

PROJECT MANUAL
INCLUDING CONSTRUCTION SPECIFICATIONS

for

**V-S035, - TERMINAL C ASC LEVEL 2
EMERGENCY EGRESS (D/B)**

ORLANDO INTERNATIONAL AIRPORT

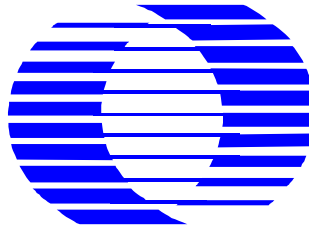
Orlando, Florida 32827

CONTRACT DOCUMENTS

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VOLUME 2 OF 10



GREATER ORLANDO AVIATION AUTHORITY

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SECTION 01 71 23 - FIELD ENGINEERING

PART 1 - GENERAL

1.1 1.2 SUMMARY

- A. General: This Section specifies administrative and procedural requirements for field-engineering services including, but not limited to, the following:
 - 1. Land survey work.
 - 2. Civil-engineering services.
 - 3. Damage surveys.
 - 4. Geotechnical monitoring.
 - 5. As-Built documentation.
 - 6. Non-destructive testing services through electromagnetic investigation.

1.2 SUBMITTALS

- A. Certificates: Submit a certificate signed by the land surveyor or professional engineer certifying the location and elevation of improvements.
- B. Final Property Survey and As-Built documentation Survey: Submit 2 paper copies, 1 mylar and and CD/DVD of AutoCAD & PDF files of the final property survey (42"x30" format).

1.3 QUALITY ASSURANCE

- A. Surveyor Qualifications: Engage a land surveyor registered in the State of Florida to perform required land-surveying services.
- B. Engineer Qualifications: Engage an engineer of the discipline required, licensed in the State of Florida to perform required engineering services.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Identification: The Contractor will be required to establish its own Project control points.
- B. Verify layout information shown on the Drawings, in relation to the property survey, existing benchmarks and location of existing underground or concealed utilities and conduits, before proceeding to lay out the Work. Locate and protect existing benchmarks and control points. Preserve permanent reference points during construction.
 - 1. Do not change or relocate benchmarks or control points without prior written approval of the OAR. Promptly report lost or destroyed reference points or requirements to relocate reference points because of necessary changes in grades or locations.

2. Promptly replace lost or destroyed Project control points utilizing the original survey control points.
 3. Establish and maintain a minimum of 5 permanent benchmarks on the site, referenced to data established by survey control points.
 4. Record benchmark locations, with horizontal and vertical data, on Project As-Built Documents.
- C. Existing Utilities and Equipment: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground or concealed utilities and other construction by use of non-destructive testing through electromagnetic investigation.
1. Prior to construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping. Document the information on the As-Built Documents.
 2. Develop a detailed plan for non-destructive testing service by use of electromagnetic investigation that includes the following (at a minimum):
 - a. area of investigation
 - b. depth of investigation
 - c. items to be located
 - d. operational constraints

3.2 PERFORMANCE

- A. Work from lines and levels established by the contract documents. Establish benchmarks and markers to set lines and levels at each story of construction and elsewhere as needed to locate each element of the Project. Calculate and measure required dimensions within indicated or recognized tolerances. Do not scale Drawings to determine dimensions.
1. Advise entities engaged in construction activities of marked lines and levels provided for their use.
 2. As construction proceeds, check every major element for line, level, and plumb.
- B. Surveyor's Log: Maintain a surveyor's log of control and other survey work. Make this log available for reference to the OAR and the Designer.
1. Record deviations from required lines and levels, and advise the OAR when deviations that exceed indicated or recognized tolerances are detected. On Project As-Built Drawings, record deviations that are accepted and not corrected.
- C. Site Improvements: Locate and lay out site improvements, including pavements, stakes for grading, fill and topsoil placement, utility slopes, and invert elevations.
- D. Building Lines and Levels: Locate and lay out batter boards for structures, building foundations, column grids and locations, floor levels, and control lines and levels required for mechanical and electrical work.
- E. Existing Utilities: Furnish information necessary to adjust, move, or relocate existing structures, utility poles, lines, services, or other appurtenances located in or affected

by construction. Coordinate with the appropriate Utility and the local Authorities Having Jurisdiction.

- F. As-Built Documents: All concealed and underground utilities, equipment, foundations or other permanent conditions shall be surveyed and documented on the As-Built Documents. This includes all discovered conditions. All shall be tied to permanent benchmarks showing horizontal and vertical data. GPS coordinates are to be provided for all beginning/end points and changes in direction. See Closeout Submittals 01 78 00 for all As-built requirements.
- G. Final Property Survey: Prepare a final property survey showing significant features (real property) for the Project. Include on the survey a certification, signed by the surveyor, that principal metes, bounds, lines, and levels of the Project are accurately positioned as shown on the survey.
 - 1. Recording: At Substantial Completion, have the final property survey recorded by or with local governing authorities as the official "property survey."

END OF SECTION 01 71 23

SECTION 01 73 00 - EXECUTION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes general administrative and procedural requirements governing execution of the Work including, but not limited to, the following:
 - 1. Installation of the Work.
 - 2. Coordination of Owner-installed products.
 - 3. Progress cleaning.
 - 4. Starting and adjusting.
 - 5. Protection of installed construction.
- B. Related Requirements:
 - 1. Section 01 10 00 "Summary" for limits on use of Project site.
 - 2. Section 01 33 23 "Design Submittals, Shop Drawings, Product Data, and Samples" for submitting surveys.
 - 3. Section 01 35 46 "Indoor Air Quality" for air quality measures.
 - 4. Section 01 74 19 "LEED v4 Construction Waste Management and Disposal" for waste disposal.
 - 5. Section 01 78 00 "Closeout Submittals" for submitting final property survey with Project Record Documents, recording of Owner-accepted deviations from indicated lines and levels, replacing defective work, and final cleaning.
 - 6. Section 01 8113.14 "Sustainable Design Requirements - LEED v4 BD+C" for LEED requirements.
 - 7. WS-110 project Section 07 84 13 "Penetration Firestopping" for patching penetrations in fire-rated construction.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Comply with requirements specified in other Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.
 - 1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
 - 2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
 - 3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

- B. Written Report: Where a written report listing conditions detrimental to performance of the Work is required by other Sections, include the following:
 - 1. Description of the Work.
 - 2. List of detrimental conditions, including substrates.
 - 3. List of unacceptable installation tolerances.
 - 4. Recommended corrections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Existing Utility Information: Furnish information to local utility that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.
- B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
- C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.
- D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to Architect according to requirements in Section 01 31 00 "Project Management and Coordination."

3.3 INSTALLATION

- A. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.
 - 1. Make vertical work plumb and make horizontal work level.
 - 2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
 - 3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.
 - 4. Maintain minimum headroom clearance of 96 inches in occupied spaces and 90 inches in unoccupied spaces.
- B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

- C. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.
- D. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.
- E. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.
- F. Tools and Equipment: Where possible, select tools or equipment that minimize production of excessive noise levels.
- G. Templates: Obtain and distribute to the parties involved templates for work specified to be factory prepared and field installed. Check Shop Drawings of other portions of the Work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.
- H. Attachment: Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned with other portions of the Work. Where size and type of attachments are not indicated, verify size and type required for load conditions.
 - 1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Architect.
 - 2. Allow for building movement, including thermal expansion and contraction.
 - 3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
- I. Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.
- J. Repair or remove and replace damaged, defective, or nonconforming Work.
 - 1. Comply with Section 01 78 00 "Closeout Submittals" for repairing or removing and replacing defective Work.

3.4 OWNER-INSTALLED PRODUCTS

- A. Site Access: Provide access to Project site for Owner's construction personnel.
- B. Coordination: Coordinate construction and operations of the Work with work performed by Owner's construction personnel.
 - 1. Construction Schedule: Inform Owner of Contractor's preferred construction schedule for Owner's portion of the Work. Adjust construction schedule based on a mutually agreeable timetable. Notify Owner if changes to schedule are required due to differences in actual construction progress.

2. Preinstallation Conferences: Include Owner's construction personnel at preinstallation conferences covering portions of the Work that are to receive Owner's work. Attend preinstallation conferences conducted by Owner's construction personnel if portions of the Work depend on Owner's construction.

3.5 PROGRESS CLEANING

- A. General: Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.
 1. Comply with the requirements of GS-42 "Green Seal Environmental Leadership Standard for Commercial Cleaning Services" and Section 01 35 46 "Indoor Air Quality".
 2. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
 3. Do not hold waste materials more than seven days during normal weather or three days if the temperature is expected to rise above 80 deg F.
 4. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.
 - a. Use containers intended for holding waste materials of type to be stored.
 5. Coordinate progress cleaning for joint-use areas where Contractor and other contractors are working concurrently.
- B. Site: Maintain Project site free of waste materials and debris.
- C. Work Areas: Clean areas where work is in progress to the level of cleanliness necessary for proper execution of the Work.
 1. Remove liquid spills promptly.
 2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.
- D. Installed Work: Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.
- E. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.
- F. Exposed Surfaces in Finished Areas: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.
- G. Waste Disposal: Do not bury or burn waste materials on-site. Do not wash waste materials down sewers or into waterways. Comply with waste disposal requirements in Section 01 74 19 "Construction Waste Management and Disposal."

- H. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.
- I. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.
- J. Limiting Exposures: Supervise construction operations to ensure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.

3.6 STARTING AND ADJUSTING

- A. Coordinate startup and adjusting of equipment and operating components with requirements in Section 01 91 13 "General Commissioning Requirements."
- B. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace with new units, and retest.
- C. Adjust equipment for proper operation. Adjust operating components for proper operation without binding.
- D. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Manufacturer's Field Service: Comply with qualification requirements in Section 01 45 00 "Quality Control".

3.7 PROTECTION OF INSTALLED CONSTRUCTION

- A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.
- B. Protection of Existing Items: Provide protection and ensure that existing items to remain undisturbed by construction are maintained in condition that existed at commencement of the Work.
- C. Comply with manufacturer's written instructions for temperature and relative humidity.

END OF SECTION 01 73 00

SECTION 01 73 29 - CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes cutting into existing construction to provide for installation or performance of the Work, subsequent fitting, and patching required to restore surfaces to original condition.
 - 1. Execute cutting, fitting, and patching, including excavation and backfill, required to perform Work and to:
 - a. Make parts fit together properly.
 - b. Remove and replace defective work.
 - c. Remove and replace Work not conforming to requirements of Contract Documents.
 - d. Uncover Work to allow for the OAR's observation of covered Work which has been covered prior to required observation of the OAR.
 - 2. Drilling of holes for the installation of fasteners and similar operations is not considered to be cutting and patching.

1.2 BUILDING MODIFICATIONS

- A. General: Modifications to existing facilities and structures shall be provided as indicated and as necessary to accomplish the Work.
 - 1. Modifications shall include the removal of existing structure, relocation of materials indicated, termination and relocation of utilities, cutting, patching, cleaning, adjusting, and refinishing, and all incidental work related and required for the installation of new Work.
 - 2. It is intended to maintain daily occupancy functions during the progress of this Work. The Contractor shall closely coordinate his Work to minimize any inconvenience to the Owner or Owner's operations.
 - 3. No Public Services or utility systems shall be interrupted without first notifying the OAR and obtaining concurrence for the interruption as instructed in Section 01 31 14.13.

1.3 SUBMITTALS

- A. Cutting and Patching Proposal: Submit a proposal describing procedures well in advance of the time cutting and patching will be performed and request approval to proceed. Include the following information, as applicable:
 - 1. Describe the extent of cutting and patching required and how it is to be performed.
 - 2. Describe anticipated results in terms of changes to existing construction; include changes to structural elements and operating components as well as changes in the building's appearance and other significant visual elements.
 - 3. List products to be used and firms that will perform Work.
 - 4. Indicate dates when cutting and patching is to be performed.

5. List utilities that will be disturbed or affected, including those that will be relocated and those that will be temporarily out-of-service. Indicate how long service will be disrupted.
 6. Where cutting and patching involves addition of reinforcement to structural elements, submit details and engineering calculations to show how reinforcement is integrated with the original structure.
 7. Approval by the OAR to proceed with cutting and patching does not waive the Owner's right to later require complete removal and replacement of Work found to be cut and patched in an unsatisfactory manner.
- B. Hot Work and Dust Hazard - Notify the OAR 48 hours (excluding weekends and holidays) in advance of any welding, cutting, burning, soldering, dust activities or any hot work. Utilize the Owners Hot Work/Dust Hazard Permit Forms.

1.4 QUALITY ASSURANCE

- A. Requirements for Structural Work: Do not cut and patch structural elements in a manner that would reduce their load-carrying capacity or load-deflection ratio.
- B. Operational and Safety Limitations: Do not cut and patch operating elements or safety related components in a manner that would result in reducing their capacity to perform as intended, or result in increased maintenance, or decreased operational life or safety.
1. Obtain approval of the cutting and patching proposal before cutting and patching the following operating elements or safety related systems:
 - a. Water, moisture, or vapor barriers.
 - b. Membranes and flashings.
 - c. Electrical wiring systems.
 - d. Control systems.
 - e. Communications systems.
 - f. Conveying systems.
 - g. Shoring, bracing, and sheeting.
 - h. Primary operational systems.
 - i. Air or smoke barriers.
 - j. Fire protection systems.
 - k. Noise and vibration control elements and systems.
 - l. Water lines.
 - m. Sewer lines.
 - n. Other special construction.
- C. Visual Requirements: Do not cut and patch construction in a manner that would degrade the building's aesthetics, or result in visual evidence of cutting and patching. Remove and replace Work cut and patched unsatisfactorily.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Use materials that are identical to existing materials. If identical materials are not available or cannot be used where exposed surfaces are involved, obtain the OAR's

approval to use substitute materials that match existing adjacent surfaces to the fullest extent possible with regard to visual effect. Use materials whose installed performance will equal or surpass that of existing materials.

- B. Verify that new materials are compatible with existing materials in all respects where cutting and patching occurs.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Before cutting existing surfaces, examine surfaces to be cut and patched and conditions under which cutting and patching is to be performed. Take corrective action before proceeding, if unsafe or unsatisfactory conditions are encountered.
 - 1. Before proceeding, meet at the site with all parties involved in cutting and patching. Review areas of potential interference and conflict. Coordinate procedures and resolve potential conflicts with OAR before proceeding.

3.2 PREPARATION

- A. Temporary Support: Provide temporary support of Work to be cut.
- B. Protection: Protect existing construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of the Project that might be exposed during cutting and patching operations.
 - 1. Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.
- C. Cutting: Take all precautions necessary to avoid cutting existing pipe or conduit serving the building, but scheduled to be removed or relocated until provisions have been made to bypass them.

3.3 PERFORMANCE

- A. General: Employ skilled workmen to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time and complete without delay.
 - 1. Cut existing construction to provide for installation of other components or performance of other construction activities and the subsequent fitting and patching required to restore surfaces to their original condition.
- B. Cutting: Cut existing construction using methods least likely to damage elements to be retained or adjoining construction. Where possible review proposed procedures with the original installer; comply with the original installer's recommendations.
 - 1. In general, where cutting is required, use hand or small power tools designed for sawing or grinding, not hammering and chopping. Cut holes and slots neatly to size required with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
 - 2. To avoid marring existing finished surfaces, cut or drill from the exposed or finished side into concealed surfaces.

3. Cut through concrete and masonry using a cutting machine such as a carborundum saw or diamond core drill.
 4. Comply with requirements of applicable sections of Division 31 specifications where cutting and patching requires excavating and backfill.
 5. By-pass utility services such as pipe or conduit, before cutting, where services are shown or required to be removed, relocated or abandoned. Cut-off pipe or conduit in walls or partitions to be removed. Cap, valve or plug and seal the remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after by-passing and cutting.
- C. Patching: Patch with durable seams that are as invisible as possible. Comply with specified tolerances.
1. Where feasible, inspect and test patched areas to demonstrate integrity of the installation.
 2. Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
 3. Where removal of walls or partitions extends one finished area into another, patch and repair floor and wall surfaces to provide an even surface of uniform color and appearance. Remove existing floor and wall coverings and replace with new materials, if necessary to achieve uniform color and appearance.
 - a. Where patching occurs in a smooth painted surface, extend final paint coat over entire unbroken surface containing the patch, after the patched area has received primer and second coat.
 4. Patch, repair, or rehang existing ceilings as necessary to provide an even plane surface of uniform appearance.

3.4 CLEANING

- A. Thoroughly clean areas where cutting and patching is performed or used as access. Remove completely any paint, mortar, oils, putty and items of similar nature. Thoroughly clean piping, conduit and similar features before painting or other finishing is applied. Restore damaged pipe covering to its original condition.

END OF SECTION 01 73 29

SECTION 01 74 19 – LEED V4 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes administrative and procedural requirements for the following:
 - 1. Salvaging nonhazardous demolition and construction waste.
 - 2. Recycling nonhazardous demolition and construction waste.
 - 3. Disposing of nonhazardous demolition and construction waste.

1.2 DEFINITIONS

- A. Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.
- B. Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.
- C. Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.
- D. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.
- E. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.
- F. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.
- G. Source Separation: Sorting of different materials comprising a waste (such as glass, concrete, wood, metal, drywall, etc.) at its point of generation

1.3 PERFORMANCE REQUIREMENTS

- A. General: Achieve end-of-Project rates for salvage/recycling of 75 percent by weight of total non-hazardous solid waste generated by the Work. In addition to the above diversion rate goals, Contractor shall identify a minimum of 4 (four) other single stream, source separated materials. Single source streams shall be included within their Waste Management Plan and source separated shall be implemented for those streams. Practice efficient waste management in the use of materials in the course of the Work. Use all reasonable means to divert construction and demolition waste from landfills and incinerators. Facilitate recycling and salvage of materials including the following:
 - 1. Demolition Waste:

- a. Asphalt paving.
- b. Concrete.
- c. Concrete reinforcing steel.
- d. Brick.
- e. Concrete masonry units.
- f. Wood studs.
- g. Wood joists.
- h. Plywood and oriented strand board.
- i. Wood paneling.
- j. Wood trim.
- k. Structural and miscellaneous steel.
- l. Rough hardware.
- m. Roofing.
- n. Insulation.
- o. Doors and frames.
- p. Door hardware.
- q. Windows.
- r. Glazing.
- s. Metal studs.
- t. Gypsum board.
- u. Acoustical tile and panels.
- v. Carpet.
- w. Carpet pad.
- x. Demountable partitions.
- y. Equipment.
- z. Cabinets.
- aa. Plumbing fixtures.
- bb. Piping.
- cc. Supports and hangers.
- dd. Valves.
- ee. Sprinklers.
- ff. Mechanical equipment.
- gg. Refrigerants.
- hh. Electrical conduit.
- ii. Copper wiring
- jj. Lighting fixtures.
- kk. Lamps.
- ll. Ballasts.
- mm. Electrical devices.
- nn. Switchgear and panelboards.
- oo. Transformers.
- 2. Construction Waste:
 - a. Masonry and CMU.
 - b. Lumber.
 - c. Wood sheet materials.
 - d. Wood trim.
 - e. Metals.

- f. Roofing.
- g. Insulation.
- h. Carpet and pad.
- i. Gypsum board.
- j. Piping.
- k. Electrical conduit.
- l. Packaging: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following uncontaminated packaging materials:
 - m. Paper.
 - n. Cardboard.
 - o. Boxes.
 - p. Plastic sheet and film.
 - q. Polystyrene packaging.
 - r. Wood crates.
 - s. Plastic pails.

1.4 ACTION SUBMITTALS

- A. Waste Management Plan: Submit plan within 30 days of date established for commencement of the Work.

1.5 INFORMATIONAL SUBMITTALS

- A. Waste Reduction Progress Reports: Concurrent with each Application for Payment, submit report. Include the following information:
 - 1. Material category.
 - 2. Generation point of waste – South Terminal C.
 - 3. Total quantity of waste in tons.
 - 4. Quantity of waste salvaged, both estimated and actual in tons.
 - 5. Quantity of waste recycled, both estimated and actual in tons.
 - 6. Total quantity of waste recovered (salvaged plus recycled) in tons.
 - 7. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.
- B. Waste Reduction Calculations: Before request for Substantial Completion, submit calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.
- C. Records of Donations: Indicate receipt and acceptance of salvageable waste donated to individuals and organizations. Indicate whether organization is tax exempt.
- D. Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals and organizations. Indicate whether organization is tax exempt.
- E. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

- F. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

1.6 QUALITY ASSURANCE

- A. Waste Management Coordinator Qualifications: Experienced firm, with a record of successful waste management coordination of projects with similar requirements.
- B. Regulatory Requirements: Comply with hauling and disposal regulations of authorities having jurisdiction.
- C. Waste Management Conference: Conduct conference at Project site. Review methods and procedures related to waste management including, but not limited to, the following:
 - 1. Review and discuss waste management plan including responsibilities of waste management coordinator.
 - 2. Review requirements for documenting quantities of each type of waste and its disposition.
 - 3. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
 - 4. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
 - 5. Review waste management requirements for each trade.

1.7 WASTE MANAGEMENT PLAN

- A. General: Develop a waste management plan according to ASTM E 1609 and requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. Distinguish between demolition and construction waste. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.
- B. Waste Identification: Indicate anticipated types and quantities of demolition, site-clearing and construction waste generated by the Work. Include estimated quantities and assumptions for estimates.
- C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.
 - 1. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work.
 - 2. Salvaged Materials for Sale: For materials that will be sold to individuals and organizations, include list of their names, addresses, and telephone numbers.

3. Salvaged Materials for Donation: For materials that will be donated to individuals and organizations, include list of their names, addresses, and telephone numbers.
 4. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
 5. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
 6. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location where materials separation will be performed.
- D. Cost/Revenue Analysis: Indicate total cost of waste disposal as if there was no waste management plan and net additional cost or net savings resulting from implementing waste management plan. Include the following:
1. Total quantity of waste.
 2. Estimated cost of disposal (cost per unit). Include hauling and tipping fees and cost of collection containers for each type of waste.
 3. Total cost of disposal (with no waste management).
 4. Revenue from salvaged materials.
 5. Revenue from recycled materials.
 6. Savings in hauling and tipping fees by donating materials.
 7. Savings in hauling and tipping fees that are avoided.
 8. Handling and transportation costs. Include cost of collection containers for each type of waste.
 9. Net additional cost or net savings from waste management plan.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

- A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.
 1. Comply with operation, termination, and removal requirements in Section 01 50 00 "Temporary Facilities and Controls."
- B. Waste Management Coordinator: Engage a waste management coordinator to be responsible for implementing, monitoring, and reporting status of waste management work plan.
- C. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work.
 1. Distribute waste management plan to everyone concerned within three days of submittal return.

2. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.
- D. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged, recycled, reused, donated, and sold.
 2. Comply with Section 01 50 00 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

3.2 SALVAGING DEMOLITION WASTE

- A. Doors and Hardware: Brace open end of door frames. Except for removing door closers, leave door hardware attached to doors.
- B. Lighting Fixtures: Separate lamps by type and protect from breakage.
- C. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.

3.3 RECYCLING DEMOLITION AND CONSTRUCTION WASTE, GENERAL

- A. General: Recycle paper and beverage containers used by on-site workers.
- B. Recycling Incentives: Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall accrue to OAR.
- C. Preparation of Waste: Prepare and maintain recyclable waste materials according to recycling or reuse facility requirements. Maintain materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.
- D. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical according to approved construction waste management plan.
 1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.
 - a. Inspect containers and bins for contamination and remove contaminated materials if found.
 2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
 4. Store components off the ground and protect from the weather.

5. Remove recyclable waste from property and transport to recycling receiver or processor.

3.4 RECYCLING DEMOLITION WASTE

- A. Asphalt Paving: Break up and transport paving to asphalt-recycling facility.
- B. Concrete: Remove reinforcement and other metals from concrete and sort with other metals.
- C. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.
- D. Metals: Separate metals by type.
 1. Structural Steel: Stack members according to size, type of member, and length.
 2. Remove and dispose of bolts, nuts, washers, and other rough hardware.
- E. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.
- F. Metal Suspension System: Separate metal members including trim, and other metals from acoustical panels and tile and sort with other metals.

3.5 RECYCLING CONSTRUCTION WASTE

- A. Packaging:
 1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
 2. Polystyrene Packaging: Separate and bag materials.
 3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
 4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.
- B. Wood Materials:
 1. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
 2. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.
 - a. Comply with requirements in Division 32 sections for use of clean sawdust as organic mulch.
- C. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location.

3.6 DISPOSAL OF WASTE

- A. General: Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.
 - 1. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B. Burning: Do not burn waste materials.
- C. Disposal: Remove waste materials from property and legally dispose of them.

END OF SECTION 01 74 19

SECTION 01 74 23 - FINAL CLEANING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: final cleaning at completion of work by individual trade and at Substantial Completion.
- B. Environmental Requirements: Final cleaning shall comply with Green Seal Standard GS 42.
- C. Conduct cleaning and waste-disposal operations in compliance with local laws and ordinances. Comply fully with federal and local environmental and antipollution regulations.
- D. Sustainable Design Requirements: Final cleaning shall comply with the requirement in Section 01 81 13.14 "Sustainable Design Requirements - LEED v4 BD+C".
- E. Do not dispose of volatile wastes, such as mineral spirits, oil, or paint thinner, in storm or sanitary drains.
- F. Burning or burying of debris, rubbish, or other waste material on the premises is not permitted.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Cleaning Agents: Use cleaning materials and agents recommended by the manufacturer or fabricator of the material to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.
 - 1. The cleaning products utilized shall be Green Seal complying with one or more of the following standards; by category:
 - a. Green Seal GS-37, for general-purpose, bathroom, glass and carpet cleaner use for industrial and institutional purposes
 - 1) Environmental Choice CCD-110, for cleaning and degreasing compounds
 - 2) Environmental Choice CCD-146, for hard-surface cleaners
 - 3) Environmental Choice CCD-148, for carpet and upholstery care.
 - b. Disinfectants, metal polish, floor finishes, strippers or other products not addressed by GS-37 or Environmental Choice CCD-110, 146, or 148 shall meet at least one of the following standards for the appropriate category:
 - 1) Green Seal GS-40, for industrial and institutional floor-care products
 - 2) Environmental Choice CCD-112, for digestion additives for cleaning and odor control
 - 3) Environmental Choice CCD-113, for drain or grease-trap additives

- 4) Environmental Choice CCD-115, for odor-control additives
- 5) Environmental Choice CCD-147, for hard-floor care
- c. California Code of Regulations maximum allowable VOC levels for the specific product category.
- d. The product shall not contain alkyl phenol ethorylates, dibutyl phthalate heavy metals, ozone-depleting compounds or optical brighteners.
- e. The product shall not be tested on animals.
- f. Cleaning materials and agents shall be in accordance with manufacturers recommendations. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

2.2 PROHIBITED PRODUCTS

- A. The following products shall not be utilized within the Work:
 - 1. Diversey Care a division of Sealed Air; Bravo Heavy-Duty Low Odor Stripper.
 - 2. Diversey Care a division of Sealed Air; BreakDown XC 40 Odor Eliminator Concentrate Fresh.
 - 3. Diversey Care a division of Sealed Air; Alpha-HP Multi-Surface Cleaner.
 - 4. Diversey Care a division of Sealed Air; Crew Clinging Toilet Bowl Cleaner.

PART 3 - EXECUTION

3.1 FINAL CLEANING

- A. General: Provide final-cleaning operations. Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit of Work to the condition expected from a commercial building cleaning and maintenance program. Comply with manufacturer's instructions.
- B. Cleaning Operations: Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for the entire Project or a portion of the Project.
 - 1. Clean the Project Site, yard and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and foreign substances.
 - 2. Sweep paved areas broom clean. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
 - 3. Broom clean concrete floors in unoccupied spaces.
 - 4. Remove petrochemical spills, stains, and other foreign deposits.
 - 5. Remove tools, construction equipment, machinery, and surplus material from the site.
 - 6. Vacuum clean carpet and similar soft surfaces, removing debris and excess nap. Shampoo, if required.
 - 7. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.

8. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, and similar spaces.
 9. Remove marks, stains, fingerprints, and other soils or other dirt from painted, decorated, and natural finished woodwork and other Work.
 10. Clean cabinet work removing stains, paint, dirt and dust.
 11. Remove spots, plaster, soil and paint from ceramic tile, marble, and other finished materials, and wash or wipe clean.
 12. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other substances that are noticeable vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
 13. Clean flooring materials thoroughly, comply with materials manufacturer's instructions and recommendations.
 14. Remove labels that are not permanent labels.
 15. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.
 - a. All restoration efforts shall be in strict accordance with LEED v4 requirements for Low Emitting Materials.
 - b. Do not paint over "UL" and similar labels, including mechanical and electrical nameplates.
 16. Clean food-service equipment to a sanitary condition, ready and acceptable for its intended use.
 17. Wipe surfaces of mechanical and electrical equipment, elevator equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
 18. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
 19. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency. Replace burned-out bulbs and defective and noisy starters in fluorescent and mercury vapor fixtures.
 20. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
 21. Clean ductwork, blowers, and coils of units that were operated during construction.
 22. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
 23. Leave the Project clean and ready for occupancy.
- C. Pest Control: Engage an experienced, licensed exterminator to make a final inspection and rid the Project of rodents, insects, and other pests. Comply with regulations of local authorities.
- D. Removal of Protection: Remove temporary protection and facilities installed during construction to protect previously completed installations during the remainder of the construction period.

- E. Compliances: Comply with governing regulations and safety standards for cleaning operations. Remove waste materials from the site and dispose of lawfully.
 - 1. Where extra materials of value remain after completion of associated Work, they become the Owner's property. Dispose of these materials as directed by the OAR.
 - 2. The Contractor shall not dispose of debris or waste materials on the Owner's property without the prior approval of the Owner.
- F. Maintenance: Provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to assure operability without damaging effects.

3.2 PROTECTIONS

- A. General: Supervise construction operations to assure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period. Where applicable, such exposures include, but are not limited to, the following:
 - 1. Excessive static or dynamic loading.
 - 2. Excessive internal or external pressures.
 - 3. Excessively high or low temperatures.
 - 4. Thermal shock.
 - 5. Excessively high or low humidity.
 - 6. Air contamination or pollution.
 - 7. Water or ice.
 - 8. Solvents.
 - 9. Chemicals.
 - 10. Light.
 - 11. Radiation.
 - 12. Puncture.
 - 13. Abrasion.
 - 14. Heavy traffic.
 - 15. Soiling, staining, and corrosion.
 - 16. Bacteria.
 - 17. Rodent and insect infestation.
 - 18. Combustion.
 - 19. Electrical current.
 - 20. High-speed operation.
 - 21. Improper lubrication.
 - 22. Unusual wear or other misuse.
 - 23. Contact between incompatible materials.
 - 24. Destructive testing.
 - 25. Misalignment.
 - 26. Excessive weathering.
 - 27. Unprotected storage.
 - 28. Improper shipping or handling.
 - 29. Theft.

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FINAL CLEANING
Section 01 74 23

END OF SECTION 01 74 23

SECTION 01 78 00 - CLOSEOUT SUBMITTALS

PART 1 - GENERAL

1.1 SUMMARY

- A. Closeout is defined to include general submittal requirements in preparation for Substantial Completion, occupancy by Owner and Final Completion of the Work. Specific requirements for individual units of Work are specified in other Sections.

1.2 SUBSTANTIAL COMPLETION

- A. General: Refer to the General Conditions of the Design/Build Contract for Construction.
- B. Substantial Completion:
 - 1. Thirty (30) days prior to requesting inspection for the certification of Substantial Completion, prepare and submit the preliminary LEED Closeout Matrix for acceptance (see specification Section 01 33 29, Sustainable Material Content Forms). Matrix shall identify all relevant specification sections.
 - 2. Five (5) business days prior to requesting inspection for certification of Substantial Completion, prepare and submit to the OAR the following:
 - a. The Contractor's prepared comprehensive punch list of items to be completed or corrected. The punch list shall include all incomplete Work items and the schedule to complete each item.
 - b. Draft Operation and Maintenance (O&M) Manuals for review by the OAR for conformance with the Contract documents. These will be returned to the Contractor.
 - c. As-Built Documents (from Contractor) for review by the OAR for conformance with the Contract Documents. These will be returned to the Contractor.
 - d. The Substantial LEED Closeout Matrix with all available documentation and final documentation delivery status
 - 3. The Contractor shall request a preliminary inspection from the OAR for the determination that the Project is ready for the Substantial Completion Inspection. The Contractor will prior to the request:
 - a. Complete its punch list and provide a copy to the OAR.
 - b. Schedule inspections from the Authorities Having Jurisdiction and provide the time and date of each such inspection to the OAR.
 - 4. If the OAR's preliminary inspection discloses any item that is not in accordance with the requirements of the Contract Documents, whether or not included on the Contractor's punch list, the OAR shall so notify the Contractor and the Contractor shall add the items to its punch list. The Contractor shall proceed to complete or correct every item on the revised punch list and request re-inspection from the OAR.
 - 5. If the OAR determines that the Work is ready, the Substantial Completion Inspection will be scheduled at a minimum of three (3) business days after the OAR's preliminary inspection.
 - 6. Form #008 Substantial Completion Acceptance (SCA) will be used to: document the time and place of the project closeout inspections, establish the participants

- to be involved in the inspections, establish the date of Substantial Completion, document the acceptance of the Substantial Completion punch list, document the date all Substantial Completion punch list items were completed and document the date of Final Completion.
7. The following parties will attend the Substantial Completion inspection: the OAR, the Contractor, the Contractor's Designers and the DCC. The following Owner representatives may attend: GOAA ARFF, GOAA Construction, GOAA Engineering, GOAA Environmental, GOAA IT, GOAA Maintenance, GOAA Operations, GOAA Properties, GOAA Risk Management, and any involved tenant(s).
 8. Following the inspection, the OAR and DCC will determine if the Work is substantially complete. If it is determined to be Substantially Complete, the OAR will use this date in the preparation of Form #007 Certificate of Substantial Completion (CoSC) and the Contractor in the preparation of the written warranties. The following will be used in the determination of the Substantial Completion date:
 - a. Certificate of Occupancy/Certificate of Completion (CofO) or Agency Sign Off (as required). The date of the CofO does not establish the date for Substantial Completion.
 - b. Recommendation from the Designer, OAR and DCC that the Project is Substantially Complete.
 - c. Acceptance from the Contractor and OAR that the preliminary Substantial Completion punch lists represent most of the items required for completion of the Work. The OAR shall distribute the preliminary Substantial Completion punch lists to the Contractor within a maximum of seven (7) business days after the date of Substantial Completion.
 - d. Acceptance by the OAR of the draft warranties.
 - e. Acceptance by the OAR of the draft Operation & Maintenance Manuals.
 - f. Agreement from the Contractor and OAR that the Owner will have complete use or occupancy and may use, operate, and maintain the Project in all respects, for its intended purpose and without undue interference by the Contractor's Final Completion efforts.
 - g. If any of the above items are not accepted or incomplete the Contractor shall correct any items found not to be in accordance with the requirements of the Contract Documents and once the items have been corrected, the Contractor shall provide a written request for re-review and or re-inspection.
 9. When the Project is determined to be Substantially Complete the OAR will prepare a typed Substantial Completion punch list which includes any items from the preliminary Substantial Completion punch list that have not yet been completed plus all punch list items from the Designer, OAR, DCC, Owner and others, and Form #007 Certificate of Substantial Completion (CoSC) within a maximum of fifteen (15) business days from the date of Substantial Completion and will schedule a meeting with the Contractor, Designer, DCC and any Owner's representatives to:
 - a. Review Form #007 CoSC, all of its requirements and submit to the Contractor for appropriate acceptance and signature.

- b. Review the attachments: Form #008 SCA, Substantial Completion punch list and the CofO.
- c. Establish the date for the completion of the Substantial Completion punch list items.
- d. Establish the responsibilities of the Owner and Contractor for security, maintenance, operations, cleaning and housekeeping, heating and cooling, utilities, damage to the Work and insurance.
- e. Review and accept the Contractor's written warranties and guarantees from its Subcontractors and Suppliers bearing the date of Substantial Completion stating the period of warranty as required by the Contract Documents, the Final Operation & Maintenance Manuals, and As-built Documents.

1.3 PARTIAL OCCUPANCY OR USE

- A. General: Refer to the General Conditions of the Design/Build Contract for Construction.
- B. The Owner may occupy or use any completed or partially completed portion of the Work at any stage and, if the Owner chooses such partial occupancy, the Contractor and Owner shall designate by a Partial Occupancy and Use Agreement (POUA), provided such occupancy or use is consented to by the Owner's insurer and authorized by public authorities having jurisdiction over the Work.
 1. Such partial occupancy or use may commence whether or not the portion is Substantially Complete.
- C. Procedures to achieving partial occupancy or use:
 1. The Owner will request the OAR to coordinate with the Contractor for a partial occupancy or use of a portion of the Work.
 2. If the OAR determines that the Work is ready, a POUA inspection will be scheduled at a minimum of three (3) business days after the OAR's preliminary inspection.
 3. Immediately prior to such POUA inspection, the Owner, OAR, Contractor, Designer and DCC shall jointly inspect the area to be occupied or portion of the Work to be used in order to determine and record the condition of the Work.
 - a. The following parties will attend the POUA inspection: the OAR, the Contractor, the Designer and the DCC. The following Owner representatives may attend: GOAA Construction, GOAA Engineering, GOAA Environmental, GOAA Maintenance, GOAA Operations, GOAA Properties, GOAA Risk Management, GOAA ARFF, and any involved Tenant(s).
 4. Following the inspection, the OAR and DCC will determine if the Work is ready for partial occupancy or use. If it is determined to be ready, the OAR will use this date in the preparation of Form #009 Partial Occupancy/Use (POUA) and the Contractor in preparation of any agreed upon written warranties. The following will be used in the determination of the POUA date:
 - a. Certificate(s) of Occupancy (CofO) / Agency Sign Off (as required) for the area being occupied.
 - b. Recommendation from the OAR, Designer and DCC that determine the Project is ready for partial occupancy or use.

- c. Acceptance from the Contractor and OAR that the preliminary punch lists represent most of the items required for completion of the Work. The OAR shall distribute the preliminary punch lists to the Contractor within a maximum of three (3) business days after the date of the POUA.
 - d. Acceptance by the OAR of the draft warranties if requested.
 - e. Acceptance by the OAR of the draft Operation & Maintenance Manuals if requested.
 - f. Agreement from the Contractor that the Owner will have complete occupancy or use and may use, operate, and maintain the Project in all respects, for its intended purpose and without undue interference by the Contractor's Final Completion efforts.
 - g. Agreement that partial occupancy or use of a portion or portions of the Work shall not constitute acceptance of Work which is not in conformance with the requirements of the Contract Documents.
5. When the Project is determined to be ready for partial occupancy or use, the OAR will prepare a typed punch list which includes any items from the preliminary Substantial Completion punch list that have not yet been completed plus all punch list items from the Designer, OAR, DCC, Owner and others, and Form #009 Partial Occupancy/Use (POUA) within a maximum of fifteen (15) business days of the date of POUA and will schedule a meeting with the Contractor, Designer, DCC and any Owner's representatives to:
- a. Review Form #009 POUA, all of its requirements and submit to the Contractor for appropriate acceptance and signature.
 - b. Review the attachments: punch list and the CofO.
 - c. Establish the date for the completion of the punch list items.
 - d. Establish the responsibilities of the Owner and Contractor for security, maintenance, operations, cleaning and housekeeping, heating and cooling, utilities, damage to the Work and insurance.
 - e. Review and accept the requested Contractor's written warranties and guarantees from its Subcontractors and Suppliers bearing the date of the POUA stating the period of warranty as required by the Contract Documents.

1.4 FINAL COMPLETION

- A. General: Refer to the Agreement/Provisions of the Contract for Construction.
- B. Procedures: Complete the following.
 - 1. Before requesting final inspection for certification of Final Completion and final payment, prepare and submit to the OAR the following:
 - a. Contractor's certified copy of the Substantial Completion punch list of items to be completed or corrected, stating that each item has been completed or otherwise resolved for acceptance, endorsed and dated by the OAR.
 - b. Final meter readings for utilities, and similar data as of the date of Substantial Completion, or when the Owner took possession of and responsibility for corresponding elements of the Work.
 - c. Closeout Documentation Manual.

2. If the OAR determines that the Work is ready, the Final Completion Inspection will be scheduled at a minimum of three (3) business days after the OAR's preliminary inspection.
 3. The following parties will attend the Final Completion inspection: the OAR, the Contractor, the Designer and the DCC. The following Owner representatives may attend: GOAA ARFF, GOAA Construction, GOAA Engineering, GOAA Environmental, GOAA IT, GOAA Maintenance, GOAA Operations, GOAA Properties, GOAA Risk Management, and any involved tenant(s).
 4. Upon acceptance of the Final Completion Inspection, the Designer, OAR, DCC and GOAA Maintenance are to sign off on Part IV of Form #008 SCA and provide the final inspection date. The OAR is to provide the Contractor's completed punch list which will be field verified and each item initialed complete by the DCC and the OAR. The OAR is to provide documentation of FAA/FDOT final inspections, as required. Part IV of Form #008 SCA must be completed prior to processing the Contractor's final pay application.
- C. If necessary, re-inspection will be repeated at the Contractor's expense. Re-inspection Procedure: The OAR, Designer and DCC will re-inspect the Work upon receipt of notice that the Work, including inspection list items from earlier inspections, has been completed, except items whose completion has been delayed because of circumstances acceptable to the OAR and DCC. Repeat Final Completion Procedures above until Final Completion is accepted.

1.5 CLOSEOUT DOCUMENTATION MANUAL

- A. Description: Submit the manual in a vinyl covered, 3-ring binder; white, with hard cover, with clear vinyl pockets on front (sized to hold 8-1/2" x 11" sheets) and spine (minimum spine size 1", maximum 3"). Binder shall be "View Binder" as manufactured by Avery Consumer Products, AVE 0560 series, or approved equal. Each section shall be divided by an 8-1/2" x 11" reinforced, clear ring binder index, 5 tabs, as manufactured by Wilson Jones, Stock No. WJ-54125, or approved equal.
1. Full size, machine lettered labels shall be inserted into the front, back, and spine pockets. Labels shall be on white paper with black print, and shall clearly identify the following:

GREATER ORLANDO AVIATION AUTHORITY
ORLANDO INTERNATIONAL AIRPORT
(PROJECT TITLE & NUMBER)
(Manual Title)
(Date)
 2. Contents of the Manual shall include:
 - a. First page shall be a Cover Page, identifying:

GREATER ORLANDO AVIATION AUTHORITY
ORLANDO INTERNATIONAL AIRPORT
(PROJECT TITLE & NUMBER)
(Manual Title)
(Date)
 - b. Second page shall be a Table of Contents.

- c. The next section shall list the Names, Addresses, Contacts, and Phone Numbers for the following:
 - 1) OAR
 - 2) DCC
 - 3) Designer(s)
 - 4) Contractor
 - 5) Subcontractors (first-tier)
- d. Change Order Summary (prepared by GOAA)
- e. Summary of Disbursements (prepared by GOAA)
- f. Receipt/Acceptance Form for As-Built Documents
 - 1) Progress and As-Built Drawing Certification(s) for each applicable Subcontractor (Exhibit D; prepared by Contractor)
 - 2) GOAA Construction Form # 011 (prepared by OAR) with Transmittal to GOAA ENGINEERING (signed by GOAA Engineering)
- g. Receipt Form for O&M Manuals (GOAA Construction Form # 012; prepared by OAR) with Transmittal to GOAA MAINTENANCE (signed by GOAA Maintenance)
- h. Parking Permit Office Release Form (GOAA Construction Form # 001; prepared by Contractor) (signed by GOAA Ground Transportation)
- i. Badge & I.D. Office Release Form (GOAA Construction Form # 002; prepared by Contractor) (signed by GOAA Access Control)
- j. Key Shop Release Form (GOAA Construction Form # 003; prepared by Contractor) (signed by GOAA Lockshop)
- k. Environmental Group Letter of Concurrence for Closeout (if applicable; prepared by GOAA)
- l. Certificate(s) of Substantial Completion (GOAA Construction Form # 007; prepared by OAR)
 - 1) Substantial Completion Acceptance with Final Substantial Completion Punch list initialed and dated by Contractor (GOAA Construction Form # 008; prepared by OAR)
 - 2) Partial Occupancy / Use Agreement(s), or POUA (GOAA Construction Form # 009; prepared by OAR)
 - 3) FAA / FDOT Final Inspection(s) (if applicable; if project has FAA and/or FDOT funding, provide documentation of the invitation to FAA / FDOT and/or the appropriate sign off)
- m. Certificate(s) of Occupancy / Agency Sign Off (furnished by Contractor)
- n. Current Certificate of Insurance: (furnished by Contractor)
 - 1) a certificate evidencing that insurance required by the Contract Documents to remain in force after final payment is currently in effect and will not be canceled or allowed to expire until at least 30 days prior written notice has been given to the Owner: and
 - 2) a written statement that the Contractor knows no substantial reason that the insurance will not be renewable to cover the period required by the Contract Documents
- o. Consent of Surety to Final Payment with Power of Attorney (AIA Form # G707; furnished by Contractor) (original)
- p. Final Release Form from Contractor (Specification Section 00 65 19.29; prepared by Contractor) (original, notarized with corporate seal)

- q. Final Release Form(s) from Subcontractors / Suppliers (Specification Section 00 65 19.33; prepared by Subcontractor)
- r. Final Payment Application (2 originals, signed and notarized by Contractor and signed by DCC and OAR (DBE/MWBE/LDB Disbursement Page completed with Subcontractor performance rating and total payment)
- s. Executed Originals of Warranties/Guarantees.

1.6 AS-BUILT DOCUMENTS

- A. General: Do not use as-built documents for construction purposes; protect from deterioration and loss in a secure, fire-resistive location; provide access to as-built documents for the OAR's reference during normal working hours.
 - 1. Submit all As-Built Documents to the OAR as specified in Paragraph 1.3.B.
 - 2. Include fire alarm and building control system(s) drawings and specifications.
- B. As-Built Documents: As-Built Documents include Drawings, Specifications, Addenda, Change Orders, and other Modifications. Maintain a clean, undamaged set of blue or black line white-prints of Contract Drawings and Shop Drawings. Mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
 - 1. Mark As-Built sets with red erasable pencil; use other colors to distinguish between variations in separate categories of the Work.
 - 2. Mark new information that is important to the Owner, but was not shown on Contract Drawings or Shop Drawings.
 - 3. Note related Change Order numbers where applicable.
 - 4. Organize As-Built drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set.
 - 5. Mark EVERY PAGE of the Drawings with "As-Built".
- C. Accurate as-built documents are very important for the Owner and serve several important functions. The Owner utilizes the as-built documents for operation and maintenance, and future modifications, renovations, and particularly for mechanical, plumbing and electrical systems, which are mostly hidden from view.
 - 1. The working as-built shall show, but shall not be limited to, the following:
 - a. All concealed and underground utilities, equipment, foundations or other permanent conditions shall be surveyed and documented. This includes all discovered conditions. All shall be tied to permanent benchmarks showing horizontal and vertical data including but not limited to: beginning/end points, changes in direction points, inverts, grades of drainage, depths below the surface, all surface or underground components such as valves, manholes, drop inlets, clean outs, meters, corner points, etc. Each of the above shall also include a description of: actual quantity, size, and material. GPS coordinates are to be provided for all.

