible after final finish without raveling.
  - d. Depth of saw cut or formed joint shall extend for a minimum depth of 1 1/4 inch (6 mm).
2. Space vertical joints in walls at least 10'-0" from corners and at 40'-0" max. Locate joints besides piers integral with walls, near corners and in concealed locations where possible.
3. Contraction joints can be provided by sawcuts, formed joints or appropriately detailed construction joints.
4. Where contraction joints coincide with construction joints, detail joint as indicated on Drawings
5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.
6. Do not use contraction joints in composite slabs.

G. Isolation Joints:

1. Provide isolation joints in slabs-on-grade around housekeeping pads and pedestals where indicated on drawings.
2. Interrupt structural continuity resulting from bond, reinforcement or keyway at points of contact to slabs-on-grade.

### 3.6 JOINT FILLING

A. Filling Contraction Joints:

1. Defer joint filling until concrete has aged at least one month. Do not fill joints until construction traffic has permanently ceased
2. Prepare, clean, and install joint filler according to manufacturer's written instructions.
3. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.
4. Install semi-rigid joint filler full depth in saw-cut joints and formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

B. Filling Isolation Joints:

1. After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as slabs, columns, walls, and other locations, as indicated.
2. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.
3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
4. 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 joint sealants, specified in Division 07 Section "Joint Sealants," are indicated

### 3.7 CONCRETE FINISHES

- A. Comply with ACI 302.1R, "Guide for Concrete Floor and Slab Construction," recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Elevated Slabs on Steel Deck: Set screeds and adjust as necessary to achieve a level floor at the required elevation allowing for beam camber and system deflection. Contractor shall account for deck, beam, and girder deflection in determining concrete quantities. No additional charges shall be made for additional concrete required to meet these requirements.
- C. Where drains occur, slope slab uniformly to drains. Slab slope to drain shall be coordinated with the floor finish to be applied including thickness of flooring at drains. In the case of tile flooring slope of concrete to drain shall be gradual and spread over sufficient area to allow the specified finish flooring to be applied smoothly and without cutting.
- D. Floor flatness/floor levelness tolerance compliance testing is to be performed no later than 24 hours after concrete placement by Owner's Testing Agency. Measure  $F_F$  and  $F_L$  according to ASTM E 1155. For shored floor slabs, measure prior to the removal of shores and forms.
- E. Within 2 ft (600 mm) of slab boundaries, construction joints, isolation joints, block-outs, penetrations or other similar discontinuities, where required for travel paths, installation of finishes and partitions, or any other requirements indicated in the Contract Documents, the following equivalent straightedge tolerances shall apply:
  1. Specified local  $F_F = 14$ , use 1/4 inch (6 mm) over 4 ft (1200 mm), no offset greater than 1/16 inch (2 mm).
  2. Specified local  $F_F = 20$ , use 1/8 inch (3 mm) over 4 ft (1200 mm), no offset greater than 1/32 inch (0.8 mm).
- F. Slab Finishes: See Architectural Drawings for locations of the various finishes listed below
  1. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch (6 mm) in 1 direction.
    - a. Finish surface to overall value of  $F_F=20$  and  $F_L=15$  and minimum local value of  $F_F = 14$  and  $F_L=10$ .
    - b. Apply scratch finish to surfaces to receive mortar setting beds for tile and other bonded cementitious floor finishes.
  2. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture.