- b. The location and dimensions of any changes within the building structure and architectural components. The dimensions shall be actual field measurements.
- c. Correct dimensions and details transferred from shop drawings.
- d. Correct grade, elevations, cross section, or alignment of roads, earthwork, structures or utilities if any changes were made from contract plans.
- e. Actual location of anchors, construction and control joints, etc., in concrete.
- f. Changes in location of equipment and architectural features.
- g. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints. Cross out such words and phrases as "optimal requirement," "or approved substitution," etc., and list specifically the items of material provided.
- h. Unusual or uncharted obstructions that are encountered in the contract work area during construction.
- i. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to fabrication, erection, installation plans and placing details, pipe sizes, insulation material, dimensions of equipment foundations, etc.
- j. If borrow material for this project is from sources on the Owner's property, or if Owner's property is used as a spoil area, the Contractor shall furnish a contour map of the final borrow pit/spoil area elevations.
- k. Layout and schematic drawings of electrical circuits and piping. See the Electrical Specifications for the level of detail required to be accurately documented.
- l. Layout and schematic drawings of mechanical and plumbing systems and piping. All shall be tied to permanent benchmarks showing horizontal and vertical data of primary and secondary branches.
- m. Systems designed or enhanced by the Contractor, such as HVAC controls, fire alarm, fire sprinkler, and irrigation systems. All shall be tied to permanent benchmarks showing horizontal and vertical data of primary and secondary branches.
- n. Changes or modifications that result from the final inspection.

1.7 RECORD DRAWINGS

- A. After completion of construction and after the OAR's acceptance of the As-Built Documents, the Contractor's Designers shall incorporate all the changes defined on these as-built drawings and documents onto the Conformed Documents to produce a complete set of drawings and documents which reflect the as-built condition of the Work. Project Manual documents are to be submitted to the Owner in MSWord and PDF format on the final CD-ROM. The Designers shall submit the completed Record Documents to the Owner in CADD and PDF electronic formats CD-ROM or DVD. The Contractor's Redlined As-Built Drawings are to be turned back over to the Owner with this package.
- B. After submittal to the OAR, the OAR and DCC will review the Record Documents against the As-Built Documents for completeness, accuracy and compliance with

CADD/BIM requirements. If not acceptable, the Record Documents will be returned to the Contractor for correction.

1.8 OPERATION & MAINTENANCE MANUALS

- A. General: If all specified information can be submitted in a single binder without being overfilled, submit two (2) copies in a white binder with white labels.
1. If all of the information cannot be submitted in a single binder, submit two (2) per design discipline as follows:
- Architectural; submit in a white binder with white labels.
 - Mechanical; submit in a white binder with green labels.
 - Fire Protection & Other Systems; submit in a white binder with red labels.
 - Electrical; submit in a black binder with white labels.
 - Civil; submit in a white binder with yellow labels.
- B. Description: Submit the manual in a vinyl covered, 3-ring binder; with hard cover, with clear vinyl pockets on front (sized to hold 8-1/2" x 11" sheets) and spine (minimum spine size 1", maximum 3"). Binder shall be "View Binder" as manufactured by Avery Consumer Products, AVE 0560 series, or approved equal. Provide additional binders if a single 3-inch binder is insufficient to contain all closeout information. Each section shall be divided by an 8-1/2" x 11" reinforced, clear ring binder index, 5 tabs, as manufactured by Wilson Jones, Stock No. WJ-54125, or approved equal.
1. Full size, machine lettered labels shall be inserted into the front, back, and spine pockets. Labels shall be on paper in color(s) specified with black print, and shall clearly identify the following:
- GREATER ORLANDO AVIATION AUTHORITY
ORLANDO INTERNATIONAL AIRPORT
(PROJECT TITLE & NUMBER)
(Manual Title)
(Date)
2. Contents of the Manual shall include:
- a. First page shall be a Cover Page, identifying:
- GREATER ORLANDO AVIATION AUTHORITY
ORLANDO INTERNATIONAL AIRPORT
(PROJECT TITLE & NUMBER)
(Manual Title)
(Date)
- b. Second page shall be a Table of Contents indicating the contents of the binder(s).
- c. The third page shall list the Names, Addresses, Contacts, and Phone Numbers for the following:
- 1) OAR
 - 2) DCC
 - 3) Designer(s)

- 4) General Contractor
 - 5) Subcontractors
 - 6) Sub-subcontractors
 - 7) Suppliers
- d. The remaining portions of the manual shall be separated by each major division of work as identified by the Contract Documents.
- 1) PROJECT INFORMATION (Exhibit A).
 - 2) Within each major division of work, each section shall be individually identified by a typed index/tab. For each specification requirement, submit the following information in the order outlined below:
 - a) Copies of all warranties/guarantees, as specifically required by the specification section, and Letters of Certification. Executed original warranties/guarantees shall be included in the appropriate section of the Closeout Manual(s).
 - b) Copies of the "Approved" Shop Drawing/Submittals/ Equipment Manufacturer's Schematics. Oversized drawings shall be folded and inserted in clear vinyl pockets or, for large sets of drawings, provide an insert page stipulating that the drawings are stored at GOAA ENGINEERING. All copies shall be stamped with the appropriate review stamp, marked, signed, and dated.
 - c) Operation and Maintenance Instructions, including but not limited to:
 - ◆ Manufacturer's Recommended Care and Cleaning
 - ◆ Installation Instructions
 - ◆ Parts Lists
 - ◆ Lubrication Checklists
 - ◆ Equipment Supplier Lists
 - ◆ Special Instructions
 - ◆ Preventive Maintenance Instructions.
 - d) Service and Maintenance Contracts: Include Name, address, and phone number and contact of Manufacturer's authorized repair company.
 - e) Completed GOAA Turnover Forms:
 - ◆ Performance Verification and Demonstration to Owner (Exhibit B) signed by Contractor and GOAA representative
 - ◆ Voltage and amperage Readings (Exhibit C) signed by Contractor, Designer and OAR
 - ◆ Motor Test Information (Exhibit D) signed by Contractor and OAR
 - ◆ Check-out Memo (Exhibit E) signed by Contractor and Manufacturer's representative

- f) Equipment and/or Systems Test Data and Conductor Insulation Resistance Test Data Sheets by installer and/or manufacturer where required. Form(s) to be provided by the installer and/or manufacturer performing the test [Exhibits G, H (signed by Contractor, Designer and GOAA representative), I (signed by Contractor, Subcontractor and GOAA), J (signed by Contractor and OAR) and K (signed by Contractor, Designer and OAR)].
 - g) Copies of electrical panel schedules and directories.
- C. Submit one copy of the O&M manual in PDF format on CD-ROM. Create a PDF file for each section of the manual. PDF files shall be named *BPXXX OM Sec XXXXX.pdf*

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 CLOSEOUT PROCEDURES

- A. Operation and Maintenance Instructions: Arrange for each installer of equipment that requires regular maintenance to meet with the Owner's personnel to provide instruction in proper operation and maintenance. If installers are not experienced in procedures, provide instruction by manufacturer's representatives. Include a detailed review of the following items:
 - 1. Operation and Maintenance manuals.
 - 2. As-Built Documents.
 - 3. Spare parts and materials.
 - 4. Tools.
 - 5. Lubricants.
 - 6. Fuels.
 - 7. Identification systems.
 - 8. Control sequences.
 - 9. Hazards.
 - 10. Cleaning.
 - 11. Warranties and bonds.
 - 12. Maintenance agreements and similar continuing commitments.
- B. As part of instruction for operating equipment, demonstrate the following procedures:
 - 1. Start-up.
 - 2. Shutdown.
 - 3. Emergency operations.
 - 4. Noise and vibration adjustments.
 - 5. Safety procedures.

3.2 CLEANING

- A. General: General cleaning during construction is required.
- B. Final Cleaning: Refer to Section 01 74 23, Final Cleaning.

3.3 ATTACHMENTS

- A. The following information sheets have been included in this Section:
1. Exhibit A: Project Information
 2. Exhibit B: Performance Verification and Demonstration to Owner
 3. Exhibit C: Voltage and Amperage Readings
 4. Exhibit D: Motor Test Information
 5. Exhibit E: Check-Out Memo
 6. Exhibit F: Progress and As-Built Document Certification
 7. Exhibit G: D-C High Voltage Cable Test Report
 8. Exhibit H: Ground Test Information
 9. Exhibit I: Spare Parts Certification Memo
 10. Exhibit J: Existing Facilities Investigation Memo
 11. Exhibit K: Conductor Insulation Resistance Test Memo
 12. Example: Description Sheet – Cover
 13. Example: Description Sheet - Spine

END OF SECTION 01 78 00

ORLANDO INTERNATIONAL AIRPORT
SOUTH TERMINAL C
TENANT AND AIRLINE BUILD-OUT PROJECTS

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Section 01 78 00

EXHIBIT A
PROJECT INFORMATION
Orlando International Airport

Contractor shall fill in the blanks below and insert in the Operation and Maintenance Manuals.
Submit one (1) sheet for each major division of Work.

Project Name: _____

Specification Division Number & Name: _____

Subcontractor: _____

Contact: _____ Phone: _____

Date Project Bid: _____

Project Start Date: _____

Days allowed for Construction: _____

Target Completion: _____

Substantial Completion Certification Date: _____

	<u>Date Submitted</u>	<u>Date Provided</u>
Close-out Documentation Manual:	_____	_____
Operation and Maintenance Manuals:	_____	_____
Owner Performance Verification and Demonstrations:	_____	_____
Manufacturer's Performance Verification Memos:	_____	_____
Manufacturer's Test Data:	_____	_____
Record Documents:	_____	_____

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EXHIBIT B
PERFORMANCE VERIFICATION AND DEMONSTRATION TO OWNER
Orlando International Airport

This form verifies that the Owner has been given a demonstration of the proper operation on the equipment or systems noted below as required in Section 01 79 00 "Demonstration and Training".

Project Name: _____

Specification Division Number & Name: _____

Equipment/Systems Demonstrated: _____

Along with a complete demonstration of the equipment/system, these items have been reviewed at this demonstration and shall be included in the Operation and Maintenance Manuals, under the appropriate specification section:

- 1) Written operating instructions.
- 2) Test data and performance verification information as required by the installer and/or manufacturer.
- 3) Maintenance information published by manufacture's representative.
- 4) Check-out Memo signed by manufacturer's representative.
- 5) Printed warranties by manufacturer of equipment.
- 6) Explanation of the warranty/guarantee on the system.
- 7) Prints showing actual "As-Built" conditions.

(Name of Contractor)

(Signature, Title, Date)

(Name of Subcontractor)

(Signature, Title, Date)

(Name of Contractor's Designer)

(Signature, Title, Date)

A demonstration of the system/equipment in operation and of the maintenance procedures has been successfully completed.

(Name of OAR)

(Signature, Title, Date)

GREATER ORLANDO AVIATION AUTHORITY

(Signature, Date)

(GOAA Department)

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EXHIBIT C
VOLTAGE AND AMPERAGE READINGS
Orlando International Airport

Project Name: _____

Switchgear/Panelboard: _____

Full Load Amperage Readings: Date: _____ Time: _____

Phase A: _____

Phase B: _____

Phase C: _____

Neutral: _____

Ground: _____

Full Load Voltage Readings: Date: _____ Time: _____

Phase: A to N _____

A to B _____

B to N _____

A to C _____

C to N _____

B to C _____

Voltage at the End of the Longest Branch: _____

Type of Load: _____

No Load Voltage Readings: Date: _____ Time: _____

Phase: A to N _____

A to B _____

B to N _____

A to C _____

C to N _____

B to C _____

(Name of Contractor)

(Signature, Title, Date)

(Name of Subcontractor)

(Signature, Title, Date)

(Name of Contractor's Designer)

(Signature, Title, Date)

(Name of OAR)

(Signature, Title, Date)

ORLANDO INTERNATIONAL AIRPORT
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EXHIBIT D
MOTOR TEST INFORMATION
Orlando International Airport

Project Name: _____

Description of Motor: _____

Checked By: _____ Date Checked: _____

a) Name and Identifying Mark of Motor (Indicate at existing): _____

b) Manufacturer: _____

c) Model Number: _____

d) Serial Number: _____

e) RPM: _____

f) Frame Size: _____

g) Code Letter: _____

h) Horsepower: _____

i) Nameplate, Voltage and Phase: _____

j) Nameplate Amps: _____

k) Actual Voltage: _____

l) Actual Amps: _____

m) Starter Manufacturer: _____

n) Starter Size: _____

o) Heater Size, Catalog No. and Amp Rating: _____

p) Manufacturer of Dual-Element Fuse: _____

q) Amp Rating of Fuse: _____

r) Power Factor: _____

(Name of Contractor)

(Signature, Title, Date)

(Name of Subcontractor)

(Signature, Title, Date)

(Name of Contractor's Designer)

(Signature, Title, Date)

(Name of OAR)

(Signature, Title, Date)

ORLANDO INTERNATIONAL AIRPORT
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EXHIBIT E
CHECK-OUT MEMO
Orlando International Airport

This form shall be completed and a copy provided to the Owner at the Owner's Performance Verification and Demonstration meeting. A copy shall also be included in the specification section of the Operation and Maintenance Manual for the equipment checked.

Project Name: _____

Type of Equipment Checked: _____

Equipment Number: _____

Name of Equipment Manufacturer: _____

Signature below by the Manufacturer's authorized representative signifies that the equipment has been satisfactorily tested and checked out on the job by the manufacturer.

1. The attached Test Data and Performance Verification information was used to evaluate the equipment installation and operation.
2. The equipment is properly installed, has been tested by the manufacturer's authorized representative, and is operating satisfactorily in accordance with all requirements, except for items noted below. *
3. Written operating and maintenance information has been presented to the Contractor, and gone over with him in detail.
4. Sufficient copies of all applicable operating and maintenance information, part lists, lubrication checklists, and warranties have been furnished to the Contractor for insertion in the Operation and Maintenance Manuals.

Manufacturer's Representative: _____
(Print or Type Name and Title)

(Print or Type Address and Phone Number)

Signature of Manufacturer's Representative: _____ Date Checked

Witnessed By: _____
(Signature and Title of Contractor's Representative)

Witnessed By: _____
(Signature and Title of Contractor's Designer)

Witnessed By: _____
(Signature and Title of OAR)

*Exceptions Noted at Time of Check-Out: (Use additional pages if necessary.)

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EXHIBIT F
PROGRESS AND AS-BUILT DRAWING CERTIFICATION
Orlando International Airport

This form shall be completed and submitted with the As-Built Documents. Submit one form for each contractor/subcontractor providing as-built information. Include a copy of this form in the Close-out Documentation Manual.

Project Name: _____

Specification Division Number & Name: _____

The Contractor's and Subcontractor's signatures below certify that the attached drawings and specifications were marked and revised as items were installed/changed during the course of construction, and that these documents represent and accurate "As-Built" condition of the work as actually installed.

(Name of Contractor)

(Signature, Title, Date)

(Name of Subcontractor)

(Signature, Title, Date)

(Name of Contractor's Designer)

(Signature, Title, Date)

(Name of OAR)

(Signature, Title, Date)

ORLANDO INTERNATIONAL AIRPORT
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EXHIBIT G
D-C HIGH VOLTAGE CABLE TEST REPORT

Project Name: _____

Location: _____

Description: _____

Rated Voltage: _____

TEST DATA

Set Leakage at Test Voltage _____ ma Variac _____

Pri. Voltage _____ Sphere Gap _____ Inches

Duct Temp. _____ Ambient Temp. _____ Weather _____

Cable Status _____ 1 hour prior to test.

TEST RESULTS

Phase or Conductor	<u>A</u>	<u>B</u>	<u>C</u>	Remarks
--------------------	----------	----------	----------	---------

Starting Time				
---------------	--	--	--	--

MA	MA	MA	
----	----	----	--

0	_____
15 sec.	_____
30 sec.	_____
45 sec.	_____
1 min.	_____
2 min.	_____
3 min.	_____
4 min.	_____
5 min.	_____

Final Test Voltage: _____ Time Finish: _____

KV DC After 1 Min.: Test Procedure _____ No. of Terminals _____

Joints _____

(Name of Person Performing Test)

(Signature, Title, Date)

(Name of Contractor)

(Signature, Title, Date)

(Name of Subcontractor)

(Signature, Title, Date)

(Name of Contractor's Designer)

(Signature, Title, Date)

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(Name of OAR)

(Signature, Title, Date)

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EXHIBIT H
GROUND TEST INFORMATION
(Refer to Specification Section 26 00 10)

Project Name: _____

Ground Type: _____

Test By: _____

Date of Test: _____

Ground Location: _____

Ground Type (rod, water pipe, etc.): _____

Prior to Connection to System: Ground: _____(OHMS)

After Connection to System: Ground: _____(OHMS)

Weather Conditions (Wet/Dry): _____ Soil Conditions (Wet/Dry): _____

(Name of Person Performing Test)

(Signature, Title, Date)

(Name of Contractor)

(Signature, Title, Date)

(Name of Subcontractor)

(Signature, Title, Date)

(Name of Contractor's Designer)

(Signature, Title, Date)

(Name of OAR)

(Signature, Title, Date)

ORLANDO INTERNATIONAL AIRPORT
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EXHIBIT I
SPARE PARTS CERTIFICATION MEMO
(Refer to Division 26 Specifications)

This form shall be completed and a copy provided to the Owner at the Owner's Performance Verification and Demonstration meeting. A copy shall also be included in the specifications section of each Operation and Maintenance Manual for the equipment checked.

Name of Project: _____

Type of Spare Parts: _____

Specification Reference: _____

Quantity of Spare Parts: _____

Signature below by the Contractor and subcontractor signifies that the spare parts required by the drawings and/or specifications have been turned over to the Owner. Signature by the Owner acknowledges receipt of the same spare parts.

Name of Contractor: _____

Authorized Signature and Title: _____

Date: _____

Name of Subcontractor: _____

Authorized Signature and Title: _____

Date: _____

Name of OAR: _____

Authorized Signature and Title: _____

Date: _____

Name of Owner: _____

Authorized Signature and Title: _____

Date: _____

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EXHIBIT J (NOT USED)

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EXHIBIT K
CONDUCTOR INSULATION RESISTANCE TEST MEMO
(Refer to Division 26 Sections)

NAME OF PROJECT: _____

Conductor Location

From: _____ To: _____

Size of Conductor _____

Insulation Type _____ Insulation Voltage Rating _____

Date of Test _____ Time of Test _____

Weather Conditions _____

Test Voltage (DC) _____ Range _____

Megger Instrument/Serial Number _____

Testing Methodology _____

INSULATION RESISTANCE MEASUREMENT

(Acceptable Measurement not to be less than one (1) Megohm)

Phase A to Ground _____

Phase B to Ground _____

Phase C to Ground _____

Neutral to Ground _____

Isolated Ground to Ground _____

(Name of Person Performing Test)

(Signature, Title, Date)

(Name of Contractor)

(Signature, Title, Date)

(Name of Subcontractor)

(Signature, Title, Date)

(Name of Contractor's Designer)

(Signature, Title, Date)

(Name of OAR)

(Signature, Title, Date)

ORLANDO INTERNATIONAL AIRPORT
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Section 01 78 00

EXAMPLE - Description Sheet - Cover

**GREATER ORLANDO
AVIATION AUTHORITY**

**ORLANDO
INTERNATIONAL
AIRPORT**

BID PACKAGE NO. 000

[DESCRIPTION OF PROJECT]

OPERATION AND MAINTENANCE MANUAL

EXAMPLE - Description Sheet - Spine

G.O.A.A.
O.I.A.
B.P. #000
[DESCRIPTION OF PROJECT]
ELECTRICAL
OPERATION AND MAINTENANCE MANUAL

G.O.A.A.
O.I.A.
B.P. #000
[DESCRIPTION OF PROJECT]
SYSTEMS
OPERATION AND MAINTENANCE MANUAL

SECTION 01 78 10 – WARRANTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes sample warranties to be executed by the Contractor and Subcontractors.

1.2 GENERAL REQUIREMENTS

- A. Forms:
 - 1. Subcontractor Warranty (FORM 01 78 10-1)
 - 2. Contractor Warranty (FORM 01 78 10-2)

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01 78 10

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FORM 01 78 10-1

SUBCONTRACTOR WARRANTY

PROGRAM: South Terminal C – Tenant and Airline Buildout Project

PROJECT NAME: _____

PROJECT NUMBER: BP-_____

OWNER: The Greater Orlando Aviation Authority

DCC: SchenkelShultz

CONTRACTOR: _____

SCOPE OF WORK: _____

LENGTH OF WARRANTY (YEARS): _____

STARTING DATE: _____ (Substantial Completion Date)

All materials and/or equipment furnished, or Work performed by _____ (hereafter called "Subcontractor") in connection with BP-S00xxx, _____ (hereafter called "Project") under the Subcontract or Purchase Agreement between _____ (hereafter called "Contractor") and the Subcontractor fully conforms to all requirements of the Contract Documents and is free of any defect in equipment, material, design furnished, or workmanship performed by the Subcontractor. This warranty shall continue for a period of ____ years commencing on the Substantial Completion Date for the aforementioned Project as determined by The Greater Orlando Aviation Authority, (hereafter called "Owner"), except to the extent any longer warranty period is called for by the Contract Documents with respect to equipment, material, design furnished, or workmanship performed by the Subcontractor. Work not conforming to these requirements including substitutions not properly approved and authorized may be considered defective. The Subcontractor agrees to promptly make good, without cost to the Contractor or the Owner, any and all defects due to faulty equipment, material, design furnished, or workmanship performed by the Subcontractor, which may appear within the established warranty period. Failure to make good such defects within thirty (30) calendar days after notification may cause the corrective work to be performed by others at the Subcontractor's expense, except in cases where failure to immediately correct the work is causing negative impacts to Owner's operations, in which case Owner may correct the defect immediately if Subcontractor is not able to do so, and then backcharge the Subcontractor for the reasonable cost of the correction. All expenses necessary to replace or repair work will be the Subcontractor's responsibility including that damaged or disturbed by making replacement or repairs. This warranty is in addition to and not in lieu of all other guarantees, warranties and rights contained in the Contract Documents or applicable law. In the event that an equipment, material, design

furnished, or workmanship performed by the Subcontractor is repaired or replaced pursuant to these warranty provisions, the Subcontractor shall extend the warranty period with respect to the equipment, material, design furnished, or workmanship performed by the Subcontractor so repaired or replaced for any additional period of time after Owner approval of the repair or replacement specified in the Contract Documents. The Subcontractor hereby acknowledges that this warranty is given for the benefit of the Owner and Contractor and agrees to honor requests or directives issued to the Subcontractor by the Owner or Contractor for enforcement of this warranty. The Subcontractor further hereby assigns to the Owner all warranties, express or implied, issued by the Subcontractor and by manufacturers, suppliers, or subcontractors to the Subcontractor for equipment, material, design furnished, or workmanship performed by the Subcontractor in connection with the Work.

IN WITNESS WHEREOF, THE Subcontractor has caused this instrument to be signed and executed this _____ day of _____, _____.

FIRM:

BY:

TITLE:

State of _
County of _

} SS.

On _____ (*enter date*) before me, _____ (*enter Notary's Name here*),
Notary Public, personally appeared _____ (*here insert name and title of person signing the instrument*) who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of that the foregoing paragraph is true and correct.
WITNESS my hand and official seal.

Signature:

(Seal)

My Commission Expires:

FORM 01 78 10-2

CONTRACTOR WARRANTY

PROGRAM: South Terminal C – Tenant and Airline Buildout Project

PROJECT NAME: _____

PROJECT NUMBER: BP-_____

OWNER: The Greater Orlando Aviation Authority

Architect of Record: SchenkelShultz

CONTRACTOR: _____

SCOPE OF WORK: _____

LENGTH OF WARRANTY (YEARS): _____

STARTING DATE: _____ (Substantial Completion Date)

All materials and/or equipment furnished, or work performed by _____, (hereafter called "Contractor") in connection with BP-S00xxx, _____, (hereafter called "Project") under the Agreement between The Greater Orlando Aviation Authority (hereafter called "Owner") and the Contractor fully conforms to all requirements of the Contract Documents and is free of any defect in equipment, material, design furnished, or workmanship performed by the Contractor. This warranty shall continue for a period of _____ years commencing on the Substantial Completion Date for the aforementioned Project as determined by the Owner, except to the extent any longer warranty period is called for by the Contract Documents with respect to equipment, material, design furnished, or workmanship performed by the Contractor. Work not conforming to these requirements including substitutions not properly approved and authorized may be considered defective. The Contractor agrees to promptly make good, without cost to the Owner, any and all defects due to faulty equipment, material, design furnished, or workmanship performed by the Contractor, which may appear within the established warranty period. Failure to make good such defects within thirty (30) calendar days after notification may cause the corrective work to be performed by others at the Contractor's expense, except in cases where failure to immediately correct the work is causing negative impacts to Owner's operations, in which case Owner may correct the defect immediately if Subcontractor is not able to do so, and then backcharge the Subcontractor for the reasonable cost of the correction. . All expenses necessary to replace or repair work will be the Contractor's responsibility including that damaged or disturbed by making replacement or repairs. This warranty is in addition to and not in lieu of all other guarantees, warranties and rights contained in the Contract Documents or applicable law. In the event that equipment, material, design furnished, or workmanship performed by the Contractor is repaired or replaced pursuant to these warranty provisions, the Contractor shall

extend the warranty period with respect to the equipment, material, design furnished, or workmanship performed by the Contractor so repaired or replaced for any additional period of time after Owner approval of the repair or replacement specified in the Contract Documents. The Contractor hereby acknowledges that this warranty is given for the benefit of the Owner and agrees to honor requests or directives issued to the Contractor by the Owner for enforcement of this warranty. The Contractor further hereby assigns to the Owner all warranties, express or implied, issued by the Contractor and by manufacturers, suppliers, or subcontractors to the Contractor for equipment, material, design furnished, or workmanship performed by the Contractor in connection with the Project.

IN WITNESS WHEREOF, THE Contractor has caused this instrument to be signed and executed this _____ day of _____, _____.

FIRM:

BY:

TITLE:

State of _
County of _

} SS.

On _____ (enter date) before me, _____ (enter Notary's Name here),
Notary Public, personally appeared _____ (here insert name and title of person
signing the instrument) who proved to me on the basis of satisfactory evidence to be the
person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me
that he/she/they executed the same in his/her/their authorized capacity(ies), and that by
his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the
person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of that the foregoing
paragraph is true and correct.

WITNESS my hand and official seal.

Signature:

(Seal)

My Commission Expires:

SECTION 01 79 00 - DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for instructing Owner's personnel where indicated in other sections, including the following:
 - 1. Instruction in operation and maintenance of systems, subsystems, and equipment.
 - 2. Demonstration and training video recordings.

1.3 INFORMATIONAL SUBMITTALS

- A. Instruction Program: Submit outline of instructional program for demonstration and training, including a list of training modules and a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.
 - 1. Indicate proposed training modules using manufacturer-produced demonstration and training video recordings for systems, equipment, and products in lieu of video recording of live instructional module.
- B. Qualification Data: For facilitator.
- C. Attendance Record: For each training module, submit list of participants and length of instruction time.
- D. Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.

1.4 CLOSEOUT SUBMITTALS

- A. Demonstration and Training Video Recordings: Submit two copies within seven days of end of each training module.
 - 1. Identification: On each copy, provide an applied label with the following information:
 - a. Name of Project.
 - b. Name and address of videographer.
 - c. Name of Owner.
 - d. Name of Architect.
 - e. Name of Construction Manager.
 - f. Name of Contractor.
 - g. Date of video recording.

2. Transcript: Prepared and bound in format matching operation and maintenance manuals. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as the corresponding video recording. Include name of Project and date of video recording on each page.
3. At completion of training, submit complete training manual(s) for Owner's use prepared in same format required for operation and maintenance manuals specified in Section 01 78 00 "Closeout Submittals".

1.5 QUALITY ASSURANCE

- A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.
- B. Instructor Qualifications: A factory-authorized service representative, complying with requirements in Section 01 45 00 "Quality Control", experienced in operation and maintenance procedures and training.
- C. Preinstruction Conference: Conduct conference at Project site to comply with requirements in Section 01 31 19 "Project Meetings". Review methods and procedures related to demonstration and training including, but not limited to, the following:

1.6 COORDINATION

- A. Coordinate instruction schedule with Owner's operations. Adjust schedule as required to minimize disrupting Owner's operations and to ensure availability of Owner's personnel.
- B. Coordinate instructors, including providing notification of dates, times, length of instruction time, and course content.
- C. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data have been reviewed and approved by Architect.

1.7 INSTRUCTION PROGRAM

- A. Program Structure: Develop an instruction program that includes individual training modules for each system and for equipment not part of a system, as required by individual Specification Sections.
- B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following as applicable to the system, equipment, or component:
 1. Basis of System Design, Operational Requirements, and Criteria: Include the following:

- a. System, subsystem, and equipment descriptions.
 - b. Performance and design criteria if Contractor is delegated design responsibility.
 - c. Operating standards.
 - d. Regulatory requirements.
 - e. Equipment function.
 - f. Operating characteristics.
 - g. Limiting conditions.
 - h. Performance curves.
2. Documentation: Review the following items in detail:
 - a. Emergency manuals.
 - b. Systems and equipment operation manuals.
 - c. Systems and equipment maintenance manuals.
 - d. Product maintenance manuals.
 - e. Project Record Documents.
 - f. Identification systems.
 - g. Warranties and bonds.
 - h. Maintenance service agreements and similar continuing commitments.
3. Emergencies: Include the following, as applicable:
 - a. Instructions on meaning of warnings, trouble indications, and error messages.
 - b. Instructions on stopping.
 - c. Shutdown instructions for each type of emergency.
 - d. Operating instructions for conditions outside of normal operating limits.
 - e. Sequences for electric or electronic systems.
 - f. Special operating instructions and procedures.
4. Operations: Include the following, as applicable:
 - a. Startup procedures.
 - b. Equipment or system break-in procedures.
 - c. Routine and normal operating instructions.
 - d. Regulation and control procedures.
 - e. Control sequences.
 - f. Safety procedures.
 - g. Instructions on stopping.
 - h. Normal shutdown instructions.
 - i. Operating procedures for emergencies.
 - j. Operating procedures for system, subsystem, or equipment failure.
 - k. Seasonal and weekend operating instructions.
 - l. Required sequences for electric or electronic systems.
 - m. Special operating instructions and procedures.
5. Adjustments: Include the following:
 - a. Alignments.
 - b. Checking adjustments.
 - c. Noise and vibration adjustments.
 - d. Economy and efficiency adjustments.
6. Troubleshooting: Include the following:
 - a. Diagnostic instructions.
 - b. Test and inspection procedures.

7. Maintenance: Include the following:
 - a. Inspection procedures.
 - b. Types of cleaning agents to be used and methods of cleaning.
 - c. List of cleaning agents and methods of cleaning detrimental to product.
 - d. Procedures for routine cleaning.
 - e. Procedures for preventive maintenance.
 - f. Procedures for routine maintenance.
 - g. Instruction on use of special tools.
8. Repairs: Include the following:
 - a. Diagnosis instructions.
 - b. Repair instructions.
 - c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
 - d. Instructions for identifying parts and components.
 - e. Review of spare parts needed for operation and maintenance.

1.8 PREPARATION

- A. Assemble educational materials necessary for instruction, including documentation and training module.
- B. Set up instructional equipment at instruction location.

1.9 INSTRUCTION

- A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.
- B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.
- C. Scheduling: Provide instruction at mutually agreed-on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.
 1. Schedule training with Owner, through Construction Manager, with at least seven days' advance notice.
- D. Training Location and Reference Material: Conduct training on-site in the completed and fully operational facility using the actual equipment in-place. Conduct training using final operation and maintenance data submittals.
- E. Evaluation: At conclusion of each training module, assess and document each participant's mastery of module by use of a demonstration performance-based test.
- F. Cleanup: Collect used and leftover educational materials and remove from Project site. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

1.10 DEMONSTRATION AND TRAINING VIDEO RECORDINGS

- A. General: Engage a qualified commercial videographer to record demonstration and training video recordings. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.
 - 1. At beginning of each training module, record each chart containing learning objective and lesson outline.
- B. Digital Video Recordings: Provide high-resolution, digital video in MPEG format, produced by a digital camera with minimum sensor resolution of 12 megapixels and capable of recording in full HD mode with vibration reduction technology.
 - 1. Submit video recordings on CD-ROM or thumb drive.
 - 2. File Hierarchy: Organize folder structure and file locations according to Project Manual table of contents. Provide complete screen-based menu.
 - 3. File Names: Utilize file names based on name of equipment generally described in video segment, as identified in Project specifications.
 - 4. Contractor and Installer Contact File: Using appropriate software, create a file for inclusion on the equipment demonstration and training recording that describes the following for each Contractor involved on the Project, arranged according to Project Manual table of contents:
 - a. Name of Contractor/Installer.
 - b. Business address.
 - c. Business phone number.
 - d. Point of contact.
 - e. Email address.
- C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to adequately cover area of demonstration and training. Display continuous running time.
 - 1. Film training session(s) in segments not to exceed 15 minutes.
 - a. Produce segments to present a single significant piece of equipment per segment.
 - b. Organize segments with multiple pieces of equipment to follow order of Project Manual table of contents.
 - c. Where a training session on a particular piece of equipment exceeds 15 minutes, stop filming and pause training session. Begin training session again upon commencement of new filming segment.
- D. Light Levels: Verify light levels are adequate to properly light equipment. Verify equipment markings are clearly visible prior to recording.
 - 1. Furnish additional portable lighting as required.
- E. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.
- F. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

- G. Preproduced Video Recordings: Provide video recordings used as a component of training modules in same format as recordings of live training.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 01 79 00

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SECTION 01 81 13.14 - SUSTAINABLE DESIGN REQUIREMENTS - LEED V4 BD+C

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes requirements and procedures for compliance with certain prerequisites and credits needed for the Project to obtain "LEED Version 4 Building Design and Construction" (LEED v4 BD+C) certification. Certification criteria is based on the USGBC's LEED v4 BD+C scorecard provided in Specification Section 01 33 29 – Sustainable Material Content Forms
 - 1. Individual material requirements for LEED compliance are also included within the individual Specification Sections and will reference back to this section for the compliance criteria.
 - 2. Some LEED prerequisites and credits needed to obtain the indicated LEED certification depend on design and construction by others and other aspects of Project that are not part of the Work of the Contract.
 - 3. Compliance with the targeted construction credits (as outlined in Specification Section 01 33 29 – Sustainable Material Content Forms) have been captured within the Design Criteria Package (DCP) documents. Achievement of those credits relies on the Contractor's successful implementation and oversight of those requirements.
 - 4. Compliance with the requirements needed to obtain LEED prerequisites and credits will be used as one of the criterion needed to evaluate substitution requests and comparable product requests.

1.2 DEFINITIONS

- A. LEED: USGBC's "LEED Version 4 Building Design and Construction."
 - 1. Below are some of the Definitions and terminology included within "LEED Version 4 Building Design and Construction" (LEED v4 BD+C) for reference.
- B. Chain-of-Custody Certificates: Certificates signed by manufacturers certifying that wood used to make products was obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001. Certificates shall include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
- C. Chemical Abstract Service Registration Number (CASRN): CAS Registry Numbers are unique numerical identifiers assigned by the Chemical Abstracts Service to every chemical described in the open scientific literature (currently including those described from at least 1957 through the present) and including elements, isotopes, organic and inorganic compounds, ions, organometallics, metals, non-structural materials (aka 'UVCB's- i.e., materials of Unknown, Variable Composition, or Biological origin).[2] They are also referred to as CAS RNs, CAS Numbers, etc.

- D. Cradle-to-gate: Cradle-to-gate assessment analysis of a product's partial life cycle, from resource extraction (cradle) to the factory gate (before it is transported for distribution and sale). It omits the use and the disposal phases of the product.
- E. Cradle to Cradle Certification: The Cradle to Cradle Certified™ Product Standard guides designers and manufacturers through a continual improvement process that looks at a product through five quality categories —material health, material reutilization, renewable energy and carbon management, water stewardship, and social fairness. A product receives an achievement level in each category — Basic, Bronze, Silver, Gold, or Platinum — with the lowest achievement level representing the product's overall mark.
- F. CDPH Emissions Testing: Standard Method for the Testing & Evaluation of VOC Emissions CDPH/EHLB/Standard Method V1.1. (February 2010) Page 4 of 52 Author/Acknowledgements The California Department of Public Health (CDPH), Indoor Air Quality (IAQ) Section, prepared this document, and CDPH approved its release on March 4, 2010.
- G. EPD: An EPD® (*Environmental Product Declaration*) is a verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of a product.
- H. Extended Producer Responsibility: Extended Producer responsibility measures undertaken by the maker of a product to accept its own and sometimes other manufacturers' products as postconsumer waste at the end of the products' useful life. Producers recover and recycle the materials for use in new products of the same type. To count toward credit compliance, a program must be widely available. For carpet, extended producer responsibility must be consistent with NSF/ANSI 140–2007. Also known as closed-loop program or product take-back.
- I. GBCI: Green Business Certification Inc. is an American organization that provides third-party credentialing and verification for several rating systems relating to the built environment.
- J. Health Product Declaration: Health Product Declaration (HPDs) provide a full disclosure of the potential chemicals of concern in products by comparing product ingredients to a wide variety of "hazard" lists published by government authorities and scientific associations.
- K. Regional Materials: Materials that have been extracted (recycling location can serve as the material harvest location), harvested, or recovered, as well as manufactured, within 100 miles of Project site.
- L. Recycled Content: The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

1. Postconsumer material is defined as waste material generated by households or by commercial, industrial, and institutional facilities in their role as end users of the product, which can no longer be used for its intended purpose.
 2. Pre-consumer material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials, such as rework, regrind, or scrap, generated in a process and capable of being reclaimed within the same process that generated it.
- M. Pilot Credit: Pilot Credits are potential LEED credits created by U.S. Green Building Council and included within the Pilot Credit Library as an opportunity to "test drive" LEED credits before member's vote to include in the next full-version iteration of the LEED rating system.
- N. Product/Material: A Product or material permanently installed within the building. An item that arrives on the project site either as a finished element ready for installation or as a component to another item assembled on-site. The product unit is defined by the functional requirement for use in the project; this includes the physical components and services needed to serve the intended function of the permanently installed building product. In addition, similar product within a specification, each contributes as a separate product.
- O. Volatile Organic Compounds (VOCs): VOCs are a class of chemicals that are volatile (evaporate easily) and are organic compounds (contain carbon atoms). Some common VOCs include acetone and automotive gasoline.

1.3 PREINSTALLATION MEETINGS

- A. Pre-installation Meeting/Conference: Conduct a Sustainable Requirement conference(s) at Project site to review LEED requirements and action plans for meeting requirements. Meeting/conference can be included as part of the pre-installation meeting agenda

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Respond to Contractor related questions and requests from the DCC, USGBC, GBCI and the LEED Facilitation Team. Question and response information may be asked post project completion. Contractor shall be required to gather and respond to all requests until the GBCI/USGBC review has been completed and determination on the Project's LEED certification application has been finalized. Document responses as informational submittals.
- B. Submit Contractor related documentation and submittals to the project Architect, USGBC, GBCI and the LEED Facilitation Team, as indicated. LEED Question and response information may be asked post project completion. Contractor shall be required to gather and respond to all requests until the final GBCI/USGBC review has been completed and determination on the Project's LEED certification application has been finalized.

1. Document correspondence with USGBC as informational submittals.
2. Utilize Reporting Forms provided in Specification Section 01 33 29 – Sustainable Material Content Forms

1.5 ACTION SUBMITTALS

- A. General: Provide any and all Sustainable Design submittals required by this section and other Specification Sections as indicated.
- B. Sustainable design submittals are in addition to other submittals.
 1. If a submitted item is identical to that submitted to comply with other submittal requirements, include an additional copy of the information along with the applicable Submittal Data form (see Specification Section 01 33 29 – Sustainable Material Content Forms).
- C. Sustainable Design Documentation Submittals (see materials section below for requirement criteria).
 1. Documentation for Environmental Product Declarations
 2. Documentation for Products with Multi-attribute optimization.
 3. Documentation for Products with Raw Material Source & Extraction Reporting
 4. Documentation for products with Leadership Extraction Practices
 5. Documentation on Material Ingredient Reporting
 6. Documentation on Material Ingredient Optimization
 7. Documentation of Product Manufacturer Supply Chain Optimization
 8. Documentation and plan as outlined in Specification Section 01 74 19 "Construction Waste Management and Disposal."
 9. Documentation on Low Emitting Materials
 10. Construction Indoor-Air-Quality (IAQ) Management Plan outlined in Specification Section 01 35 46.
 11. IAQ Assessment Documentation and Testing as outlined in specifications Specification Section 01 35 46

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For LEED coordinator.
- B. Provide Materials Cost Data for all scopes of work as indicated in specifications section 01 29 73 "Schedule of Values". Material costs shall exclude labor, overhead, and profit.
- C. Sustainable Design Action Plans: Provide preliminary submittals within 30 days of date established for commencement of the Work. Plan shall indicate how the following requirements will be met:
 1. Submittal log indicating all Sustainable Design submission requirements outlined. (see Specification Section 01 33 23 Shop drawings product data and samples and 01 78 00 Closeout Submittals for additional guidance)
 2. Project Specific Waste Management Plan complying with Section 01 74 19 "Construction Waste Management and Disposal."

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3. Construction IAQ Management Plan complying with Specification Section 01 35 46.
 4. No Smoking Plan indicating designated smoking areas, implementation and oversight.
 5. Commissioning Implementation Plan complying with Specification Section 01 91 13 General Commissioning and 01 91 15 Facility Exterior Enclosure Commissioning.
 6. Clean Construction Tracking Plan: See Clean Construction requirement included elsewhere within this section.
- D. Sustainable Design Progress Reports: Concurrent with each Application for Payment, submit monthly status report provided in Specification Section 01 33 29

1.7 QUALITY ASSURANCE

- A. LEED Coordinator: Engage an experienced LEED-accredited professional to coordinate LEED requirements. LEED coordinator must have practical related experience from at least one LEED BD & C project. LEED Coordinator may also serve as waste management coordinator.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Provide products and procedures necessary to obtain the LEED construction credits as required within this Specification Section, other Specification Sections and throughout the contract documents as outlined in the following:
1. Documentation for Environmental Product Declarations
 - a. Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one quarter (1/4) of a product for the purposes of credit achievement calculation.
 - b. Environmental Product Declarations which conform to ISO 14025, 14040, 14044, and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
 - 1) Industry-wide (generic) EPD -- Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator are valued as one half (1/2) of a product for purposes of credit achievement calculation.
 - 2) Product-specific Type III EPD - Products with third-party certification (Type III), including external verification in which the manufacturer is explicitly recognized as the participant by the program operator are valued as one whole product for purposes of credit achievement calculation.
 2. Documentation for Products with Multi-attribute optimization.

- a. Third party certified products that demonstrate impact reduction below industry average in at least three of the following categories are valued at 100% of their cost for credit achievement calculations. ° global warming potential (greenhouse gases), in CO₂e; ° depletion of the stratospheric ozone layer, in kg CFC-11; ° acidification of land and water sources, in moles H⁺ or kg SO₂; ° eutrophication, in kg nitrogen or kg phosphate; ° formation of tropospheric ozone, in kg NO_x or kg ethene; and depletion of nonrenewable energy resources, in MJ. · USGBC approved program
- b. Include documentation for regional material compliance. Documentation should indicate location of the material manufacturer, material extraction point, harvest, or recovery for each raw material including their and distance from the Project Site. Provide costs for all materials.
3. Documentation for Products with Raw Material Source & Extraction Reporting
 - a. Raw Material Reporting: Products that have publicly released a report from their raw material suppliers which include raw material supplier extraction locations, a commitment to long-term ecologically responsible land use, a commitment to reducing environmental harms from extraction and/or manufacturing processes, and a commitment to meeting applicable standards or programs voluntarily that address responsible sourcing criteria.
 - b. CSR Products sourced from manufacturers with self-declared reports are valued as one half (1/2) of a product for credit achievement. · Third-party verified corporate sustainability reports (CSR) which include environmental impacts of extraction operations and activities associated with the manufacturer's product and the product's supply chain.
 - c. All Reports must be published within one year of the project's LEED registration date.
 - d. A compliant report must be issued by either the manufacturer or the raw material supplier and cover at least the criteria listed in the rating system requirements.
 - e. At least 90% of the contents of each product must be from raw materials covered by a compliant report; no partial credit is allowed for products that do not meet this threshold.
 - f. Reports obtained directly from raw material suppliers must verify the use of the raw material in products purchased for the project building. A manufacturer's report must trace activities to the source of extraction of the product's raw materials. In either case, acceptable frameworks for raw material reporting include the following:
 - 1) Global Reporting Initiative (GRI) Sustainability Report
4. Documentation for products with Leadership Extraction Practices
 - a. Extended producer responsibility - Products purchased from a manufacturer (producer) that participates in an extended producer responsibility program or is directly responsible for extended producer responsibility. Products meeting extended producer responsibility

- criteria are valued at 50% of their cost for the purposes of credit achievement calculation.
- b. Bio-based materials - Bio-based products must meet the Sustainable Agriculture Network's Sustainable Agriculture Standard. Bio-based raw materials must be tested using ASTM Test Method D6866 and be legally harvested, as defined by the exporting and receiving country. Exclude hide products, such as leather and other animal skin material. Products meeting bio-based materials criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
 - c. Wood products - Wood products must be certified by the Forest Stewardship Council or USGBC-approved equivalent. Products meeting wood products criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
 - d. Materials reuse - Reuse includes salvaged, refurbished, or reused products. Products meeting materials reuse criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
 - e. Recycled Content - Recycled content is the sum of postconsumer recycled content plus one-half the pre-consumer recycled content, based on cost.
 - f. Products meeting Leadership Extraction Practice Criteria above shall report regional material information. Information should include extraction (recycling location can serve as the material harvest location), harvest, or recovery locations, as well as manufacturing locations that are within 100 miles of Project site.
5. Documentation on Material Ingredient Reporting
- a. Demonstrate the chemical inventory of the product to at least 0.1% (1000 ppm) using one of the following:
 - 1) Manufacturer Inventory - The manufacturer has published complete content inventory for the product following these guidelines: ° A publicly available inventory of all ingredients identified by name and Chemical Abstract Service Registration Number (CASRN)
 - 2) Health Product Declaration - The end use product has a published, complete Health Product Declaration with full disclosure of known hazards in compliance with the Health Product Declaration Open Standard.
 - 3) Cradle to Cradle - The end use product has been certified at the Cradle to Cradle v2 Basic level or Cradle to Cradle v3 Bronze level.
6. Documentation on Material Ingredient Optimization
- a. Use products that document their material ingredient optimization using the paths below:
 - 1) GreenScreen v1.2 Benchmark. Products that have fully inventoried chemical ingredients to 100 ppm that have no Benchmark 1 hazards

- 2) Cradle to Cradle Certified. End use products are certified Cradle to Cradle. Products will be valued as follows: ° Cradle to Cradle v2 Gold: 100% of cost ° Cradle to Cradle v2 Platinum: 150% of cost ° Cradle to Cradle v3 Silver: 100% of cost ° Cradle to Cradle v3 Gold or Platinum: 150% of cost
 - 3) International Alternative Compliance Path – REACH Optimization. End use products and materials that do not contain substances that meet REACH criteria for substances of very high concern.
7. Documentation of Product Manufacturer Supply Chain Optimization
 - a. Products sourced from product manufacturers who engage in validated and robust safety, health, hazard, and risk programs which at a minimum document at least 99% (by weight) of the ingredients used to make the building product or building material, and
 - b. Products sourced from product manufacturers with independent third party verification of their supply chain that at a minimum verifies:
 - 1) Processes are in place to communicate and transparently prioritize chemical ingredients along the supply chain according to available hazard, exposure and use information to identify those that require more detailed evaluation
 - 2) Processes are in place to identify, document, and communicate information on health, safety and environmental characteristics of chemical ingredients ° Processes are in place to implement measures to manage the health, safety and environmental hazard and risk of chemical ingredients ° Processes are in place to optimize health, safety and environmental impacts when designing and improving chemical ingredients ° Processes are in place to communicate, receive and evaluate chemical ingredient safety and stewardship information along the supply chain ° Safety and stewardship information about the chemical ingredients is publicly available from all points along the supply chain
8. Documentation complying with Section 01 74 19 "Construction Waste Management and Disposal."
9. Documentation on Low Emitting Materials
 - a. Product data for adhesives and sealants used inside the weatherproofing system. Products shall indicate VOC content and laboratory test reports showing compliance with requirements for low-emitting materials including the requirements of the California Department of Public Health (CDPH) Standard Method v1.1–2010, and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers. Contractor shall provide documentation on VOC amounts for all materials used in the Work.
 - 1) All adhesives and sealants wet-applied on site must meet the applicable chemical content requirements of SCAQMD Rule 1168, July 1, 2005, Adhesive and Sealant Applications, as analyzed by the methods specified in Rule 1168. The provisions of SCAQMD

Rule 1168 do not apply to adhesives and sealants subject to state or federal consumer product VOC regulations.

- 2) Wood Glues: 30 g/L.
- 3) Metal-to-Metal Adhesives: 30 g/L.
- 4) Adhesives for Porous Materials (Except Wood): 50 g/L.
- 5) Subfloor Adhesives: 50 g/L.
- 6) Plastic Foam Adhesives: 50 g/L.
- 7) Carpet Adhesives: 50 g/L.
- 8) Carpet Pad Adhesives: 50 g/L.
- 9) VCT and Asphalt Tile Adhesives: 50 g/L.
- 10) Cove Base Adhesives: 50 g/L.
- 11) Gypsum Board and Panel Adhesives: 50 g/L.
- 12) Rubber Floor Adhesives: 60 g/L.
- 13) Ceramic Tile Adhesives: 65 g/L.
- 14) Multipurpose Construction Adhesives: 70 g/L.
- 15) Fiberglass Adhesives: 80 g/L.
- 16) Contact Adhesives: 80 g/L.
- 17) Structural Glazing Adhesives: 100 g/L.
- 18) Wood Flooring Adhesives: 100 g/L.
- 19) Structural Wood Member Adhesives: 140 g/L.
- 20) Single-Ply Roof Membrane Adhesives: 250 g/L.
- 21) Special-Purpose Contact Adhesives (That Are Used to Bond Melamine-Covered Board, Metal, Unsupported Vinyl, Rubber, or Wood Veneer 1/16 Inch or Less in Thickness to Any Surface): 250 g/L.
- 22) Top and Trim Adhesives: 250 g/L.
- 23) Plastic Cement Welding Compounds: 250 g/L.
- 24) ABS Welding Compounds: 325 g/L.
- 25) CPVC Welding Compounds: 490 g/L.
- 26) PVC Welding Compounds: 510 g/L.
- 27) Adhesive Primer for Plastic: 550 g/L.
- 28) Sheet-Applied Rubber Lining Adhesives: 850 g/L.
- 29) Aerosol Adhesive, General-Purpose Mist Spray: 65 percent by weight.
- 30) Aerosol Adhesive, General-Purpose Web Spray: 55 percent by weight.
- 31) Special-Purpose Aerosol Adhesives (All Types): 70 percent by weight.
- 32) Other Adhesives: 250 g/L.
- 33) Architectural Sealants: 250 g/L.
- 34) Nonmembrane Roof Sealants: 300 g/L.
- 35) Single-Ply Roof Membrane Sealants: 450 g/L.
- 36) Other Sealants: 420 g/L.
- 37) Sealant Primers for Nonporous Substrates: 250 g/L.
- 38) Sealant Primers for Porous Substrates: 775 g/L.
- 39) Modified Bituminous Sealant Primers: 500 g/L.

- 40) Other Sealant Primers: 750 g/L.
- b. Product data for paints and coatings used inside the weatherproofing system. Products shall indicate VOC content and laboratory test reports showing compliance with requirements for low-emitting materials, including the requirements of the California (?) Department of Public Health (CDPH) Standard Method v1.1–2010, and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers. Also:
- 1) All paints and coatings wet-applied on site must meet the applicable VOC limits of the California Air Resources Board (CARB) 2007, Suggested Control Measure (SCM) for Architectural Coatings, or the South Coast Air Quality Management District (SCAQMD) Rule 1113, effective June 3, 2011
 - 2) Flat Paints and Coatings: 50 g/L.
 - 3) Non-flat Paints and Coatings: 50 g/L.
 - 4) Dry-Fog Coatings: 150 g/L.
 - 5) Primers, Sealers, and Undercoaters: 100 g/L.
 - 6) Rust-Preventive Coatings: 100 g/L.
 - 7) Zinc-Rich Industrial Maintenance Primers: 100 g/L.
 - 8) Pretreatment Wash Primers: 420 g/L.
 - 9) Clear Wood Finishes, Varnishes: 275 g/L.
 - 10) Clear Wood Finishes, Lacquers: 275 g/L.
 - 11) Floor Coatings: 50 g/L.
 - 12) Shellacs, Clear: 730 g/L.
 - 13) Shellacs, Pigmented: 550 g/L.
 - 14) Stains: 100 g/L.
- c. Laboratory test reports for flooring, indicating compliance with the requirements of the California Department of Public Health (CDPH) Standard Method v1.1–2010, and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.
- 1) Laboratory test reports for products containing composite wood, agrifiber products or wood glues. Composite wood, as defined by the California Air Resources Board, Airborne Toxic Measure to Reduce Formaldehyde Emissions from Composite Wood Products Regulation, must be documented to have low formaldehyde emissions that meet the California Air Resources Board ATCM for formaldehyde requirements for ultra-low-emitting formaldehyde (ULEF) resins or no added formaldehyde resins.
 - 2) Laboratory test reports for ceilings, walls, and thermal insulation (both interior and exterior), indicating compliance with the requirements of the California Department of Public Health (CDPH) Standard Method v1.1–2010, and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.

PART 3 - EXECUTION

3.1 NONSMOKING BUILDING

- A. Smoking is not permitted within the building or within 25 feet of entrances, operable windows, or outdoor-air intakes. Comply with Specification Section 01 35 46

3.2 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with Section 01 74 19 "Construction Waste Management and Disposal."

3.3 CONSTRUCTION IAQ MANAGEMENT

- A. Comply with Specification Section 01 35 46 "Indoor Air Quality".

3.4 IAQ ASSESSMENT AND TESTING

- A. Comply with Specification Section 01 35 46 "Indoor Air Quality".

END OF SECTION 01 81 13.14

SECTION 01 91 13 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- B. Division 01 Section 01 81 13.14 Sustainable Design Requirements – LEED v4 BD+C for additional LEED v4 requirements related to commissioning.
- C. ASHRAE standard 90.1-2010, ASHRAE Guidelines 0-2013 (The Commissioning Process) and 1.1-2007 (The HVAC Commissioning Process), ASHRAE Standard 202-2013 Commissioning Process for Buildings and Systems, and NIBS Guideline 3-2012 Building Enclosure Commissioning Process.
- D. The South Terminal C Program Commissioning Plan (Cx Plan) (Construction Phase) will be developed by the CMARs and the Owner. The Cx Plan is a live document that is maintained by the Cx Authority; updated periodically during the course of the project, as required.

1.2 SUMMARY

- A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.
- B. Commissioning is systematic processes to provide documented confirmation that building systems perform according to the criteria set forth in the Design Criteria Package (DCP) and as required to satisfy the Owner's operational needs. This is achieved by the Contractor beginning in the design phase and documenting design intent and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. The Commissioning process shall comply with ASHRAE Guidelines 0-2013 and 1.1-2007.
- C. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:
 - 1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
 - 2. Verify and document proper performance of equipment and systems.
 - 3. Verify that O&M documentation left on site is complete.
 - 4. Verify that the Owner's operating personnel are adequately trained.

- D. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.
- E. Abbreviations. The following are common abbreviations used in the *Specifications* and in the *Commissioning Plan*. Definitions are found in Section 1.3.

A/E-	Contractor's Architect and Design Engineers	FPT-	Functional Performance Test
BoD-	Basis of Design	MC-	Mechanical Contractor
BECxA-	Building Envelope Cx Authority	OPR-	Owner's Project Requirements
CxA-	Commissioning Authority	OAR-	Owner's Authorized Representative
CxC-	CMAR's Commissioning Coordinators	VC-	Verification checklist (CVC)
GC	Contractor	PM-	Project Manager (of the Owner)
Cx-	Commissioning	Subs-	Subcontractors to Contractor
GOAA-	Greater Orlando Aviation Authority (Owner)	RFI-	Requests for Information
CC-	Controls Contractor	OIA-	Orlando International Airport
CMARS-	Owner's Construction Managers at Risk		
Cx Plan-	Commissioning Plan document	TAB-	Test and Balance contractor
DCC-	Design Criteria Consultant		
EC-	Electrical contractor	LEED AP	USGBC LEED Administrator

F. Related Sections:

1. Division 01 Section on "Design Submittals, Shop Drawings, Products and Samples" which defines documentation (product data, shop drawings, samples, etc.) to be submitted for review and approval. GC shall forward copies of all submittals related to commissioned systems to the CxA through the OAR.
2. Division 01 Sections on "Field Test for Water Leakage" and "Structural Testing and Inspections" which define specific tests to be performed or witnessed by the Building Envelope Cx Authority (BECxA).
3. Division 01 Section on "Closeout Submittals" which defines substantial completion and functional completion, relative to commissioning. Contractor shall forward copies of final Test and Balance Report, completed Verification Checklists, as-build control (BAS) drawings, and approved fire alarm system testing report to the CxA through the OAR.
4. Division 01 Section on "Demonstration and Training" defines Contractor's training requirements for the Owner's O&M and Facilities' personnel. GC shall forward copies of the training syllabuses and attendee sign-in sheets for each training session scheduled for the commissioned equipment and systems on the project to the CxA through the OAR.
5. Division 01 Section on "Sustainable Design Requirements – LEED v4 BD+C" defines the Contractors requirements for complying with sustainable practices, including LEED requirements.

6. Division 01 Section "Facility Exterior Enclosure Commissioning" defines the Contractor's requirements for commissioning activities associated with the building envelope; wall and roof assemblies, materials, and components.
7. Division 21 Section "Commissioning of Fire Suppression Systems" defines the Contractor's requirements for commissioning process activities for fire suppression systems, assemblies, equipment, and components, including, but not limited to, fire pumps, jockey pumps, standpipes and sprinkler systems.
8. Division 22 Section "Commissioning of Plumbing Systems" defines the Contractor's requirements for commissioning process activities for plumbing systems, assemblies, equipment, and components.
9. Division 23 Section "Commissioning of HVAC Systems" f defines the Contractors requirement's or commissioning process activities for HVAC&R systems, assemblies, equipment, and components.
10. Division 26 Section "Commissioning of Electrical Systems" defines the Contractor's requirements for commissioning process activities for electrical systems, assemblies, equipment, and components.
11. Division 28 Section "Commissioning of Life Safety and Security Systems" defines the Contractor's requirements for commissioning process activities for fire detection and alarm, smoke control and stair pressurization, elevator recall and override, and security systems.

1.3 DEFINITIONS

- A. Acceptance Phase. Phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and training occurs.
- B. Approval. Acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes according to the Contract Documents.
- C. Architect/Engineer (A/E): The Contractors prime consultant (Designer) and sub-consultants who comprise the design team, generally the HVAC mechanical designer/engineer and the electrical designer/engineer.
- D. BECxA: Building Envelope Commissioning Authority. An independent agent, not otherwise associated with the A/E team members or the GC, hired by the Owner. The BECxA directs and coordinates the day-to-day commissioning activities associated with the building envelope components; such as, waterproofing, curtain wall, glazing, and roofing. The BECxA does not take an oversight role like the GC. The CxA is part of the Owner's Authorized Representative (OAR) team or shall report directly to the Owner.
- E. BoD: Basis of Design. A document prepared by the A/E that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

- F. CxA: Commissioning Authority. An independent agent, not otherwise associated with the A/E team members or the GC, hired by the Owner. The CxA directs and coordinates the day-to-day commissioning activities. The CxA does not take an oversight role like the CM. The CxA is part of the Owner's Authorized Representative (OAR) team or shall report directly to the Owner.
- G. Cx Plan: Commissioning Plan: A document prepared by the CxA that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process
- H. Datalogging: Monitoring flows, currents, status, pressures, etc. of equipment using stand-alone dataloggers separate from the control system.
- I. Deferred Functional Tests : FTs that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.
- J. Deficiency : A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent)
- K. Design Intent: A dynamic document that provides the explanation of the ideas, concepts and criteria that are considered to be very important to the owner. It is initially the outcome of the programming and conceptual design phases.
- L. Design Narrative or Design Documentation: Sections of either the Design Intent or Basis of Design.
- M. Factory Testing: Testing of equipment on-site or at the factory by factory personnel with an Owner's representative present.
- N. Functional Performance Test (FPT) or (FT): Test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The commissioning authority develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. FTs are performed after pre-functional checklists and start-up are complete.

- O. Contractor (GC): See definitions in the General Conditions of the Design-Build Contract for Construction.
- P. Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed
- Q. Manual Test: Using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").
- R. Monitoring: The recording of parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of control systems.
- S. Non-Compliance: See Deficiency.
- T. Non-Conformance: See Deficiency.
- U. Over-written Value: Writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50°F to 75°F to verify economizer operation). See also "Simulated Signal."
- V. OPR: Owner's Project Requirements. The Design Criteria Package, which details the functional requirements of a project and the expectations of how it will be used and operated. Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information may also be included.
- W. Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.
- X. Seasonal Performance Tests: FT that are deferred until the system(s) will experience conditions closer to their design conditions.
- Y. Simulated Condition: Condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).
- Z. Simulated Signal: Disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.
- AA. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.
- BB. Startup: The initial starting or activating of dynamic equipment, including executing prefunctional checklists.

- CC. Subs: The subcontractors to the GC who provide and install building components and systems.
- DD. Test Procedures: The step-by-step process which must be executed by the Contractor to fulfill the test requirements. The test procedures are developed by the CxA.
- EE. Test Requirements: Requirements specifying what modes and functions, etc. shall be tested. The test requirements are not the detailed test procedures. The test requirements are specified in the Contract Documents
- FF. Trending: Monitoring using the building control system.
- GG. Vendor: Supplier of equipment.
- HH. Verification Checklist (VC): A list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CxA to the GC & Subs. Verification checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor). Verification checklists augment and are combined with the manufacturer's start-up checklist. Even without a commissioning process, contractors typically perform some, if not many, of the verification checklist items a commissioning authority will recommend. However, few contractors document in writing the execution of these checklist items. Therefore, for most equipment, the contractors execute the checklists on their own. The commissioning authority only requires that the procedures be documented in writing, and does not witness much of the verification checklisting, except for larger or more critical pieces of equipment.
- II. Warranty Period: Warranty period for entire project, including equipment components. Warranty begins at Substantial Completion and extends for at least one year, unless specifically noted otherwise in the Contract Documents and accepted submittals.

1.4 COORDINATION

- A. Commissioning Team: The members of the commissioning team consist of the Commissioning Authority (CxA), the Building Envelope Commissioning Authority (BECxA), the OAR, the DCC, the designated representative of the Contractor (GC), the CxC, the A/E (particularly the Mechanical and Electrical Engineers), the Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB contractor, the Controls Contractor (CC), any other installing subcontractors or suppliers of equipment. If known, the Owner's building or operator/engineer is also a member of the commissioning team.

- B. Management: The CxA is hired by the Owner directly. The CxA directs and coordinates the commissioning activities and the reports to the OAR. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
- C. Scheduling: The CxA will work with the Contractor (GC) according to established protocols to schedule the commissioning activities. The CxA will provide sufficient notice to the GC for scheduling commissioning activities. The GC will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.
- D. The CxA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. The *Commissioning Plan—Construction Phase* provides a format for this schedule. As construction progresses more detailed schedules are developed by the CxA. The Commissioning Plan also provides a format for detailed schedules.

1.5 COMMISSIONING PROCESS

- A. Commissioning Plan: The *Commissioning Plan – Construction Phase* will be developed and provided by the CxA prior to the start of construction. The commissioning plan provides guidance in the execution of the commissioning process. Just after the initial commissioning scoping meeting, the CxA will update the plan which is then considered the “final” plan, though it will continue to evolve and expand as the project progresses. The *Specifications* will take precedence over the *Commissioning Plan*.
- B. Commissioning Process: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.
 - 1. Commissioning during construction begins with a scoping meeting conducted by the CxA where the commissioning process is reviewed with the OAR, the A/E, the DCC, the GC and the Subcontractors.
 - 2. Additional meetings will be required throughout construction, scheduled by the CxA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
 - 3. Equipment documentation is submitted to the CxA during normal submittals, including detailed start-up procedures.
 - 4. The CxA works with the GC and the Subs in developing startup plans and startup documentation formats, including providing the GC and the Subs with Verification Checklists to be completed, prior to the startup process.
 - 5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with Verification Checklists being completed before functional testing.
 - 6. The Subcontractors, under the direction of GC, execute and document the Verification Checklists and perform startup and initial checkout. The CxA

documents that the VC and startup were completed according to the approved plans. This may include the CxA witnessing start-up of selected equipment.

7. The CxA develops specific equipment and system Functional Performance Test procedures. The OAR, the DCC, the A/E, the GC and the Subs review the test procedures.
8. The procedures are executed by the GC and the Subs, under the direction of, and documented by the CxA.
9. Items of non-compliance in material, installation or setup are corrected at the Sub's expense and the system retested.
10. The CxA and the A/E review the O&M documentation for completeness prior to submittal to the OAR.
11. Commissioning is completed before Substantial Completion.
12. The CxA, the OAR, the DCC and the A/E review, pre-approves and coordinates the training provided by the GC and the Subs and verifies that is was completed.
13. Deferred testing is conducted, as specified or required.

C. Cloud-based Web Application Software

1. For this project, the Cx Authority will be utilizing a cloud-based web application for managing the commissioning documentation associated with the project. A dedicated project site will be established and this web application will provide real time data and a single interface for all project team members to share information and collaborate effectively.
2. Commissioning documentation will be maintained on this site and secure access will be provided to all team members. Cx documentation will be maintained in an electronic format, with automatic synchronization with the cloud as it is updated. However, provisions will be provided to create PDF versions of select Cx files for printing.
3. Team members will be notified of updates to the site through e-mails on a regular basis (typically daily). Discrete commissioning files will not be e-mailed to the team. This system will require contractors and subcontractors to monitor Cx activities and documentation through the site, and will allow the use of tablet (or laptop) PCs when completing the checklists and addressing issues in the field, if desired. Tablets and/or laptop PCs will be the responsibility of the individual team members. Alternately, contractors may print paper versions of the checklists and forms for completion in the field. If paper forms are utilized, it will be the responsibility of the contractor to accurately update the system with the information gathered in the field on paper forms in a timely manner. Requirements for same (compatible operating systems and browsers) will be provided by the Cx Authority.
4. The Cx Authority will provide initial instruction on the use of this web application and answer questions at a Cx kick-off meeting. Contractor and all subcontractors will be expected to have designated representatives from their firms available for training.

1.6 COMMISSIONING TEAM

- A. Members Appointed by Contractor: Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, the Contractor (GC) and A/E, including Project superintendent, Commissioning coordinators, and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
- B. Members Appointed by Owner:
 - 1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
 - 2. Representatives of the facility user and operation and maintenance personnel.
 - 3. The OAR
 - 4. The DCC.

1.7 OWNER'S RESPONSIBILITIES

- A. Provide the OPR documentation with assistance from the OAR to the CxA for development of an OPR document.
- B. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.
- C. Provide the BoD documentation, prepared by A/E and approved by OAR and DCC, to the CxA for use in developing the; OPR, commissioning specifications, commissioning plan, systems manual, and assist with the operation and maintenance manuals, training plan.
- D. Follow the Commissioning Plan.
- E. Attend commissioning scoping meetings and additional meetings as necessary.

1.8 OWNER'S AUTHORIZED REPRESENTATIVE'S RESPONSIBILITIES

- A. The OAR shall represent the Owner during the commissioning process as follows:
 - 1. Manage the contracts of the GC and its A/E.
 - 2. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the *Commissioning Plan – Construction Phase*.
 - 3. Provide final approval for the completion of the commissioning work.
 - 4. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.
 - 5. Follow the Commissioning Plan.
 - 6. Attend commissioning scoping meetings and additional meetings as necessary.

1.9 CONTRACTOR'S A/E'S RESPONSIBILITIES

- A. The Contractor's A/E shall comply with the fullest extent with the latest edition of the GOAA's Design Guidelines and Standards, including the latest Sustainability Management Plan, including all sections shall apply. The A/E shall participate in and perform commissioning process activities including, but not limited to, the following:
1. Attend the commissioning scoping meeting and selected commissioning team meetings.
 2. Perform normal submittal review and approve of the following documents; submittals, shop drawings, as-built drawing, O&M manual, etc., as contracted.
 3. Provide all design narrative and sequence documentation requested by the CxA. The A/E shall assist (along with the GC) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 4. Respond to design and/or construction issues identified and assigned to them by the CxA and/or BECxA through the cloud-based Cx web application.
 5. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.
 6. Review and approve final as-built design intent documentation for inclusion in the O&M manuals. Review and approve the O&M manuals issued by the GC. Issue the approved O & M manuals to the CxA.
 7. Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.
 8. Participate in the resolution of non-compliance, non-conformance and design deficiencies identified during commissioning during warranty-period commissioning.

1.10 CONTRACTOR (GC) RESPONSIBILITIES

- A. The GC shall participate in and perform commissioning process activities including, but not limited to the following:
1. Facilitate the coordination of the commissioning work by the CxA, with complete knowledge of commissioning activities which will be incorporated into the master construction project schedule.
 2. Comply with all fundamental and enhanced commissioning requirements as required under LEED v4 BD+C, including providing input and all required documentation for LEED v4 certification of Cx activities, including, but not limited to: Current Facility Requirements, O&M Plan, Systems Manuals, Ongoing Commissioning Plan, and Final Commissioning Report.
 3. Review and approve the final *Commissioning Plan—Construction Phase*.
 4. Attend a commissioning scoping meeting and other commissioning team meetings.
 5. Issue subcontractor submittals for A/E approval & CxA review.
 6. Furnish a copy of all construction documents, addenda, requests for information, change orders and approved submittals and shop drawings related to commissioned equipment to the CxA.

7. Completing verification checklists and responding to issues identified by the CxA and/or BECxA. Note: For this project, the CxA and BECxA will be utilizing a cloud-based Cx web application for managing the commissioning documentation associated with the project.
8. Issue O & M manuals to A/E for approval within 45 days of approved submittals. A/E to issue to the O & M manuals to the CxA through the OAR for review of design compliance.
9. Review and approve the Functional Performance test procedures submitted by the CxA, prior to testing.
10. Review commissioning progress, including: checklist progress, outstanding issues and deficiency reports. Report on status weekly.
11. Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.
12. Coordinate with the CxA for resolution of issues recorded in the CxA Issues Log.
13. Review and accept construction Verification Checklists provided by the CxA.
14. Complete electronic construction Verification Checklists as work is completed and provide to the CxA. Complete commissioning process test procedures.
15. Include the cost of for coordinating commissioning with the CxA in the total contract price.
16. Coordinate the training of Owner personnel and provide the times and dates of training to the CxA.
17. Execute seasonal or deferred functional performance testing witnessed by the CxA to facilitate the Cx process.
18. Provide a list of final settings, setpoints, ranges, schedules, and / or trend logs required by the CxA.
19. Follow the Commissioning Plan throughout the entire project duration.

1.11 SUBCONTRACTOR'S RESPONSIBILITIES

- A. The GC shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
 2. Assist in completing verification checklists and responding to issues identified by the CxA and/or BECxA. Note: For this project, the CxA and BECxA will be utilizing a cloud-based Cx web application for managing the commissioning documentation associated with the project.
 3. Assist in equipment testing per agreements with the GC.
 4. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the GC's Total Contract Price, except for stand-alone data logging equipment that may be used by the CxA.
 5. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
 6. Review test procedures for equipment installed by factory representatives.
 7. Follow the Commissioning Plan.

8. Attend commissioning scoping meetings and additional meetings as necessary.
9. From the red-line drawings, edit and update one-line diagrams developed as part of the design narrative documentation, and those provided by the vendor as shop drawings, for the BAS, central chilled and hot water systems, domestic HW systems, AHU systems, VAV systems, exhaust systems, fire suppression systems, normal and emergency power systems, and life safety and security systems.

1.12 EQUIPMENT SUPPLIERS' RESPONSIBILITIES

- A. The GC shall assign the equipment suppliers & representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
 2. Assist in equipment testing per agreements with the GC and the Subs. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the GC, except for stand-alone datalogging equipment that may be used by the CxA.
 3. Through the GC and the Subcontractors they supply products to, analyze specified products and verify that the designer has specified the newest most updated equipment reasonable for this project's scope and budget.
 4. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
 5. Review test procedures for equipment installed by factory representatives.
 6. Follow the Commissioning Plan.
 7. Attend commissioning scoping meetings and additional meetings as necessary.

1.13 Cx AUTHORITY'S RESPONSIBILITIES

- A. The CxA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxA may assist with problem-solving, non-conformance or deficiencies, but ultimately that responsibility resides with the GC and the A/E. The primary role of the CxA is to develop and coordinate the execution of a testing plan, observe and document performance—that systems are functioning in accordance with the documented design intent and in accordance with the Contract Documents. The GC & subcontractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems.
 1. Coordinates and directs the commissioning activities using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.

2. Coordinate the commissioning work and, with the GC & subcontractors, ensure that commissioning activities are being scheduled into the master schedule.
3. Revise, as necessary, the *Commissioning Plan—Construction Phase*.
4. Plan and conduct a commissioning scoping meeting and other commissioning meetings.
5. Request and review additional information required to perform commissioning tasks, including O&M materials, subcontractor start-up and checkout procedures.
6. Before startup, gather and review the current control sequences and interlocks and work with subcontractors and Design Engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
7. Review and comment on normal GC submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews / approvals.
8. Write and distribute pre-functional tests and checklists.
9. Develop an enhanced start-up and initial systems checkout plan with GC and the Subcontractors.
10. Perform site visits, as necessary, to observe component and system installations. Attends selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.
11. Witness representative HVAC piping test and flushing procedures, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owner's representative of any deficiencies in results or procedures.
12. Witness representative ductwork testing and cleaning procedures, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owner's representative of any deficiencies in results or procedures.
13. Approve pre-functional tests and checklist completion by reviewing pre-functional checklist reports and by selected site observation and spot checking.
14. Approve systems startup by reviewing start-up reports and by selected site observation.
15. Review TAB execution plan.
16. Oversee sufficient functional testing of the control system and approve it to be used for TAB, before TAB is executed.
17. Approve air and water systems balancing by spot testing, by reviewing completed reports and by selected site observation.
18. With necessary assistance and review from the GC and installing subcontractors, write the Functional Performance test procedures for equipment and systems. This may include energy management control system trending, stand-alone datalogger monitoring or manual functional testing. Submit to the A/E, and OAR for review and approval.

19. Analyze any functional performance trend logs and monitoring data to verify performance.
20. Coordinate, witness and approve manual functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
21. Maintain a master deficiency and resolution log and a separate testing record. Provide the GC with written progress reports and test results with recommended actions.
22. Witness performance testing of smoke control system interfaced with the HVAC systems, by others and all other owner contracted tests or tests by manufacturer's personnel over which the CxA may not have direct control. Document these tests and include this documentation in Commissioning Report.
23. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined.
24. Oversee and review the training plan by the GC & subcontractors for the Owner's operating personnel.
25. Compile and maintain a commissioning record and building systems book(s).
26. Review the preparation of the O&M manuals, the CxA will issue comments to the A/E, DCC and the OAR.
27. Provide a final commissioning report to the Owner.
28. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.
29. Return to the completed project site for a 10 month warranty review, prior to the 12 months warranty period and review with Owners facility staff the current building operation and the condition is performing in compliance with design intent of the project design and to ensure issues related to the original and seasonal commissioning are still intact. Also interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.

1.14 SYSTEMS TO BE COMMISSIONED

A. The following checked systems will be commissioned in this project.

Equipment and System	Applicable Specification Sections:	Equipment and System	Applicable Specification Sections:
<u>Building Envelope</u>		Small Capacity Split System Air Conditioners	23 08 00 and 23 81 26.13
Walls, glazing, roof assemblies, waterproofing and expansion joints	01 91 15 and all related sections	Fan Coil Units	23 08 00 and 23 82 19
<u>Conveying Equipment</u>		PCA Units and Specialties	23 08 00 and 23 90 00

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GENERAL COMMISSIONING REQUIREMENTS
Section 01 91 13

Equipment and System	Applicable Specification Sections:	Equipment and System	Applicable Specification Sections:
Traction Elevators	14 21 00		
Hydraulic Elevators	14 24 00	<u>Fire Suppression Systems</u>	
Escalators	14 31 00	Commissioning of Fire Suppression Systems	21 08 00
<u>HVAC Systems</u>		Fire Suppression Standpipes	21 08 00 and 21 12 00
Common Motor Requirements for HVAC Equipment	23 08 00 and 23 05 13	Wet Pipe Sprinkler Systems	21 08 00 and 21 13 13
Variable Frequency Motor Controllers	23 08 00 and 23 05 14	Dry Pipe Sprinkler Systems	21 08 00 and 21 13 16
Control Wiring	23 08 00 and 23 05 18	Electric Drive, Centrifugal Fire Pumps	21 08 00 and 21 31 13
Meters and Gages for HVAC Piping	23 08 00 and 23 05 19	<u>Plumbing Systems</u>	
General Duty Valves for HVAC Piping	23 08 00 and 23 05 23	Commissioning of Plumbing Systems	22 08 00
Valves for PCA Piping	23 08 00 and 23 05 23.01	Domestic Water Piping and Domestic Water Piping Specialties	22 08 00, and 22 11 16, and 22 11 19
Air Control and Accessories	23 08 00 and 23 05 80	Domestic Water Pumps	22 08 00 and 22 11 23
Testing, Adjusting and Balancing for HVAC	230800 and 23 05 93	Domestic Water Packaged Booster Pumps	22 08 00 and 22 11 23.13
Commissioning of HVAC Systems	23 08 00	Sump Pumps	22 08 00 and 22 14 29
Instrumentation and Control for HVAC	23 08 00 and 23 09 00	Electric Domestic Water Heaters	22 08 00 and 22 33 00
Refrigerant Detection and Alarm	23 08 00 and 23 09 20	Natural Fuel Gas Systems - Plumbing	22 08 00 and 22 70 00
Facility Fuel Oil Piping	23 08 00 and 23 11 13	<u>Electrical Systems</u>	
Hydronic Piping	23 08 00 and 23 21 13	Power Systems Study with Arc Flash Analysis	26 08 00 and 26 05 73
PCA Hydronic Piping	23 08 00 and 23 21 13.01	Commissioning of Electrical Systems	26 08 00
Pre-insulated Underground Piping System	23 08 00 and 23 21 13.15	Demonstration of Completed Electrical Systems	26 08 00 and 26 08 03

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GENERAL COMMISSIONING REQUIREMENTS
Section 01 91 13

Equipment and System	Applicable Specification Sections:	Equipment and System	Applicable Specification Sections:
Hydronic Piping Specialties	23 08 00 and 23 21 16	Tests and Performance Verification	26 08 00 and 26 08 13
Hydronic Pumps	23 08 00 and 23 21 23	Architectural Lighting Controls for Public Spaces	26 08 00 and 26 09 24
PCA Hydronic Pumps	23 08 00 and 23 21 23.01	Occupancy Sensors	26 08 00 and 26 09 24
HVAC Water Treatment	23 08 00 and 23 25 00	Network Lighting Controls	26 08 00 and 26 09 24
PCA Water Treatment	23 08 00 and 23 25 00.01	Medium Voltage Generator	26 08 00 and 26 32 18
Air Duct Accessories	23 08 00 and 23 33 00	Switchboards	26 08 00 and 26 24 13
Axial HVAC Fans	23 08 00 and 23 34 13	Electrical Metering and Monitoring	26 08 00 and 26 27 13
Centrifugal HVAC Fans	23 08 00 and 23 34 16	Demonstration of Completed Electrical Systems	26 08 00 and 01 79 00
HVAC Power Ventilators	23 08 00 and 23 34 23	Outdoor Engine Generator, Sub-Base Tank	26 08 00 and 26 32 18
Air Curtains	23 08 00 and 23 34 33	Medium Voltage Diesel Engine Driven Generator	26 08 00 and 26 32 18
Air Terminal Units	23 08 00 and 23 36 00	Static Uninterruptible Power Supply	26 08 00 and 26 33 53
Particulate Air Filtration	23 08 00 and 23 41 00	Automatic Transfer Switches	26 08 00 and 26 36 23
Heat Exchangers for PCA	23 08 00 and 23 57 00.01	Lightning Protection System	26 08 00 and 26 41 13
Centrifugal Water Chillers	23 08 00 and 23 64 16	Surge Protective Devices	26 08 00 and 26 43 00
PCA Centrifugal Water Chillers	23 08 00 and 23 64 16.01	Architectural Lighting Fixtures, Lamps, Ballasts for Public Spaces	26 08 00 and 26 50 10
Scroll Water Chiller	23 08 00 and 23 64 23	Interior Lighting	26 08 00 and 26 51 00
Packaged Cooling Towers	23 08 00 and 23 65 00	400- Hertz Frequency Converters	26 08 00 and 26 61 00
Air to Air Energy Recovery Unit	23 08 00 and 23 72 00	<u>Electronic Safety and Security</u>	
Modular Indoor Central-Station Air Handling Units	23 08 00 and 23 73 13	Physical Access Control System (SSI)	28 08 00 and 28 13 00

Equipment and System	Applicable Specification Sections:	Equipment and System	Applicable Specification Sections:
Dedicated Outdoor Air Units	23 08 00 and 23 74 33	Intrusion Detection System (SSI)	28 08 00 and 28 16 00
Computer Room Air Conditioners	23 08 00 and 23 81 23	Video Surveillance System (SSI)	28 08 00 and 28 23 00
Split System Air Conditioners	23 08 00 and 23 81 26	Addressable Fire Detection and Alarm	28 08 00 and 28 31 00

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities. Two-way radios shall be provided by the subcontractor.
- B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the Total Contract Price and left on site, except for stand-alone datalogging equipment that may be used by the CxA.
- C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the *Specifications*. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.
- D. Refer to Section 01 91 13, Part 3.5 E for details regarding equipment that may be required to simulate required test conditions.

PART 3 - EXECUTION

3.1 MEETINGS

- A. Scoping Meeting: To be within 90 days of commencement of construction, the CxA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties

by the CxA. Information gathered from this meeting will allow the CxA to revise the *Commissioning Plan* to its "final" version, which will also be distributed to all parties.

- B. Miscellaneous Meetings: Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with GC & Subs. The CxA will plan these meetings and will minimize unnecessary time being spent by the GC & Subs. These meetings will be held monthly, until the final 3 months of construction when they may be held as frequently as one per week.

3.2 REPORTING

- A. The CxA will provide regular reports to the GC and the OAR, with increasing frequency as construction and commissioning progresses. Standard forms are provided and referenced in the *Commissioning Plan*.
- B. The CxA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.
- C. Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.
- D. A final summary report (about four to six pages, not including backup documentation) by the CxA will be provided to the GC and the OAR, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report. Verification Checklist, Functional Performance tests and monitoring reports will not be part of the final report, but will be stored in the Commissioning Record in the O&M manuals.
- E. The sample reports included in the Commissioning Plan are to provide the GC and the Subcontractors with an example of a format and an indication of the rigor of the required documentation for various report types.

3.3 SUBMITTALS

- A. The CxA will provide appropriate contractors with a specific request for the type of submittal documentation the CxA requires to facilitate the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning authority. All

documentation requested by the CxA will be included by the Subs in their O&M manual contributions.

1. Requested Submittals:
 - a. Air Handling Units – Modular Central Station
 - b. Air Terminal Units
 - c. Air-to-Air Energy Recovery
 - d. Building Automation System (DDC Temperature Controls)
 - e. Centrifugal Water Chillers
 - f. Computer Room Air Conditioners
 - g. Cooling Tower(s)
 - h. Dedicated Outdoor Air Units
 - i. Domestic Water Heaters - Electric
 - j. Domestic Water Pumps
 - k. Ductwork Insulation
 - l. Elevators and escalators
 - m. Engine Generator(s)
 - n. Fan Coil Units
 - o. Fire Pump
 - p. HVAC Fans
 - q. Hydronic Pumps
 - r. Lift-Net and Power Xpert Systems
 - s. Lift Station
 - t. Lighting Controls, including occupancy sensors
 - u. Particulate Air Filtration
 - v. Pipe Insulation
 - w. Scroll Water Chillers
 - x. Split DX System Air Conditioners
 - y. Sump Pumps
 - z. Testing, Adjusting, and Balancing
 - aa. Transfer Switches (Automatic and Non-Automatic)
 - bb. Unit Heaters
 - cc. Variable Frequency / Variable Speed Drives
 - dd. Water Treatment
 2. Requested Shop Drawings:
 - a. BAS / Temperature Control Shop Drawings
 - b. Campus and Building Distribution Piping
 - c. Ductwork
 - d. Fire Alarm System
 - e. Fire Protection Standpipe and Sprinkler Systems
 - f. Lighting Control System
 - g. Security access control system
 - h. Power Systems Coordination Study and Arc Flash Analysis
 - i. Water treatment systems
 - j. Video Surveillance System
- B. The Commissioning authority will review and provide comment on submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the

equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications. The Commissioning authority will notify the GC, OAR, DCC and A/E as requested, of items missing or areas that are not in conformance with Contract Documents and which require resubmission.

- C. The CxA may request additional design narrative from the A/E and Controls Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.
- D. These submittals to the CxA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the GC, though the CxA will review them.
- E. GC responsibility for deviations in submittals from requirements of the Contract Documents is not relieved by the Commissioning Authority's review.

3.4 START-UP, VERIFICATION CHECKLISTS AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment to be commissioned, according to Section 1.14, Systems to be Commissioned. Some systems that are not comprised so much of actual dynamic machinery, e.g., electrical system power quality, may have very simplified PCs and startup.
- B. General. Verification Checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that Functional Performance Testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- C. Start-up and Initial Checkout Plan. The CxA shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for prefunctional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms. GC, subcontractors and manufacturer's technicians shall be responsible for executing Functional Performance Tests for their representative equipment and systems.
 - 1. The CxA develops the Verification Checklists for all equipment and/or systems to be commissioned and delivers the VC, (via upload to the cloud-based CxAlloy site) to the GC for completion. These VC indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.

2. These VC and tests are provided by the CxA to the GC. The GC determines which trade is responsible for executing and documenting each of the line item tasks and assigns same to that subcontractor. Each form will have more than one trade responsible for its execution.
 3. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan. The full start-up plan could consist of something as simple as:
 - a. The CxA's Verification Checklists.
 - b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
 - c. The manufacturer's normally used field checkout sheets.
 4. The subcontractor submits the full startup plan to the GC & CxA for review and approval.
 5. The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.
 6. The full start-up procedures and the approval form may be provided to the GC for review and approval, depending on management protocol.
- D. Sensor and Actuator Calibration.
1. All field-installed temperature, relative humidity, CO₂ and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Alternate methods may be used, if approved by the Owner before-hand. All test instruments shall have had a certified calibration within the last 12 months. Sensors installed *in* the unit at the factory with calibration certification provided need not be field calibrated.
 2. All procedures used shall be fully documented on the prefunctional checklists or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.
 3. Sensor Calibration Methods.
 - a. All Sensors. Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable, are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading, of each other, for pressure. Tolerances for critical applications may be tighter.
 - b. Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table

- below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.
- c. **Sensors With Transmitters--Standard Application.** Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
 - d. **Critical Applications.** For critical applications (process, manufacturing, etc.) more rigorous calibration techniques may be required for selected sensors. Describe any such methods used on an attached sheet.

Tolerances, Standard Applications

<u>Sensor</u>	<u>Required Tolerance (+/-)</u>	<u>Sensor</u>	<u>Required Tolerance (+/-)</u>
Cooling coil, chilled water temps	0.4°F	Flow rates, water	4% of design
AHU wet bulb or dew point	2.0°F	Relative humidity	4% of design
Hot water coil water temp	1.5°F	Oxygen or CO ₂ monitor	0.1 % pts
Outside air, space air, duct air temps	0.4°F	Barometric pressure	0.1 in. of Hg
Watthour, voltage & amperage	1% of design	Pressures, air, water	3% of design
		Flow rates, air	10% of design

4. **Valve and Damper Stroke Setup and Check.**
 - a. **EMS Readout.** For all valve and damper actuator positions checked, verify the actual position against the BAS readout.
 - b. **Set pumps or fans to normal operating mode.** Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
5. **Closure for heating coil valves (NO):** Set heating setpoint 20°F above room temperature. Observe valve open. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set heating setpoint to 20°F below room temperature. Observe the valve close. Restore to normal.

6. Closure for cooling coil valves (NC): Set cooling setpoint 20°F above room temperature. Observe the valve close. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set cooling setpoint to 20°F below room temperature. Observe valve open. Restore to normal.
- E. Execution of Verification Checklists and Startup.
1. Four weeks prior to startup, the GC and the Subcontractors and vendors schedule startup and checkout with the CxA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the GC and the Subcontractor or vendor. When checking off prefunctional checklists, signatures may be required by the GC and/or their Subs for verification of completion of their work.
 2. The CxA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved by the GC). In no case will the number of units witnessed be less than four, nor less than 20% of the total number of identical or very similar units.
 3. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CxA shall observe a sampling of the prefunctional and start-up procedures. The sampling procedures are identified in the commissioning plan.
 4. The GC and the Subcontractors and vendors shall execute startup and provide the CxA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.
 5. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.
- F. Deficiencies, Non-Conformance and Approval in Checklists and Startup.
1. The GC and the Subs shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CxA within two days of test completion.
 2. The CxA reviews the report and submits either a non-compliance report or an approval form to the GC and the Sub. The CxA shall work with the GC and the Subs and vendors to correct and retest deficiencies or uncompleted items. The CxA will involve the GC and the Subs as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the GC and the CxA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CxA recommends approval of the execution of the checklists and startup of each system to the GC using a standard form.

3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in back charges to the responsible party. Refer to Part 3.7 herein for details.

3.5 FUNCTIONAL PERFORMANCE TESTING

- A. This sub-section applies to all commissioning functional testing for all divisions.
- B. The general list of equipment to be commissioned is found in Section 01 91 13, Part 1.14. The specific system Functional Performance Tests (with required modes and sequences to be tested) will be developed after complete review of the control shop drawings and discussion with the Engineer-of-Record.
- C. The parties responsible to execute each test are GC's installing subcontractors and associated vendors, manufacturer's representatives and technicians.
- D. Objectives and Scope. The objective of Functional Performance Testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
 1. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, no flow, equipment failure, etc. shall also be tested.
 2. Development of Test Procedures. Before test procedures are written, the CxA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. The CxA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. The GC's Sub or vendor responsible to execute a test, shall provide assistance to the CxA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CxA shall provide a copy of the test procedures to the GC and the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection. The CxA will submit the tests to the A/E and the OAR for review.
 3. The CxA shall review owner-contracted, factory testing or required owner acceptance tests which the CxA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.
 4. The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.

5. The test procedure forms developed by the CxA shall include (but not be limited to) the following information:
 - a. System and equipment or component name(s)
 - b. Equipment location and ID number
 - c. Unique test ID number, and reference to unique prefunctional checklist and start-up documentation ID numbers for the piece of equipment
 - d. Date
 - e. Project name
 - f. Participating parties
 - g. A copy of the specification section describing the test requirements
 - h. A copy of the specific sequence of operations or other specified parameters being verified
 - i. Formulas used in any calculations
 - j. Required pre-test field measurements
 - k. Instructions for setting up the test.
 - l. Special cautions, alarm limits, etc.
 - m. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
 - n. Acceptance criteria of proper performance with a Yes / No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
 - o. A section for comments
 - p. Signatures and date block for the CxA
- E. Test Methods.
 1. Functional Performance Testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers. The final Functional Performance Test protocols, as developed by the CxA, shall specify which methods shall be used for each test. The CxA may substitute specified methods or require an additional method to be executed, other than what was specified, with the approval of the GC. This may require a change order and adjustment in charge to the Owner. The CxA will determine which method is most appropriate for tests that do not have a method specified.
 2. Note: Commissioning functional performance testing for HVAC and related systems associated with the building automation system (BAS) will NOT be conducted through the Java Application Control Engine (JACE) controller. All Cx functional performance testing will be conducted through the BAS front end under the direction of the Cx Authority and the BAS controls contractor.
 3. Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
 4. Overwritten Values. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test

a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.

5. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.
6. Altering Setpoints. Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AHU lockout work at an outside air temperature below 55°F, when the outside air temperature is above 55°F, temporarily change the lockout setpoint to be 2°F above the current outside air temperature.
7. Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during prefunctional testing.
8. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.
9. Sampling. Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference. The specific recommended sampling rates for each type of equipment will be dictated by the CxA. It is noted that no sampling by GC's & Subs is allowed in prefunctional checklist execution.
 - a. A common sampling strategy referenced in the *Specifications* as the "xx% Sampling—yy% Failure Rule" is defined by the following example.

xx = the percent of the group of identical equipment to be included in each sample.

yy = the percent of the sample that if failing, will require another sample to be tested.
 - b. The example below describes a 20% Sampling—10% Failure Rule.

- 1) Randomly test at least 20% (xx) of each group of identical equipment. In no case test less than three units in each group. This 20%, or three, constitute the "first sample."
 - 2) If 10% (yy) of the units in the first sample fail the functional performance tests, test another 20% of the group (the second sample).
 - 3) If 10% of the units in the second sample fail, test all remaining units in the whole group.
 - 4) If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CxA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.
- F. Coordination and Scheduling. The GC & Subs shall provide sufficient notice to the CxA regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The CxA will schedule Functional Performance Tests through the GC & Subs. The CxA shall direct, witness and document the Functional Performance Tests of all equipment and systems. The GC & Subs shall execute the tests.
1. In general, Functional Performance Testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CxA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.
- G. Test Equipment. Refer to Section 01 91 13, Part 2 for test equipment requirements.
- H. Problem Solving. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the GC & Subs and A/E.

3.6 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Documentation. The CxA shall witness and document the results of all Functional Performance Tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the GC for review and approval, the GC shall issue to the Subs for execution. The CxA will include the filled out and executed forms in the O&M manuals.
- B. Non-Conformance.
1. The CxA will record the results of the Functional Performance Test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the GC on a standard non-compliance form.

2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form.
3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the GC.
4. As tests progress and a deficiency is identified, the CxA discusses the issue with the GC & Subs.
 - a. When there is no dispute on the deficiency and the GC & Sub accepts responsibility to correct it:
 - 1) The CxA documents the deficiency and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CxA submits the non-compliance reports to the GC for signature. A copy is provided to the Sub and CxA. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.
 - 2) The CxA reschedules the test and the test is repeated.
 - b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1) The deficiency shall be documented on the non-compliance form with the Sub's response and a copy given to the GC and to the Sub representative assumed to be responsible.
 - 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E and the OAR. Final acceptance authority is with the Project Manager.
 - 3) The CxA documents the resolution process.
 - 4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA reschedules the test and the test is repeated until satisfactory performance is achieved.
 - c. Cost of Retesting.
 - 1) The cost for the *Sub* to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the GC.
 - 2) For a deficiency identified, not related to any prefunctional checklist or start-up fault, the following shall apply: The CxA and GC will direct the retesting of the equipment once at no "charge" to the Subs for their time. However, the CxA's and GC's time for a second retest will be charged to the Subs.
 - 3) The time for the CxA and GC to direct any retesting required because a specific *prefunctional* checklist or start-up test item,

- reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the Subs.
- 4) Refer to the sampling section of Section 01 91 13, Part 3.6 for requirements for testing and retesting identical equipment.
 5. The GC & Subs shall respond in writing to the CxA at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
 6. The CxA retains the original non-conformance forms until the end of the project.
 7. Any required retesting by any subcontractor shall not be considered a justified reason for a claim of delay or for a time extension by the GC.
- C. Failure Due to Manufacturer Defect. If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the GC or the A. In such case, the GC shall provide the Owner with the following:
1. Within one week of notification from the GC or the OAR, the subcontractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the GC or the OAR within two weeks of the original notice.
 2. Within two weeks of the original notification, the subcontractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
 3. The GC or the OAR will determine whether a replacement of all identical units or a repair is acceptable.
 4. Two examples of the proposed solution will be installed by the subcontractor and the GC will be allowed to test the installations for up to one week, upon which the GC or the OAR will decide whether to accept the solution.
 5. Upon acceptance, the subcontractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.
- D. Approval. The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the Functional Performance Test is made later after review by the CxA and by the GC and the OAR. The CxA recommends acceptance of each test to the GC using a standard form. The GC gives final approval on each test using the same form, providing a signed copy to the CxA and the OAR.

3.7 DEFERRED TESTING

- A. Unforeseen Deferred Tests. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the OAR. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.
- B. Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CxA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with Owner facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made by the GC.

3.8 TRAINING OF OWNER PERSONNEL

- A. The GC shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed. GC shall ensure that certified factory manufactures representatives are present for training of Owners Personnel in the field and classroom setting.
- B. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.
 - 1. The CxA shall interview the Owners facility manager and lead Owners operations engineer to determine the special needs and areas where training will be most valuable. The Owner and CxA shall decide the training requirements for each piece of commissioned equipment. The CxA shall communicate the results to the GC & Subs and vendors who have training responsibilities.
 - 2. In addition to these general requirements, the specific training requirements of the Owner's personnel by Subcontractors and vendors, is specified in Divisions 01, 21, 22, 23, 26, and 28.
 - 3. Each Sub and vendor responsible for training will submit a written training plan to the GC, the CxA, and the OAR for review and approval prior to training. The plan will cover the following elements:
 - a. Equipment (included in training)
 - b. Intended audience
 - c. Location of training
 - d. Objectives
 - e. Subjects covered (description, duration of discussion, special methods, etc.)
 - f. Duration of training on each subject
 - g. Instructor for each subject
 - h. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
 - i. Instructor and qualifications

- j. For the primary HVAC equipment, the Controls Contractor shall provide a discussion of the control of the equipment during the mechanical or electrical training conducted by others.
- 4. The CxA develops the overall training plan with assistance from the A/E, the GC and the Subcontractor(s) and coordinates and schedules, with the GC and the Subs for overall training of the commissioned systems. The CxA develops criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CxA recommends approval of the training to the GC using a standard form. The GC also signs the approval form at one of the training sessions. Video recording of the training sessions will be provided by the subcontractors and or vendors with media cataloged and added to the O&M manuals by the GC.
- 5. At the Owner's option, at the first training session, the M/E/P/FP Engineers of record shall present the overall systems' design concept & intent and the design concept of each equipment section. This presentation shall be one to two hours in length and include a review of all systems using simplified system schematics (one-line drawings) including chilled water systems, condenser water systems, PCA systems, supply air systems, exhaust air system and outdoor air strategies.

3.9 OPERATION AND MAINTENANCE MANUALS

A. Standard O&M Manuals.

- 1. GC shall submit two draft copies of the complete operating and maintenance manual to the A/E and the CxA for review within 45 calendar days after approval of equipment shop drawings. One approved copy will be returned to the contractor within 30 days after receipt by the A/E.
- 2. GC shall submit corrected final approved O & M manuals prior to functional performance testing & training of Owners Personnel. Prior to final submittal, the CxA shall review the O&M manuals (in addition to the initial draft O&M manual), and documentation, with redline as-builts, for systems that were commissioned to verify compliance with the specifications. The CxA will communicate, through the GC, deficiencies in the manuals to the subcontractor. Upon a successful review of the corrections, the CxA will recommend approval and acceptance of these sections of the O&M manuals to the GC. The CxA will also review each piece of equipment warranty and verify that all requirements to keep the warranty valid are clearly stated. This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract.
- 3. A/E Contribution. The A/E will include in the beginning of the O&M manuals a separate section describing the systems including:
 - a. The design intent narrative prepared by the A/E and provided as part of the bid documents, updated to as-built status by the A/E.
 - b. Simplified professionally drawn single line system diagrams on 8 1/2" x 11" or 11" x 17" sheets. These shall include: the domestic hot water (DHW) system, the chilled water systems, condenser water systems, PCA systems, supply air distribution systems, exhaust air systems and electrical distribution system. These shall show major pieces of

- equipment such as chillers, cooling towers, pumps, VAV system, AHU, HX, and control valves, service valves, switchboards, motor control centers, panel boards, VFDs and ATS, etc.
4. The CxA shall review prior to substantial completion, the O&M manuals, documentation and redline as-builds *for systems that were commissioned* to verify compliance with the *Specifications and Design intent*. The CxA will communicate deficiencies in the manuals to the GC, the A/E, and the OR. Upon a successful review of the corrections, the CxA recommends approval and acceptance of these sections of the O&M manuals to the GC, the OAR, and the A/E. The CxA also reviews each piece of equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract.

B. Commissioning Record in O&M Manuals.

1. The GC and the CxA are responsible to coordinate and compile, organize and index the following O&M, Systems', and commissioning data by systems, both electronically and hard copy; in labeled, indexed and tabbed, three-ring binders and deliver it to the Owner. Two copies of the manuals will be provided. The format of the manuals shall be:

Tab I-1 Commissioning Plan

Tab I-2 Final Commissioning Report (see (B.2) below)

Tab 01 System Type 1 (chilled water system, condenser water system, etc.)

Sub-Tab A Design narrative and criteria, sequences, approvals for Equipment 1

Sub-Tab B Startup plan and report, approvals, corrections, blank pre-functional checklists

Colored Separator Sheets—for each equipment type (AHU, VAV, pumps, etc.)

Sub-Tab C Functional tests (completed), trending and analysis, approvals and corrections, training plan, record and approvals, blank functional test forms and a recommended re-commissioning schedule.

Tab 02 System Type 2.....repeat as per System 1

2. Final Report Details. The final commissioning report shall include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the commissioning authority regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas: 1) Equipment meeting the equipment specifications, 2) Equipment installation, 3) Functional performance and efficiency, 4) Equipment documentation and design intent, and 5) Operator training. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-

compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented. The functional performance and efficiency section for each piece of equipment shall include a brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

3. Other documentation will be retained by the CxA

3.10 WRITTEN WORK PRODUCTS

- A. The commissioning process generates a number of written work products described in various parts of the *Specifications*. The *Commissioning Plan—Construction Phase*, lists all the formal written work products, describes briefly their contents, who is responsible to create them, their due dates, who receives and approves them and the location of the specification to create them. In summary, the written products are:

<u>Product</u>	<u>Developed By</u>
1. Develop and maintain a commissioning plan	CxA
2. Issue Cx Specifications	CxA
3. Commissioning milestones coordinated into the construction schedule.	CxA with GC
4. Equipment documentation submittals	GC & Subs
5. Sequence of Operation clarifications	GC, Subs and A/E as needed
5. Develop Verification checklists	CxA
6. Startup and initial checkout plan	GC, Subs and CxA
7. Startup and executed Verification checklist	GC, Subs with witness of CxA & OAR
8. Final TAB report	TAB
9. Develop Master Issues Log (deficiencies)	CxA
10. Commissioning Progress Record	CxA
11. Develop Functional Performance tests	CxA with GC & Subs, TAB contractor, A / E, and OAR
12. Execute the functional performance tests	GC & Subcontractors
13. Issue O&M manuals for approval / review	GC & Subcontractors
14. Issue approved O & M manuals	GC & Subcontractors
15. Current Facility Requirements and Operation and Maintenance Plan	CxA with GC, subcontractors, and Owner's O&M personnel
16. Overall training plan	GC & Subcontractors with Mfr's. Factory Representatives
17. Execute specific training	GC & Subs
18. Systems manual	CxA with GC, subcontractors, and Owner's O&M personnel
19. Ongoing Commissioning Plan	CxA and Owner's Facility Management and O&M personnel
20. Final commissioning report	CxA

END OF SECTION 01 91 13

SECTION 01 91 15 - FACILITY EXTERIOR ENCLOSURE COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes exterior enclosure commissioning procedures, including substructure, superstructure, exterior enclosure, and roofing construction that protects climate controlled interior space from unconditioned spaces and the exterior environment.
- B. Commissioning
 - 1. A systematic process ensuring that all building enclosure systems perform interactively according to the Design Criteria Package (DCP) and the Contractor's Designer's BOD. This is to be achieved through actual verification of systems performance during the construction period.
 - 2. The commissioning process does not take away from, or reduce the responsibility of, the Contractor and installing subcontractors to provide a finished and fully functioning product.
 - 3. Whole building commissioning includes both MEP commissioning authorities (CxA) and building enclosure commissioning authorities (BECxA). This specification only addresses building enclosure commissioning.
- C. Building Envelope/Enclosure Commissioning Service Procurement: The Owner shall retain a commissioning agent, who will hire a consultant for the Project to provide building enclosure coordination and to oversee the commissioning of all building enclosure components.
- D. Systems to be Commissioned: Sections of work to be commissioned include, but are not limited to, the sections of the building that include materials and assemblies that are responsible for creating environmental separation. All performance values shall be as described within each individual section.
- E. Description: The following describes the steps involved in building enclosure commissioning and the services provided by the Building Envelope Commissioning Authority (BECxA):
 - 1. Pre-Design/Design Phase: The steps included in this phase include the following:
 - a. Attend initial Team Meeting.
 - b. Evaluate design concepts against OPR and Architect's BOD.
 - c. Incorporate commissioning requirements into the Construction Documents via commissioning specification.
 - d. Construction Documents review prior to Bid Set.
 - e. Back check Construction Documents review.
 - 2. Preconstruction Phase: The steps included in this phase include the following:
 - a. Develop functional Test Plan for exterior enclosure.
 - b. Review of pertinent Shop Drawings/Submittals.

- c. Observe construction and testing mockup(s).
- d. Develop/define the exterior enclosure Commissioning Plan.
- e. Attend preconstruction conferences.
- 3. Construction Phase: The steps included in this phase include the following:
 - a. Finalize Commissioning Plan.
 - b. Attend pertinent Preconstruction and Progress Meetings (as needed).
 - c. Review mockups and witness all mockup testing.
 - d. Field observations of exterior enclosure installations.
 - e. Observe testing and performance of functional tests.
- 4. Operations and Maintenance (O&M) Phase: The steps included in this phase include the following:
 - a. Finalization of Project commissioning record with Warranties and Closeout Documentation.
 - b. Verify applicable training procedures of building maintenance personnel.

1.2 RELATED DOCUMENTS

- A. This section is only a portion of the Contract Documents. All of the Contract Documents, including General Conditions of the Design-Build Contract for Construction and Division 01 General Requirements (including Section 01 91 13 – General Commissioning Requirements), apply to this section. Refer to Divisions 03 through 14 for requirements specific to each Section.
- B. Owner's Project Requirements (OPR), defined by the DCP, and the Basis of Design (BOD), prepared by the Contractor's Designer, documentation are included by reference for information only.
- C. Division 01 Section 01 81 1308 81 13.14 - Sustainable Design Requirements – LEED v4 BD+C for additional LEED v4 requirements related to commissioning.
- D. ASHRAE standard 90.1 -2010, ASHRAE Guideline 0-2005 (The Commissioning Process), NIBS Guideline 3-2012 Building Enclosure Commissioning Process and ASHRAE Standard 202-2013 Commissioning Process for Buildings and Systems.

1.3 COMMISSIONING TEAM MEMBERS

- A. Commissioning Team
 - 1. Owner (PM) and his/her Consultants.
 - 2. Owners Authorized Representative (OAR)
 - 3. Contractor (GC).
 - 4. Contractor's Designers .
 - 5. Commissioning Authority (CxA).
 - 6. Building Envelope/Enclosure Commissioning Authority (BECxA)
 - 7. Specialty Subcontractors.
 - 8. Design Criteria Consultant (DCC)

1.4 CONTRACTOR'S RESPONSIBILITIES

- A. Provide Coordination Drawings (see 1.7 Building Enclosure Coordination Drawings) showing the complete coordination and integration of all work of commissioned envelope systems to the Commissioning Authority. The Contractor shall be responsible for coordinating all aspects of intersecting building envelope trades/systems and develop the coordination drawings and review the coordination drawings with the Contractor's Designers and the DCC as required. The OAR shall also review the proposed coordination drawings with the BECxA.
- B. Provide cut sheets and Shop Drawings Submittals of commissioned systems to the Commissioning Authority. The Contractor shall be responsible for reviewing the Shop Drawings for accuracy and to identify conflicts requiring resolution prior to submitting to the Architect. This shall include coordinating all aspects of intersecting building envelope trades/systems and providing graphic documentation of mockup details as required to ensure accurate revisions of shop drawings are implemented.
- C. Conduct Preconstruction, Design, and Construction Phase building enclosure coordination meetings. Coordinate preconstruction meetings as required to ensure attendees include the installing subcontractor, installing subcontractors whose work interfaces with the systems being discussed, applicable manufacturers, BECxA, the Contractor's Designers and the OAR unless other specified.
- D. Provide Test Data, Letters of Compatibility, and Certificates to the Commissioning Agent.
- E. Coordinate trades in accordance with the requirements in the General Conditions and General Requirements of the Construction Contract.
- F. Permit and provide access to locations of installed systems, subsystems, and components for testing and inspection.
- G. Review test procedures to ensure feasibility, safety and equipment protection and provide necessary written limits to be used during tests.
- H. Provide schedule and accommodate field quality control tests and inspections required by the Contract Documents and product manufacturers to the Commissioning Authority.
 - 1. Upgrade schedule biweekly throughout the construction period.
- I. Completing verification checklists and responding to issues identified by the BECxA. Note: For this project, the BECxA will be utilizing a cloud-based Cx web application for managing the commissioning documentation associated with the project. Refer to Section 01 91 13.
- J. Provide field quality control testing and conduct systematic field quality control inspections on all exterior enclosure construction and submit reports to the BECxA and project's Commissioning Authority through the cloud-based Cx web site. Provide weekly updates of checklists provided by the BECxA for applicable building envelope systems and related components.

- K. Participate in testing/inspection procedures meetings.
- L. Direct appropriate subcontractors to correct deficiencies as interpreted by the Commissioning Agent, the Contractor's Designers, DCC, OAR and Owner. Field verify deficiencies have been corrected and provide written documentation and corresponding photographs of same through the cloud-based Cx web site.
- M. During construction, maintain as-built redline drawings for all drawings.
- N. Coordinate with manufacturers to determine specific requirements to maintain the validity of the warranty. This should include coordinating all required manufacturer's participation including any required preconstruction/progress meetings, site visits/inspections (including all required 3rd party inspections) and field testing. Additionally, this should include confirming the manufacturer's approval of all installing contractors (subcontractors) prior to bidding.
- O. Provide input and required documentation for LEED v4 certification of envelope Cx activities, including, but not limited to, Current Facility Requirements, O&M Plan, Ongoing Commissioning Plan, and Final Commissioning Report to the BECxA and the project's Commissioning Authority.
- P. Submit operation, maintenance and warranty data for systems, subsystems, and components to the Commissioning Authority.
- Q. Participate in maintenance orientation, training, and inspection.

1.5 CONTRACTOR'S DESIGNERS'S RESPONSIBILITIES

- A. Provide paper and electronic copies of Project Drawings and Specifications to the BECxA.
- B. Provide paper and electronic copies of submittals and shop drawings approved for construction to the BECxA.
- C. Provide written responses to design review comments from the BECxA, the Commissioning Authority or other parties as requested.
- D. Attend Design, Preconstruction, and Construction Phase coordination meetings.
- E. Design mock-up wall, incorporating required components and details as required for integrating project specific conditions for visual evaluation and testing; after discussions with the BECxA and the CxA.
- F. Participate in testing/inspection procedures meetings.
- G. Provide resolution for items for which the BECxA, the Commissioning Authority and Contractor may be in disagreement.

1.6 BUILDING ENCLOSURE COMMISSIONING AUTHORITY RESPONSIBILITIES

- A. The BECxA will begin work in the Pre-Design or Design Phases and continue until all building enclosure systems have been accepted by both the Designer and the Owner. The specific tasks/responsibilities of the BECxA include the following:
1. Incorporate commissioning requirements into the Construction Documents via a commissioning specification.
 2. Initial review of preliminary Construction Documents against OPR and BOD.
 3. Perform back check review of Construction Documents against OPR and BOD.
 4. Develop functional Test Plan for exterior enclosure.
 5. Develop inspection checklists for applicable building envelope systems and related components which shall be provided to the Construction Manager for distribution to subcontractors.
 6. Review of Project Drawings and Specifications at 60%, and 95% completion for constructability, durability, and performance of exterior enclosure conformance.
 7. Review of pertinent building enclosure Shop Drawings/Submittals and Coordination Drawings for compliance with Contract Documents.
 8. Review spray racks, testing equipment and test protocols for specified field testing outlined in Section 01 45 16.
 9. Observe the construction of mockups and observe testing of same.
 10. Document construction of commissioned components at the completion of mockup testing. This documentation will consist of photographs documentation provided by the BECxA and graphic representation of mockup details developed by the GC for use in revising shop drawings as needed.
 11. Attend pertinent Progress Meetings (as needed).
 12. Perform field observations of exterior enclosure installations.
 13. Maintain a log of deficient conditions.
 14. Direct contractor(s) and witness functional or manual field performance (in-situ) testing.
 15. Evaluate substitution requests for compliance with Contract Documents and for compatibility with work of other subcontractors.
 16. Compile test data, inspection reports, and certificates through the cloud-based Cx web application and include them in the final LEED documentation and Commissioning Record.
 17. Work in conjunction with the Contractor, the subcontractors and the Contractor's Designers to resolve conflicts in the installation of materials and assemblies specific to the building enclosure trades.
 18. Finalize Commissioning Record with warranties and closeout documentation.
 19. Verify applicable training procedures of building maintenance personnel.

1.7 BUILDING ENCLOSURE COORDINATION DOCUMENTS

- A. The Contractor shall be fully responsible for coordinating all trades, assuring proper construction sequences and schedules, and coordinating the actual installed location and interface of all work that impacts the building enclosure. Before materials are fabricated or the work begun, the Contractor shall supervise and direct the creation of one complete set of Coordination Drawings showing the complete

coordination and integration of all work of this Project relating to the thermal, drainage, air barrier, vapor barrier, expansion joints and structural systems of enclosure. Coordination Drawings are intended to assist the Contractor during construction, and may be produced using Architect's drawings, shop drawings, or other drawings as needed to communicate coordination requirements to all concerned subcontractors.

- B. Specifically, Coordination Drawings shall include, but are not limited to the following detail conditions and system connections:
1. Masonry and/or concrete panel tie-in to adjacent cladding and backup membranes.
 2. Thru-wall flashing tie-ins to adjacent waterproofing/air barrier membranes.
 3. Cladding type transitions (same plane and corners)
 4. Cladding transition flashing and closure metal as required at wall fenestrations and intersections between different building envelope systems.
 5. Canopy tie-in flashing at adjacent walls or cladding above.
 6. Below grade waterproofing systems along finished grade (landscape or hardscape) terminations, below grade vapor barrier transitions and adjacent wall cladding systems.
 7. All other major transition points between trades.
- C. Mockup Shop Drawings: Provide shop drawings for construction of windows, curtain-walls, wall claddings and related transition flashing, closure metal, expansion joints, sealant joints, etc., for mockups. Field revisions to mockups due to testing failure or other causes shall be documented in revised shop drawings to be identified as "Post Mockup Revision". The Contractor shall record changes to mockup details and review same with the BECxA, the Contractor's Designers, the DCC and the OAR for accuracy and concurrence
- D. In regard to coordination of building envelope systems and components, coordination of work and multiple trades shall include the following:
1. Building Enclosure Subcontractors: The GC shall circulate the Coordination Drawings to other subcontractors and trades whose work might conflict with other work and require these subcontractors to accurately and neatly show the actual size and location of all their work. These subcontractors shall note any apparent conflicts, suggest alternate solutions, and return the Coordination Drawings to the Contractor.
 2. After each trade completes its drawings, a meeting will be held to resolve conflicts between the trades and establish sequencing.
 - a. Trades Coordination Drawings shall be submitted to the Contractor for the Contractor's Designers's review prior to starting any installations.
 - b. Coordination issues or requests for variance shall be called to the Construction Manager's attention for the Architect's resolution.
 - c. The Coordination Drawings, including all Designers's resolutions, shall be reviewed with the BECxA before work in the field is begun.

- d. Contractor Review and Submission: The Contractor shall carefully review, modify, and approve Coordination Drawings in cooperation with the subcontractors to assure that conflicts, if any, are resolved before work in the field is begun.

1.8 FUNCTIONAL AND MANUAL PERFORMANCE TESTING (IN-SITU)

- A. Objectives and Scope: The objective of functional performance testing is to demonstrate that each building enclosure/assembly system is operating according to the documented design intent of the Contract Documents and in accordance with the OPR. Functional testing facilitates bringing the material assembly from a state of substantial completion to full operation. Additionally, during the testing process, areas of non-compliant performance are identified and corrected, improving the operation and functioning of the building enclosure/assemblies.
- B. Development of Test Procedures: Before test procedures are written, the BECxA shall obtain all requested documentation and a current list of change orders affecting building enclosure/assemblies. The BECxA shall develop specific test procedures for each building enclosure/assembly. Prior to execution, the BECxA shall provide a copy of the test procedures to the subcontractor(s) who will review the tests for feasibility, building enclosure/assemblies warranty protection.
 1. The BECxA shall direct and witness Owner-contracted performance testing.
 2. The Contractor shall construct or arrange for construction of test chambers, and shall provide staging and access equipment as needed to position spray racks at the exterior. The Contractor shall be responsible for locating and providing all water and electrical sources to perform testing.
 3. All testing shall be conducted by a qualified independent test agency with at least 5 years of documented experience in performing the specified testing.
 4. The purpose of any given specific test is to verify and document compliance with the stated criteria of the Construction Documents.
- C. Test Methods
 1. Functional and manual performance testing and verification will typically follow ASTM industry standards. The BECxA will determine which method is most appropriate for tests and modify test methods when an existing industry method is not available or applicable.
 2. Simulated Conditions: Simulating conditions may be allowed at the direction of the BECxA, though testing actual conditions is encouraged wherever practical.
- D. Coordination and Scheduling: The Contractor and their subcontractors shall provide sufficient notice to the Commissioning Authority regarding their completion schedule for the functional checklists and construction of the assemblies or building enclosure systems. The BECxA will schedule functional tests through the GC and affected subcontractors. All functional testing of all building enclosure assemblies or building enclosure systems shall be performed by the Contractor under the direction of the BECxA.

- E. In general, functional testing is conducted after mockup testing has been satisfactorily completed.
- F. Problem Solving: The BECxA may recommend solutions to problems found, however, the burden of responsibility to solve, correct, and retest problems is with the contractor responsible for the installation of the tested assembly.
- G. Failed tests will result in additional testing of the failed specimen in addition to conducting at least 1 additional test on a different test specimen at the location selected and mutually agreed upon between the Architect and the BECxA. In the event another failure occurs during the additional testing, 2 more test specimens will be selected for additional testing and the process will be repeated until passing results are achieved. In addition, the installing contractor and Construction Manager shall be responsible for field verifying that similar anomalies, to those that resulted in failure, do not exist elsewhere throughout all similar project wide units. The cost of re-staging and constructing test chamber shall be responsibility of the deficient Contractor. The cost for the BECxA to conduct or observe one (1) retest of the failed specimen will be borne by the Owner. Costs for subsequent retests due to failure shall be the responsibility of the deficient contractor. Test will be concluded only when satisfactory results are achieved.
- H. Testing reports shall be provided by the independent test agency within five (5) working days of each test. All test reports shall be distributed to the Contractor, Contractor's Designers, OAR, DCC, CxA, BECxA and applicable subcontractors. All test reports shall be uploaded through the cloud-based Cx web site.
- I. Non-Conformance:
 - 1. The independent test agency and the BECxA will record the results of the functional tests in a written report. All deficiencies or non-conformance issues shall be noted and reported.
 - 2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the BECxA. In such cases, the deficiency and resolution will be documented in the written report.
 - 3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.
 - 4. As tests progress and a deficiency is identified, the BECxA discusses the issue with the OAR and Contractor.
 - a. When there is no dispute on the deficiency and the subcontractor accepts responsibility to correct it:
 - 1) The BECxA documents the deficiency and the subcontractor's response and intentions and work proceeds.
 - 2) The Contractor and BECxA will coordinate the rescheduled test with the affected Contractor, and the test is repeated.
 - b. If there is a dispute about a deficiency regarding whether it is a deficiency or who is responsible:
 - 1) The deficiency shall be documented on the Non-Compliance Form with the subcontractor's response and copy given to the

Contractor and to the subcontractor's representative assumed to be responsible.

- 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Interpretive authority is with the A/E. Final acceptance authority is with the Owner's PM.
- 3) The BECxX documents the resolution process.
- 4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the Statement of Correction on the Non-Compliance form, and provides it to the Contractor and the BECxX. The Contractor and the BECxX will reschedule the test with the affected Contractors on a mutually agreed upon date, and the test(s) are repeated until satisfactory performance is achieved.
- 5) Any required retesting that is a result of deficient installation shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 COMMISSIONED SYSTEMS

- A. The BECxX shall develop and coordinate a systematic process to verify the building envelope/enclosure systems have been constructed according to the requirements of the OPR and BOD.
- B. Building envelope/enclosure commissioning shall be accomplished via the responsibilities outlined previously and may include a combination of submittal reviews, mockup inspection/testing, field observations, material sampling/testing, verification checklists completed by the installing contractor, functional performance testing, closeout documentation review, etc. Extent of Building Envelope/Enclosure Commissioning shall be determined during a Commissioning scoping meeting prior to construction.
- C. Building envelope/enclosure systems and associated components to be commissioned may include, but are not limited to:
 1. Section 03 30 00 - Cast In Place Concrete
 - a. Inspections or test observations may include:
 - 1) Inspect associated waterstops and vapor barriers.
 - 2) Monitor concrete placement and inspect finishes/surfaces scheduled to receive roofing, waterproofing, expansion joints, membranes, air barriers, sealants, sealers, paints, coatings, etc.
 - 3) Inspect penetration detailing, laps, membrane repairs, etc. at vapor barrier installations.

- 4) ASTM F 1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
- 5) .
- 2. Section 06 10 00 – Rough Carpentry
- 3. Section 06 16 00 – Sheathing
 - a. Inspections or test observations may include:
 - 1) Inspect fastening requirements, sheathing joint treatment and all surfaces scheduled to receive roofing, membranes, air barriers, etc.
- 4. Section 07 13 26 – Self Adhering Sheet Waterproofing
 - a. Inspections or test observations may include:
 - 1) Inspect substrates to receive waterproofing membrane and associated insulation, protection board, drainage panels counter flashing, etc.
 - 2) Flood testing or modified AAMA 501.2 hose testing.
 - 3) Monitor concrete placement, U.V. exposure limitations, back filling techniques, repairs, etc.
- 5. Section 07 18 00/01 – Traffic Coatings
 - a. Inspections or test observations may include:
 - 1) Substrates to receive traffic coatings.
 - 2) Wet/dry film mil thickness sampling.
 - 3) Evaluation/sampling of related sealants.
- 6. Section 07 19 00 – Water Repellents
 - a. Inspections or test observations may include:
 - 1) Substrates to receive water repellents.
 - 2) Verify with manufacturer application/coverage rates including required mockup assemblies prior to widespread installation,
 - 3) Evaluation/sampling of water repellents mockups/installation.
- 7. Section 07 21 00 – Thermal Insulation
 - a. Inspections or test observations may include:
 - 1) Visual observations.
 - 2) Infrared survey of roofing assemblies.
 - 3) ASTM C1060 – Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings.
- 8. Section 07 21 19 – Foamed-In-Place Insulation
 - a. Inspections or test observations may include:
 - 1) Visual observations.
 - 2) ASTM C1060 – Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings.
- 9. Section 07 27 29 – Air-Barrier Coatings
 - a. Inspections or test observations may include:
 - 1) Substrates to receive air-barrier coatings.
 - 2) Wet/dry film mil thickness sampling.
 - 3) Inspect penetration detailing, laps, membrane repairs, etc.
 - 4) Evaluation/sampling of related sealants.
- 10. Section 07 41 10 - Metal Canopy Cladding System"

- a. Inspections or test observations may include:
 - 1) Inspect associated weather barrier membrane, insulation, flashing, sealants, etc.
 - 2) AAMA 501.2 (modified) – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems.
 - 3) Flood testing roof gutters to the highest water level possible (at overflow capacity) for a minimum 2 hours duration.
- 11. Section 07 42 13.23 – Metal Composite Material Wall Panels
 - a. Inspections or test observations may include:
 - 1) Inspect associated weather barrier membrane, insulation, flashing, sealants, etc.
 - 2) AAMA 501.2 (modified) – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems.
- 12. Section 07 92 00/01 – Joint Sealants
 - a. Inspections or test observations may include:
 - 1) ASTM C 1521 – Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
- 13. Section 07 95 01 – Expansion Control
 - a. Inspections or test observations may include:
 - 1) AAMA 501.2 (modified) – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems.
- 14. Section 07 95 13.16 – Exterior Expansion Joint Cover Assemblies
 - a. Inspections or test observations may include:
 - 1) AAMA 501.2 (modified) – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems.
- 15. Section 08 11 13 – Hollow Metal Doors and Frames
 - a. Inspections or test observations may include:
 - 1) Inspection of weatherproof gaskets, door sweeps, etc., intended to provide weather tightness.
- 16. Section 08 80 00 – Glazing
- 17. Section 08 91 19 – Fixed Louvers
 - a. Inspections or test observations may include:
 - 1) AAMA 501.2 (modified) – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems.
- 18. Section 09 24 00 – Portland Cement Plastering
 - a. Inspections or test observations may include:
 - 1) AAMA 501.2 (modified) – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems.
- 19. Section 09 91 13 – Exterior Painting
 - a. Inspections or test observations may include:
 - 1) Wet/dry film mil thickness sampling.

- 2) ASTM D 3359 – Standard test Methods for Measuring Adhesion by Tape Test.
- 20. Section 09 96 00 – High Performance Coatings
 - a. Inspections or test observations may include:
 - 1) Wet/dry film mil thickness sampling.
 - 2) ASTM D 3359 – Standard Test Methods for Measuring Adhesion by Tape Test.

3.2 SAMPLE SCHEDULE OF TESTS

- A. Window Mockup: Two (2) air infiltration tests and two (2) water infiltration tests of each window mockup type and surrounding components and systems. Infiltration tests to be performed by constructing a wood framed chamber with 10-mil clear polyethylene at the interior side and introducing negative pressure (suction) in the chamber during spray rack water test at the exterior side. Test Criteria: Air infiltration – ASTM E783-02; Water Infiltration – ASTM E1105-00. GC shall construct or arrange construction of the test chamber and associated spray rack per the size and specifications as provided by the Architect and as reviewed by the BECxA. Contractor shall also provide or arrange staging and access equipment for positioning of spray rack and provide water and electrical sources. All testing shall be performed with pressures equal to laboratory test pressures without reduction
- B. Window In-Situ Tests (Functional Performance Testing): Air and water infiltration tests shall be performed on a minimum of 5% of all storefront windows and 5% of glazed curtain walls throughout the project, prior to adjacent interior finish installation including wall insulation. Test protocols to match those on window mockup. Contractort shall construct or arrange construction of the test chamber and associated spray rack per the size and specifications as provided by the Contractor's Designer and as reviewed by the BECxA. OAR and DCC, and shall also provide or arrange staging and access equipment for positioning of spray rack and provide water and electrical sources. All testing shall be performed with test pressures equal to laboratory test pressures without reduction.

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SPECIFICATION ISSUE KEY

Issue Date:	Rev. #	Issue Title:
June 7, 2017	0	PKG – Permit Set
July 18, 2017	1	PKG – Addendum #1
July 28, 2017	2	FDN – 100% Bid Documents
August 4, 2017	3	PKG – Addendum #2
August 25, 2017	4	FDN – LST/GTF 100% Bid Documents Addendum #1
July 11, 2017	5	GSE – 100% Bid Documents **
August 11, 2017	6	CHD – 100% Bid Documents **
September 8, 2017	7	FDN – ASC 100% Bid Documents Addendum #1
September 12, 2017	8	CEP – 100% Bid Documents **
September 25, 2017	--	PKG – DSI-001
October 6, 2017	9	FDN – LST/ASC 100% Bid Documents Addendum #2
October 13, 2017	10	ASC/LST – 95% Review Documents
October 17, 2017	11	Site Logistics Expansion Package
October 25, 2017	12	PKG – DSI-002
December 1, 2017	13	LSC/AFC – For Permit & Construction
December 15, 2017	14	Campus-Wide Specification – For Permit & Construction
January 3, 2018	15	Response to RFC 0016 (Informal Issue)
February 5, 2018	16	Campus-Wide Specification – Bulletin #001
February 26, 2018	17	Campus-Wide Specification – Bulletin #002

May 4, 2018	18	Campus-Wide Specification – Bulletin #003
May 25, 2018	19	Campus-Wide Specification – DSI #001
June 29, 2018	20	Campus-Wide Specification – Bulletin #004
July 2, 2018	21	Response to RFI HP-0306
August 10, 2018	22	Campus-Wide Specification – Bulletin #005
September 20, 2018	23	Campus-Wide Specification – Bulletin #006
November 21, 2018	24	Campus-Wide Specification – Bulletin #007
January 24, 2019	25	Campus-Wide Specification – Bulletin #008
February 19, 2019	26	Response to RFI HP-0899.1
March 5, 2019	27	Campus-Wide Specification – Bulletin #009
March 22, 2019	28	Campus-Wide Specification – Bulletin #010
March 26, 2019	29	Campus-Wide Specification – Bulletin #011
April 2, 2019	30	Response to RFI HP-0927.3
June 18, 2019	31	Campus-Wide Specification – Bulletin #012
July 2, 2019	32	Campus-Wide Specification – Bulletin #013
August 8, 2019	33	Response to RFI HP-1632
August 15, 2019	34	Campus-Wide Specification – Bulletin #014
August 26, 2019	35	Response to RFI TK-2832
August 27, 2019	36	Response to RFI TK-0.0906 (GTF)
September 13, 2019	37	Campus-Wide Specification – Bulletin #015
October 2, 2019	38	Campus-Wide Specification – Bulletin #016
November 14, 2019	39	Campus-Wide Specification – Bulletin #017
December 10, 2019	40	Campus-Wide Specification – Bulletin #018
March 25, 2020	41	Campus-Wide Specification – Bulletin #019
March 30, 2020	42	Response to RFI TK-3676.1
March 31, 2020	43	Response to RFI TK-4134
April 3, 2020	44	Campus-Wide Specification – Bulletin #020
<u>June 11, 2020</u>	<u>45</u>	<u>Campus-Wide Specification – Bulletin #021</u>

** Documents not Issued – Voided Deliverable

REVISIONS:

Rev. # column represents the sequence in which the specifications, whole or in part, were issued.

BOLD and Underlined are new, revised, or edited sections in this issue.

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SECTION 02 41 19 - SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Demolition and removal of selected portions of building or structure.
 - 2. Demolition and removal of selected site elements.
 - 3. Salvage of existing items to be reused or recycled.
- B. Related Requirements:
 - 1. Section 01 10 00 "Summary" for restrictions on use of the premises, Owner-occupancy requirements, and phasing requirements.
 - 2. Section 01 73 29 "Cutting and Patching" for cutting and patching procedures.
 - 3. Section 01 74 19 "LEED v4 Construction Waste Management and Disposal" for demolition waste disposal.

1.3 DEFINITIONS

- A. Remove: Detach items from existing construction and dispose of them off-site unless indicated to be salvaged or reinstalled.
- B. Remove and Salvage: Detach items from existing construction, in a manner to prevent damage, and deliver to Owner ready for reuse.
- C. Remove and Reinstall: Detach items from existing construction, in a manner to prevent damage, prepare for reuse, and reinstall where indicated.
- D. Existing to Remain: Leave existing items that are not to be removed and that are not otherwise indicated to be salvaged or reinstalled.
- E. Dismantle: To remove by disassembling or detaching an item from a surface, using gentle methods and equipment to prevent damage to the item and surfaces; disposing of items unless indicated to be salvaged or reinstalled.

1.4 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.

1.5 PREINSTALLATION MEETINGS

- A. Predemolition Conference: Conduct conference at Project site.
 - 1. Inspect and discuss condition of construction to be selectively demolished.
 - 2. Review structural load limitations of existing structure.

3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
5. Review areas where existing construction is to remain and requires protection.

1.6 INFORMATIONAL SUBMITTALS

- A. Engineering Survey: Submit engineering survey of condition of building.
- B. Proposed Protection Measures: Submit report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection and for dust control. Indicate proposed locations and construction of barriers.
- C. Schedule of Selective Demolition Activities: Indicate the following:
 1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's on-site operations are uninterrupted.
 2. Interruption of utility services. Indicate how long utility services will be interrupted.
 3. Coordination for shutoff, capping, and continuation of utility services.
 4. Use of elevator and stairs.
 5. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.
- D. Predemolition Photographs or Video: Show existing conditions of adjoining construction, including finish surfaces, that might be misconstrued as damage caused by demolition operations. Comply with Section 01 32 33 "Photographic Documentation." Submit before Work begins.
- E. Warranties: Documentation indicating that existing warranties are still in effect after completion of selective demolition.

1.7 CLOSEOUT SUBMITTALS

- A. Inventory: Submit a list of items that have been removed and salvaged.

1.8 FIELD CONDITIONS

- A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.
- B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
- C. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

- D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
 - 1. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.
- E. Storage or sale of removed items or materials on-site is not permitted.
- F. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.
 - 1. Maintain fire-protection facilities in service during selective demolition operations.

1.9 WARRANTY

- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials and using approved contractors so as not to void existing warranties.
- B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

1.10 COORDINATION

- A. Arrange selective demolition schedule so as not to interfere with Owner's operations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- B. Standards: Comply with ASSE A10.6 and NFPA 241.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that utilities have been disconnected and capped before starting selective demolition operations.
- B. Review Project Record Documents of existing construction or other existing condition and hazardous material information provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in Project Record Documents.

- C. Engage a professional engineer to perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective building demolition operations.
 - 1. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.
- D. Steel Tendons: Locate tensioned steel tendons and include recommendations for de-tensioning.
- E. Verify that hazardous materials have been remediated before proceeding with building demolition operations.
- F. Survey of Existing Conditions: Record existing conditions by use of preconstruction photographs or video.
 - 1. Comply with requirements specified in Section 01 32 33 "Photographic Documentation."
 - 2. Inventory and record the condition of items to be removed and salvaged. Provide photographs or video of conditions that might be misconstrued as damage caused by salvage operations.
 - 3. Before selective demolition or removal of existing building elements that will be reproduced or duplicated in final Work, make permanent record of measurements, materials, and construction details required to make exact reproduction.

3.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

- A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
- B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.
 - 1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
 - 2. Arrange to shut off utilities with utility companies.
 - 3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
 - 4. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated on Drawings to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.

- d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
- e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
- g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material and leave in place.

3.3 PROTECTION

- A. Temporary Protection: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 - 1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
 - 2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
 - 3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
 - 4. Cover and protect furniture, furnishings, and equipment that have not been removed.
 - 5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Section 01 50 00 "Temporary Facilities and Controls."
- B. Temporary Shoring: Design, provide, and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.
 - 1. Strengthen or add new supports when required during progress of selective demolition.
- C. Remove temporary barricades and protections where hazards no longer exist.

3.4 SELECTIVE DEMOLITION, GENERAL

- A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
 - 1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
 - 2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.
 - 3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.

4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
 5. Maintain fire watch during and for at least six hours after flame-cutting operations.
 6. Maintain adequate ventilation when using cutting torches.
 7. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
 8. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
 9. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
 10. Dispose of demolished items and materials promptly. Comply with requirements in Section 01 74 19 "LEED v4 Construction Waste Management and Disposal".
- B. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

~~C. Work in Historic Areas: Selective demolition may be performed only in areas of Project that are not designated as historic. In historic spaces, areas, and rooms, or on historic surfaces, the terms "demolish" or "remove" shall mean historic "removal" or "dismantling" as specified in Section 02 42 96 "Historic Removal and Dismantling."~~

D.C. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area designated by Owner.
5. Protect items from damage during transport and storage.

E.D. Removed and Reinstalled Items:

1. Clean and repair items to functional condition adequate for intended reuse.
2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.
4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

F.E. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and reinstalled in their original locations after selective demolition operations are complete.

3.5 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS

- A. Concrete: Demolish in small sections. Using power-driven saw, cut concrete to a depth of at least 3/4 inch at junctures with construction to remain. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete. Neatly trim openings to dimensions indicated.
- B. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, and then remove masonry between saw cuts.
- C. Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished, and then break up and remove.
- D. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI's "Recommended Work Practices for the Removal of Resilient Floor Coverings." Do not use methods requiring solvent-based adhesive strippers.
- E. Roofing: Remove no more existing roofing than what can be covered in one day by new roofing and so that building interior remains watertight and weathertight.

3.6 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove demolition waste materials from Project site and recycle or dispose of them according to Section 01 74 19 "LEED v4 Construction Waste Management and Disposal".
 - 1. Do not allow demolished materials to accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
 - 3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
 - 4. Comply with requirements specified in Section 01 74 19017419 "LEED v4 Construction Waste Management and Disposal".
- B. Burning: Do not burn demolished materials.

3.7 CLEANING

- A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.
- B. Refer to Section 01 74 23 "Final Cleaning" for additional cleaning requirements.

END OF SECTION 02 41 19

SECTION 03 15 13 - WATERSTOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section provides for an expanding hydrophilic waterstop as specified herein, illustrated on project drawings, or as required to complete the work to comply with waterproofing warranty requirements.
- B. System Description:
 - 1. Waterstop Strip: A non-Bentonite hydrophilic waterstop with a minimum swell as per Section 2.02
 - 2. Accessories for complete waterstop application
- C. Related Requirements:
 - 1. Section 03 30 00 "Cast-In-Place Concrete"
 - 2. Section 07 13 26 "Self-Adhering Sheet Waterproofing"

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations.
- B. Shop drawings showing locations and extent of waterstop.
- C. Written documentation demonstrating Installers qualifications under the "Quality Assurance" article including reference projects of a similar scope.
- D. Samples: Submit representative sample of actual product.
- E. Warranty: Submit a sample warranty identifying the terms and conditions stated in Section 1.7.

1.4 QUALITY ASSURANCE

- A. Manufacturer: Waterstop systems shall be manufactured and marketed by a firm with a minimum of 20 years' experience in the production and sales of building materials. Manufacturers proposed for use, but not named in these specifications shall submit evidence of ability to meet all requirements specified, and include a list of projects of similar design and complexity completed within the past five years.
- B. Installer Qualifications: A firm which has at least three (3) years experience in work for the type required by this section.