- a. Finish surfaces to overall value of  $F_F=20$  and  $F_L=15$  and minimum local value of  $F_F=14$  and  $F_L=10$ .
  - b. Apply float finish to surfaces to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.
3. Trowel Finish on Slab-on-Grade and Formed Concrete Floors: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighen until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
  - a. Finish surfaces to overall value of  $F_F=35$  and  $F_L=25$  and minimum local value of  $F_F=24$  and  $F_L=17$ .
  - b. Apply a trowel finish to surfaces exposed to view, and to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
  - c. For concrete fill on deck supported by steel framing, Contractor shall finish surfaces to an overall value of  $F_F=35$  and minimum local value of  $F_F=24$ . In addition:
    - 1) Contractor shall place concrete slabs for elevated concrete fill on deck so that the finish surface is screeded level within  $\frac{1}{4}$ " of the top of slab elevation shown in the Drawings.
    - 2) Concrete slabs on steel deck shall be placed with a thickness tolerance of  $-0" / +1"$ . Contractor shall identify locations where surveyed top of steel locations indicate this is not achievable and notify SER for additional recommendations.
4. Trowel and Fine-Broom Finish: Apply a trowel finish to surfaces. While concrete is still plastic, slightly scarify surface with a fine broom.
  - a. Comply with flatness and levelness tolerances for trowel finished floor surfaces.
  - b. Apply a trowel and fine broom finish to surfaces where ceramic or quarry tile is to be installed by either thickset or thin-set method.
5. Broom Finish: Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.
  - a. Provide sample panel of texture for approval by Architect. Texture shall be approved prior to placing concrete.
  - b. Finish surfaces to overall value of  $F_F=20$  and  $F_L=15$  and minimum local value of  $F_F=14$  and  $F_L=10$ .
  - c. Apply a broom finish to surfaces of exterior sidewalks platforms, steps, and ramps.
6. Slip-Resistive Finish: Before final floating, apply slip-resistive aggregate. Apply according to manufacturer's written instructions and as follows:
  - a. Uniformly spread 25 lb./100 sq. ft. of dampened slip-resistive aggregate over surface in 1 or 2 applications. Tamp aggregate flush with surface, but do not force below surface.
  - b. After broadcasting and tamping, apply float finish.
  - c. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aggregate
  - d. Finish surfaces to overall value of  $F_F=20$  and  $F_L=15$  and minimum local value of  $F_F=14$  and  $F_L=10$ .
  - e. Apply a slip-resistive finish to surfaces of concrete stair treads, platforms, and ramps.



7. Dry-Shake Floor Hardener Finish: Dry-Shake Floor Hardener Finish: After initial floating, apply dry-shake floor hardener to surfaces indicated on Drawings according to manufacturer's written instructions and as follows:
  - a. Uniformly apply dry-shake floor hardener at a rate of 100 lb./100 sq. ft. unless greater amount is recommended by manufacturer.
  - b. Uniformly distribute approximately two-thirds of dry-shake floor hardener over surface by hand or with mechanical spreader, and embed by power floating. Follow power floating with a second dry-shake floor hardener application, uniformly distributing remainder of material, and embed by power floating.
  - c. After final floating, apply a trowel finish. Cure concrete with curing compound recommended by dry-shake floor hardener manufacturer and apply immediately after final finishing.
  - d. Apply a dry-shake hardener finish to surfaces of concrete stair treads, platforms, and ramps.
- G. Finishing Formed Surfaces: See Architectural Drawings for locations of the various finishes listed below.
  1. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed 1/4 inch (6 mm) in height. Meet ACI 347, Class B Surface.
    - a. Apply to concrete surfaces not exposed to view.
  2. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed 1/8 inch (3mm) in height. Match mock-up as approved by Architect. At a minimum, meet ACI 347, Class A Surface.
    - a. Apply to concrete surfaces exposed to view to receive a rubbed finish.
  3. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
  4. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one-part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
  5. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one-part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.
- H. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

### **3.8 MISCELLANEOUS CONCRETE ITEMS**

- A. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.
- B. 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 Curbs: Provide machine and equipment bases and curbs as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.
- D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and finish concrete surfaces.