- C. Material: Waterstop shall be by single source manufacturer and shall be specially engineered to be a swellable and conformable polyurethane/butyl blended rubber free of sodium bentonite that expands when in contact with water.
- D. Pre-Installation Conference: A pre-installation conference shall be held prior to commencement of field operations to establish procedures to maintain optimum working conditions and to coordinate this work with related and adjacent work. Agenda for meeting shall include review of surface preparation, installation procedures, special details, inspection, protection, and repair procedures.
- E. Concrete: Concrete shall be normal weight structural concrete and provide a minimum cover of 3" around waterstop.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials and products in the original, unopened containers with seals unbroken, labeled with the manufacturer's name, product brand name and type, date of manufacture and directions for storage and use.
- B. Store and handle materials in strict compliance with manufacturer's instructions, recommendations and material safety data sheets. Protect from damage from sunlight, weather, excessive temperatures and construction operations. Remove damaged material from the site and dispose of in accordance with applicable regulations.
 - 1. Store material off ground and keep dry.
 - 2. Provide cover for material to protect top and sides.
- C. Sequence deliveries to avoid delays, but minimize on-site storage.

1.6 PROJECT CONDITIONS

- A. Perform work only when existing and forecasted weather conditions are within the limits established by the manufacturer of the materials and products used.
- B. Proceed with installation only when substrate construction and preparation work is complete and in condition to receive waterstop.
- C. Do not allow waste products (i.e. petroleum, grease, oil, solvents, vegetable or mineral oil, animal fat, acids, etc.) to come into contact with the waterstop. Any exposure to foreign materials or chemical discharges must be presented to the Membrane Manufacturer to determine the impact on the waterstop performance.
- D. Maintain environmental conditions within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.
- E. Construction Manager shall assure adequate protection during and after the application of the waterstop.

1.7 WARRANTY

- A. Provide written watertight warranty from the manufacturer that includes both labor and material for the below grade walls and the under slab waterproofing. The warranty to be issued by the membrane manufacturer upon completion of the work.
 - 1. Warranty Period: Five years from date of Substantial Completion.
 - 2. Refer to Section 07 13 26 "Self-Adhering Sheet Waterproofing" for additional warranty information.

PART 2 - PRODUCTS

2.1 WATERSTOPS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide GCP Applied Technologies, Inc., Grace Adcor or comparable product by one of the following manufacturers.
 - 1. Henry Company
 - 2. JP Specialties, Inc.
 - 3. Sika Corporation
 - 4.

2.2 MATERIALS

- 1. Hydrophilic Waterstop Strip: swellable, conformable polyurethane/butyl blended rubber based material free of sodium bentonite.
- 2. Waterstop Physical Properties:

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. Examine conditions of substrates and other conditions under which this work is to be performed and notify the Architect, in writing, of circumstances detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected.

3.2 PREPARATION OF SUBSTRATES

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- C. Do not install waterstop onto any substrates with standing water.

3.3 INSTALLATION

- A. Refer to manufacturer's literature for recommendations on installation, including but not limited to, the following:

1. Construction Joint:
 - a. On irregular concrete faces, apply a ½ in. Adhesive as bedding.
 - b. Secure waterstop using masonry nails 1½ in. - 2 in. (40 mm – 50 mm) long with a washer ¾ in. (20 mm) in diameter. Hilti EM6-20-12 FP8 shot fired fixings with ¼ in. (6 mm) nuts and ¾ in. (20 mm) diameter washers may also be used. Fixings should be spaced at a maximum of 12 in. (300 mm) centers with a minimum spacing that ensures proper contact to substrate.
 - c. waterstop joints should overlap a minimum of 4 in. (100 mm), ensuring full contact between jointed pieces.
 - d. waterstops can be bent around corners; however on complex geometry use manufacturer's approved Adhesive to fill any gaps.
 - e. Any damaged sections should be removed and repaired with a new section of waterstop.
 - f. Keep waterstop dry prior to pouring concrete.
2. Pipe Penetration:
 - a. Waterstop Adhesive must be applied to dry substrates only. Apply by brush to the substrate. Wait until surface is dry to touch, and then press waterstop firmly into place.
 - b. Waterstop joints should overlap a minimum of 4 in. (100 mm), ensuring full contact between jointed pieces.
 - c. Keep waterstop dry prior to pouring concrete.

3.4 CLEANING AND PROTECTION

- A. Protect membrane in accordance with manufacturer's recommendations until placement of concrete.
- B. Inspect for damage just prior to placement of concrete and make repairs in accordance with manufacturer's recommendations.

END OF SECTION 03 15 13

SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. All cast-in-place concrete, incidental construction, and miscellaneous structural concrete items, in accordance with the Contract Documents.
 - 2. Providing services of testing laboratory to design concrete mixes.
 - 3. Furnishing, erecting, and removing forms, falsework, shoring, and bracing required for work under this Section.
 - 4. Furnishing, fabricating, and placing reinforcing bars and wire mesh reinforcing.
 - 5. Furnishing and placing joint materials.
 - 6. Furnishing and placing inserts required to be installed under this Specification Section and other Specification Sections.
 - 7. Finishing, saw cutting, and concrete repairs.
 - 8. Curing concrete.
 - 9. Cleaning concrete.
- B. Related Work Specified Elsewhere:
 - 1. Section 05 12 00 "Structural Steel"
 - 2. Section 31 20 00 "Earth Moving for Building Slabs" for drainage fill under slabs-on-grade.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Concrete Subcontractor.
 - e. Special concrete finish Subcontractor.
 - 2. Review special inspection and testing and inspecting agency procedures for field quality control, concrete finishes and finishing, hot-weather concreting procedures, curing procedures, construction contraction and isolation joints,

forms and form removal limitations, shoring and reshoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, methods for achieving specified floor and slab flatness and levelness floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

1.4 ACTION SUBMITTALS

- A. Sustainable Design Documentation Submittals: Refer to section 01 81 13.14 "Sustainable Design Requirements – LEED V4 BD+C".
1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance
 - b. Leadership Extraction Practices for Recycled Content
 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
 - b. Corporate Sustainability Reporting (CSR's)
- B. General: Submit the following in accordance with the Contract Provisions:
1. Product Data: Submit product data for proprietary materials and items, including reinforcement, forming accessories, admixtures, patching compounds, waterstops, joint systems, curing compounds, vapor retarders and others as requested by the Architect.
 2. Include descriptive data, catalog cuts, laboratory test reports, and any other information necessary to show acceptable materials and confirm Contract compliance.
 3. Annotate data to show specific products to be used.
- C. Coordination Drawings: Submit original coordination drawings that identify the type and location of embeds, penetrations or other provisions required to execute the work of structural, architectural, plumbing, electrical or other trades. These items shall be located both by plan dimension and proposed elevation. Do not finalize shop drawings for reinforcement or formwork until the coordination drawings have been approved.
- D. Shop Drawings for Reinforcement: Submit original shop drawings for fabrication, bending, and placement of concrete reinforcement. Include special reinforcement required for openings through concrete structures.
1. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures".
 2. Show bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement.
- E. Shop Drawings for Formwork: Submit shop drawings for fabrication and erection of forms for specific finished concrete surfaces. Show form construction including jointing, special form joints or reveals, location and pattern of form tie placement, and other items that visually affect exposed concrete.
1. Submit complete and accurate shop drawings as required to adequately illustrate and control the finished work. Show all dimensions, kind, type, and quality of all materials, applicable specification references, and all other information as may

- be necessary to detail finished construction of the work covered. Reproductions of the Contract Drawings are not acceptable as shop drawings.
2. Shop drawings shall show walls in elevation and cross-section. Shop drawings shall show clear cover over reinforcing bars and interface with all columns, walls and beam/slab reinforcement.
 3. Shop drawings shall show locations of all embedded items.
 4. Submit details indicating contraction joints and joint sealers.
 5. Indicate materials utilized for sealing formwork joints and as a form release agent for coordination of subsequent coverings.
- F. Setting Drawings: Provide setting drawings and templates showing the location of all anchorage items that are to be cast into concrete.
- G. Concrete Mix Design Data: Not less than four weeks prior to the first concrete placement submit concrete mix design data to the Architect for review and approval. Mix designs shall be calculated and certified by the testing laboratory, and shall indicate the weight of each ingredient of the mixture, aggregate gradation, slump, air content, water-cement ratio and 7 day and 28-day compressive strength test results. Include a complete list of materials including admixtures and applicable reference specifications.
- H. Test and Inspection Reports: Provide reports as necessary to ensure that the tests and inspections specified have been executed.

1.5 INFORMATIONAL SUBMITTALS

- A. Certificates of Compliance: Submit manufacturer's certificates of compliance for the following materials showing that the named material conforms to the requirements of the Contract Documents. The manufacturer's certifications shall name the appropriate materials, the publication or publications specified as controlling the quality of that item, and shall state that the item conforms to the requirements specified. Certificates shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official authorized to sign certificate of compliance, and having legal authority to bind the manufacturer. Furnishing certificates of compliance shall not provide relief of responsibility for providing materials that conform to the requirements of the Contract Documents.
1. Aggregates.
 2. Admixtures.
 3. Reinforcement
 4. Cement.

1.6 QUALITY ASSURANCE

- A. Testing Service and Quality Control Testing During Construction: The **Contractor** will retain the services of a testing services to provide, plant testing, field sampling, in-place testing, and quality control testing required under the Contract Documents.

- B. The following requirements are intended to supplement GOAA's specification 01 4529 Structural Testing and Inspection. Where conflict exist specification 01 4529 Structural Testing and Inspection shall govern.
- C. Materials' Laboratories: All mix design testing and material evaluation tests of the work specified in this Section shall be performed by independent, commercial testing laboratories employed under this Section and accepted by the Architect. The basis of acceptance includes the following:
1. Laboratories performing work in connection with concrete materials shall conform to the requirements of ASTM E 329 and ASTM E 699.
 2. Provide proof that the laboratory satisfies the requirements of the American Council of Independent Testing Laboratories' Recommended Requirements for Independent Laboratory Qualification.
- D. Control of Material Uniformity: All cast-in-place concrete which is exposed to view shall not have the respective sources, brands, types, and/or grades of fine aggregate (sand), coarse aggregate, cement, and admixtures changed or switched after acceptance design mixes. Obtain concrete materials from one manufacturer for each cementitious component and from one source and producer for each aggregate component. Procure and store on site sufficient quantities of materials to cover all exposed concrete work to ensure color and texture match. If any doubt exists as to the timely availability of any material from designated sources, the Engineer shall be immediately informed, in writing, of the potential problem and of the action to be taken to guaranty the availability of such uniformly sourced materials.
1. Cement and aggregate used for all surfaces exposed to public view shall be obtained from a single source and in such quantities to ensure sufficient materials are available to complete the entire project. Uniformity of color and texture for all concrete exposed to public view is a mandatory project requirement.
 2. Changes in the sources, types of materials, and/or proportions of materials shall not be made during construction until accepted and until the requirements for verification as specified herein have been satisfied and accepted by the Architect.
 3. Sampling of materials shall be performed in accordance with the standard methods of ACI, AASHTO, and ASTM.
 4. Materials shall be inspected at the original or intermediate source of supply. Inspection shall not diminish the responsibility to furnish materials that conform to the Specifications. The laboratory representative shall have ready access to all parts of any processing plant furnishing material for the Project. Access for sampling and inspecting materials or plant equipment shall include secure, sturdy platforms conforming to local, state, and federal safety regulations.
- E. Applicable Publications: The following publications listed below form a part of this Specification to the extent referenced.
1. American Association of State Highway and Transportation Officials (AASHTO) Publications:

M 182 Burlap Cloth Made From Jute or Kenaf
T 103 Soundness of Aggregates by Freezing and Thawing

03 30 00 - 4

2. American Concrete Institute (ACI) Publications:

- 207.1R Guide to Mass Concrete
- 211.1 Selecting Proportions for Normal, Heavy Weight, and Mass Concrete
- 211.2 Selecting Proportions for Structural Lightweight Concrete
- 213R Guide for Structural Lightweight Aggregate Concrete
- 214 Recommended Practice for Evaluation of Strength Test Results of Concrete
- 301 Specifications for Structural Concrete for Buildings
- 302.1R Guide for Concrete Floor and Slab Construction
- 304R Guide for Measuring, Mixing, Transporting and Placing Concrete
- 304.2R Placing Concrete by Pumping Methods
- 305R Hot Weather Concreting
- 308 Standard Practice for Curing Concrete
- 309R Guide for Consolidation of Concrete
- 315 Manual of Standard Practice for Detailing Reinforced Concrete Structures
- 318 Building Code Requirements for Reinforced Concrete
- 347R Guide to Formwork for Concrete

3. American Society for Testing and Materials (ASTM) Publications:

- A 36 Structural Steel
- A 185 Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement
- A 307 Carbon Steel Bolts and Studs
- A 563 Carbon and Alloy Steel Nuts
- A 615 Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
- A 775 Epoxy Coated Reinforcing Bars
- B 633 Electrodeposited Coatings of Zinc on Iron and Steel
- C 31 Making and Curing Concrete Test Specimens in the Field
- C 33 Concrete Aggregates
- C 39 Compressive Strength of Cylindrical Concrete Specimens
- C 42 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- C 78 Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
- C 88 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- C 94 Ready-Mixed Concrete
- C 143 Slump of Portland Cement Concrete
- C 150 Portland Cement
- C 171 Sheet Materials for Curing Concrete
- C 172 Sampling Freshly Mixed Concrete
- C 173 Air Content of Freshly Mixed Concrete by the Volumetric Method
- C 192 Making and Curing Concrete Test Specimen in the Laboratory
- C 227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations
- C 231 Air Content of Freshly Mixed Concrete by the Pressure Method

C 260 Air-Entraining Admixtures for Concrete
C 494 Chemical Admixtures for Concrete
C 496 Splitting Tensile Strength of Cylindrical Concrete Specimens
C 567 Unit Weight of Structural Lightweight Concrete
C 641 Test Method for Staining Materials in Lightweight Concrete Aggregates
C 881 Epoxy-Resin-Base Bonding Systems for Concrete
D 1751 Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)
D 1752 Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
E 154 Methods of Testing Materials for Use as Vapor Barriers Under Concrete Slabs and as Ground Cover in Crawl Spaces
E 329 Practice for Use in the Evaluation of Testing and Inspection Agencies as Used in Construction
E 699 Practice for Criteria for Evaluation of Agencies Involved in Testing, Quality Assurance and Evaluation Building Components in Accordance with the Test Methods Promulgated by ASTM Committee E-6

4. American Welding Society (AWS) Publications:

- a. D1.1 Structural Welding Code--Steel
- b. D1.4 Structural Welding Code--Reinforcing Steel

5. Concrete Reinforcing Steel Institute (CRSI) Publication:

F. Placing Reinforcing Bars

1. Federal Specification (FS) Publication:

FF-S-325 Shield Expansion, Nail Expansion, and Nail, Drive Screw (Devices Anchoring, Masonry)

2. U.S. Army Corps of Engineers (COE) Waterways Experiment Station Publications:

CRD-C-572 Corps of Engineers Specification for Polyvinyl Waterstops

CRD-C-621 Handbook for Concrete and Cement, Specification for Nonshrink Grout, Volume II (1949 Ed.)

3. U.S. Department of Commerce Product Standard (PS):
PS 1 Construction and Industrial Plywood

4. The Florida Building Code latest edition

G. Modification of Applicable Publications: In the ACI and other publications referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had substituted for "should" wherever it appears; reference to the "authority having jurisdiction", "Building Official", the "Structural Engineer", and the "Architect/Engineer" shall be interpreted to mean the Architect.

- H. Mock-up: Mockups: Before casting concrete in above grade column construct a mockup to illustrate color and finish of work that will be exposed to public view. Build mockup to comply with the following requirements, using materials indicated for the completed Work: Also refer to specification 01 4339 Visual Mock-up Requirements.
1. Mockup shall consist of a 3'-0"x3'-0"x10" panel located within 10 feet of the proposed column. (LST, east side)
 2. Mockup shall be completed not less than 45 days prior to the proposed date for placement of concrete column.
 3. Mockup shall be finished to a class A finish as specified elsewhere in this section.
 4. Concrete for the mockup shall be placed with sufficient time for curing to allow the concrete to reach specified minimum compressive strength before applying the abrasive blast finish.
 5. Do not proceed with placement of concrete for column until the mockup has been approved by the architect.
 6. The accepted mockups shall become the standard for judging acceptability of all concrete surfaces that will be exposed to public view.
 7. Following acceptance of the finished column by the architect, remove the mockup from the project site and legally dispose of it.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver packaged materials to Project Site in original unopened and undamaged containers plainly labeled with manufacturer's name, product name and designation, expiration period for use, mixing instructions for multi-component materials, and other pertinent data. Store and handle materials to prevent their deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breakage, and other causes.
- B. Product handling shall comply with the applicable requirements of ACI 301, Chapter 2, Paragraph 2.5. Reinforcing bars and accessories shall be stored above the ground on platforms, skids, or other supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration.
- C. Damaged or non-conforming materials shall be removed from the Project site and replaced with new materials satisfactory to the Architect at no additional cost to the Owner.

1.8 ENVIRONMENTAL CONDITIONS

- A. Hot Weather Concreting: Comply with ACI 305R.
- B. Inclement Weather: Under conditions of rain, the placing of concrete shall not commence unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface. During inclement weather conditions concrete shall be provided with adequate protection to prevent damage.

1.9 PROJECT CONDITIONS

- A. Protection Against Spatter: Protect adjacent work, construction, and materials against spatter during concrete placement.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

- A. General: Furnish all forms required or necessary to ensure that completed work is in accordance with the Contract Documents.
 - 1. Responsibility for selection of proper form materials, for acceptable construction, alignment, and support of forms, and for proper wetting and precoating of forms, shall rest with Contractor.
 - 2. Forms shall be furnished in the largest practicable sizes to minimize the number of joints and to conform to the joint system shown on the Contract Drawings or accepted on the approved shop drawings.
- B. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.
- C. Forms for Exposed Finish Concrete: Plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials, to provide continuous, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Drawings or accepted on approved shop drawings.
 - 1. Plywood Form Material: Use plywood complying with U.S. Product Standard PS-1 "B-B (Concrete Form) Plywood," Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.
- D. Form Release: Provide commercial formulation form-release compounds with a maximum VOC of 350 mg/l that shall not bond with, stain, or adversely affect concrete surfaces.
- E. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. For securing forms where surfaces will be exposed in the finished work, use tie screws with removable plastic cones, removable bolts, special removable ties, or series 300 stainless steel snap ties. For all other forms, use bolts or other approved ties.
 - 1. Provide units that shall not leave any metal closer than 1-1/2 inches to finished exposed surface.
 - 2. Provide ties that, when removed, shall not leave holes larger than 1-inch diameter in concrete surface.

2.2 REINFORCING MATERIALS

- A. Reinforcing Bars:
 - 1. **Recycled Content of Steel Products:** Postconsumer recycled content plus one-half of preconsumer recycled content not less than 60 percent.
 - 2. Reinforcing Bars: ASTM A 615, Grade 60

- a. Fabrication tolerances shall conform to ACI 315, Paragraph 4.3.
 3. For slab reinforcement, AASHTO M 31 M grade 420, epoxy coated.
 4. Welded Wire Fabric: ASTM A 185, for interior; and ASTM A 884, Class A for exterior concrete.
 5. Supports for Reinforcement: Provide bolsters, chairs, spacers, and other devices required for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place.
 - a. Use wire bar type supports complying with CRSI specifications.
 - b. Provide supports with legs that are plastic protected (CRSI, Class 1) or stainless steel protected (CRSI, Class 2), for exposed to view concrete surfaces, where legs of support are in contact with forms.
- B. Fiber Reinforcement:
1. Synthetic Fiber: Provide fiber reinforcement for composite slab and wearing surface Fibrillated polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C1116, Type III, 1" to 2" long. Provide one of the following or approved equal:
 - a. "Tuf-strand SF"; (Euclid Chemical Company)
 - b. "Fibermesh 650"; (Propex Operating Company)
 - c. "Grace Fibers"; (WR Grace & Co.)

2.3 CONCRETE MATERIALS

- A. **Regional Materials:** Concrete shall be manufactured within 100 miles of Project site from aggregates that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.
- B. Cementitious Materials
1. Portland Cement: ASTM C 150, Type I or II.
 - a. Use one brand of cement throughout Project, unless otherwise acceptable to the Architect. The alkali content shall not exceed 0.6 percent unless the manufacturer certifies that no alkali reactivity is produced with the proposed combination of materials when tested in accordance with ASTM C 227.
 - b. Cement shall be a standard brand and shall meet the approval of the Architect.
 - c. Cement, to be acceptable, shall be of a well-known brand which has been in successful use for large engineering works in the United States of America for at least 10 years, and which has an established reputation for uniform character, and which, by their records, show a tendency to maintain high strength of mortar with increased age.
 2. Fly Ash: ASTM C 618, Class F, 20% maximum by weight.
 3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120, 25% maximum by weight.
 4. The contractor shall provide a minimum of 10% by weight fly ash or slag in all concrete mix designs.

- C. Normal Weight Aggregates: Unprocessed pit-run or naturally mixed aggregates will not be permitted. Naturally mixed aggregates must in every case be screened and washed, and all fine and coarse aggregates shall be stored and handled as specified herein. Use aggregate from the same source for all Class A concrete to ensure consistency in color.
1. Fine Aggregate shall be natural sand or stone screenings, or a combination thereof. All fine aggregate shall conform to the requirements of ASTM C 33, except as modified herein, and shall be graded within the limits specified in Table 1.

TABLE 1 - GRADATION FOR FINE AGGREGATE

Sieve Designation	Percentage by Weight Passing Square Mesh Sieve
3/8 inch	100
No. 4	95 - 100
No. 16	45 - 80
No. 30	25 - 55
No. 50	10 - 30
No. 100	2 - 10

2. Blending of manufactured sand fractions, manufactured sand and natural sand, or of two natural sands, when required to meet the gradation requirements or to obtain workable mixes, shall be performed at the batch plant.
3. The amount of deleterious substances in fine aggregate, each determined independently on samples complying with the grading requirements, shall not exceed the limits listed in Table 2.

TABLE 2 - DELETERIOUS SUBSTANCES-FINE AGGREGATE

Item	Maximum Percent by Weight
Clay Lumps	1.00
Shale	1.00
Coal and Lignite	.25
Materials Finer than No. 200	3.00
Total Combined Deleterious Substances	5.00

4. In addition to the requirements of ASTM C 88, the sodium sulphate soundness test, provide evidence, satisfactory to the Architect that the fine aggregate has been exposed to natural weathering, either directly or in concrete, for a period of at least 5 years without appreciable disintegration. In the case where new sources are recently developed, at the option of the Architect, the service requirement may be waived and the aggregate shall be subjected to testing under the provisions of AASHTO T-103, "Soundness of Aggregates by Freezing and Thawing". If the weighed percentage of loss at the end of 50 cycles does not exceed 10 percent, the fine aggregate shall be accepted as pertains to soundness requirements.
 5. Coarse Aggregate shall be crushed stone or gravel conforming to the requirements ASTM C 33 size #57 or 67.
 - a. The amount of deleterious substances in coarse aggregate, each determined on independent samples complying with the designated grading requirements, shall not exceed the limits specified in ASTM C 33.
 6. Water: Natural, drinkable, with no pronounced taste, odor, impurities, suspended particles, or dissolved natural salts in quantities detrimental to reinforcing or concrete.
- D. Water-Reducing Admixture: ASTM C 494, Type A, except as modified by applicable local code requirements of the authority having jurisdiction. Structural concrete shall contain a water reducing (plasticizing) admixture. Subject to compliance with requirements, provide one of the following products:
1. "Eucon WR-75" (Euclid Chemical Co.).
 2. "Pozzolith 200N" (Master Builders Co.).
 3. "Plastocrete 161" (Sika Chemical Corp.).
 4. Or approved equal

- E. Water-Reducing, Retarding Admixture: ASTM C 494, Type D, and containing not more than 0.1 percent chloride ions. Subject to compliance with requirements, provide one of the following products:
 - 1. "Daratard-17"; W.R. Grace.
 - 2. "Plastiment"; Sika Chemical Co.
 - 3. "Pozzolith Retarder"; Master Builders.
 - 4. Or approved equal
- F. Crystalline Integral Concrete Waterproofing Admixture:
 - 1. Where indicated on drawings provide a permeability reducing admixture for hydrostatic conditions in accordance with ACI 212.3R-10, Chapter 15. Dosage shall be equal to 1.5% of the total weight of all cementitious content of the mix but shall not exceed pounds per cubic yard. Supply admixture in sealed buckets or in disintegrating paper bags.
 - 2. Provide one of the following products or approved equal:
 - a. Krystol Internal Membrane, Kryton International, Inc.
 - b. Xypex Admix C-500, Xypex Chemical Corp.
 - c. Vandex AM 10, Vandex International, Ltd.
- G. Other Admixtures: Use only with the prior written approval of the Architect. Do not use any admixtures which contain chlorides.

2.4 RELATED MATERIALS

- A. Concrete Topping Materials: Where applied concrete slopes to drain are indicated provide one of the following products or approved equal. Mixing and application shall be in strict accordance with manufacturer's written instructions. Products may be extended if permitted by the manufacturer.
 - 1. SikaTop 122 Plus, Sika Corporation
 - 2. Master Emaco t 302, BASF Corporation
 - 3. TammsPatch II, Euclid Chemical Company
- B. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.
- C. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.
 - 1. Waterproof paper.
 - 2. Polyethylene film.
 - 3. Polyethylene-coated burlap.
- D. Expansion/Contraction Joint Filler: ASTM D 1751 or ASTM D 1752, 1/2-inch thick, unless otherwise indicated.
- E. Expansion Anchors: Expansion anchors shall be stud type with a single piece three-section wedge and zinc plated in accordance with ASTM B 633. Anchors shall meet the description requirements indicated in Federal Specification FF-S-325, Group II, Type 4, Class I for concrete expansion anchors.

1. Anchors shall be Hilti Kwik Bolt TZ as supplied by Hilti Fastening Systems or approved equal.
 2. Anchors shall be installed in holes drilled with Hilti, or approved equal, carbide tipped drill bits.
 3. Anchors shall be installed per manufacturer's recommendations.
- F. Nuts and Washers: ASTM A 563.
1. Nut heads shall be hexagonal.
- G. Non-Shrink, Non-Metallic Grout: Factory pre-mixed grout product complying with U.S. Army Corps of Engineers Handbook CRD-C-621. Subject to compliance with requirements, provide one of the following:
1. "Euco-NS"; Euclid Chemical Co.
 2. "Five Star Grout"; U.S. Grout Corp.
 3. "Set Grout"; Master Builders.
 4. Or approved equal
- H. Chemical Dustproofer and Hardener: Colorless aqueous solution containing a blend of magnesium fluosilicate and zinc fluosilicate combined with a wetting agent, containing not less than 2 lbs. of fluosilicate per gallon. Subject to compliance with requirements, provide one of the following products:
1. "Burk-O-Lith"; The Burke Company
 2. "Masterplate 200"; Master Builders
 3. "Lapidolith"; Sonneborne-Rexcord.
- I. Epoxy Bonding Compound: ASTM C 881, Type V for load bearing applications, Grade 1, Class A (if placement temperature is below 40 degrees F); Class B (if placement temperature is between 40 and 60 degrees F); or Class C (if placement temperature is above 60 degrees F). Provide Grade 1 or 2 for horizontal surfaces and Grade 3 for vertical surfaces.
- J. Steel plates shall conform to ASTM A36.
- K. Stud welding shall conform AWS D1.1.
- L. VAPOR RETARDERS
1. Sheet Vapor Retarder: ASTM E 1745, Class A, 15 MIL. Include manufacturer's recommended adhesive or pressure-sensitive tape.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Poly-America, L.P.
 - 2) Stego Industries, LLC.
 - 3) W. R. Meadows, Inc.

2.5 PROPORTIONING AND DESIGN OF MIXES

- A. Preparation of Design Mixes: Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301.

- B. Mix Design Reports: Submit written reports to the Architect of each proposed mix for each class of concrete at least 28 days prior to the first concrete placement. Do not begin concrete production until proposed mix designs have been reviewed by the Architect. Review by the Architect shall not be deemed to relieve any obligation to provide cast-in-place concrete in accordance with the Contract Documents.
- C. Design of Mixes: Design mixes to produce concrete of proper workability, durability, strength, maximum density, minimum shrinkage, and permeability. Assume full responsibility for the strength, consistency, water-cement ratio, and handling of concrete.
 - 1. Design mixes to have minimum water content per cubic yard of concrete, cement content corresponding to appropriate water-cement ratio, largest permissible maximum size specified of coarse aggregate available, and optimum percentage of fine aggregate.
 - 2. Use water-cement ratio in accordance with ACI 211.1 and ACI 211.2 as determined by type of structure and exposure conditions, or 0.45 by weight, whichever is less, as approved and supplemented or modified as specified herein.
 - a. Water-cement ratio shall not exceed 0.40 by weight for concrete to receive a Class A finish.
 - 3. Trial mixtures shall be made based on at least three different water-cement ratios. Trial mixes shall be proportioned to produce concrete strengths specified below. Trial mixtures shall be designed for maximum permitted slump and air content. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192. They shall be tested at 7 and 28 days in accordance with ASTM C 39. From these test results a curve shall be plotted showing the relationship between water-cement ratio and strength. For each strength of concrete the maximum allowable water-cement ratio shall be that shown by these curves to produce the strength specified.
 - 4. The concrete used in the work shall be produced using a water-cement ratio corresponding to a point on the strength vs. water-cement ratio curve representing a strength, at the design slump, in accordance with ACI 318 or at least 25 percent higher than that indicated or specified, whichever is greater. When the Contractor demonstrates to the satisfaction of the Architect that his quality control warrants a change in the 25 percent factor, a change will be permitted. However, in no case shall the concrete strength used in construction be less than 15 percent higher than that specified or indicated.
 - 5. The approved laboratory prepared mix design proportions shall govern during the progress of the work. If concrete having the required consistency cannot be produced without exceeding the maximum allowable water-cement ratio, the cement content shall be increased so the maximum allowable water-cement ratio is not exceeded.
 - 6. Use approved chemical admixtures, air-entraining admixtures or suitable combinations thereof to improve workability, as well as to reduce water and cement content or minimize shrinkage and permeability of concrete, provided such admixtures do not adversely affect other specified properties of concrete.

7. Admixtures shall be added within a limit of accuracy of 3 percent and dispensed to the mixing water by means of an approved, graduated, transparent measuring device before they are introduced into the mixer. If more than one admixture is to be used, they shall be released into the mixing water in sequence rather than at the same instant. Once established, the sequence of dispensing admixtures shall not be altered. Admixtures shall be used in accordance with the manufacturer's recommendations. However, when the amount of admixture required to give the specified results deviates appreciably from the manufacturer's recommended dosage, use of the material shall be discontinued.
 8. Adjust the consistency of concrete mixes to allow for specific placing conditions. Measure materials for concrete by weighing. Separately weigh cement and each size of aggregate, each accurate within 1%. Cement in sacks of ninety-four pounds need not be weighted. Weigh bulk cement and fractional packages. Measure mixing water by volume, and within 1 percent of quantity required.
- D. Design Mixes:
1. Concrete for Cast in Place Concrete Pile Caps, Grade Beams and Slabs on Grade: Design mixes to provide normal weight concrete with a minimum of 4000 psi compressive strength at 28 days.
 2. Concrete for Cast in Place Concrete Columns:
 - a. Design mixes to provide normal weight concrete with a minimum compressive strength at 28 days.
 - 1) LST – 5000 psi
 - 2) Promenade – 6000 psi
 - 3) Pedestrian Bridge – 6000 psi
 - b. Lightweight Concrete: Proportioning, mixing, transporting, placing, finishing, and curing of lightweight concrete shall conform to the applicable requirements for normal weight concrete, together with the additions and modifications specified herein.
 - 1) Use lightweight aggregates for lightweight concrete in accordance with ACI Standards 211.2. and 213 R.
 - 2) Concrete on metal decking shall be lightweight concrete having a minimum compressive strength of 4000 psi at 28 days and shall have 5 lbs/cy fiber reinforcement. Maximum unit weight at 28 days shall be 115 lbs/cf.
 - 3) Proportioning, mixing, transporting, placing, finishing, and curing shall be as recommended by the lightweight concrete producer.
- E. Adjustment to Concrete Mixes: Mix design adjustments may be requested when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to Owner and as accepted by the Architect.
1. Laboratory test data for revised mix design and strength results shall be submitted to and accepted by the Architect before using in work.
- F. Admixtures: Use water-reducing admixture in concrete as required for placement and workability.
1. Use non-chloride accelerating admixture in concrete slabs placed at ambient temperatures below 50 degrees F.

2. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.
3. If the entrained air content falls below the specified limit, add a sufficient quantity of admixture to bring the entrained air content within the specified limits.
4. Dissolve admixtures in the mixing water and mix in the drum to uniformly distribute the admixture throughout the batch.

G. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:

1. Slabs and Sloping Surfaces: 3" +/- inches prior to admixtures.
2. Other Concrete: 4" +/- inches prior to admixtures..

2.6 CONCRETE MIXING

A. Ready-Mix Concrete: Comply with requirements of ASTM C 94, supplemented and amended as specified herein.

1. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required. Discharge the concrete completely at the site within 1-1/2 hours after the introduction of the cement to the aggregates. Reduce this time limit in hot weather to prevent stiffening of concrete until after it has been placed. Begin the mixing operation within thirty minutes after the cement has been intermingled with the aggregates.
2. Ready-Mix Concrete Delivery Tickets: Before unloading at the site, provide a delivery ticket from concrete supplier with each batch delivered to the site bearing the following information:
 - a. Name of supplier.
 - b. Name of batching plant and location.
 - c. Serial number of ticket.
 - d. Date.
 - e. Truck number.
 - f. Specific job designation, location, complete Project Name, and ProjectNumber.
 - g. Volume of concrete in cubic yards.
 - h. Class and type of concrete.
 - i. Time loaded.
 - j. Type and brand of cement.
 - k. Weight of cement.
 - l. Maximum size of aggregates.
 - m. Source of aggregates.
 - n. Type of aggregate.
 - o. Weight of coarse aggregate.
 - p. Weight of fine aggregate.
 - q. Maximum amount of water to be added and amount of water added at the site.
 - r. Kind and amount of admixtures.
 - s. Mix design designation,
 - t. Signature of a certified plant batcher, or a certified plant concrete technician, or a responsible officer or other authorized employee of the concrete supplier.

- B. Batch Mixing at Site: Comply with ACI 301, Chapter 7, Paragraph 7.2, supplemented and amended as specified herein.
 - 1. Excessive mixing, requiring the addition of water to preserve the required consistency shall not be permitted. Mix concrete to a consistency which can be readily placed without segregation. Where admixtures are specified, equip mixers with a device for measuring and dispensing the admixture.
 - a. Provide batch ticket for each batch discharged and used in work, indicating project identification name and number, date, mix type, mix time, quantity, amount of water introduced, revolution counter readings, aggregate dial settings, the class of concrete delivered, and mixer operator's signature.
 - b. Delivery tickets shall also indicate the strength of the concrete being delivered, the type of coarse aggregate (i.e. lightweight or stone) and, the exact time the cement and aggregate were discharged into the delivery truck, and a list of admixtures.
- C. Hand-Mixed Concrete: Hand-mixed concrete is not allowed.
- D. Retempering: Comply with ACI 301, Chapter 7, Paragraph 7.5. The following are in addition to requirements specified in ACI 301, Chapter 7, Paragraph 7.5. Retempering concrete by adding water or by other means will not be permitted except when concrete arrives at the project with slump below that suitable for placing. Water may be added only if neither the accepted mix design water-cement ratio nor the maximum slump is exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing required. Such water addition shall be acceptable to the Architect and shall be performed under the supervision and sanction of the Testing Laboratory.
 - 1. Concrete that becomes non-plastic, unworkable, or outside of the limits of the slump specified shall not be used. Concrete which has set shall be discarded and shall not be retempered.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. A pre-installation meeting shall be held.
 - 1. Prior to the commencement of any work under this Section, and when directed by the Architect, meet at the Project Site to review installation and coordination procedures. Among other topics, the coordination meeting shall address scheduling, method and sequence of concrete construction, standard of workmanship, material selection, testing and quality control requirements, detailed requirements of design mixes, placement procedures, off-site batching requirements, coordination of the Work with other trades, preparation of surfaces contiguous with this work, adjacent construction, and interferences, if any. This meeting shall be attended by any and all trades, manufacturer's representatives, and other interested parties whose work will be affected by the execution of the work under this Section.

3.2 FORMS

- A. Formwork: Design, erect, support, brace, and maintain formwork to support vertical, lateral, static, and dynamic loads that might be applied until concrete structure can support such loads. Forms shall be well constructed, carefully aligned, substantial, firm, securely braced and fastened together in their final position and set to give the finished structure the specified camber, plus allowance for shrinkage and settlement. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction complying with ACI 347R. Tolerances shall conform to ACI 301, Paragraph 4.3, unless otherwise indicated or specified.
1. Hydraulic Pressure: Design forms, studs and wales to limit deflections between supports to 1/360th of the span. All joints, gaps and apertures in forms, wherever located shall be gasketed, plugged or sealed with a suitable material so that they will withstand the full concrete hydraulic pressure and remain watertight.
 2. Tolerances and Finish Lines: Position formwork to maintain hardened concrete finish lines within the following permissible deviations:
 - a. Variation from Plumb
 - 1) In any 10 ft.: 1/4 in.
 - 2) In 40 ft. or more: 1/2 in.
 - 3) Cross-Sectional Dimensions: Minus 1/8 in., Plus 1/4 in.
 - 4) Surface Tolerances: Maximum offset between butt joints of individual or ganged forms: +/- 1/32 in.
 - b. Variation from Building Line: Variation of the linear building lines from established position to plan and related position of columns and walls:
 - 1) In any 10 ft.: 1/4 in.
 - 2) In 40 ft. or more: 1/2 in.
 - c. Design formwork to be readily removable without impact, shock, or damage to cast-in-place concrete surfaces and adjacent materials. Prying against the face of the concrete will not be permitted. Only wooden wedges shall be used.
 - d. Forms shall be strong enough to prevent fresh concrete from bulging the forms between supports and to withstand the action of mechanical vibrators. Provide for openings, offsets, sinkages, keyways, recesses, reglets, chamfers, blocking, screeds, bulkheads, anchorages, inserts, and other features required in work.
 - e. Position Tolerances: For cast-in items measured from datum line locations as shown on reviewed shop drawings:
 - 1) Blockouts and Reinforcements: Within 1/4 in. of position shown on shop drawings, where such positions have structural implications or affect concrete cover; otherwise within plus or minus 1/2 in.
 - 2) Anchors and Inserts: Within 3/8 in. of centerline location.
 3. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only.
 4. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

5. Exposed joint edges and external corners shall be chamfered a minimum of 3/4-inch, unless otherwise specified or indicated. Where new concrete abuts existing concrete, match existing chamfers. Use wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
 6. In long spans, where intermediate supports are not possible, the anticipated deflection in the forms due to weight of fresh concrete shall be accurately figured and taken into account in the design of the forms, so that finished concrete members will have true surfaces conforming accurately to required lines, planes, and elevations.
 7. Bolts and rods used for temporary internal form ties shall be so arranged that when the forms are removed, all metal will be not less than 1-1/2 inches from any finish concrete surface. Wire ties will not be permitted. The design of form ties shall be subject to the approval of the Architect.
 8. Where shoring bears on ground, spread load from shores by suitable mud sills in order to prevent settlement. Where height of shores exceed ten feet, provide adequate diagonal bracing in both longitudinal and transverse directions. In addition, provide adequate diagonal braces at end of framework. Diagonal bracing shall extend from top to bottom of shores. Unbraced length of wood shores supporting forms shall not exceed fifty times least dimension.
 9. Strike off concrete at top of forms and screed with wood to a float finish.
- B. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.
- C. Rustication Strips: Mill rustication strips smooth to avoid protruding splinters which may become embedded in the concrete.
- D. Construction Joints: Construction joints shall be at locations shown or as approved on Shop Drawings. Remove loose material from the surface prior to the erection of forms. The formwork for the succeeding lift shall be held tight against the top of the previous lift and gasketed or caulked to prevent leakage.
- E. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before concrete is placed as necessary to obtain the smooth surfaces required. Retighten forms and bracing before concrete placement so as to prevent mortar leaks and maintain proper alignment.
- F. PREPARATION OF FORM SURFACES
1. Clean re-used forms of concrete matrix residue in accordance with ACI 301, Paragraph 4.4, repair and patch as required to return forms to acceptable surface condition.
 2. Coat contact surfaces of forms with an approved, nonresidual, low-VOC, form-coating compound before reinforcement is placed.
 3. Moisten wood forms immediately before placing concrete where form coatings are not used.

4. Thin form-coating compounds only with thinning agent of type, amount, and under conditions of form-coating compound manufacturer's directions. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete shall be placed. Apply in compliance with manufacturer's instructions.
5. Coat steel forms with a non-staining, rust-preventative material. Rust-stained steel formwork is not acceptable.

3.3 VAPOR-RETARDER INSTALLATION

1. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.
2. Lap joints 6 inches and seal with manufacturer's recommended tape or per manufacturer's recommendations.

3.4 PLACING REINFORCEMENT

- A. CRSI Requirements: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports, and as herein specified.
 1. Avoid cutting or puncturing vapor retarder during reinforcement placement and concreting operations. Placing tolerances shall comply with ACI 301, Chapter 5, Paragraph 5.6. When splices not shown on the Drawings are approved by the Architect, such splicing shall conform to ACI 318.
 2. Place reinforcing bars having assigned positions so that they agree with those given on the shop drawings relating to or calling for the bars.
 3. Secure reinforcing bars in place with high-density plastic supporting and spacing devices and metal tying devices. Reinforcing in concrete members that have one or more surfaces exposed, whether painted or unpainted finish, shall be tied with 14 gage soft annealed galvanized wire. Uncoated tie wire in exposed members shall not be accepted.
 4. Restore damaged bars to full capacity in accordance with CRSI requirements and in a manner acceptable to the Architect.
- B. Cleaning Reinforcement: Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.
- C. Positioning, Supporting, and Securing Reinforcement: Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as required and approved by the Architect. Place reinforcement to obtain at least minimum coverages for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces. Comply with ACI 301, Paragraph 5.
- D. Installation of Welded Wire Fabric: Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.5 JOINTS

- A. Expansion Joints: Expansion joints shall be provided as indicated on the Contract Drawings. Unless otherwise shown, do not extend reinforcement or other embedded metal items through any expansion joints. Expansion joints shall be provided with premolded fillers and waterstops where shown.
- B. Contraction Joints: Provide horizontal contraction joints in slabs by soft cutting, and in walls by formed or saw cutting to the indicated depth after the surface has been finished. Sawed joints in horizontal surfaces shall be completed within 4 to 12 hours after concrete placement. Protect joints from intrusion of foreign matter.
- C. Construction Joints: Locate and install construction joints as indicated or, if not indicated, locate so as not to impair strength. Joints shall be provided by placing concrete in alternate pours not sooner than 72 hours of the placing of contiguous members. Waterstops shall be provided where indicated.
 - 1. Provide keyways at least 1-1/2 inches deep, unless otherwise shown, in construction joints in walls and slabs and between walls and footings.
 - 2. Unless otherwise indicated, place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
- D. Bonding Construction Joints: Bonding of construction joints shall conform to the requirements specified. In joining fresh concrete to set concrete, the work already in place shall have its surface roughened thoroughly. All loose and foreign material shall be removed. The surface shall be washed and scrubbed with wire brooms when necessary to remove substances that will interfere with bonding. Concrete of the preceding placement shall be thoroughly wetted prior to placement of the next unit of fresh concrete.

3.6 INSTALLATION OF EMBEDDED ITEMS

- A. Setting Anchorage Devices: 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.
- B. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to obtain required elevations and contours in finished surfaces. Provide and secure units to support screed strips using strike-off templates or compacting-type screeds.
- C. Embedded Steel Items: Insure that all required steel members required to be cast into concrete are properly placed and secured. In particular, coordinate the work with Section 055000, "Metal Fabrications" and drawing details.

3.7 CONCRETE PLACEMENT

- A. General: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Comply with

ACI 304, "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete", supplemented and amended as specified herein.

1. Do not place concrete when sun, heat, wind, or limitations of facilities shall prevent finishing and curing.
 2. Deposit concrete as closely as possible to its final position to avoid rehandling. Deposit concrete continuously or in layers of such thickness that no concrete shall be placed on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete to avoid segregation at its final location. Deposit concrete in forms in horizontal layers not deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.
 3. Force the concrete under and around the reinforcement without displacement. Avoid jarring the forms or placing any strain on the ends of projecting reinforcement after the concrete has taken its initial set.
 4. Do not place concrete which has attained initial set. Place concrete within 90 minutes of either addition of mixing water to cement and aggregates or addition of cement to aggregates if the air temperature is less than 85 degrees F. Reduce mixing time and place concrete within 75 minutes if the air temperature is between 85-90 degrees F. Further reduce mixing and placement time to 60 minutes when the air temperature is above 90 degrees F. Retempering of concrete which has partially set is prohibited.
 5. Cast-in-place concrete shall not be mixed, placed, or finished without sufficient natural light or an adequate and accepted artificial lighting system. Do not place concrete when weather conditions detrimentally affect the quality of finished work.
 6. When placing operations would involve dropping the concrete more than 5 feet, the concrete shall be dropped through a tube fitted with a hopper head, or through other approved devices, as necessary to prevent segregation of the mix and spattering of mortar on forms above the elevation of the lift being placed.
- B. Preparation Before Placing: Conform to ACI 301, Chapter 8, Paragraph 8.1, and as specified.
1. Apply temporary protective covering to lower 24 inches of finished work and guard against spattering during placement.
 2. Clean mixer thoroughly prior to batching all concrete. Load truck mixers at only the capacity which will ensure a uniform batch at the slump specified. In the event that mixing in any truck mixer is not uniform, the truck load will be rejected and shall not be used on the Project.
 3. Handle concrete from the mixer to the place of final deposit as rapidly as practical by methods which prevent separation or loss of the ingredients.
 4. Clean transporting and handling equipment at frequent intervals and flush thoroughly with water before and after each day's run.
- C. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.

1. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI 309, supplemented and amended as specified herein.
 2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. Limit duration of vibration at each insertion to time necessary to consolidate concrete and to complete embedment of reinforcement and other embedded items without causing segregation of mix.
- D. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until the placing of a panel or section is completed.
1. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners. Maintain reinforcing in proper position during concrete placement.
 2. Bring slab surfaces to correct level with straightedge and strike off. Use bull floats or darbies to smooth surface, free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.
- E. Hot-Weather Placing: Place concrete in compliance with ACI 305 and as herein specified when hot weather conditions exist that would impair quality and strength of concrete.
1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 95 degrees F. Mixing water may be chilled, or chopped ice may be used to control temperature provided, that when ice is used it shall be added with the water and counted as part of the water-cement ratio.
 2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature shall not exceed the ambient air temperature immediately before embedment in concrete.
 3. Fog spray forms, reinforcing steel, and subgrade just before concrete is placed.
 4. Use water-reducing retarding admixture when required by high temperatures, humidity, or other adverse placing conditions, when acceptable to the Architect.
- F. Conveying:
1. Comply with ACI 301, Chapter 8, Paragraph 8.2. and ACI 304R.
 2. Provide a spout or downpipe and elephant trunk or other appropriate method to prevent concrete from falling freely through a height greater than 5 ft. Free fall in walls and columns shall not exceed 15 ft.
 3. Pumping: ACI 304R and ACI 304.2R. Pumping shall not result in separation or loss of materials nor cause interruptions sufficient to permit loss of plasticity between successive increments. Loss of slump in pumping equipment shall not exceed 2 inches. Concrete shall not be conveyed through pipe made of aluminum or aluminum alloy. Minimum size of pipe diameter shall be 5 inches. Rapid changes in pipe sizes shall be avoided. Maximum size of coarse aggregate shall be limited to 33 percent of the diameter of the pipe. Maximum size of well rounded aggregate shall be limited to 40 percent of the pipe

- diameter. Samples for testing shall be taken at both the point of delivery to the pump and at the discharge end.
4. Placing concrete by pumping will be permitted only when authorized by the Architect. Equipment shall be arranged such that no vibrations that might damage freshly placed concrete will occur. Equipment shall be thoroughly cleaned prior to use. The operation of the pump shall be such that a continuous stream of concrete without air pockets is delivered. If concrete remaining in the pipe line is to be used, it shall be ejected in such a manner that there will be no contamination of concrete or separation of ingredients.
- G. Vibration: Conform to ACI 309. Concrete shall be thoroughly consolidated during and immediately following placement. Consolidation shall be accomplished by mechanical vibration subject to the following provisions:
1. Vibration shall be internal to the concrete but not applied directly to reinforcement or formwork.
 2. Vibrators shall be per ACI 309R
 - a. Vibrators used to consolidate concrete containing epoxy-coated bar reinforcement shall have a resilient covering to prevent damage to such reinforcement.
 - b. The intensity of vibration shall visibly affect a mass of concrete over a radius of at least 18 inches.
 - c. Provide a sufficient number of vibrators to consolidate each batch immediately after it is placed in forms.
 - d. Vibrators shall be manipulated to work concrete thoroughly around reinforcement and embedded fixtures and into corners and angles of forms.
 - e. Vibration shall be applied at the point of deposit and in the area of the freshly placed concrete.
 - f. Vibrators shall not be pulled through concrete and shall be inserted, withdrawn slowly and maintained nearly vertical at all times.
 - g. Vibration shall be of sufficient duration and intensity to consolidate concrete thoroughly but shall not be continued so as to cause segregation.
 - h. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed.
 - i. Application of vibrators shall be at points uniformly spaced and not further apart than 1 1/2 times the radius over which the vibration is visibly effective.
 - j. Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations inaccessible to vibrators.
 - k. External vibrators shall be used on the exterior surface of the forms when internal vibrators do not provide adequate consolidation of the concrete.
 - l. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer.
 - m. Do not insert vibrators into lower layers of concrete that have begun to set.
 - n. Limit duration of vibration at each insertion to time necessary to consolidate concrete and to complete embedment of reinforcement and other embedded items without causing segregation of mix.

3.8 SURFACE FINISHES

- A. Not Against Forms (Top of Walls): Surfaces not otherwise specified shall be finished with wood floats to even surfaces.
- B. Formed Surfaces:
 - 1. Class A per ACI 347 R14 - 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 specified limits on formed-surface irregularities. Class A permits gradual or abrupt irregularities of +1/8 inch.
 - a. Apply to concrete surfaces - exposed to view
 - 2. Class B per ACI 347 R14 Coarse textured 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 specified limits on formed-surface irregularities. Class B permits gradual or abrupt irregularities of +1/4 inch.
 - a. Apply to concrete surfaces - covered with a coating or covering material applied directly to concrete. Coordinate texture with covering material.
 - 3. Class C per ACI 347 R14 - Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities. Class C permits gradual or abrupt irregularities of +1/2 inch.
 - a. Apply to concrete surfaces – not exposed to view.
 - 4. Class D per ACI 347 R14 - 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 specified limits on formed-surface irregularities. Class D permits gradual or abrupt irregularities of +1 inch.
 - a. Apply to concrete surfaces – foundations not exposed to public view.
- C. In order to secure a satisfactory "true and even surface," the surface of the concrete shall, where required, be rubbed down in an approved manner to the extent necessary.
- D. The quality of casting and the finished members shall be subject to inspection and approval by the Architect. Individual members may be rejected because of any of the following:
 - 1. Variations in the exposed face that substantially deviates from designated standards.
 - 2. Dimensions not conforming to designated tolerances.
 - 3. Defects which would affect the structural integrity, physical characteristics, or architectural appearance of the member.
 - 4. Defects that indicate imperfect casting or forming.
 - 5. Defects indicating honeycombed concrete, cracks, casting fractures, exposed reinforcing steel, or insufficient concrete compressive strength.
 - 6. Concrete exposed to public view does not match the on-site reference sample in color or texture.
 - 7. Shrinkage cracking beyond acceptable ACI standards.
- E. The Architect will determine whether defective concrete shall be repaired or rejected. Repair of concrete, if allowed, shall be done in a manner satisfactory to the Architect.

Repair to concrete surfaces which will be exposed- to-view after completion of construction shall be subject to approval by the Architect.

- F. Repair formed surfaces by removing minor honeycombs, pits greater than one square inch surface area or 0.25 inches' maximum depth, or otherwise defective areas, as determined by the Architect. Provide edges perpendicular to the surface and patch with patch material. Patch tie holes and defects when the forms are removed. Concrete with extensive honeycomb (including exposed steel reinforcement, cold joints, entrapped debris, separated aggregate, or other defects) which affect the serviceability or structural strength will be rejected, unless correction of defects is approved. Obtain approval of corrective action prior to repair. The surface of the concrete shall not vary more than the allowable tolerances of ACI 347. Exposed surfaces shall be uniform in appearance and finished to a smooth form finish unless otherwise specified.
- G. Slab, and Pavement Finishes and Miscellaneous Construction: ACI 302.1R, unless otherwise specified. Slope floors uniformly to drains where drains are provided. Provide interior floor slabs with a steel troweled finish.
 - 1. Concrete floors shall meet the following floor flatness and levelness tolerances:
 - a. Slabs Cast on Grade: $F_f=20$; $F_l=17$ (as defined by ASTM E1155) unless noted otherwise on the drawings.
 - b. Slabs Cast on Metal Deck: $F_f=20$ unless noted otherwise on the drawings.
 - 2. Dustproofing: Provide dustproofer on concrete floor surfaces: After trowelling, apply two (2) coats of dustproofer, in accordance with the approved manufacturer's printed instructions.
 - 3. Finishing: Place, consolidate, and immediately strike-off concrete to obtain proper contour, grade, and elevation before bleedwater appears. Permit concrete to attain a set sufficient for floating and supporting the weight of the finisher and equipment. If bleedwater is present prior to floating the surface, drag the excess water off or remove by absorption with porous materials. Do not use dry cement to absorb bleedwater.
 - a. Floated: Provide for machinery pads and exterior slabs where not otherwise specified. Float the surface by hand with a wood or magnesium float, or use a power-driven float. Floating of any one area shall be the minimum necessary to produce an even finish, level within 1/4 inch in 10 feet for exterior work and level within 1/8 inch in 10 feet for interior work where floor drains are not provided.
 - b. Steel Troweled: Provide for interior floor slabs. First, provide a floated finish. When slab attains a proper set, trowel to a smooth, hard, dense finish. Finished surfaces shall be free of troweled marks, uniform in texture, and a true plane, flat within 0.01 foot (approximately 1/8 inch) in 10 feet. Hand-finish portions of the slab not accessible to power finishing equipment (e.g., edges, corners) to match the remainder of the slab. Power trowel twice and finally hand trowel for exposed concrete floors.
 - c. Broomed: Provide for exterior walks, platforms, patios, and ramps, unless otherwise indicated. Provide a floated finish, then finish with a flexible bristle broom. Permit surface to harden sufficiently to retain the scoring or ridges. Broom transverse to traffic or at right angles to the slope of the slab.

- d. Areas to receive floor coatings the floor finish shall be per the manufacturer's recommendations.
- 4. Concrete Saw Cutting: When sawing of joints is specified, provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. Provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. Provide adequate artificial lighting facilities for sawing. All of this equipment shall be on the job both before and at all times during concrete placement.
 - a. When joints in concrete are sawed, the joints shall be cut as shown on the plans. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot indicated, and to the depth shown. When shown on the plans or required by the specifications, the top portion of the slot or groove shall be widened by means of a second shallower cut or by suitable and approved beveling to provide adequate space for joint sealers. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing. Sawing shall be carried on both during the day and night as required. The joints shall be sawed at the required spacing consecutively in sequence of the concrete placement, unless otherwise approved by the Architect.
 - b. Provide backup rod and sealant which is fuel resistant as specified under other Sections of the specifications.

3.9 CONSTRUCTION TOLERANCES

- A. Variation in alignment, grade, and dimensions of structure from established alignment, grade, and dimensions shown on the Drawings shall be within the tolerances as specified within ACI 117-

3.10 CONCRETE CURING AND PROTECTION

- A. Protection: Protection of concrete shall begin immediately following concrete placement in the formwork and shall continue without interruption during the curing period. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply in accordance with manufacturer's instructions after screeding and bull floating, but before floating.
- B. Initial Curing: Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
- C. Final Curing: Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI 301 procedures, supplemented and amended as specified herein. Avoid rapid drying at end of final curing period.

- D. Curing Methods: Perform curing of concrete by moist curing, by moisture-retaining cover curing, or by combinations thereof, as herein specified or by the application of a spray applied, membrane type curing compound. Moist curing is the only method allowed for concrete having a water-cement ratio of 0.40 or less.
1. Moisture Curing: All material, equipment, and labor necessary to promptly apply the moist curing shall be on Project Site before any concrete is placed. Provide moisture curing in accordance with ACI 308 and by the following methods.
 - a. Keep concrete surface continuously wet by covering with water.
 - b. Use continuous water-fog spray.
 - c. Cover concrete surface with specified absorptive cover, thoroughly saturate cover with water, and keep continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4-inch lap over adjacent absorptive covers.
 - d. The entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed. The moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.
 - e. The rate of water application shall be controlled to the maximum rate that can be applied without causing excessive runoff, spattering, splashing, or other water damage. Steps shall be taken to properly protect surrounding work and construction from damage by water or water runoff. The nozzle size, water pressure, sprinkling or wetting equipment, etc., shall be adjusted and regulated so that the optimum quantity of water is applied to the curing area. Care shall be taken to insure that the overlay absorptive cover is clean, thoroughly saturated over its entire area, drained of excess water, and remains flat at all times.
 - f. Curing shall be done so that the concrete is always moist. Improperly cured concrete will be considered defective. Failure to use, or lack of water to adequately provide for curing requirements shall be cause for immediate suspension of concrete placing operations. Placing operations shall not be resumed until proper procedures are used.
 - g. Failure to completely cover concrete surfaces with saturated absorptive covers immediately after the concrete has been placed shall be cause for rejection as determined by the Architect.
 - h. After moisture curing has been properly completed, sprinkling equipment, wetting lines, connections, and appurtenances shall be removed in a manner acceptable to the Architect and the work left in a first class and satisfactory condition. Any damage shall be repaired or the damaged work replaced to the satisfaction of the Architect at no additional cost to the Owner.
 - i. Cured concrete shall be uniform in color, texture, and finish, with no objectionable form marks or irregularities. Concrete containing plastic shrinkage cracks will be considered defective and shall be repaired or removed and replaced as directed by the Architect at no additional cost to the Owner.
 - j. Continuous sprinkling coverage shall be complete, shall prevent loss of moisture from the entire concrete surface, and shall prevent early drying shrinkage.

- k. Continuous wetting shall be replaced by wetting at regular intervals if, in the opinion of the Architect, expected ambient air temperature could result in freezing of run-off water.
 - l. Concrete shall not be left exposed for more than 30-minutes during the curing period.
- 2. Moisture Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
- 3. Spray Applied, Membrane Type Curing Compound:
 - a. Before using a membrane type curing compound, verify compatibility with proposed floor finishes.
 - b. Apply at the maximum rate recommended by the compound manufacturer.
 - c. Apply curing compound immediately after finishing operation have been completed.
 - d. Provide two coats of curing compound applied at right angles to each other.
- E. Curing Formed Surfaces: For vertical and other formed surfaces, after the concrete has hardened and the forms are removed apply curing compound.
- F. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, pile caps and other flat surfaces, by application of appropriate curing method.
- G. Condition of Cured Concrete: Cured concrete shall be uniform in color, texture, and finish, with no objectionable form marks or irregularities.

3.11 REMOVAL OF FORMS

- A. Do not remove forms until the concrete has thoroughly hardened and has attained sufficient strength to support its own weight and construction live loads to be placed thereon, without damage to the structure. In general, do not disturb forms for framing until the concrete has attained at least 40% of design strength for side forms and 80% of design strength for bottom forms.
 - 1. Formwork supporting weight of concrete, such as beam soffits, joists, slabs, and similar structural elements may not be removed in less than 14 days or until the concrete has achieved at least 80 percent of its 28-day design compressive strength.
 - 2. Assume all responsibility for proper form removal, and replace any work damaged due to inadequate maintenance or improper or premature form removal.
 - 3. Any work, labor materials, etc., required to effect such replacement shall be provided at no additional cost to the Owner.
- B. If used, and unless directed by the Architect, stripping cylinders shall be taken as follows:

1. 6 during the first two hours of the pour and 6 during the last two hours of the pour. These shall be broken into 3 sets of four cylinders; 2 from the samples taken during the first two hours and 2 from the samples taken during the last two hours of the pour. One set of 4 cylinders shall be tested at 2 days, one set at 3 days and one set at 4 days after the pour, or at such intervals of time as are consistent with the expected time of form removal, or as directed by the Architect.
- C. Any defective work disclosed after the forms have been removed shall be removed and replaced immediately. If any dimensions are deficient, or if the surface of the concrete is bulged, uneven, or shows honeycomb which cannot be repaired satisfactorily in opinion of the Architect, the entire section shall be removed and replaced at no additional the expense to the Owner. When defects in work do not, in the opinion of the Architect justify removal and replacement, such work shall be patched or otherwise repaired immediately to the satisfaction of the Architect.

3.12 REUSE OF FORMS

- A. Clean and repair surfaces of forms to be reused in work. Split, frayed, delaminated, or otherwise damaged form-facing material shall not be acceptable for exposed surfaces. Apply new form-coating compound as specified for new formwork.
- B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joints to avoid offsets. Do not use "patched" forms for exposed concrete surfaces, except as acceptable to the Architect.

3.13 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as herein specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.
- B. Curbs: Provide finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases, Pads and Foundations: Provide machine and equipment bases, pads and foundations, as shown on the Contract Drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.
 1. The concrete to be provided beneath the various pieces of mechanical and electrical equipment shall be at locations shown, however, the extent shall be governed by the configuration of the equipment finally selected and approved by the Architect.

3.14 CONCRETE SURFACE REPAIRS

- A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to the Architect. Comply with ACI 301, Chapter 9, supplemented and amended as specified herein.

1. Cut out honeycomb, rock pockets, voids over 1/4 inch in any dimension, and holes left by tie rods and bolts, down to solid concrete but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with specified bonding agent. Place patching mortar before bonding compound has dried. Apply patching material per manufacturer's recommendations.
 2. Remove and replace concrete that, in the Architect's opinion, does not satisfy the requirements of the Contract Documents.
 3. For exposed-to-view surfaces, blend white portland cement and standard portland cement so that, when dry, patching mortar shall match surrounding color.
 4. Compact mortar in place and strike-off slightly higher than surrounding surface.
- B. Repair of Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of the Architect. Flush out form tie holes, fill with dry-pack mortar, or precast cement cone plugs secured in place with bonding agent.
1. Correct low and high areas as herein specified.
 2. Repair finished surfaces containing defects affecting durability of concrete.
 3. Correct high areas in surfaces by grinding after concrete has cured at least 14 days.
 4. Correct low areas in surfaces during or immediately after completion of surface finishing operations by cutting out low areas and replacing with patching compound. Finish repaired areas to blend into adjacent concrete.
 5. Repair defective areas, except random cracks and single holes not exceeding 1 inch in diameter, by cutting out and replacing with fresh concrete.
 6. Dampen concrete surfaces in contact with patching concrete and apply bonding compound.
 7. Mix patching concrete of same materials to provide concrete of same type or class as original concrete.
 8. Place, compact, and finish to blend with adjacent finished concrete.
 9. Cure in same manner as adjacent concrete.
- C. Additional Repair Methods: Repair methods not specified above may be used, subject to acceptance of the Architect.

3.15 PROTECTION FROM AND REMOVAL OF STAINS

- A. Protect concrete structure from rust staining by structural steel members and from other substances during the work.
- B. If staining should occur, remove stains and restore concrete to its original color.
- C. Remove all dust, dirt, mortar, and other foreign matter which would mar appearance of exposed concrete or prevent bond of applied materials.
 1. Use approved methods, to complete satisfaction of the Architect.

3.16 DEFECTIVE CONCRETE AND CORRECTIVE WORK

- A. Concrete shall be considered defective unless it is structurally sound, properly finished, and within specified tolerances.

- B. Replace, strengthen, or correct defective concrete as directed. This work shall be provided at no additional cost to the Owner. The Architect will have the sole authority to decide whether concrete shall be removed and replaced or repaired.
- C. Before final acceptance of the work, neatly repair damaged surfaces, corners of concrete and concrete finish.
- D. Where surface repairs are permitted, finish damaged areas to smooth, dense water-tight condition.
- E. Where corrective work is unsatisfactory, completely remove such work and replace with new work conforming to specified requirements.

3.17 FIELD QUALITY CONTROL

- A. Refer to specification Field Quality Control 03 45 00
- B. Prior to the commencement of any work under this Section, and when directed by the Engineer or OAR meet at the Project Site to review installation and coordination procedures. Among other topics, the coordination meeting shall address scheduling, method and sequence of concrete construction, standard of workmanship, material selection, testing and quality control requirements, detailed requirements of design mixes, placement procedures, off-site batching requirements, coordination of the Work with other trades, preparation of surfaces contiguous with this work, adjacent construction, and interferences, if any. This meeting shall be attended by any and all trades, manufacturer's representatives, and other interested parties whose work will be affected by the execution of the work under this Section, including the following:
 - 1. Architect
 - 2. Appropriate Design Consultant(s)
 - 3. Contractor
 - 4. Concrete Subcontractor
 - 5. Testing Laboratories
 - 6. Ready-mix Concrete Supplier
 - 7. Any other subcontractor and/or material supplier or manufacturer required
- C. Sampling and Testing:
 - 1. The following requirements are intended to supplement GOAA's specification 01 4529 Structural Testing and Inspection. Where conflict exist specification 01 4529 Structural Testing and Inspection shall govern.
 - 2. Sampling: ASTM C 172. The Contractor's testing agency will collect samples of fresh concrete to perform tests specified. ASTM C 31 for making test specimens.
 - 3. Testing:
 - a. Slump Tests: ASTM C 143. Take concrete samples during concrete placement. The maximum slump may be increased as specified with the addition of an approved admixture provided that the water-cement ratio is not exceeded. Perform tests at commencement of concrete placement, when test cylinders are made, and for each batch (minimum) or every 10 cubic yards (maximum) of concrete.
 - b. Temperature Tests: Test the concrete delivered and the concrete in the forms. Perform tests in hot or cold weather conditions (below 50 degrees F

and above 80 degrees F) for each batch (minimum) or every 10 cubic yards (maximum) of concrete, until the specified temperature is obtained, and whenever test cylinders and slump tests are made.

- c. Compressive Strength Tests: For concrete to be placed in walls, slabs or other structural members. ASTM C 39. Make five test cylinders for each set of tests in accordance with ASTM C 31. Test two cylinders at 7 days, two cylinders at 28 days, and hold one cylinder in reserve. Provide concrete cylinders for compressive tests not less than once a day, nor less than once for each 150 cubic yards of concrete, nor less than once for each 5000 square feet of surface area for slabs or walls. If the average strength of the 28-day test cylinders is less than f'_c and a maximum of one single cylinder is less than f'_c minus 300 psi, take three ASTM C 42 core samples and test. If the average strength of the 28-day test cylinders is less than f'_c and two or more cylinders are less than f'_c minus 300 psi, take six core samples and test. The Architect will determine if concrete represented by core tests is considered structurally adequate. Locations represented by erratic core strengths shall be retested. Remove concrete not meeting strength criteria and provide new, acceptable concrete. Repair core holes with nonshrink grout.
- d. Air Content: ASTM C 173 or ASTM C 231. Test air-entrained concrete for air content at the same frequency as specified for slump tests.
- e. Verification of Material Suitability: Prior to manufacture, establish the suitability of any material used in the concrete work, prepare design mixes that will produce concrete of specified compressive strengths, make preliminary tests in accordance with ACI 301, Chapter 3, Paragraph 3.8, Method 1 or Method 2, and submit data certifying that proposed concrete ingredients and proportions will result in concrete mixes meeting specified requirements.
- f. Concrete Mix Tests: Separate design mixes are required for each anticipated and/or actual change in mix materials.
- g. Identification of Design Mixes: Each design mix shall be fully identified as to its proposed use.
- h. Review of Proposed Mix Designs: Proposed mix designs, preliminary testing procedures, and results will be subject to review and approval by the Architect.
- i. Additional "Preliminary Tests": Whenever either a change of brand or a change of source for any of the concrete ingredients occurs, additional "preliminary tests" will be required and the cost of these tests shall be at no additional cost.
- j. Standard Deviation: The Testing Laboratory will establish an initial standard deviation for the statistical evaluation of concrete for the Project. The standard deviation will be established for the Project on the basis of not less than 30 test results from any one class of concrete. Be fully acquainted with all provisions relative to standard deviation and fully comply with the applicable requirements.
 - 1) The Testing Laboratory will maintain a moving average for compressive strength based on the 3 latest 28-day test results to check compliance with specification requirements. The figures for the standard deviation and moving average for strength will be kept

continuously up to date by the Testing Laboratory on the Project Site, and reported without delay to the Architect.

- 2) The Testing Laboratory will maintain a continuous up-to-date log in both graphical and tabulated form for each class of concrete.
 - 3) The Testing Laboratory will maintain a moving average for range of test results for quality control purposes as described in ACI 214, Chapter 4, Paragraphs 4.4 and 4.5, respectively.
 - 4) The standard deviation shall be assumed to be greater than 600 psi unless another value has been determined from current similar tests, or until it may be calculated from the results of 30 or more job tests. The computation is described in ACI 214.
- k. Strength Requirements: Concrete will be considered to meet strength requirements of the Specifications when in compliance with ACI 301, Chapter 17, Paragraph 17.2., supplemented and amended as specified herein.
- l. Inspection: The testing agency retained by the Owner will perform the following inspections as a minimum:
- m. Plant and Field Inspection: Concrete work will be subject to detailed inspection at the plant and in the field.
- 1) Do not allow placement of concrete until the following is inspected and all deficiencies have been corrected:
 - a) Placement and alignment of forms.
 - b) Spacing of reinforcement.
 - c) Placement of embedded items such as angles, sleeves, PVC weep holes, waterstops and other structural or nonstructural embedments.
 - d) Placement of granular base and vapor barrier.
 - 2) Verify that concrete placement procedures are followed.
 - 3) Verify that cold-weather or hot-weather placing procedures of concrete are strictly followed.
 - 4) Verify that concrete curing procedures are strictly followed.
 - 5) Verify that forms are not removed before time specified.
 - 6) Verify that the delivery ticket shall contain the following information:
 - a) The strength of the mix of concrete being delivered.
 - b) The type of coarse aggregate; lightweight or stone.
 - c) The exact time the cement and aggregate were discharged into the delivery truck.
 - d) List of admixtures.
 - e) Name of supplier.
 - f) Name of batching plant and location.
 - g) Serial number of ticket.
 - h) Truck number and batch number.
 - i) Job designation (Contract number and location).
 - j) Amount of water added.
 - k) Type and brand of cement.
 - l) Weight of cement.
 - m) Maximum permissible amount of water to be added to the site, if any.
 - n) Mix design designation.

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concrete mix and the hydraulic cement concrete operations are producing the desired results.

- 1) Check for workmanship. Initial inspection for workmanship shall include installation of the forms; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete placement, concrete vibration and, concrete finishing.
- 2) Check for defective or damaged materials.
- 3) Assure that damaged and/or defective materials are removed from the site and replaced.
- 4) Batching and Mixing Operations:
 - a) Check mixing time.
 - b) Continually check for assurance of complete control over batching and mixing.
 - c) Check volumes of material used in mix, mixing time, and other controlling features.
 - d) Check moisture content of aggregates frequently. Adjust batch weights in accordance with variations in moisture content.
 - e) Check gradations of aggregates frequently.
 - f) Check the freshly mixed concrete to see that uniformity is maintained. Any marked change from normal consistency or appearance indicates something wrong with the batching or the mixing, and the concrete shall not be accepted for placement.
 - g) Record rejected batches with reasons for rejection.
 - h) Check slump and entrained air content as often as necessary to confirm visual checks.
- 5) Preplacement Inspection: Check all of the following prior to each placement. Do not permit placing to start until all are satisfactory.
 - a) Verify that sufficient quantities of all materials are on hand to permit continuous placement and completion.
 - b) Verify location, dimensions, alignment and grade.
 - c) Verify that the mud slab has been properly installed.
 - d) Verify that excavations are free from frost, ice or mud; moist as required; free from standing or running water.
 - e) Check form materials.
 - f) Check to see that re-used form materials have been reconditioned as required.
 - g) Verify that construction is mortar-tight; smooth; free from offsets and blemishes.
 - h) Verify that ties and bracing is adequate to maintain position, shape, and alignment of form.
 - i) Verify that temporary spreaders are arranged so as to be easily removable as the concrete rises in the form.
 - j) Verify that ties are installed where permitted so that they may be withdrawn or broken off to leave no metal closer than the specified minimum distance from the concrete surface.
 - k) Verify that forms have been oiled, wetted, or sealed. Check to see that surplus oil has been removed from forms and that there is no oil on steel reinforcement, on construction joints, or

- on other surfaces where bonding is required. Verify that forms are clean prior to placing concrete.
- l) Check forms for movement which may occur during placing operations. Verify that measuring devices or reference lines have been set up.
 - m) Verify that necessary clean-outs have been provided for in the bottom of the forms.
- 6) Joints:
- a) Verify that all joints (expansion, contraction, construction) are located as shown on Contract Drawings or as otherwise approved.
 - b) Verify that construction joints have been prepared as required. Check requirements for air-water cutting, wet sand-blasting, roughening, wetting, etc.
 - c) Verify that filler has been installed and securely fastened in expansion joints.
 - d) Verify that expansion joints are free from irregularities or debris which would interfere with free movement.
 - e) Verify that all arrangements are in place for sawcutting of joints in the slabs (where specified) within the time indicated in this Specification. If this requires night time work verify that all arrangements of lighting the work area are in place.
 - f) Check all joints which are intended to allow for expansion or contraction. Reinforcement or other fixed metal shall not be continuous through the joint.
- 7) Reinforcement:
- a) Verify that all reinforcement is in place in accordance with accepted shop drawings. Check bar diameters, bar lengths, lengths of splices, bar-to-bar spacing and clearances.
 - b) Verify that reinforcement has been cleaned of all loose, flaky, rust and scale, dried concrete, oil, grease or other foreign material which would reduce or prevent bond.
 - c) Verify that reinforcement is tied and supported securely so that displacement will not occur during concrete placement.
 - d) Verify that reinforcement spacers, ties, plastic covered chairs, and supports are as specified or approved.
- 8) Miscellaneous Preparation:
- a) Verify that satisfactory arrangements have been made to get concrete into all parts of the placement without segregation, loss of ingredients, formation of air pockets or cold joints, vertical drops in excess of permissible limit, "running" of concrete by means of vibrator, and within the maximum time allowed after mixing.
 - b) Verify that conveying equipment (i.e., crane, buggies, truck mixers, pumpcrete pipe, etc.) is capable of reaching all parts of the placement.
 - c) Verify that temporary form openings, tremies, chutes, conveyors or other special equipment have been provided as necessary and approved.

- d) Verify that arrangements have been made, and all necessary equipment is on hand and in working order to provide curing and protection (including cold weather protection if needed).
 - e) Verify that safe access and footing have been provided by means of ladders, platforms, walkways, and stagings.
- 9) Assure that damaged or defective work is corrected.
- 10) Note and discuss any deficiencies observed and corrective action to be taken. If corrective action is to be taken, conduct an additional initial inspection to verify that proper adjustments, corrections, or revisions have been made.
- 11) Assure that accomplishment of corrective action is in accordance with requirements.
- q. Follow-Up Inspections: Follow-up inspections shall be performed daily and more frequently as necessary, and shall include continued testing and examinations to assure continued conformance with Contract Document requirements.
 - 1) Conveying and Placing Operations:
 - a) Check requirements pertaining to placing fresh concrete on concrete which has set.
 - b) Verify that the time between completion of mixing and placement in final position in the form is within the maximum allowed by the Specifications.
 - c) Check method of placement in handling of concrete to prevent segregation. Check height concrete is allowed to drop freely and method used to guide concrete into place.
 - d) Verify that concrete is placed rapidly enough to avoid formation of cold joints.
 - e) Verify that layers are maintained approximately horizontal and not exceeding specified thickness.
 - f) Verify that form ties and supports are checked frequently and are adjusted as necessary to prevent or correct movements of the form.
 - g) Verify that the rate of placement is within safe limits, such that forms will not be overstressed by too-rapid rise of fluid concrete.
 - h) Verify that each layer of concrete is vibrated until fully consolidated.
 - i) Do not allow vibration to be overdone to the extent of promoting segregation. Do not allow vibrators to be used to transport concrete in the forms.
 - j) Check use of hand compaction tools insofar as practicable to assist in obtaining smooth, dense surfaces.
 - k) Do not allow excessive working of the concrete surface in completing a lift.
- r. Removal of Forms:
 - 1) Verify that care is being taken to assure that concrete is sufficiently hard and strong before removal of forms.
 - 2) Check to see that forms used for curing are left in place until expiration of required curing period. Forms shall be tightened and maintained "snug" against concrete surfaces at all times while curing.

- 3) Verify that spalling, chipping, and gouging of concrete is avoided during the form removal operation.
- 4) Verify that safety practices are being completely exercised during the form removal.

s. Finishing:

- 1) Check the type of finish required.
- 2) Verify that defective areas have been repaired and that fins, forms marks and holes are completely removed immediately upon removal of forms.
- 3) Check the cleaning of areas to be patched. Have honeycomb and rock pockets been cut back to solid material? Has loose material been removed.
- 4) Check the requirements for the treatment of areas containing defective concrete.
- 5) Check for complete curing of patched areas.
- 6) Check surfaces for specified smoothness tolerances. Require rough areas and high spots to be ground smooth.
- 7) Check that all work is properly and continuously cured for a minimum total of 14 days.
- 8) Correct deficiencies in cast-in-place concrete work that inspections have indicated as non-conforming.
- 9) Perform additional inspections as necessary to reconfirm any non-conformance of original work and to show conformance of corrected work.
- 10) Do not allow any addition to, or building upon, non-conforming work unless correction can be made without disturbing the continuing work.
- 11) Verify that damaged or defective work is corrected properly and approved by the Architect.
- 12) Re-inspect replaced materials to determine conformance with Contract Document requirements.
- 13) Work accomplished shall be considered satisfactory only when inspections show that all variances have been corrected in an acceptable manner and that the completed work is in conformance with the Contract Documents.
- 14) If, following submission of inspection results, the Architect finds that such inspection reveals a failure of the work to conform to the requirements of the Contract Documents, the deficiencies shall be corrected in a manner approved by the Architect.
- 15) The final and governing determination of conformance or non-conformance with the Contract Documents will be made by the Architect based on inspection results and Controlled Inspection documentation after all work of this Section has been fully completed in accordance with the Contract Documents.

3.18 Special Inspections:

- A. The inspection agency retained by the owner will perform inspections in accordance with the provisions of the Florida Building Code.

- B. The Contractor shall coordinate his operations with the Owners inspection agency to insure that inspections can be completed in a timely fashion.

END OF SECTION 03 30 00

SECTION 03 3001 - CAST-IN-PLACE CONCRETE - PARKING GARAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this Section.

1.2 SUMMARY

- A. This Section specifies cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture proportions, placement procedures, finishes, architectural finishes, and other miscellaneous items related to cast-in-place concrete.
- B. Cast-in-place concrete includes project requirements specified herein and on drawings:
 - 1. Water/cementitious materials ratio: See General Notes on Drawings.
 - 2. Water Reducing Admixture: See Part 2 Article "Admixtures."
 - 3. High strength: See General Notes on Drawings.
- C. Work in other Sections related to Cast-in-Place Concrete:
 - 1. Division 1 Section "Project Management and Coordination."
 - 2. Division 1 Section "Quality Control."
 - 3. Division 3 Section "Post-Tensioned Concrete (Parking Garage)."
 - 4. Division 7 Section "Traffic Coatings (Parking Garage)."
 - 5. Division 7 Section "Water Repellants (Parking Garage)."
 - 6. Division 7 Section "Expansion Control (Parking Garage)."
 - 7. Division 7 Section "Concrete Joint Sealants (Parking Garage)."
 - 8. Division 9 Section "Painting (Parking Garage)."

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans and ground granulated blast-furnace slag.
- B. Self-Consolidating Concrete (SCC): Highly flowable, non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation.

1.4 ACTION SUBMITTALS

- A. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 - 1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance
 - b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)

b. Corporate Sustainability Reporting (CSR's)

- B. Submit Product data for concrete component materials and other concrete related items, including, but not limited to:
 - 1. Material Certificates: Signed by Manufacturer that each of the following items complies with requirements:
 - a. Cementitious materials and aggregates
 - b. Admixtures
 - c. Form materials and form-release agents
 - d. Steel reinforcement and accessories
 - e. Fiber reinforcement
 - f. Waterstops
 - g. Curing materials
 - h. Floor and slab treatments
 - i. Bonding agents
 - j. Vapor barriers/reducer
 - k. Repair materials
 - 2. Submit certification that curing compound or evaporation reducer, if used, is compatible with sealer specified in Division 7 Section "Water Repellants", traffic topping specified in Division 7 section "Traffic Coatings", sealant specified in Division 7 Sections "Concrete Joint Sealants" and "Architectural Joint Sealants", and expansion joint assemblies specified in Division 7 Section "Expansion Joint Assemblies."
 - 3. Submit certification that curing compound or evaporation reducer is compatible with pavement markings specified in Division 9.
- C. Submit materials certificates in lieu of materials laboratory test reports when permitted by Engineer. Materials certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with or exceeds specified requirements. Provide certification from admixture manufacturers that chloride content complies with specification requirements.
- D. Submit evidence of licensure in Florida for professional engineer providing professional services as required for Contractor in order to carry out the Contractor's responsibilities for construction means, methods, techniques, sequences and procedures.
 - 1. Contractor's responsibilities include formwork, shoring and re-shoring procedures, and other work described in Article "Contractors Professional Design Services", Article "Formwork", and Article "Shores and Re-shores".
 - 2. Performance and design criteria are shown on the Drawings and in Article "Contractor's Professional Services- Performance and Design Criteria".
 - 3. Contractor's Professional Engineer shall furnish Owner a Certificate of Professional Liability Insurance in the amounts required per Division 1 of the specifications.
 - 4. Submit calculations and dimensions for "Nominal Form Width" for linear gap at time of forming or erecting concrete elements bounding the expansion joints in accordance with Drawings and Specification "Expansion Joint Assemblies".
- E. Submit concrete mixture proportions to Engineer for each concrete mixture. Submit alternate mixture proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1. Provide mixture proportions not less than four weeks before placing concrete and not less than one week before pre-installation conference (pre-concrete meeting).
 2. Proportion mixtures as defined in ACI 301 Section 4 header "Proportioning," Mixtures shall be proportioned by party other than Testing Agency responsible for testing Project concrete.
 3. Proportion mixtures to minimize effects of thermal and drying shrinkage. See Part 2 heading "Concrete Mixtures" header "Shrinkage" for drying shrinkage limit.
 4. Use mixture proportions submission form at end of this Section for each concrete mixture, which identifies the following:
 - a. Mixture Proportions Identification and use.
 - b. Method used for documentation of required average compressive strength, (ACI 301 Section 4 – *Field test data* or *Trial mixtures*).
 - c. Gradation of fine and coarse aggregates.
 - d. Proportions of all ingredients including all admixtures added either at time of batching or at job site.
 - e. Water/cementitious materials ratio.
 - f. Slump, ASTM C143.
 - g. Certification of the chloride content of admixtures.
 - h. Strength at 4 and 28 days, per ASTM C39. In addition, for post-tensioned concrete provide a strength gain curve with sufficient number of data points from 6 to 96 hours to accurately estimate when the minimum compressive strength for tensioning the concrete will be achieved. See Section "Unbonded Post-Tensioned Concrete."
 - i. Water soluble chloride ion content of concrete: ASTM C 1218.
 - j. Rapid Chloride Permeability test results per ASTM C 1202.
 - k. Shrinkage (length change), ASTM C157 (modified) for cast-in-place post-tensioned concrete only. See Part 2 heading "Concrete Mixtures" header "Shrinkage" for modifications to ASTM C157.
 - l. Certificate of analysis of coal fly ash or processed ultra fine fly ash: Comply with ASTM C618, Class C or F:
- F. Testing Agency: Promptly report all field concrete test results to Engineer, Contractor and Concrete Supplier. Include following information:
1. See Article "Quality Assurance."
 2. Density (unit weight) of concrete, ASTM C 138.
 3. Slump, ASTM C 143.
 4. Slump Flow, ASTM C 1611 (for SCC).
 5. Concrete temperature at placement time. ASTM C 1064.
 6. Air temperature at placement time.
 7. Strength determined in accordance with ASTM C 39.
 8. Rapid Chloride Permeability Test of core samples in accordance with ASTM C 1202, as and when directed by Specification or Owner.
 9. Shrinkage (length change) of superstructure concrete, ASTM C 157 (modified) for post-tensioned concrete and other concrete as noted on the drawings. Shrinkage shall be equal to or less than 0.04% at 28 days
 10. Calcium Nitrite presence in plastic concrete: See Part 3 heading, "Quality Control."
- G. Contractor: Submit grout temperature limitations with grout submittal.

- H. Submit current certification of welders.
- I. Provide certification that curing compound conforms to requirements of ASTM C 1315.
- J. All concrete flatwork finishers on Project shall hold current ACI Concrete Flatwork Finisher certification. Submit certification for each concrete flatwork finisher at Concrete Pre-Installation Conference and obtain Engineer's written acceptance.
- K. Submit steel producer's certificates of mill analysis, tensile tests, and bend tests for reinforcing steel. Coordinate with welders and welding procedures.
- L. Submit shop drawings for steel reinforcement:
 - 1. Prepare placing drawings that detail fabrication, bending, and placement of concrete reinforcement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement. Comply with ACI SP-66, "ACI Detailing Manual." Include special reinforcement required for openings through concrete structures, elevations of all walls and columns with locations of all splices and couplers.
 - 2. Prepare steel reinforcement placing drawings in coordination with the Work of Section "Unbonded Post-Tensioned Concrete". Review the Unbonded Post-Tensioned Concrete tendon shop drawings to determine placement details and clearances. Notify Engineer of potential interference or conflicts for placing reinforcement and post-tensioning tendons.
- M. Resubmittals: Engineer will review each of Contractor's submittals the initial time and, should resubmittal be required, one additional time to verify that reasons for resubmittal have been addressed by Construction Manager and corrections made. Resubmittal changes/revisions/corrections shall be circled. Engineer will review only circled items and will not be responsible for non-circled changes/revisions/corrections and additions.
 - 1. Make resubmittals in same form and number of copies as initial submittal.
 - a. Note date and content of previous submittal.
 - b. Note date and content of revision in label or title block and clearly indicate extent of revision.
- N. Resubmit submittals until they are marked with approval notation from Engineer's and Construction Manager's action stamp
- O. Submit shop drawings for architectural finishes for specific exposed finish concrete surfaces. Show form construction including jointing, special form joint or reveals, location and pattern of form tie placement, and other items that affect exposed concrete visually.
- P. Submit samples of materials as requested by Engineer, including names, sources, and descriptions as follows:
 - 1. Normal weight aggregates.
 - 2. Fibrous reinforcement.
 - 3. Reglets.

- 4. Waterstops.
- 5. Vapor retarder.
- Q. Submit laboratory test reports for concrete materials and mixtures.
- R. Submit Minutes of concrete pre-installation conference.

1.5 CONTRACTOR'S PROFESSIONAL SERVICES - PERFORMANCE AND DESIGN CRITERIA

- A. Provide professional services for temporary conditions during construction and portions of the Work required to carry out the Contractor's responsibilities for construction means, methods, techniques, sequences and procedures. Specific requirements and criteria include, but are not limited to the following:
 - 1. Design, erect, shore, brace, and maintain formwork, according to ACI 301 and ACI 347 to support vertical, lateral, static and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads. The contractor is responsible for layout and design, reviews, approvals, and inspections.
 - 2. Design formwork, shoring, bracing, and other conditions for structural requirements and stability during construction and until final structure is completed and accepted.
 - a. Comply with ACI 347.2 for design, installation, and removal of shoring and reshoring.
 - b. Superimposed loads to the concrete structure, slab-on-grade, and soil shall be less than the design loads as shown on Drawings.
 - c. Check early-age strength of concrete members against anticipated construction loads. Reduce the load on concrete members at the critical concrete age or change the concrete mixture for accelerated strength gain to avoid distress of concrete members.
 - d. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads such that no floor or member would be excessively loaded or would induce tensile stresses in concrete members.
 - e. Plan sequence of removal of shores and reshores to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excess stress or deflection.
 - f. Consider the effects of post-tensioning sequence for post-tensioned beams and girders. Review post-tensioning design criteria on the drawings and in specification Section "Unbonded Post-tensioned Concrete".
- B. Design the "Nominal Form Width" for linear gap at time of forming or erecting concrete elements bounding the expansion joints in accordance with Drawings and Specification Section "Expansion Joint Assemblies".

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed concrete work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

- The minutes shall include a statement by the Concrete Contractor indicating that the proposed mixture proportions and placing/finishing/curing techniques can produce the concrete quality required by these specifications.

- H. Welders and welding procedures shall conform to requirements of AWS D1.4. Except where shown on Drawings, welding of reinforcing steel is prohibited unless accepted by Engineer in writing.
- I. Threshold Inspection of steel reinforcement is required in accordance with Florida Building Code, Section 105. Inspections shall be conducted by an inspection agency employed by Owner and approved by Engineer. Inspector shall provide report in approved format to Owner with copy to Engineer and Contractor. Inspection agency has authority to reject reinforcing not meeting Contract Documents. Inspections for all reinforcing steel for conformance to shop drawings and Contract Documents shall be completed prior to concrete placement.
- J. Threshold Inspector shall submit following information on Inspection of Reinforcement unless modified in writing by Engineer.
 - 1. Project name and location.
 - 2. Contractor's name.
 - 3. Inspection Agency's name, address, and phone number.
 - 4. Date and time of inspection.
 - 5. Inspection Agency technician's name.
 - 6. Fabricator's name.
 - 7. Weather data:
 - a. Air Temperatures.
 - b. Weather.
 - c. Wind speed.
 - 8. Inspection location within structure.
 - 9. Reinforcement inspection data (including but not limited to):
 - a. Bar size, spacing, cover, and grade.
 - b. Splices, bends, anchorages, welding.
 - c. Support methods and construction sequencing.
 - 10. Inspection of other items related the concrete pour such as embed anchor bolts and connection plates, sleeves and openings or other items related to the structure. Refer to the Threshold Inspection Notes on the drawings.
 - 11. Diary of general progress of Work.
- K. Owner's or Contractors Testing Agency Qualifications:
 - 1. Independent agency, acceptable to engineer, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
 - 2. Testing laboratory shall submit documented proof of ability to perform required tests.
 - 3. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 4, according to ACI CP-1 or an equivalent certification program.
- L. Owner's or Contractors Testing Agency is responsible for conducting, monitoring and reporting results of all tests required under this Section. Testing Agency shall immediately report test results showing properties that do not conform to Project Specification requirements to General Contractor's authorized on-site representative and to Owner's authorized on-site representative.
- M. Both Owner's and Contractors Testing Agency shall submit following Field Test information for Project Concrete unless modified in writing by Engineer:

1. Project name and location.
 2. Contractor's name.
 3. Testing Agency's name, address, and phone number.
 4. Concrete supplier.
 5. Date of report.
 6. Testing Agency technician's name (sampling and testing).
 7. Placement location within structure.
 8. Time of batching.
 9. Time of testing.
 10. Elapsed time from batching at plant to discharge from truck at site.
 11. Concrete mixture data (quantity and type):
 - a. Cement.
 - b. Fine aggregates.
 - c. Coarse aggregates.
 - d. Water.
 - e. Water-reducing admixture and high-range water-reducing admixture.
 - f. Other admixtures, including supplementary cementitious materials.
 12. Weather data:
 - a. Air temperatures.
 - b. Weather.
 - c. Wind speed.
 13. Field test data:
 - a. Date, time and place of test.
 - b. Slump.
 - c. Concrete Temperature.
 - d. Slump flow (for SCC).
 - e. Water content.
 - f. Density (Unit weight).
 14. Compressive test data:
 - a. Cylinder number.
 - b. Age of concrete when tested.
 - c. Date and time of cylinder test.
 - d. Curing time (field and lab).
 - e. Cross-sectional area of cylinder.
 - f. Compressive strength.
 - g. Type of failure (at break).
 - h. Rapid chloride permeability test results.
- N. Mockups: Before casting concrete, build mockups to verify selections made under sample submittals and to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
1. Build two acceptable test panels approximately 600 sq. ft. for flatwork in parking drive areas slab-on-grade in the location indicated or, if not indicated, submit a request for acceptance of the proposed location at the project site. See additional requirements for test panels in specification article "Finishing Floors and Slabs."
 2. Build panel approximately 100 sq. ft. for Smooth Form Finish - formed surface in the location indicated or, if not indicated, submit a request for acceptance of the proposed location at the project site.

- a. Submit a request for acceptance of the proposed location for concrete ceilings.
 - b. Submit a request for acceptance of the proposed location for typical interior walls.
 3. Build mockups of typical exterior wall of cast-in-place concrete as shown on Drawings.
 4. Stains, bugholes or other surface blemishes that deviate from the mockup will not be acceptable.
 5. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.
 6. In presence of Engineer, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
 7. Obtain Engineer's acceptance of mockups before casting concrete with specified finishes.
- O. Coal fly ash and processed ultrafine fly ash supplier shall make available qualified individual, experienced in placement of fly ash concrete, to aid Contractor. Qualification of supplier's representative shall be acceptable to Owner. Representative shall attend pre-construction meeting, and shall be present for all trial placements, initial startup and then as required by Owner.
- P. At all times during high-evaporation conditions, maintain adequate supply of evaporation reducer at site. Do not use evaporation reducer as finishing aid. See Part 3.
- Q. Testing Agency: Identify those trucks of concrete supplier's which meet requirements of NRMCA Quality Control Manual. Permit only those trucks to deliver concrete to Project.

1.7 REFERENCES

The following publications listed below form a part of this Specification to the extent referenced.

- A. American Association of State Highway and Transportation Officials (AASHTO):
1. AASHTO, "Standard Specifications for Highway Bridges."
 2. AASHTO T 318, "Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying."
- B. American Concrete Institute (ACI):
1. ACI 214R, "Evaluation of Strength Test Results of Concrete."
 2. ACI 302.1R, "Guide for Concrete Floor and Slab Construction."
 3. ACI 305R, "Hot Weather Concreting."
 4. ACI 306.1, "Cold Weather Concreting."
 5. ACI 308R, "Guide to Curing Concrete."
 6. ACI 308.1, "Standard Specifications for Curing Concrete."
 7. ACI 347, "Guide to Formwork for Concrete."
 8. ACI 347.2 "Guide to Shoring/Reshoring of Concrete Multistory Buildings."
 9. ACI 362.1, "Guide for the Design of Durable Parking Structures."
 10. ACI SP15, "Field Reference Manual."

- C. American Iron and Steel Institute (AISI):
 - 1. AISI, "Specification for the Design of Cold-Formed Steel Structural Members."
- D. American Society for Testing and Materials (ASTM):
 - 1. ASTM A 36, "Standard Specification for Carbon Structural Steel."
 - 2. ASTM A 185, "Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete Reinforcement."
 - 3. ASTM A 497, "Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete Reinforcement."
 - 4. ASTM A 615, "Standard Specification for Deformed and Plain Carbon -Steel Bars for Concrete Reinforcement."
 - 5. ASTM A 706, "Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement."
 - 6. ASTM B 633, "Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel."
 - 7. ASTM C 31, "Standard Practice of Making and Curing Concrete Test Specimens in the Field."
 - 8. ASTM C 33, "Standard Specification for Concrete Aggregates."
 - 9. ASTM C 39, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens."
 - 10. ASTM C 94, "Standard Specification for Ready-Mixed Concrete."
 - 11. ASTM C 109, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)."
 - 12. ASTM C 138, "Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete."
 - 13. ASTM C 143, "Standard Test Method for Slump of Hydraulic Cement Concrete."
 - 14. ASTM C 150, "Standard Specification for Portland Cement."
 - 15. ASTM C 157, "Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete."
 - 16. ASTM C 171, "Standard Specification for Sheet Materials for Curing Concrete."
 - 17. ASTM C 172, "Standard Practice for Sampling Freshly Mixed Concrete."
 - 18. ASTM C 173, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method."
 - 19. ASTM C 231, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method."
 - 20. ASTM C 260, "Standard Specification for Air-Entraining Admixtures for Concrete."
 - 21. ASTM C 309, "Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete."
 - 22. ASTM C 311, "Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete."
 - 23. ASTM C 330, "Standard Specification for Lightweight Aggregates for Structural Concrete."
 - 24. ASTM C 457, "Standard Test Method for Microscopical Determination of Air-Void Content and Parameters of the Air-Void System in Hardened Concrete."
 - 25. ASTM C 494, "Standard Specifications for Chemical Admixtures for Concrete."
 - 26. ASTM C 567, "Standard Test Method for Determining the Density of Structural Lightweight Concrete."
 - 27. ASTM C 595, "Standard Specification for Blended Hydraulic Cements."

- E. American Welding Society (AWS):

- F. US Army Corps of Engineers (CE):
 - 1. CE CRD-C 513 "Specifications for Rubber Waterstops."
 - 2. CE CRD-C 572 "Specifications for Polyvinyl Chloride Waterstops."
 - 3. CE CRD-C 662 "Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar Bar Method)."
- G. Contractor shall have following ACI publications at Project construction site:
 - 1. ACI SP-15, "Field Reference Manual: Standard Specifications for Structural Concrete ACI 301 with selected ACI References."
 - 2. ACI 302.1R, "Guide for Concrete Floor and Slab Construction."
 - 3. ACI 305R, "Hot Weather Concreting."
 - 4. ACI 306.1, "Cold Weather Concreting."
- H. Accessibility Requirements:
 - 1. "Americans with Disabilities - Act Accessibility Guidelines for Buildings and Facilities", as published by U.S. Architectural & Transportation Barriers Compliance Board, 1331 F Street, N.W., Suite 1000, Washington, DC 20004-1111, 1-800-872-2253, <http://www.access-board.gov/adaag/ADAAG.pdf>

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store all formwork and formwork materials clear of ground, protected, to preclude damage.
- B. Deliver reinforcement to Project site bundled, tagged and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings shown on placement diagrams.
- C. Store concrete reinforcement materials at site to prevent damage and accumulation of dirt or excessive rust.
- D. Concrete transported by truck mixer or agitator shall be completely discharged within one and one half-hours (one hour for hot weather concreting) after water has been added to cement or cement has been added to aggregates. Schedule deliveries to allow for delays due to weather, traffic, etc.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

- A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
 - 1. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
 - a. High-density overlay, Class 1 or better.

- b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
- B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Forms for Textured Finish Concrete: Unit of face design, size, arrangement, and configuration to match control sample. Provide solid backing and form supports to ensure stability of textured form liners.
- D. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.
- E. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
 - 1. Products include all corrugated cardboard void forms that temporarily support concrete walls, grade beams, structural concrete slabs and top portion of concrete piers; includes filling the circular section where required.
 - a. Related accessory products include seam caps, end caps and protective cover boards or any other product to maintain above general products.
 - b. Submit all product data and manufacturer's installation instructions under provisions of this Section, based on the design loads specified in contract documents and depth and width indicated.
- F. Form Coatings: Provide commercial formulation form-coating compounds with a maximum VOC of 350 grams/liter that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces, including but not limited to water-curing, curing compound, stains or paints.
- G. Form Ties: Factory - fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units that will leave no metal closer than 1.5 in. to exposed surface.
 - 1. Provide ties that, when removed, will leave holes not larger than 1 in. diameter in concrete surface.
- H. Chamfer strips: Wood, metal, PVC, or rubber strips. 0.75 in. by 0.75 in. min. unless noted otherwise.
- I. Nails for P-T Anchors: Stainless steel ring shank nails.
 - 1. Clendenin Brothers, Baltimore, MD.
 - 2. Or Equal.

2.2 STEEL REINFORCEMENT

- A. Provide in Bid 20 additional tons of placed reinforcement bars or welded wire reinforcement for inclusion in Project as Engineer directs. Return cost of unused portion to Owner. Submit to Engineer breakdown of use each month.
- B. Reinforcement Bars: ASTM A 615, deformed, yield strength: as noted on Drawings.

- C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706, deformed.
- D. Post-tensioned Reinforcement: See Section "Unbonded Post-Tensioned Concrete."
- E. Steel Bar Mats: ASTM A 184, assembled with clips.
 - 1. Steel Reinforcement: ASTM A 615, Grade 60, deformed bars.
- F. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
 - 1. Welded wire reinforcement: provide in mats only. Roll stock prohibited.
- G. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 60 percent.

2.3 REINFORCEMENT ACCESSORIES

- A. Bar supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from all plastic of greater compressive strength than concrete, and as follows:
 - 1. In manner acceptable to Engineer solely, bar and welded wire reinforcement supports shall be color-coded to visually differentiate supports by height and shall be fabricated to resist overturning during construction operations.
 - 2. For slabs on ground, use all-plastic supports with sand plates or horizontal runners where base materials will not support chair legs. All supports shall have sufficient surface area in contact with ground so that they shall not allow clearance loss when reinforcement installed or concrete placed.
 - 3. For concrete surfaces exposed to view where bar supports contact forms, supports shall have minimal contact, shall not cause voids and shall not cause damage to surrounding concrete. Use all-plastic supports conforming to CRSI Class 1 protection requirements.
 - 4. Chairs shall be sized and spaced to prevent cover loss during construction operations.
 - 5. Acceptable manufacturers:
 - a. Aztec Concrete Accessories, Inc.
 - b. General Technologies, Inc.
 - c. Accepted equivalent.
 - 6. For welded wire reinforcement, provide continuous bar supports spaced at 2 feet o.c., maximum."
- B. For mechanical tension splices of reinforcement:
 - 1. All splices to develop 125 percent of specified yield strength of bars, or of smaller bar in transition splices. Acceptable products:
 - a. Bar-Lock Rebar Coupler, by Dayton Superior.
 - b. Bar-Grip or Grip-Twist, by Barsplice Products, Inc.
 - c. Extender Coupler, by Headed Reinforcement.
 - d. Splice Sleeve, by NMB.
 - e. LENTON Splices, by Erico.

- C. Compression splices: Mechanically coupled splices in accordance with ACI 318, Chapter 12.

2.4 CONCRETE MATERIALS

- A. Ready Mixed Concrete: Obtain concrete from plant with current certification from:
1. Concrete Materials Engineering Council.
 2. Florida Department of Transportation.
 3. National Ready Mixed Concrete Association.
- B. Portland Cement (ACI 301, Section 4 header "Cementitious Materials"):
1. Portland cement, Type I, ASTM C 150. Use one cement supplier throughout project. No change in brand or supplier without prior written acceptance from Engineer.
 2. Blended cement, ASTM C 595, Type IP only with prior written acceptance from Engineer.
- C. Coal Fly Ash:
1. Permitted in all parts of structure.
 2. ASTM C 618, Class C or F.
 3. Testing: ASTM C311.
 4. Percentage of fly ash in Mixture Proportion shall be by weight, not by volume. Water/cement ratio will be calculated as water/cementitious (total cement and fly ash) ratio.
 5. If project contains post-tensioned members, see Section "Unbonded Post-Tensioned Concrete," for high early strength requirements for concrete to be post-tensioned.
 6. Prohibited: Fly ash in same mix with Type IP blended cement.
 7. If strength or air content varies from value specified by more than specified tolerances, Engineer or designated representative shall reject that concrete.
 8. Submit all fly ash concrete Mixture Proportions per ACI 301.
- D. Slag – (Ground Granulated Blast-Furnace Slag – GG-BFS):
1. ASTM C 989, Grade 100 or higher.
 2. Percentage of GGBF slag in Mixture Proportion shall be by weight, not by volume. Water-cement ratio shall be calculated as water-cementitious (total portland cement + GGBF slag) ratio.
 3. If strength or air content varies from value specified by more than specified tolerances, Engineer or designated representative shall reject that concrete.
 4. Submit all GGBF slag concrete mixture proportions per ACI 301.
- E. Normal Weight Aggregates (ACI 301, Section 4 header "Aggregates"):
1. Normal weight concrete aggregates:
 - a. Coarse aggregate: Crushed and graded limestone or approved equivalent conforming to ASTM C33 except as noted here, minimum class designations as listed below:
 - 1) Below grade construction and below frost line: Class 1N.
 - 2) Walls not exposed to public view: Class 1N.
 - 3) Walls exposed to public view: Class 1N.
 - 4) Slabs on ground: Class 1N.
 - 5) All other concrete: Class 1N.

- b. No deleterious materials such as, but not limited to, chert or opaline.
 - c. Fine aggregate: Natural or Manufactured sand conforming to ASTM C 33 and having preferred grading shown for normal weight aggregate in ACI 302.1R, Table 5.1.
 - d. Coarse Aggregate shall not contain crushed hydraulic-cement concrete.
 - 2. Coarse aggregate: Nominal maximum sizes indicated below, conforming to ASTM C 33, Table 2:
 - a. Footings/Foundations: Size number 57 or 357.
 - b. Slab on grade: Size number 57.
 - c. All other members: Size number 67.
 - 3. Chloride Ion Level: ASTM C 1218. Chloride ion content of cement, aggregates and all other ingredients: tested by laboratory making trial mixes.
- F. Water: Comply with ASTM C 1602.
- G. Storage of Materials (ACI 301, Section 4 header "Materials Storage and Handling").

2.5 ADMIXTURES

- A. Use water-reducing admixture, mid-range water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete as required for placement and workability.
- B. Use non-chloride accelerating admixture in concrete slabs placed at ambient temperatures below 50 deg. F as required for schedule.
- C. Use high-range water-reducing admixture (HRWR) in pumped concrete, and for concrete with water/cementitious ratio of less than or equal to 0.45. Use high-range or mid-range water-reducing admixtures in pumped concrete and normal or mid-range water reducing admixtures for concrete with water/cementitious ratios greater than 0.45.
- D. Self-consolidating concrete (SCC) may be used where placement due to either dense reinforcement or form design requires both a high level of workability (horizontal slump flow greater than 24 in. diameter) and the water/cementitious ratio is less than or equal to 0.45.
- E. Only admixture manufacturers listed acceptable. Do not submit alternate manufacturers.
- F. Concrete supplier and manufacturer shall verify via trial mixes and certify compatibility (no adverse effect on workability, strength, durability, entrained air content, etc.) of all ingredients in each Mixture. Use admixtures in strict accordance with manufacturer's recommendations.
- G. Prohibited Admixtures: Calcium chloride or admixtures containing intentionally added chlorides shall not be used.
- H. Normal Water-Reducing Admixture: ASTM C 494, Type A.
 - 1. Products: Subject to compliance with requirements, provide one of following:

- a. "Eucon Series," Euclid Chemical Co.
 - b. "WRDA Series," GCP Applied Technologies (Grace)
 - c. "Pozzolith Series," or "PolyHeed Series," BASF Construction Chemicals.
 - d. "Plastocrete Series", Sika Corporation.
- I. Mid Range Water-Reducing Admixture: ASTM C 494, Type A.
- 1. Subject to compliance with requirements, provide one of following:
 - a. "Eucon MR" or "Eucon X-15 and X-20," Euclid Chemical Co.
 - b. "Daracem Series" or "MIRA Series," GCP Applied Technologies (Grace)
 - c. "PolyHeed Series," BASF Construction Chemicals.
 - d. "Sikaplast Series" or "Plastocrete Series", Sika Corporation.
 - e. "Catexol 2000 NI," Axim Concrete Technologies.
 - f. "Polychem 1000" or "KB Series," General Resource Technology.
 - g. "Finishease-NC," Russ Tech Admixtures, Inc.
- J. High Range Water-Reducing Admixture (Superplasticizer): ASTM C 494, Type F.
- 1. Products: Subject to compliance with requirements, provide one of following:
 - a. "Eucon 37" or "Eucon SP-Series" or "Plastol Series," Euclid Chemical Co.
 - b. "Daracem Series" or "ADVA Series," GCP Applied Technologies (Grace)
 - c. "Rheobuild 1000", "PS 1466" or "Glenium Series," BASF Construction Chemicals.
 - d. "Sikament Series" or "Sika ViscoCrete Series," Sika Corporation.
 - e. "Catexol 1000 SP-MN," Axim Concrete Technologies.
 - f. "Melchem Series," General Resource Technology.
 - g. "Superflo 443" or "Superflo 2000 Series," Russ Tech Admixtures, Inc.
- K. High-Range Water-Reducing Admixture (Superplasticizer) for Self-Consolidating Concrete, ASTM C 494 Type F.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. "Plastol Series" or "Eucon SPC or SPJ," Euclid Chemical Co.
 - b. "ADVA Series," GCP Applied Technologies (Grace)
 - c. "Glenium Series" or "PS1466," BASF Construction Chemicals.
 - d. "Sika ViscoCrete Series" or "Sikament Series", Sika Corporation.
- L. Viscosity Modifying Admixture for Self-consolidating Concrete:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. "Visctrol" or "Eucon ABS," Euclid Chemical Co.
 - b. "Rheomac VMA Series," BASF Construction Chemicals.
 - c. "Sika Stabilizer Series," Sika Corporation.
- M. High Range water reducing retarding (superplasticizer), ASTM C 494 Type G:
- 1. Products: Subject to compliance with requirements, provide one of following:
 - a. "Eucon 537 or RD2," Euclid Chemical Co.
 - b. "Daracem 100," GCP Applied Technologies (Grace)
- N. Non-Chloride, Non-Corrosive Water-Reducing, Accelerating Admixture: ASTM C 494, Type C or E.
- 1. Products: Subject to compliance with requirements, provide one of following:

- a. "Eucon AcN-Series," "Accelguard 80," "Accelguard NCA," or "Accelguard 90," Euclid Chemical Co.
 - b. "DCI," "PolaraSet," "Lubricon NCA," or "Gilco," GCP Applied Technologies (Grace)
 - c. "Pozzutec 20+" or "Pozzolith NC 534," BASF Construction Chemicals.
 - d. "Sika Set NC," "Plastocrete 161FL," or "Sika Rapid-1," Sika Corporation.
 - e. "Catexol 2000 RHE," Axim Concrete Technologies.
- O. Water-Reducing or retarding Admixture: ASTM C 494, Type D or B.
1. Products: Subject to compliance with requirements, provide one of following:
 - a. "Eucon Retarder-75," "Eucon DS" or "Eucon W.O." Euclid Chemical Co.
 - b. "Daratard-17" or "Recover," GCP Applied Technologies (Grace)
 - c. "Pozzolith Series" or "Delvo Series," BASF Construction Chemicals.
 - d. "Sikatard Series," or "Plastiment Series" or "Plastocrete Series," Sika Corporation.
 2. Products:
 - a. "ASRx 30LN," BASF Construction Chemicals.
 - b. "Eucon Integral ARC," Euclid Chemical Co.
 - c. "Sika Control ASR," Sika Corporation.
 - d. "Rasir," GCP Applied Technologies (Grace)
 3. Include water content in admixture when calculating water-to-cement ratio.
 4. Provide satisfactory CE CRD-C667 results with lithium admixture as defined in "Alkali-Aggregate Reactivity Resistance" paragraph below.
- P. Shrinkage Reducing Admixture:
1. Design requires using materials with combined drying shrinkage characteristic of 0.04 percent maximum at 28 days. Proposed concrete Mixture(s), using actual aggregates, admixtures and cement of the proposed mix for Project as detailed herein and in Drawings, shall meet criteria. Submit ASTM C 157 (may be modified by curing period duration) results for at least 3 specimens. Test takes 28 days minimum. Begin tests as soon as possible so final test results available for submittal to Engineer.
 2. Products: Subject to compliance with requirements, provide one of following:
 - a. If calcium nitrite is present in the original concrete mixture:
 - 1) "Eclipse 4500," GCP Applied Technologies (Grace)
 - 2) "Eucon SRA +" Euclid Chemical Company.
 - 3) "Sika Control 40," Sika Corporation.
 - b. If calcium nitrite is not present in the original concrete mixture:
 - 1) "Eucon SRA," or "Eucon SRA+," Euclid Chemical Company.
 - 2) "Eclipse Plus," GCP Applied Technologies (Grace)
 - 3) "Tetraguard AS 20," BASF Construction Chemicals.
 - 4) "Sika Control 40," Sika Corporation.
 - 5) "SRA-157," Russ Tech Admixtures, Inc.

2.6 FIBER REINFORCEMENT:

- A. Polypropylene fibers for plastic shrinkage control in concrete members.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. "Fiberstrand 100," Euclid Chemical Co.

- b. "Mighty-Mono," Forta Corp.
 - c. "Polymesh," General Resource Technology.
 - d. "Gilco," or "Grace Fibers," or "Grace Microfibers," GCP Applied Technologies (Grace), Inc.
 - e. "Durafiber," Industrial Systems, Ltd.
 - f. "MasterFiber F or M Series," BASF Construction Chemicals.
 - g. "Fibermesh 150," Propex Concrete Systems.
 - h. "Sika Fibers," or "Sika Microfibers," Sika Corporation.
2. Additional requirements:
- a. Collated fibrillated materials: Dosage rate 1.0 lb/cu. yd. of concrete minimum, containing at least 3 million individual fibers.
 - b. Multifilament (microfilament) fibers: Dosage rate 0.5 lb/cu. yd. of concrete minimum, containing at least 25 million individual fibers. Minimum length 0.75 in.
 - c. Meet requirements of ASTM C 1116, "Standard Specification for Fiber-Reinforced Concrete and Shotcrete," designation Type III,
 - d. Meet minimum plastic shrinkage crack reduction of 70 percent when tested in accordance with ICBO ES, Appendix B (7-92).
- B. Use shall not change water requirement of mix. Slump loss due to addition of fiber shall be offset by addition of superplasticizer.
- C. Conform to manufacturer's recommendations for quantity of fiber. See paragraph "Additional Requirements" above for minimums.
- D. See Drawings for locations of allowable use.
- E. Fiber manufacturer or approved distributor: Provide services of qualified representative at pre-construction meeting, concrete pre-installation meeting and first concrete placement containing fibers.

2.7 WATERSTOPS

- A. Flexible Rubber Waterstops: CE CRD-C 513, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
- 1. Profile: Flat, dumbbell without center bulb.
- B. Flexible PVC Waterstops: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
- 1. Profile: Flat, dumbbell without center bulb.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Rubber Waterstops:
 - a. Greenstreak.
 - b. Progress Unlimited Inc.
 - c. Williams Products, Inc.
 - 2. PVC Waterstops:
 - a. Greenstreak.

- b. Meadows: W.R. Meadows, Inc.
 - c. Progress Unlimited Inc.
 - d. Sternson Group.
- D. Self-Expanding Strip Waterstops: Manufactured rectangular or trapezoidal strip, butyl rubber with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Superstop; Tremco Inc.
 - b. Volclay Waterstop-RX; Colloid Environmental Technologies Co.
 - c. Hydrotite; Greenstreak.
 - d. Mirastop; Miradri, Div. Of Royal Ten Cate (USA), Inc.
 - e. Superstop; Progress Unlimited Inc.
 - f. SikaSwell Profile; Sika Corporation.

2.8 VAPOR BARRIERS

- A. Vapor Barrier: Provide vapor barrier which conforms to ASTM E 1745, Class A. The membrane shall have a water-vapor transmission rate less than or equal to 0.008 gr./ft²/hr when tested, in accordance with ASTM E96. Vapor barrier shall be no less than 15 mils thick. The vapor barrier shall be placed over prepared base material where indicated below slabs on ground.
- 1. New ISO certified virgin resins, polyolefin based maximum.
 - 2. Available Product: Subject to compliance with requirements, a product that may be incorporated into the Work includes, but is not limited to "Griffolyn Vaporguard" by Reef Industries, Inc., Stego Wrap (15-Mil) Vapor Barrier by Stego Industries LLC, or Perminator (15 Mil) Underground Vapor Barrier by W.R. Meadows,.
- B. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

2.9 CURING MATERIALS

- A. Evaporation Reducer: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- 1. Evaporation Retarder:
 - a. Cimfilm; Axim Concrete Technologies.
 - b. Aquafilm; Conspec Marketing & Manufacturing Co., Inc.
 - c. Eucobar; Euclid Chemical Co.
 - d. E-Con; L&M Construction Chemicals, Inc.
 - e. Confilm; BASF Construction Chemicals, LLC.
 - f. SikaFilm; Sika Corporation.
 - g. Sure-Film (J-74); Dayton Superior Corporation.
 - h. "EVRT", Russ Tech Admixtures, Inc.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.

- C. Moisture-Retaining Cover: Polyethylene coated burlap comprised of a minimum 4 mil polyethylene extruded onto 10- ounce burlap with components complying with AASHTO M171, AASHTO M182 Class II and ASTM C-171. The cover shall be suitable for multiple uses. Acceptable products:
 - 1. Hydracure M5 by Hydracure Covers
 - 2. Bur Lene by Max Katz Bag Co. Inc
 - 3. Curelap-Poly Coated Burlap by Midwest Canvas Corp.
 - 4. UltraCure DOT by Sika Corporation..
- C. Water: Potable.
- D. Curing Compound (VOC Compliant, less than 350 g/l): Comply with ASTM C 309, Type 1, Class A or B. Moisture loss shall be not more than 0.55 kg/m² when applied at 200 sq. ft/gal. Manufacturer's certification is required. Silicate based compounds prohibited.
 - 1. Subject to project requirements provide one of the following products:
 - a. "Kurez DR VOX" or "Kurez RC," or "Kurez RC Off," Euclid Chemical Company.
 - b. "RxCure WB," or "RxCure VOC" or "W.B. Cure VOC," Conspec Marketing & Manufacturing.
 - c. "Kure N Seal W" or "Kure N Seal WB" BASF Construction Chemicals, LLC.
 - 2. Additional requirements:
 - a. With product submittal provide plan and procedures for removal of residual curing compound prior to application of sealers, coatings, stains, pavement markings and other finishes.
 - b. Provide a summary of testing to show adequate surface preparation for successful application of sealers, coatings, stains, pavement markings, and other finishes.

2.10 RELATED MATERIALS

- A. Bonding Additive: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- B. Epoxy-Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements, and as follows:
 - 1. Type II, non-load bearing, for bonding freshly mixed concrete to hardened concrete.
 - 2. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- C. Reglets: Fabricate reglets of not less than 0.0217-inch- thick galvanized steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
- D. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

- E. Mechanical and chemical anchors as specified on the drawings or used for attaching supports for miscellaneous electrical, plumbing and mechanical components along with repairs for missing embedded anchor bolts shall be manufactured by Hilti Fastening Systems, Tulsa Oklahoma, ITW Ramset/Red Head, Wood Dale, IL, Simpson Anchor Systems, Columbus, OH, Powers Fasteners, Brewster, NY, SimpsonStrong-Tie Co., Inc., Pleasanton, CA, Powers Fasteners, Brewster, NY, or accepted equivalent. Anchor bolt composition shall be from one or more of carbon steel and stainless steel, lead, Zamac alloy, nylon, plastic, polypropylene, and jute fiber.
1. Strength of all anchors shall comply with ICC-ES-AC 193 or ICC-ES AC308 and ACI 318-11 Appendix D.
 2. Carbon steel anchors shall be either zinc plated in accordance with ASTM B 633, or hot-dipped galvanized in accordance with ASTM A-153-78. Provide mill test reports and manufacturer's quality control certification upon Engineer's request.
 3. Stainless steel anchors shall be manufactured from ASTM A304, or A663 stainless steel. Provide mill test reports and manufacturer's quality control certification upon Engineer's request.
 4. Plastic, lead, or Zamac alloy anchors shall not be used for overhead applications. Chemical anchors shall not be used to resist pullout forces in overhead and wall installations unless proper consideration is given to fire conditions. For chemical anchors, consult with manufacturer's engineer.
 5. Safety Factors: Static load safety factors shall be per manufacturer's published data. Critical load (vibratory, overhead, etc. or more) safety factors shall be 10:1 minimum. Chemical anchors are not permitted for critical loads and where resistance to direct sustained tension is required.
 - a. If necessary for purposes of determining tensile and/or shear capacity in questionable base material, testing shall be done prior to actual anchor installation. Proof load, load duration and ASTM procedures will be provided for the testing procedure. A maximum of five tension and/or shear tests shall be performed by manufacturer's engineer. Anchors shall be proof loaded in tension and/or shear to assure that working load capacity is within specified allowable load limit as published by manufacturer.
 6. Anchor spacing and edge distance per manufacturer's limits. Loading and cluster spacing shall be as established by minimum industry standards for anchors, except as follows: Anchor loading, cluster spacing and edge distances shall be as published in manufacturer's literature. Consult with manufacturer's engineer for specific requirements.
 7. Anchor installation shall be as required by manufacturers written instructions.
 8. Refer to the general notes for additional information on "Post-Installed Anchors".
- F. Inserts and Coil Rods:
1. Yield strength: 65,000 psi minimum.
 2. Galvanizing: Where indicated, electrodeposited zinc coating, ASTM B 633, Service condition 1, Type III.
 3. Acceptable manufacturers:
 - a. Dayton/Richmond Concrete Accessories, Inc., Miamisburg, OH.
 4. Details shown on drawings are based on Dayton/Richmond Concrete Accessories, Inc. products and their respective capacities. Other products may

be used only if contractor submits calculations, sealed by professional engineer or structural engineer licensed in Florida, substantiating strength of connection with other product. Calculations are subject to Engineer's acceptance before fabrication is to proceed.

G. Joint Filler:

1. Joint filler in slabs and curbs: Asphalt impregnated fiber board; as shown on Drawings. Acceptable products:
 - a. "Flexcell," Knight-Celotex Corp.
 - b. "Fibre Expansion Joint," W.R. Meadows, Inc.
2. Joint filler used vertically to isolate walls from columns or other walls: White molded polystyrene beadboard type.
3. Joint cover used to bridge gap between columns and grade walls, retaining walls, or basement walls: Minimum width: Gap width plus 4 in. For gaps over 3 in. wide, protect cover with protection board sized to span gap satisfactorily. Acceptable products:
 - a. "Sealtight Melgard," W.R. Meadows, Inc., Elgin, Illinois and shall be applied according to manufacturer's instructions.
 - b. Acceptable substitute.

H. Slide Bearing System at Expansion Joints:

1. Provide slide bearing system as shown and detailed on Drawings:
 - a. Beam and double tee bearings shall be reinforced PTFE: 100 percent virgin tetrafluoroethylene polymer and ground glass fiber reinforcing aggregate, prebonded to stainless steel and/or preformed fabric (Section "Plant Precast Structural Concrete," Part 2 Article "Materials," paragraph "Bearing Pads") bearing pads. Acceptable slide bearing systems:
 - 1) "Fluorogold," Seismic Energy Products, L.P. Pine Brook, New Jersey.
 - 2) "Balco," Balco, Inc., Wichita, Kansas.
 - 3) "Alert 15175 Shock Pads with TFE," Alert Manufacturing and Supply Co. Chicago, Illinois.
 - 4) "Dura-Slide," Tobi Engineering, Inc., Elk Grove Village, Illinois.
 - 5) "Dynalon Slide Bearings with Masticord," JVI, Inc., Skokie Illinois.
 - b. Slab and plank bearings shall be ultrahigh molecular weight, high-density polyethylene resin: Acceptable material:
 - 1) "Korolath PE," Korolath Corporation, Hudson, Mass.
 - 2) "Tivar-1000," Poly-Hi/Menasha Corporation, Fort Wayne, Indiana.
 - 3) "UHMW Econ-o-Shim," Deslausiers, Inc., Bellwood IL.
2. Backing materials for reinforced PTFE slide bearing systems as shown on Drawings:
 - a. Galvanized steel.
 - b. Stainless steel.
 - c. Reinforced elastomer, having durometer hardness of 90 +/- 5 and meeting requirements of Article 2.10.3(L) of AASHTO Standard Specifications for Highway Bridges (1983).

2.11 REPAIR MATERIALS

A. Acceptable repair materials:

1. Extended Open Time Epoxy Bonding Agent: Three-component, water based, epoxy modified portland cement bonding agent and corrosion inhibitor coating providing the recommended Manufacturer's open time in which to apply repair mortar. Product shall be capable of achieving bond strength of 2,700 psi per ASTM C 882.
 - a. "Duralprep A.C.", by The Euclid Chemical Company, Cleveland, OH.
 - b. "Emaco P24", by BASF Building Systems, Shakopee, MN.
 - c. "Sika Armatec 110 EpoCem", by Sika Corporation, Lyndhurst, NJ.
 - d. "Planibond 3-C" or "Mapefer 1K", by Mapei Corporation, Deerfield Beach, FL.
2. Epoxy Adhesive: 2 or 3 component, 100 percent solids, 100 percent reactive compound suitable for use on dry or damp surfaces:
 - a. "Euco #452 Epoxy Series", or "Duralcrete Epoxy Series", by The Euclid Chemical Company, Cleveland, OH
 - b. "Emaco P24", or "Concresive Liquid LPL", by BASF Building Systems, Shakopee, MN.
 - c. "Sikadur 32 Hi-Mod LPL" by Sika Corporation, Lyndhurst, NJ.
3. Trowel Applied Repair Mortar: Shall be prepackaged polymer-modified cementitious repair mortar capable of vertical/overhead application by trowel achieving a minimum 3,000 psi compressive strength at 7 days and 5,000 psi compressive strength at 28 days per ASTM C 109 as certified by manufacturer. All patches shall be squared or rectangular in shape with 1/2" deep sawcut edges, except at locations of reinforcement or tendons. Minimum repair thickness shall be 1/2" unless specified greater by the manufacturer and maximum lift thickness according to manufacturer requirements.
 - a. "EMACO R Series", "Thorite Rapid Vertical", or HBA or HB2 Repair Mortars", by BASF Building Systems, Shakopee, MN.
 - b. "Duraltop Gel", "Speedcrete PM", or "Verticoat", by The Euclid Chemical Company, Cleveland, OH.
 - c. "SikaRepair 223 with Latex R", "SikaRepair SHB with Latex R", or SikaRepair SHA with Latex R", by Sika Corporation, Lyndhurst, NJ.
 - d. "Planitop 23" by MAPEI Corporation, Deerfield, FL.
4. Horizontal Repair Mortar: Shall be prepackaged polymer-modified, cementitious repair mortar capable of horizontal, pour and screed, form and pour, partial depth, partial and full depth, or full depth applications. Material shall achieve a minimum 3,000 psi compressive strength at 7 days and 5,000 psi compressive strength at 28 days per ASTM C109 if neat and ASTM C39 if extended as certified by manufacturer. Manufacturer shall submit volume and size of SSD aggregate used for mix extension. All patches shall be squared or rectangular in shape with 1/2" deep sawcut edges, except at locations of reinforcement or tendons. Minimum thickness shall be 1/2" and maximum thickness of placement according to manufacturer requirements.
 - a. "Duraltop Flowable Mortar", by The Euclid Chemical Company, Cleveland, OH.
 - b. "Emaco S66 CI", or "Emaco R310 CI", by BASF Building Systems, Shakopee, MN.
 - c. "SikaTop 111 Plus", "Sikatop 122 Plus", or Sika Repair 222 with Latex R", by Sika Corporation, Lyndhurst, NJ.
 - d. "LS-S6 or S10" or "LM-S6 or S10", by King Packaged Materials Company, Burlington, ON.

- e. "Topcem Premix with Planitop AC", by MAPEI Corporation, Deerfield Beach, FL.
- 5. Immediate upon conclusion of finishing operation cure concrete in accordance with ACI 308 for duration of at least seven days by moisture curing or moisture retaining covering. Provide additional wet curing immediately following initial curing and as necessary before concrete has dried.
 - a. Continue method used in initial curing.
 - b. Material conforming to ASTM C171.
 - c. Other moisture retaining covering as approved by Engineer.
 - d. During initial and final curing periods maintain concrete above 50°.
 - e. Prevent rapid drying at end of curing period.

2.12 CONCRETE MIXTURES

- A. Proportion mixtures determined by either laboratory trial mix or field test data bases, as follows:
 - 1. Proportion normal-weight concrete according to ACI 211.1 and ACI 301.
 - 2. Provide different mixtures as the season warrants, as well as each type and strength of concrete or for different placing methods.
- B. Use a qualified independent testing agency for preparing and reporting proposed Mixture Proportions for the laboratory trial mix basis.
- C. Requirements for normal-weight concrete mix are shown on Drawings:
 - 1. Compressive strength
 - 2. Slump
 - 3. Water-cementitious materials ratio
- D. Supplementary cementitious materials: For concrete exposed to deicers, limit percentage, by weight, of cementitious materials according to ACI 318 requirements.
- E. Supplementary cementitious materials: Maximum weight of fly ash, natural pozzolans, processed ultrafine fly ash or slag included in concrete shall not exceed percentages of total weight (see footnotes for ACI 301 Part 4 Table "Requirements for Concrete Exposed to Deicing Chemicals") of cementitious materials as follows:
 - 1. Fly Ash or other pozzolans conforming to ASTM C 618: 25 percent.
 - 2. Slag conforming to ASTM C 989: 50 percent.
 - 3. Processed ultra fine fly ash conforming to ASTM C 618: 15 percent.
 - 4. Total of fly ash or other pozzolans and slag: 50 percent.
- F. Chloride Ion Content of Mixture:
 - 1. Water soluble chloride ion content of concrete shall not exceed 0.06 percent by weight of cement for pre-stressed concrete and 0.15 percent for reinforced concrete. (ACI 318 Chapter 4 Table 4.4.1 "Maximum Chloride Ion Content for Corrosion Protection of Reinforcement") Test to determine chloride ion content shall conform to ASTM C 1218.
 - 2. Concrete chloride ion content shall be determined by Testing Agency prior to placement. Cast samples from current production of concrete mix proposed for superstructure.
 - 3. Concrete not meeting the requirements of paragraph "Water soluble chloride ion content of concrete..." above, shall contain appropriate amount of calcium

nitrite. Concrete supplier shall provide laboratory test results showing the amount of excess chloride ion content in the concrete mixture contributed by the aggregates. For each pound of chloride ion in excess of the amount allowed, mix shall contain calcium nitrite (30 percent, plus or minus 2 percent, solids content) on one-to-one basis (one gallon of calcium nitrite for one lb of excess chloride ion). Calcium nitrate used to offset chloride ions is in addition to calcium nitrate used as a corrosion inhibitor. Maximum of 1.5 lb of chloride ion per cubic yard may be offset in this manner.

- G. Alkali-Aggregate Reactivity Resistance: Provide one of the following:
1. Total equivalent alkali content of mixture less than 5 lb/cu. yd.
 2. ASTM C1293: Expansion less than 0.04 % after 1 year for each of the aggregates (both coarse and fine) in the proposed concrete mixture. This data shall be less than 1 year old.
 3. ASTM C1260: Expansion less than 0.1 % after 14 days for each of the aggregates (both coarse and fine) in the proposed concrete mixture.
 4. ASTM C1567: Expansion less than 0.1 % after 14 days with each of the aggregates (both coarse and fine) and the supplementary cementing materials (both source and quantity) of the proposed concrete mixture design. Alternatively, if satisfactory ASTM C1260 test results can be provided for one of the aggregates that are being used, ASTM C1567 testing does not need to be provided for that aggregate.
 5. CE CRD-C662: Expansion less than 0.1 % after 28 days with the each of the aggregates (both coarse and fine), the supplementary cementing materials (both source and quantity) of the proposed concrete mixture design and the lithium admixture source and dosage level of the proposed mixture design. Alternatively, if satisfactory ASTM C1260 test results can be provided for one of the aggregates that are being used, CRD-C662 testing does not need to be provided for that aggregate.
- H. Synthetic Fiber (collated fibrillated or monofilament): Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 1 lb/cu. yd.
- I. Admixtures: Use admixtures according to manufacturer's written instructions.
1. Consider using water-reducing admixture or high-range water-reducing admixture (Superplasticizers), OR admixtures that achieve self-consolidating concrete, as required, for placement, workability, finishing and when required, increased flowability.
 2. Consider using water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 3. Use high range water-reducing admixture in pumped concrete, concrete for parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio of 0.45 or less. Use normal or mid-range water reducing admixture for concrete with water-cementitious materials ratio greater than 0.45.
- J. Slump (ACI 301, Part 4 header "Slump"):
1. Maximum slump for concrete is indicated on Drawings. Where field conditions require slump to exceed that shown, increased slump shall be obtained by use of high range water reducers (superplasticizers) only, and Contractor shall

obtain written acceptance from Engineer who may require an adjustment to mix.

2. All concrete containing high-range water-reducing admixture (superplasticizer) shall have a verified initial slump of 2– 3 in. Final slump after the addition of the superplasticizer shall be 6–9 in. as required by the contractor to properly place the concrete. Before permission for plant addition of superplasticizer to be granted by Engineer, fulfill following requirements:
 - a. Submit letter from testing laboratory which developed original mixture proportions, for each superplasticized mixture, certifying volume of mix water which will produce specified slump and water/cement ratio, taking into account aggregate moisture content.
 - b. Submit plant computer printout of mixture ingredients for each truckload of superplasticized concrete with delivery of that truckload. Mix water volume greater than that certified shall be cause for concrete rejection.
 - c. Over-retarding or crusting of flatwork surface: cause for concrete rejection.
 - d. Segregation or rapid slump loss (superplasticizer life) due to incompatibility or under-dosing: cause for concrete rejection.

K. Shrinkage (Length Change):

1. Determine length change of hardened concrete test specimens in accordance with ASTM C 157, except as noted in paragraph below. Existing test data from previous project with same materials may be acceptable.
2. Test specimens shall be moist cured, including period in molds for 7 days. Then store specimens in air for period of 28 days.
3. Utilize concrete materials and mix proportions submitted, for use in floor slab beam, in accordance with Part 1 Article "Submittals".
4. Report length change of specimens after periods of air drying after curing of 4, 7, 14, 21, and 28 days.
5. Average length change after 28 days shall be limited to 0.04%, unless otherwise accepted by Engineer. Values exceeding 0.04% shall be rejected.

L. Self-Consolidating Concrete:

1. Minimum flow of 24 in. to 28 in. or as required by the successful test placement. All self-consolidating concrete shall contain the specified high-range water-reducing admixture and viscosity-modifying admixture as required.
2. Measure slump flow using slump cone upright or inverted in accordance with ASTM C1611. Measured flow shall be greater than 24 inches and consistent with submitted mixture test parameters plus or minus 2 in.
3. Measure passing ability in accordance with ASTM C 1621/C 1621M. Use the slump cone in the same way as in the slump flow test. Difference in average slump flow between slump flow and passing ability tests shall not exceed 2 in.
4. Determine the static segregation (stability) in accordance with ASTM C 1610/C 1610M. Segregation factor of the mixture shall not be more than 15 percent.

- M. Engineer's acceptance of mixture proportions shall not relieve Contractor from responsibility for any variation from requirements of Contract Documents unless Contractor has in writing called Engineer's attention to each such variation at time of submission and Engineer has given written approval of each such variation.

- N. Adjustment to Concrete Mixtures: Adjustments to mixture proportions may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Engineer. Laboratory test data for revised mixture and strength results shall be submitted to and accepted by Engineer before using in work.

2.13 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.14 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94 and ASTM C 1116, and furnish batch plant-printed ticket information at delivery to site.
 - 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Provide plant-printed batch ticket for each batch discharged and used in work, indicating project identification name and number, date, mixture identification number, date, time of batching, mixing time, quantity and details of materials, amount of water introduced and water permitted by plant to be added, if any.
- C. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least one and one-half minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For mixer capacity larger than 1 cu. yd. increase mixing time by 15 seconds for each additional 1 cu. yd.
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, mixture identification number, date, time of batching, mixing time, quantity and details of materials, and amount of water added. Record approximate location of final placement in structure.

2.15 TOOLS

- A. Slab Jointing
 - 1. Concrete groovers: For tooled joints in concrete:
 - a. For concrete not exceeding 4 in. thickness, use groover with 1 in. deep v-cut bit, 0.5 in. surface width and 3/16 in. to 1/4 in. edge radius.
 - b. For concrete exceeding 4 in. thickness, use groover with 1.5 in. deep v-cut bit, 0.5 in. surface width and 3/16 in. to 1/4 in. edge radius.
 - 2. Saw Cut Joints:

- a. Acceptable tool: "Soff-Cut Saw Model 310" or "Model G2000," Soff-Cut International, Corona, CA.
 - 1) Cut joint as soon as concrete will support weight of operator and saw without deforming.
 - 2) Joint shall be 1 in. deep for concrete thickness of 4 in. or less. Joint shall be 1.5 in. deep for concrete exceeding 4 in. thickness. Do not cut reinforcement.
 - 3) Extend joint to adjacent vertical surface within 30 minutes of cutting.
 - 4) Retool or grind sawcut joint before installing sealant to provide equivalent dimensions, shape and volume as joint obtained by tooled joint. Surface width shall be 0.5 in. with 3/16 to 1/4 in. edge radius.
 - 5) All joints subject to acceptance by sealant installer. Rework rejected joints until acceptable to sealant installer.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads and in accordance with Article 1.5 "Contractor's Professional Services – Performance and Design Criteria".
- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117, except as modified below:
 1. Drilled Pier Caps and Pile Caps:
 - a. Variation of center from specified plan location: 0.5 in.
 - b. Variation of bearing surface from specified location: Plus or minus 0.5 in.
 - c. Variation from specified dimensions in plan: Plus 2 in. minus 0 in.
 - d. Variation decrease from specified thickness: 0.5 in.
 2. Footings:
 - a. Footings other than those to receive masonry construction: Variation of bearing surface from specified elevation: Plus or minus 0.5 in.
 - b. Footings to Receive Masonry Construction:
 - 1) Variation of center from specified location in plan: Plus or minus 0.25 in. in any 10 ft but not to exceed plus or minus 0.5 in.
 - 2) Variation of bearing surfaces for specified elevation: Plus or minus 0.25 in. in any 10 ft but not to exceed plus or minus 0.5 in.
 3. Piers, Columns, Walls, Beams, and Slabs:
 - a. Variation in cross-sectional dimensions of piers, beams and columns and in thickness of walls and slabs: 12 in. or less: Plus 0.375 in., minus 0.25 in. Greater than 12 in.: Plus 0.5 in., minus 0.375 in.
 - b. Variation in elevation from specified elevation for piers, columns and walls: Plus or minus 0.5 in.
 4. Anchor bolts: concrete contractor shall place anchor bolts within tolerances stated under heading "Anchor Bolts and Bearing Plates" of PCI "Code of Standard Practice for Precast Concrete."

C. Void Forms:

1. Protect all forms from moisture prior to concrete placement.
2. Install all forms and accessories in accordance with manufacturer's recommendations.
3. Protect all forms from puncture and moisture during concrete placement including accessories such as taped joints, seam pads and end caps.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

1. Install keyways, reglets, recesses, and the like, for easy removal.
2. Kerf wood inserts for easy removal.
3. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEMS

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

1. Install anchor bolts, accurately located, to elevations required.
2. Install reglets to receive top edge of foundation sheet waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
3. Install dovetail anchor slots in concrete structures as indicated.