### **3.9 CONCRETE PROTECTING AND CURING**

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 305.1 for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb./sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.
- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
- E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
  - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.
  - 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. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

- a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
    - b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
    - c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.
  3. Curing Compound: Apply uniformly in 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. Maintain continuity of coating and repair damage during curing period.
    - a. Solvent based curing compounds may only be used in cold weather.
    - b. After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.
  4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated 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 curing period.
- F. Mass Concrete:
1. Protect concrete after placement such that the maximum temperature does not exceed 160 deg F (70 deg C). Protection shall be continued until the concrete temperature is within 20 F deg (10 C deg) of the ambient air temperature.
  2. Cool the concrete gradually so the difference in temperature between mid-depth and top surface is no greater than 35 F deg (20 C deg) and so that the drop in top surface temperature during and at the conclusion of the curing period does not exceed 20 F deg (10 C deg) in any 24 hour period.

### **3.10 LIQUID FLOOR TREATMENTS**

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.
1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
  2. Do not apply to concrete that is less than three days old, or as allowed by manufacturer.
  3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.
- B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

### **3.11 WATERSTOP INSTALLATION**

- A. Flexible Waterstops: Install in construction joints and at other locations indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed

waterstops during progress of the work. Field fabricate joints in waterstops according to manufacturer's written instructions.

### **3.12 REPAIR OF DEFECTIVE WORK**

- A. Where concrete is under strength, out of line, level or plumb, or shows objectionable cracks, honeycombing, rock pockets, voids, spalling, exposed reinforcement, signs of freezing or is otherwise defective, and, in the Architect's judgment, these defects impair proper strength or appearance of the work, the Architect will require its removal and replacement at the Contractor's expense.
- B. Repairing Formed Surfaces: Surface defects include those described in ACI 309,.02 as well as 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. Immediately after form removal, cut out honeycombs, rock pockets, and voids.
  - 1. Voids left by Form Ties: Fill and compact with patching mortar or fill with cone plugs secured in place with bonding agent.
  - 2. Defects up to 1 inch (25 mm) in depth: Make edges of cuts perpendicular to concrete surface and avoid feathered edges. Clean and dampen with water. Fill and compact with patching mortar before bonding agent has dried.
    - a. Compact mortar in place and strike off slightly higher than surrounding surface.
    - b. Protect and cure in same manner as adjacent concrete.
  - 3. Defects up to 4-inch (25 mm) in depth: Make edges of cuts perpendicular to concrete surface and avoid feathered edges. Clean and apply pre-packaged repair mortar.
    - a. Follow repair mortar manufacturer's written instructions.
      - 1) Extend with aggregate as required by depth of defect.
      - 2) Protect and cure.
  - 4. Defects greater than 4-inch (25 mm) in depth: Make edges of cuts perpendicular to concrete surface and avoid feathered edges. Clean, dampen with water, and brush-coat surfaces of defect with bonding agent. Form and fill with same concrete as substrate before bonding agent has dried.
    - a. Protect and cure in same manner as adjacent concrete
- C. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
  - 1. Repair finished surfaces containing defects. Surface defects include 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.
  - 2. After concrete has cured at least 14 days, correct high areas by grinding.
  - 3. Correct low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with self-leveling concrete topping. Finish repaired areas to blend into adjacent concrete.
  - 4. 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. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original

- concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
5. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
- D. Perform structural repairs of concrete, subject to Architect's approval, using epoxy bonding adhesive according to ACI 503.2 and epoxy mortar according to ACI 503.4.
  - E. Repair materials and installation not specified above may be used, subject to Architect's approval.

### **3.13 CLEAN UP**

- A. Perform Work under this Section to keep affected portions of building site neat, clean, and orderly. Remove, immediately upon completion of Work under this Section, surplus materials, rubbish, and equipment associated with or used in performance. Be aware that failure to perform clean-up operations within 24 hours of notice by Architect will be considered adequate grounds for having work done by others at no added expense to the Owner.
- B. Remove curing compounds, form release agents and other materials employed in concrete work that prevent proper application of finishes, sealants, waterproofing materials, or other treatments. Use positive method, as recommended by manufacturer, to achieve complete removal.
  1. For floors scheduled to receive glue-adhered floor finishes, chemically strip ASTM C 309 curing compound 7 days minimum to 14 days maximum following placement.

### **END OF SECTION**