3.3 REMOVING AND REUSING FORMS

- A. General: Formwork, for sides of beams, walls, columns, and similar parts of the Work, that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.
- B. Leave formwork, for beam soffits, joists, slabs, and other structural elements, that supports weight of concrete in place until concrete has achieved the following:
 - 1. At least 70 percent of 28-day design compressive strength.
 - 2. For post-tensioned concrete, formwork shall remain in place until post-tensioning has been completed. Do not place additional loads on structure until concrete has been properly reshored.
 - 3. Specified compressive strength of 5000 psi. Determine compressive strength of in-place concrete by testing representative field cured test specimens according to ACI 301.
 - 4. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- C. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
- D. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.4 SHORES AND RESHORES

- A. Comply with ACI 347.2, ACI 318 and ACI 301, for design, installation, and removal of shoring and reshoring and in accordance with Article 1.5 "Contractor's Professional Services – Performance and Design Criteria".
 - 1. Do not remove shoring until measurement of slab tolerances is completed.
- B. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.
- C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.5 VAPOR BARRIER

- A. Vapor Barrier: Place, protect, and repair vapor-barrier or vapor sheets according to ASTM E 1643 and manufacturer's written instructions.

3.6 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
 - 1. Do not cut or puncture vapor barrier. Repair damage and reseal vapor barrier before placing concrete.

- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain specified concrete cover. Do not tack weld crossing reinforcing bars.
 - 1. Shop- or field-weld reinforcement according to AWS D1.4, where indicated.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- E. Install welded wire reinforcement in longest practicable lengths on continuous bar supports spaced at 2 ft o.c., maximum. Lap edges and ends of adjoining sheets per ACI 318 and as follows:
 - 1. Length of overlap measured between outermost cross wires of each sheet shall not be less than one spacing of cross wires plus two inches nor less than one and one-half times the development length nor 6 in. minimum where development length is calculated per section 12.8 of ACI 318.
 - 2. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
- F. Splices:
 - 1. Provide standard reinforcement splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements of ACI 318 for minimum lap of spliced bars.
 - 2. For mechanical tension splices of reinforcement:
 - a. Column bar lengths shall not exceed 30 ft between splices. In any bar, no splices shall occur at any floor level.
 - b. Exercise care to assure that no reduction of cross-sectional area of reinforcement occurs.
 - c. For all mechanical splices, perform splicing in strict accordance with manufacturer's requirements and instructions.
 - d. Stagger splices in adjacent bars.
 - e. Except where shown on Drawings, welding of reinforcement prohibited without prior written authorization by Engineer.
 - 3. Compression splices: Mechanically coupled splices in accordance with ACI 318, Chapter 12.
 - 4. Welded wire reinforcement shall not extend through contraction joints.

3.7 JOINTS

- A. Joints in Concrete (ACI 301, Section 5):
 - 1. Construction, control and isolation joints are located and detailed on Drawings:
 - a. Tool joints at time of finishing. Tool: Part 2 Article "Tools."
 - b. Saw Cut Joints:
 - 1) Cut joint as soon as concrete will support weight of operator and saw without deforming.
 - 2) Joint shall be 1 in. deep for concrete thickness of 4 in. or less. Joint shall be 1.5 in. deep for concrete exceeding 4 in. thickness. Do not cut reinforcement.
 - 3) Extend joint to adjacent vertical surface within 30 minutes of cutting.

- 4) Retool or grind saw cut joint before installing sealant to provide equivalent dimensions, shape, and volume as joint obtained by tooled joint. Surface width shall be 0.5 in. with 3/16 in. to 1/4 in. edge radius.
 - 5) All joints subject to acceptance by sealant installer. Rework rejected joints until acceptable to sealant installer.
 - c. Isolation joints: Interrupt structural continuity resulting from bond, reinforcement or keyway.
 - d. Construction and control joints in walls: Space joints at 20 ft. on center unless smaller spacing is shown on Drawings.
 - e. Construction or control joints in floor slabs on ground: Maximum slab area controlled by jointing 400 sq ft. Space joints at 20 ft. on center maximum unless different spacing is shown on Drawings.
 - f. Coordinate configuration of tooled joints with control joint sealants.
- B. Provide keyways at least 1-1/2 in. deep in construction joints in walls and slabs. Accepted bulkheads designed for this purpose may be used for slabs.
- C. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints except as otherwise indicated. Do not continue reinforcement through sides of strip placements.
- D. Use bonding grout, containing the specified bonding admixture, on existing concrete surfaces that will be joined with fresh concrete.
- E. Isolation Joints in Slabs-on-Ground: Construct isolation joints in slabs-on-ground at points of contact between slabs-on-ground and vertical surfaces, such as column pedestals, foundation walls, grade beams, and elsewhere as indicated.
1. Joint filler and sealant materials are specified in Division 7 Sections of these Specifications.
- F. Contraction (Control) Joints in Slabs-on-Ground: Construct contraction joints in slabs-on-ground to form panels of patterns as shown.
1. Tool contraction joints.
 2. If joint pattern not shown, provide joints not exceeding 20 ft in either direction and located to conform to bay spacing wherever possible (at column centerlines, half bays, third bays).
- G. Joint sealant material is specified in Division 7 Sections.

3.8 WATERSTOPS

- A. Flexible Waterstops: Install in construction joints as indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of Work. Field-fabricate joints in waterstops according to manufacturer's written instructions.
- B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, bonding or mechanically fastening and firmly pressing into place. Install in longest lengths practicable.

3.9 CONCRETE PLACEMENT

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3. Use only the specified non-corrosive accelerator. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators, unless otherwise specified and approved in mixture proportions.
- G. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F 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. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.10 FINISHING FORMED SURFACES

- ~~As Cast Finishes: As cast concrete texture imparted by form facing material in accordance with ACI 301 and as specified below in accordance with Class of Finish:~~
- ~~Rough Form Finish: As cast concrete texture imparted by form facing material with tie holes and defective areas repaired and patched. Remove fins and other projections exceeding limits for class of surface specified.~~
 - ~~Provide class C finish as described in ACI 347, for surfaces permanently concealed from public view, unless otherwise noted in the Contract Documents. Class C permits gradual or abrupt irregularities of 1/2 inch.~~
- ~~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 defective areas. Remove fins and other projections exceeding limits for class of surface specified.~~
 - ~~Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, or painting.~~
 - ~~Provide class B finish as described in ACI 347. Class B permits gradual or abrupt irregularities of 1/4 inch.~~
- ~~Rubbed Finish: Apply the following to smooth-formed finished concrete to Architectural Exposed Concrete (AEC):~~
 - ~~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.~~
 - ~~Locations: Where indicated on drawings.~~
- A. Refer to Section 033300.

~~A. Refer to Section 033300.~~

3.11 FINISHING FLOORS AND SLABS

- A. Flatwork in Parking and Drive Areas (BROOM Finish, ACI 301, Section 5 header "Broom or Belt Finish"):
1. Bullfloat immediately after screeding. Complete before any excess moisture or bleed water is present on surface (ACI 302.1R, Article 8.3.3). The use of power trowels is discouraged; however, if they are used the following applies:
 - a. Use minimal passes so as to not overwork the concrete.
 - b. At the contractor's expense a petrographic analysis will be required in each area where a power trowel is used to verify the air content at the slab surface is within specified limits.
 - c. After excess moisture or bleed water has disappeared and concrete has stiffened sufficiently to allow operation, give slab surfaces coarse transverse scored texture by drawing broom across surface. Texture shall be as accepted by Engineer from sample panels.
 2. Finish tolerance: ACI 301, Paragraph 5.3.4.2 and ACI 117, paragraph 4.5.7: The gap at any point between the straightedge and the floor (and between the high spots) shall not exceed 0.5 in. In addition, floor surface shall not vary more than plus or minus 0.75 in. from elevation noted on Drawings anywhere on floor surface.
 3. Before installation of flatwork and after submittal, review, and approval of concrete mixture proportions, Contractor shall fabricate two acceptable test panels simulating finishing techniques and final appearance to be expected and used on Project. Test panels shall be minimum of 20 ft. by 30 ft. in area and shall be reinforced and cast to thickness of typical parking and drive area wearing surface in Project. (Maximum thickness of test panels need not exceed 6 in.) Test panels shall be cast from concrete supplied by similar concrete batch, both immediately after addition of superplasticizer or water-reducing admixture, and at maximum allowed time for use of admixture-treated concrete in accordance with Specifications. Intent of test panels is to simulate both high and low workability mixes, with approximate slump at time of casting of test panels to be 6 in. and 3 in., respectively. Contractor shall finish panels following requirements of paragraphs above, and shall adjust finishing techniques to duplicate appearance of concrete surface of each panel. Finished panels (one or both) may be rejected by Engineer, in which case Contractor shall repeat procedure on rejected panel(s) until Engineer acceptance is obtained. Accepted test panels shall be cured in accordance with Specifications and may be incorporated into Project. Accepted test panels shall serve as basis for acceptance/rejection of final finished surfaces of all flatwork.
 4. Finish all concrete slabs to proper elevations to ensure that all surface moisture will drain freely to floor drains, and that no puddle areas exist. Contractor shall bear cost of any corrections to provide for positive drainage.
- B. Flatwork in Stairtowers and enclosed, Finished Areas (Float Finish, ACI 301, Paragraph 5.3.4.2.b):
1. Give slab floated finish. Texture shall be as accepted by Engineer from sample panels.

2. Finishing tolerance ACI 301, Section 5 header "Measuring Tolerances for Slabs" and ACI 117, paragraph 4.5.7: The gap at any point between the straightedge and the floor (and between the high spots) shall not exceed 0.5 in. In addition, floor surface shall not vary more than plus or minus 3/8 in. from elevation noted on Drawings anywhere on floor surface.
- C. Flatwork in Stair towers and Parking Garage floor subject to pedestrian traffic:
 1. Refer to Section 033300.

3.12 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 Work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still workable and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.

3.13 CONCRETE PROTECTION AND CURING

- A. General: Comply with ACI 308.1. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.
- B. Evaporation Reducer: Apply evaporation reducer to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft./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. Do not finish immediately after evaporation reducer applied. Wait until after (green, if Confilm used – pink, if Eucobar used) film disappears.
- C. Formed Surfaces: Cure formed concrete surfaces of columns, walls, and upturned beams. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing 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. Tepid (within 20 deg F of concrete temperature) water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch 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, 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.
 3. Curing Compound: After Moisture or Moisture-Retaining-Cover Curing, 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. Apply two separate coats with first allowed to become tacky before applying second. Direction of second application shall be at right angles to direction of first.
 - b. Curing compound prohibited when concrete has specified water-cementitious materials ratio less than or equal to 0.40 or air temperature above 80 deg F. Use moist cure instead.
- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces, 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. Tepid (within 20 deg. F of concrete temperature) water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch 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, 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 recommends for use with floor coverings.
 3. Curing Compound: Where permitted, apply uniformly in continuous operation by power spray or roller immediately after final finishing and the absence of surface moisture, 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. Apply two separate coats with first allowed to become tacky before applying second. Direction of second application shall be at right angles to direction of first.
- b. Curing compound prohibited when concrete has specified water-cementitious ratio less than or equal to 0.40 or air temperature above 80 deg F. Use moist cure instead.
- c. Removal: If curing compounds are used on surfaces (exterior or interior, formed or unformed) that are scheduled or specified to receive surface-adhered treatment (including but not limited to cementitious toppings/overlays, adhesive applied carpet, resilient flooring, terrazzo, thin-set ceramic tile/stone, wood, coatings, paint, waterproofing, membranes, athletic flooring, epoxy overlay/adhesive, hardeners, sealers, water repellents, or other covering system adhered with water-based adhesive), then the following requirements apply:
 - 1) Remove curing compound no later than 7 days after end of curing period by mechanical bead blast process acceptable to Architect.
 - 2) Allow sufficient additional time after curing compound removal to achieve proper concrete moisture and/or water vapor limitation for successful application of subsequent surface treatment as specified in appropriate surface treatment specification Section.

3.14 CONCRETE SURFACE REPAIRS

- A. Defective Concrete: Repair and patch defective areas when approved by Engineer/Architect. Remove and replace concrete that cannot be repaired and patched to Engineer/Architect's approval.
- B. 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 sieve, using only enough water for handling and placing. Use this repair procedure only with Engineer/Architect approval.
- C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
 1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than ½ inch in any dimension in solid concrete but not less than 1 inch in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with specified bonding agent. Fill and compact with specified patching mortar before specified bonding agent has dried. Fill form-tie voids with specified patching mortar or cone plugs secured in place with specified bonding agent.
 2. Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area on mockup, or if none, at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Engineer/Architect.

4. Repair isolated random cracks that have little movement and single holes not over 1 in. in diameter in accordance with procedures and materials specified in Division 7 Section "Concrete Joint Sealants." Receive Engineer's written acceptance of methods and materials selected prior to application.
 - a. Repair isolated random horizontal cracks less than 0.01 in. wide, using silane sealer product specified in Division 7 "Water Repellants"
 - b. Repair isolated random horizontal cracks 0.01 in. to less than 0.03 in. wide, using crack sealer product specified in Division 7 "Water Repellants."
 - c. Repair isolated random horizontal cracks 0.03 in. to 0.06 in. wide: route and seal with specified sealant product in Division 7 "Concrete Joint Sealants."
 - d. Repair isolated random vertical cracks more than 0.01 in. wide, using epoxy injection product specified in part 2 heading "Related Materials" of this section.
- D. 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, pop-outs, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch 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 localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
 4. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of $\frac{1}{4}$ inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 5. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete or latex modified concrete as approved by the Engineer. Remove defective areas with clean, square cuts and expose steel reinforcement with at least $\frac{3}{4}$ inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mix as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
 6. Repair single holes 1 inch or less in diameter with patching mortar. 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.
 7. Repair isolated random cracks that have little movement and single holes not over 1 in. in diameter in accordance with procedures and materials specified in

Division 7 Section "Concrete Joint Sealants." Receive Engineer's written acceptance of methods and materials selected prior to application.

- a. Repair isolated random horizontal cracks less than 0.01 in. wide, using silane sealer product specified in Division 7 "Water Repellants"
 - b. Repair isolated random horizontal cracks 0.01 in. to less than 0.03 in. wide, using crack sealer product specified in Division 7 "Water Repellants."
 - c. Repair isolated random horizontal cracks 0.03 in. to 0.06 in. wide: route and seal with specified sealant product in Division 7 "Concrete Joint Sealants."
 - d. Repair isolated random vertical cracks more than 0.01 in. wide, using epoxy injection product specified in part 2 heading "Related Materials" of this section.
- E. Perform structural repairs of concrete, subject to Engineer/Architect's approval, using epoxy adhesive and patching mortar, latex modified concrete or other materials as approved by the Engineer.
- F. Repair materials and installation not specified above may be used, subject to Engineer/Architect's approval.

3.15 FIELD QUALITY CONTROL

- A. CM At Risk will employ a testing laboratory to perform tests and to submit test reports.
- B. Sample concrete in accordance with ASTM C 172.
- C. Temperature:
1. Test temperature of concrete in accordance with ASTM C 1064/C 1064M and ACI 301 each time cylinders are taken or as directed by the Engineer.
- D. Slump Test:
1. Conduct one slump test in accordance with ASTM C 143/C 143M per truck load of ready-mixed concrete delivered to Project at truck for superstructure concrete.
 2. Conduct slump test in accordance with ASTM C143/C 143M and ACI 301 for foundation concrete.
 3. When high-range water-reducing admixture (superplasticizer) is used, initial slump must be verified by Testing Agency.
- E. Slump Flow Test (SCC):
1. Conduct one slump flow test in accordance with ASTM C 1611/C 1611M per truck load of ready mixed concrete delivered to Project at truck for superstructure concrete.
 2. Conduct slump flow test in accordance with ASTM C1611/C 1611M and ACI 301 for foundation concrete.
- F. Water Content:
1. Water content and water-cementitious materials ratio shall be verified by use of the Microwave Test in accordance with AASHTO T 318.

2. Conduct test each time test cylinders are taken and as directed by Engineer.
- G. Concrete Compressive Strength:
1. Mold test cylinders in accordance with ASTM C 31 and test in accordance with ASTM C 31 as follows:
 - a. Take minimum of six cylinders (eight for post-tensioned cast-in-place concrete) for each 100 cu yd or fraction thereof, of each Mixture of concrete placed in any one day.
 - b. Additional cylinders shall be taken under conditions of cold weather concreting per Part 3 Heading "Concrete Curing and Protection."
 - c. At Contractor's option and cost, cylinders may be taken to verify concrete strength prior to form removal.
 - d. Testing Agency: Provide and maintain site cure box for cylinders.
 2. Sample plastic concrete for testing at point of final placement, in accordance with ASTM C 172. Engineer will select sampling locations which may include points where plastic concrete has already been screeded and floated. Sample concrete for test cylinders to be used to verify concrete compressive strength for post-tensioning as near as possible to actual tendon anchorages.
 3. Cover specimens properly, immediately after finishing. Protect outside surfaces of cardboard molds, if used, from contact with sources of water for first 24 hours after molding.
 4. Cure test cylinders per ASTM C 31 as follows:
 - a. To verify compressive strength prior to post-tensioning or form removal or for additional test cylinders required due to cold weather concreting conditions:
 - 1) Store test specimens on structure as near to point of sampling as possible and protect from elements in same manner as that given to portion of structure as specimen represents.
 - 2) Transport to test laboratory no more than 4 hours before testing. Remove molds from specimens immediately before testing.
 - b. To verify 28-day compressive strength:
 - 1) During first 24 hours after molding, store test specimens under conditions that maintain temperature immediately adjacent to specimens in range of 60 to 80 degrees F. and prevent loss of moisture from specimens.
 - 2) Remove test specimens from molds at end of 20 +/- 4 hours and store in moist condition at 73.4 +/- 3 degrees F. until moment of test. Laboratory moist rooms shall meet requirements of ASTM C 511.
 5. Compression test for non-prestressed concrete:
 - a. Test 2 cylinders at 7 days.
 - b. Test 2 cylinders at 28 days.
 - c. Test 2 cylinders at 56 days for concrete strength requirement of 7000 psi or greater, otherwise hold 2 cylinders in reserve for use as Engineer/Architect directs.

6. Compression tests for post-tensioned concrete:
 - a. Test 2 cylinders immediately before tensioning slabs and 2 cylinders before tensioning beams. Cylinders must be field cured in accordance with paragraph "Cure test cylinders per ASTM C 31...."
 - b. Test 2 cylinders at 28 days.
7. Hold 2 cylinders in reserve for use as Engineer directs.
8. Unless notified by Engineer, reserve cylinders may be discarded without being tested after 56 days.
- H. Report all nonconforming test results to Engineer and others on distribution lists via fax or email. Follow up with colored paper copies to flag the non-conformances.
- I. Monthly, submit a graph showing distribution of compressive strength test results and air content test results. Include microwave test results for concretes with a water cementitious ratio less than or equal to 0.40 concrete.

EVALUATION AND ACCEPTANCE OF CONCRETE

- J. Concrete Compression test will be evaluated by Engineer in accordance with ACI 301. If number of tests conducted is inadequate for evaluation of concrete or test results for any type of concrete fail to meet specified strength requirements, core tests may be required as directed by Engineer. Air content and parameters of air-void system shall meet requirements of this Section.
- K. Core tests, when required, in accordance with ASTM C42 and ACI 301.
- L. Should tested hardened concrete meet Specifications, Owner will pay for coring and testing of hardened concrete. Should tested hardened concrete not meet Specifications or should concrete have to be tested because Contractor did not conform to Project specifications, Contractor shall pay for coring and testing of hardened concrete and for any corrective action required for unaccepted concrete.

3.16 ACCEPTANCE OF STRUCTURE

- A. Acceptance of completed concrete Work will be according to provisions of ACI 301.
- B. "RAPIDLOAD" testing is acceptable, by Structural Preservation Systems, Baltimore, MD.

END OF SECTION

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

I. GENERAL INFORMATION:	
Project:	City:
General Contractor:	
Concrete Supplier:	
Mixture Identification No.:	Concrete Grade:
Use (Describe) ¹ :	

¹ example: Footings, interior flatwork, floor slabs, topping, columns, etc.

II. MIXTURE PROPORTIONING DATA:		
Proportioning Based on (Check only one):		
<p>Standard Deviation Analysis: _____(see section VIII)</p> <p>or Trial Mix Test Data: _____ (see Section IX)</p>		
Mixture	Density: _____ pcf;	Air: _____ % specified
Characteristics:	Slump _____ in. before superplasticizer	Slump _____ in. after superplasticizer
(see Mixtures in Drawings General Notes)	Or	for SCC: Spread _____ in.
	Strength: _____ psi (28 day);	

WALKER SUBMITTAL STAMP

CONTRACTOR
SUBMITTAL STAMP

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

III. MATERIALS:		
Aggregates: (size; type; source; gradation report; specification)		
Coarse:		
Fine:		
Other Materials:	Type	Product-Manufacturer (Source)
Cement:		
Flyash, slag, or other pozzolan:		
Silica Fume		
Processed Ultra Fine Fly Ash		
HRM		
Air Entraining Agent:		
Water Reducer		
High Range Water Reducer (HRWR / superplasticizer)		
Non-Corrosive Accelerator		
Retarder		
Fibers		
Other(s):		

IV. <u>MIX PROPORTIONS</u> ⁽²⁾		
	WEIGHT (lbs.) (per yd ³)	ABSOLUTE VOL. (cu. ft.) (per yd ³)
Cement:		
Fine Aggregate: ⁽³⁾		
Coarse Aggregate: ⁽³⁾		
Flyash, slag, or other pozzolan:		
Silica Fume		
Processes Ultra Fine Fly Ash		

HRM		
Water: ⁽⁴⁾ (gals. & lbs)		
Entrained Air: (oz.)		
Fibers:		
(Other) _____:		

TOTALS:		
NOTES: ⁽²⁾ Mix proportions indicated shall be based on data used in section VII or IX. ⁽³⁾ Based on saturated surface dry weights of aggregates. ⁽⁴⁾ Includes ALL WATER, including added water and free water contained on aggregates.		

V. <u>RATIOS</u>		VI. SPECIFIC GRAVITIES
Water ⁽¹⁾	lb	Fine Aggregate:
=	=	
Cementitious Material ⁽²⁾	lb	Coarse Aggregate:
Fine Agg.	lb	
=	=	
Total Agg.	lb	
NOTES: ⁽¹⁾ Includes ALL water, including added water and free water contained on aggregates. ⁽²⁾ Cementitious materials include cement, fly ash, slag, silica fume, HRM, Processed Ultra Fine Fly Ash or other pozzolan.		

VII. <u>ADMIXTURES</u>				
Air Entraining Agent (A.E.A.):	___ oz.	per yd ³	___ oz.	per 100# cement
Superplasticizer	___ oz.	per yd ³	___ oz.	per 100# cement
Water Reducer	___ oz.	per yd ³	___ oz.	per 100# cement
Non-corrosive Accelerator	___ oz.	per yd ³	___ oz.	per 100# cement
Retarder	___ oz.	per yd ³	___ oz.	per 100# cement
Other	___ oz.	per yd ³	___ oz.	per 100# cement
Lithium Nitrate	___ gal.	per yd ³		

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

VIII. <u>STANDARD DEVIATION ANALYSIS:</u>		<u>Yes</u>	<u>N/A</u>
(Complete this section only if Mixture was developed using standard deviation analysis of previous project test results. If other method was used, check "N/A".)			
<u>Number of Tests Evaluated:</u> (One test is average of two cylinder breaks)		<u>Standard Deviation:</u> (Single Group)	
<u>Attach copy of test data considered:</u>		<u>Standard Deviation:</u> (Two Groups)	
Required average compressive strength: $f'_{cr} = f'_c + \underline{\hspace{2cm}}$ psi			
<p>NOTE:</p> <p>Mixture shall be proportioned in accordance with ACI 301 section 4.2.3 to achieve average compressive strength f'_{cr} equal to or greater than the larger of one of the following equations:</p> <p>(4.-3) $f'_{cr} = f'_c + 1.34ks$ [s= calculated standard deviation]</p> <p>or</p> <p>(4-4) $f'_{cr} = f'_c + 2.33ks - 500$</p> <p>or</p> <p>(4-5) $f'_{cr} = 0.9f'_c + 2.33ks$ (for $f'_c > 5,000$ psi)</p> <p>(Refer to ACI 301 for required average when data are not available to establish standard deviation. For post-tensioning projects, see also special requirements for strength required to apply initial post-tensioning.)</p>			
MIXTURE CHARACTERISTICS (As shown on drawings)			
Slump = <u> </u> in.		Air Content = <u> </u> %	
Unit Wet Wt. = <u> </u> pcf		Unit Dry Wt. = <u> </u> pcf	
MIXTURE CHARACTERISTICS (Based on proportioning data)			
Initial Slump = <u> </u> in.		Final Slump <u> </u> in.	
Unit Wet Wt.= <u> </u> pcf.		Unit Dry Wt. = <u> </u> pcf.	
Air Content = <u> </u> %			

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

IX. TRIAL MIXTURE TEST DATA:		Yes	N/A
(Complete this section only if Mixture Proportion is based on data from trial test mixture(s) batched by testing agency or Contractor. If other method was used, check "N/A".)			
Age (days)	Mix #1 (comp. str.)	Mix #2 (comp. str.)	Mix #3 (comp. str.)
7			
7			
28			
28			
28			
28 day average compressive strength, psi			
<p>NOTE:</p> <p>Mixture shall be proportioned in accordance with ACI 301 section 4.2.3 to achieve average compressive strength f'_{cr} equal to or greater than the larger of one of the following equations:</p> <p>(Less than 3000) $f'_{cr} = f'_c + 1000$</p> <p>or</p> <p>(3000 to 5000) $f'_{cr} = f'_c + 1200$</p> <p>or</p> <p>(Over 5000) $f'_{cr} = 1.1f'_c + 700$</p> <p>For post-tensioning projects, see also special requirements for strength required to apply initial post-tensioning.</p>			
MIXTURE CHARACTERISTICS (as shown on drawings)			
Slump = _____ in.		Air Content = _____ %	
Unit Wet Wt. = _____ pcf		Unit Dry Wt. = _____ pcf	
MIXTURE CHARACTERISTICS (Based on proportioning data)			
Initial Slump = _____ in.		Final Slump _____ in.	
Unit Wet Wt.= _____ pcf.		Unit Dry Wt. = _____ pcf.	
Air Content = _____ %			

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

X. OTHER REQUIRED TESTS			
Water Soluble Chloride Ion Content of mix:	_____ % (by weight of cement)		ASTM C 1218
Hardened Air Content (per ASTM C457):			
Air content: _____ %	Air void spacing Factor _____ in.	Specific surface: _____ in ² /in ³	
Chloride Ion Content of Concrete Mixture: ASTM C 1218			
Shrinkage (Length Change, Average) per ASTM C157:			
_____ % @ 4 days	_____ % @ 7 days	_____ % @ 14 days	
_____ % @ 21 days	_____ % @ 28 days		

XI. Remarks:

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CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

Ready Mix Concrete Supplier Information
Name:
Address:
Phone Number:
Date:
Main Plant Location:
Miles from Project Site:
Secondary or Backup Plant Location:
Miles from Project Site:

My signature below certifies that I have read, understood, and will comply with the requirements of this Section.

Signature _____

Typed or Printed Name

REQUIRED ATTACHMENTS	
	Coarse aggregate grading report
	Fine aggregate grading report
	Concrete compressive strength data used for calculation of required average strength and for calculation of standard deviation
	Chloride ion data and related calculations
	Admixture compatibility certification letter
	Shrinkage information per ASTM C157
	ASTM C 457
	Alkali Content Data and Calculations OR ASTM C1293, ASTM C1260, ASTM C 1567 or CE CRD-C662 Test report for each aggregate

SECTION 03 3001 - CAST-IN-PLACE CONCRETE - PARKING GARAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this Section.

1.2 SUMMARY

- A. This Section specifies cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture proportions, placement procedures, finishes, architectural finishes, and other miscellaneous items related to cast-in-place concrete.
- B. Cast-in-place concrete includes project requirements specified herein and on drawings:
 - 1. Water/cementitious materials ratio: See General Notes on Drawings.
 - 2. Water Reducing Admixture: See Part 2 Article "Admixtures."
 - 3. High strength: See General Notes on Drawings.
- C. Work in other Sections related to Cast-in-Place Concrete:
 - 1. Division 1 Section "Project Management and Coordination."
 - 2. Division 1 Section "Quality Control."
 - 3. Division 3 Section "Post-Tensioned Concrete (Parking Garage)."
 - 4. Division 7 Section "Traffic Coatings (Parking Garage)."
 - 5. Division 7 Section "Water Repellants (Parking Garage)."
 - 6. Division 7 Section "Expansion Control (Parking Garage)."
 - 7. Division 7 Section "~~Concrete~~ Joint Sealants (Parking Garage)."
 - 8. Division 9 Section "Painting ~~(Parking Garage)~~."

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans and ground granulated blast-furnace slag.
- B. Self-Consolidating Concrete (SCC): Highly flowable, non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation.

1.4 ACTION SUBMITTALS

- A. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 - 1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance
 - b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)

b. Corporate Sustainability Reporting (CSR's)

- B. Submit Product data for concrete component materials and other concrete related items, including, but not limited to:
 - 1. Material Certificates: Signed by Manufacturer that each of the following items complies with requirements:
 - a. Cementitious materials and aggregates
 - b. Admixtures
 - c. Form materials and form-release agents
 - d. Steel reinforcement and accessories
 - e. Fiber reinforcement
 - f. Waterstops
 - g. Curing materials
 - h. Floor and slab treatments
 - i. Bonding agents
 - j. Vapor barriers/reducer
 - k. Repair materials
 - 2. Submit certification that curing compound or evaporation reducer, if used, is compatible with sealer specified in Division 7 Section "Water Repellants", traffic topping specified in Division 7 section "Traffic Coatings", sealant specified in Division 7 Sections "~~Concrete~~ Joint Sealants – Parking Garage" and "~~Architectural~~ Joint Sealants", and expansion joint assemblies specified in Division 7 Section "Expansion ~~Joint Assemblies~~Control – Parking Garage."
 - 3. Submit certification that curing compound or evaporation reducer is compatible with pavement markings specified in Division 9.
- C. Submit materials certificates in lieu of materials laboratory test reports when permitted by Engineer. Materials certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with or exceeds specified requirements. Provide certification from admixture manufacturers that chloride content complies with specification requirements.
- D. Submit evidence of licensure in Florida for professional engineer providing professional services as required for Contractor in order to carry out the Contractor's responsibilities for construction means, methods, techniques, sequences and procedures.
 - 1. Contractor's responsibilities include formwork, shoring and re-shoring procedures, and other work described in Article "Contractors Professional Design Services", Article "Formwork", and Article "Shores and Re-shores".
 - 2. Performance and design criteria are shown on the Drawings and in Article "Contractor's Professional Services- Performance and Design Criteria".
 - 3. Contractor's Professional Engineer shall furnish Owner a Certificate of Professional Liability Insurance in the amounts required per Division 1 of the specifications.
 - 4. Submit calculations and dimensions for "Nominal Form Width" for linear gap at time of forming or erecting concrete elements bounding the expansion joints in accordance with Drawings and Specification "Expansion Joint Assemblies".
- E. Submit concrete mixture proportions to Engineer for each concrete mixture. Submit alternate mixture proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1. Provide mixture proportions not less than four weeks before placing concrete and not less than one week before pre-installation conference (pre-concrete meeting).
 2. Proportion mixtures as defined in ACI 301 Section 4 header "Proportioning," Mixtures shall be proportioned by party other than Testing Agency responsible for testing Project concrete.
 3. Proportion mixtures to minimize effects of thermal and drying shrinkage. See Part 2 heading "Concrete Mixtures" header "Shrinkage" for drying shrinkage limit.
 4. Use mixture proportions submission form at end of this Section for each concrete mixture, which identifies the following:
 - a. Mixture Proportions Identification and use.
 - b. Method used for documentation of required average compressive strength, (ACI 301 Section 4 – *Field test data* or *Trial mixtures*).
 - c. Gradation of fine and coarse aggregates.
 - d. Proportions of all ingredients including all admixtures added either at time of batching or at job site.
 - e. Water/cementitious materials ratio.
 - f. Slump, ASTM C143.
 - g. Certification of the chloride content of admixtures.
 - h. Strength at 4 and 28 days, per ASTM C39. In addition, for post-tensioned concrete provide a strength gain curve with sufficient number of data points from 6 to 96 hours to accurately estimate when the minimum compressive strength for tensioning the concrete will be achieved. See Section "~~Post Tensioned Concrete – Parking Garage~~~~Unbonded Post-Tensioned Concrete.~~"
 - i. Water soluble chloride ion content of concrete: ASTM C 1218.
 - j. Rapid Chloride Permeability test results per ASTM C 1202.
 - k. Shrinkage (length change), ASTM C157 (modified) for cast-in-place post-tensioned concrete only. See Part 2 heading "Concrete Mixtures" header "Shrinkage" for modifications to ASTM C157.
 - l. Certificate of analysis of coal fly ash or processed ultra fine fly ash: Comply with ASTM C618, Class C or F:
- F. Testing Agency: Promptly report all field concrete test results to Engineer, Contractor and Concrete Supplier. Include following information:
1. See Article "Quality Assurance."
 2. Density (unit weight) of concrete, ASTM C 138.
 3. Slump, ASTM C 143.
 4. Slump Flow, ASTM C 1611 (for SCC).
 5. Concrete temperature at placement time. ASTM C 1064.
 6. Air temperature at placement time.
 7. Strength determined in accordance with ASTM C 39.
 8. Rapid Chloride Permeability Test of core samples in accordance with ASTM C 1202, as and when directed by Specification or Owner.
 9. Shrinkage (length change) of superstructure concrete, ASTM C 157 (modified) for post-tensioned concrete and other concrete as noted on the drawings. Shrinkage shall be equal to or less than 0.04% at 28 days
 10. Calcium Nitrite presence in plastic concrete: See Part 3 heading, "Quality Control."

- G. Contractor: Submit grout temperature limitations with grout submittal.
- H. Submit current certification of welders.
- I. Provide certification that curing compound conforms to requirements of ASTM C 1315.
- J. All concrete flatwork finishers on Project shall hold current ACI Concrete Flatwork Finisher certification. Submit certification for each concrete flatwork finisher at Concrete Pre-Installation Conference and obtain Engineer's written acceptance.
- K. Submit steel producer's certificates of mill analysis, tensile tests, and bend tests for reinforcing steel. Coordinate with welders and welding procedures.
- L. Submit shop drawings for steel reinforcement:
 - 1. Prepare placing drawings that detail fabrication, bending, and placement of concrete reinforcement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement. Comply with ACI SP-66, "ACI Detailing Manual." Include special reinforcement required for openings through concrete structures, elevations of all walls and columns with locations of all splices and couplers.
 - 2. Prepare steel reinforcement placing drawings in coordination with the Work of Section "~~Post Tensioned Concrete – Parking Garage~~~~Unbonded Post-Tensioned Concrete~~". Review the Unbonded Post-Tensioned Concrete tendon shop drawings to determine placement details and clearances. Notify Engineer of potential interference or conflicts for placing reinforcement and post-tensioning tendons.
- M. Resubmittals: Engineer will review each of Contractor's submittals the initial time and, should resubmittal be required, one additional time to verify that reasons for resubmittal have been addressed by Construction Manager and corrections made. Resubmittal changes/revisions/corrections shall be circled. Engineer will review only circled items and will not be responsible for non-circled changes/revisions/corrections and additions.
 - 1. Make resubmittals in same form and number of copies as initial submittal.
 - a. Note date and content of previous submittal.
 - b. Note date and content of revision in label or title block and clearly indicate extent of revision.
- N. Resubmit submittals until they are marked with approval notation from Engineer's and Construction Manager's action stamp
- O. Submit shop drawings for architectural finishes for specific exposed finish concrete surfaces. Show form construction including jointing, special form joint or reveals, location and pattern of form tie placement, and other items that affect exposed concrete visually.
- P. Submit samples of materials as requested by Engineer, including names, sources, and descriptions as follows:

1. Normal weight aggregates.
2. Fibrous reinforcement.
3. Reglets.
4. Waterstops.
5. Vapor retarder.

Q. Submit laboratory test reports for concrete materials and mixtures.

R. Submit Minutes of concrete pre-installation conference.

1.5 CONTRACTOR'S PROFESSIONAL SERVICES - PERFORMANCE AND DESIGN CRITERIA

- A. Provide professional services for temporary conditions during construction and portions of the Work required to carry out the Contractor's responsibilities for construction means, methods, techniques, sequences and procedures. Specific requirements and criteria include, but are not limited to the following:
1. Design, erect, shore, brace, and maintain formwork, according to ACI 301 and ACI 347 to support vertical, lateral, static and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads. The contractor is responsible for layout and design, reviews, approvals, and inspections.
 2. Design formwork, shoring, bracing, and other conditions for structural requirements and stability during construction and until final structure is completed and accepted.
 - a. Comply with ACI 347.2 for design, installation, and removal of shoring and reshoring.
 - b. Superimposed loads to the concrete structure, slab-on-grade, and soil shall be less than the design loads as shown on Drawings.
 - c. Check early-age strength of concrete members against anticipated construction loads. Reduce the load on concrete members at the critical concrete age or change the concrete mixture for accelerated strength gain to avoid distress of concrete members.
 - d. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads such that no floor or member would be excessively loaded or would induce tensile stresses in concrete members.
 - e. Plan sequence of removal of shores and reshores to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excess stress or deflection.
 - f. Consider the effects of post-tensioning sequence for post-tensioned beams and girders. Review post-tensioning design criteria on the drawings and in specification Section "Post Tensioned Concrete – Parking Garage~~Unbonded Post-tensioned Concrete~~".
- B. Design the "Nominal Form Width" for linear gap at time of forming or erecting concrete elements bounding the expansion joints in accordance with Drawings and Specification Section "Expansion Control – Parking Garage~~Joint Assemblies~~".

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed concrete work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Manufacturer Qualification: An experienced supplier who is experienced in manufacturing ready-mixed concrete products complying with ASTM C94 requirement for production facilities and equipment. Manufacturer shall also be certified according to the National Ready Mixed Concrete Association's Certifications of Ready Mixed Concrete Production Facilities.
- C. Codes and Standards: Comply with provisions of following codes, specifications, and standards, except where more stringent requirements are shown or specified:
 - 1. ACI 301, "Specifications for Structural Concrete."
 - 2. ACI 318, "Building Code Requirements for Structural Concrete and Commentary."
 - 3. ACI 117, "Standard Specifications for Tolerances for Concrete Construction and Materials."
 - 4. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice."
 - 5. Florida Building Commission: FBC, "Florida Building Code."
- D. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in Florida and who is experienced in providing professional engineering services of the kind indicated. See Article "Contractor's Professional Services Performance and Design Criteria".
- E. Materials and installed work may require retesting at any time during progress of work. Tests, including retesting of rejected materials for installed work, shall be done at Contractor's expense.
- F. PRE-INSTALLATION CONFERENCE: At least 21 days prior to scheduled start of concrete construction, contractor shall conduct meeting to review proposed mixture proportions and methods and procedures to achieve required concrete quality. Contractor shall send pre-concrete conference agenda to all attendees 14 days prior to scheduled date of conference indicating review requirements. Representatives of each entity directly concerned with cast-in-place concrete shall attend conference, including, but not limited to, the following:
 - 1. Contractor's superintendent.
 - 2. Agency (laboratory) responsible for concrete mixture proportions).
 - 3. Agency (laboratory) responsible for field quality control.
 - 4. Ready-mixed concrete producer.
 - 5. Concrete subcontractor.
 - 6. Primary admixture manufacturers.
 - 7. Engineer.
 - 8. Owner's representative.
 - 9. At the pre-concrete meeting the contractor shall provide a summary of concrete procedures to protect fresh concrete from rain.The minutes shall include a statement by the Concrete Contractor indicating that the proposed mixture proportions and placing/finishing/curing techniques can produce the concrete quality required by these specifications.
- G. Welders and welding procedures for permanent steel formwork shall conform to requirements or AWS D1.1.

- H. Welders and welding procedures shall conform to requirements of AWS D1.4. Except where shown on Drawings, welding of reinforcing steel is prohibited unless accepted by Engineer in writing.
- I. Threshold Inspection of steel reinforcement is required in accordance with Florida Building Code, Section 105. Inspections shall be conducted by an inspection agency employed by Owner and approved by Engineer. Inspector shall provide report in approved format to Owner with copy to Engineer and Contractor. Inspection agency has authority to reject reinforcing not meeting Contract Documents. Inspections for all reinforcing steel for conformance to shop drawings and Contract Documents shall be completed prior to concrete placement.
- J. Threshold Inspector shall submit following information on Inspection of Reinforcement unless modified in writing by Engineer.
 - 1. Project name and location.
 - 2. Contractor's name.
 - 3. Inspection Agency's name, address, and phone number.
 - 4. Date and time of inspection.
 - 5. Inspection Agency technician's name.
 - 6. Fabricator's name.
 - 7. Weather data:
 - a. Air Temperatures.
 - b. Weather.
 - c. Wind speed.
 - 8. Inspection location within structure.
 - 9. Reinforcement inspection data (including but not limited to):
 - a. Bar size, spacing, cover, and grade.
 - b. Splices, bends, anchorages, welding.
 - c. Support methods and construction sequencing.
 - 10. Inspection of other items related the concrete pour such as embed anchor bolts and connection plates, sleeves and openings or other items related to the structure. Refer to the Threshold Inspection Notes on the drawings.
 - 11. Diary of general progress of Work.
- K. Owner's or Contractors Testing Agency Qualifications:
 - 1. Independent agency, acceptable to engineer, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
 - 2. Testing laboratory shall submit documented proof of ability to perform required tests.
 - 3. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 4, according to ACI CP-1 or an equivalent certification program.
- L. Owner's or Contractors Testing Agency is responsible for conducting, monitoring and reporting results of all tests required under this Section. Testing Agency shall immediately report test results showing properties that do not conform to Project Specification requirements to General Contractor's authorized on-site representative and to Owner's authorized on-site representative.
- M. Both Owner's and Contractors Testing Agency shall submit following Field Test information for Project Concrete unless modified in writing by Engineer:

1. Project name and location.
 2. Contractor's name.
 3. Testing Agency's name, address, and phone number.
 4. Concrete supplier.
 5. Date of report.
 6. Testing Agency technician's name (sampling and testing).
 7. Placement location within structure.
 8. Time of batching.
 9. Time of testing.
 10. Elapsed time from batching at plant to discharge from truck at site.
 11. Concrete mixture data (quantity and type):
 - a. Cement.
 - b. Fine aggregates.
 - c. Coarse aggregates.
 - d. Water.
 - e. Water-reducing admixture and high-range water-reducing admixture.
 - f. Other admixtures, including supplementary cementitious materials.
 12. Weather data:
 - a. Air temperatures.
 - b. Weather.
 - c. Wind speed.
 13. Field test data:
 - a. Date, time and place of test.
 - b. Slump.
 - c. Concrete Temperature.
 - d. Slump flow (for SCC).
 - e. Water content.
 - f. Density (Unit weight).
 14. Compressive test data:
 - a. Cylinder number.
 - b. Age of concrete when tested.
 - c. Date and time of cylinder test.
 - d. Curing time (field and lab).
 - e. Cross-sectional area of cylinder.
 - f. Compressive strength.
 - g. Type of failure (at break).
 - h. Rapid chloride permeability test results.
- N. Mockups: Before casting concrete, build mockups to verify selections made under sample submittals and to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
1. Build two acceptable test panels approximately 600 sq. ft. for flatwork in parking drive areas slab-on-grade in the location indicated or, if not indicated, submit a request for acceptance of the proposed location at the project site. See additional requirements for test panels in specification article "Finishing Floors and Slabs."
 2. Build panel approximately 100 sq. ft. for Smooth Form Finish - formed surface in the location indicated or, if not indicated, submit a request for acceptance of the proposed location at the project site.

- a. Submit a request for acceptance of the proposed location for concrete ceilings.
 - b. Submit a request for acceptance of the proposed location for typical interior walls.
 3. Build mockups of typical exterior wall of cast-in-place concrete as shown on Drawings.
 4. Stains, bugholes or other surface blemishes that deviate from the mockup will not be acceptable.
 5. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.
 6. In presence of Engineer, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
 7. Obtain Engineer's acceptance of mockups before casting concrete with specified finishes.
- O. Coal fly ash and processed ultrafine fly ash supplier shall make available qualified individual, experienced in placement of fly ash concrete, to aid Contractor. Qualification of supplier's representative shall be acceptable to Owner. Representative shall attend pre-construction meeting, and shall be present for all trial placements, initial startup and then as required by Owner.
- P. At all times during high-evaporation conditions, maintain adequate supply of evaporation reducer at site. Do not use evaporation reducer as finishing aid. See Part 3.
- Q. Testing Agency: Identify those trucks of concrete supplier's which meet requirements of NRMCA Quality Control Manual. Permit only those trucks to deliver concrete to Project.

1.7 REFERENCES

The following publications listed below form a part of this Specification to the extent referenced.

- A. American Association of State Highway and Transportation Officials (AASHTO):
1. AASHTO, "Standard Specifications for Highway Bridges."
 2. AASHTO T 318, "Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying."
- B. American Concrete Institute (ACI):
1. ACI 214R, "Evaluation of Strength Test Results of Concrete."
 2. ACI 302.1R, "Guide for Concrete Floor and Slab Construction."
 3. ACI 305R, "Hot Weather Concreting."
 4. ACI 306.1, "Cold Weather Concreting."
 5. ACI 308R, "Guide to Curing Concrete."
 6. ACI 308.1, "Standard Specifications for Curing Concrete."
 7. ACI 347, "Guide to Formwork for Concrete."
 8. ACI 347.2 "Guide to Shoring/Reshoring of Concrete Multistory Buildings."
 9. ACI 362.1, "Guide for the Design of Durable Parking Structures."
 10. ACI SP15, "Field Reference Manual."

- C. American Iron and Steel Institute (AISI):
 - 1. AISI, "Specification for the Design of Cold-Formed Steel Structural Members."
- D. American Society for Testing and Materials (ASTM):
 - 1. ASTM A 36, "Standard Specification for Carbon Structural Steel."
 - 2. ASTM A 185, "Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete Reinforcement."
 - 3. ASTM A 497, "Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete Reinforcement."
 - 4. ASTM A 615, "Standard Specification for Deformed and Plain Carbon -Steel Bars for Concrete Reinforcement."
 - 5. ASTM A 706, "Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement."
 - 6. ASTM B 633, "Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel."
 - 7. ASTM C 31, "Standard Practice of Making and Curing Concrete Test Specimens in the Field."
 - 8. ASTM C 33, "Standard Specification for Concrete Aggregates."
 - 9. ASTM C 39, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens."
 - 10. ASTM C 94, "Standard Specification for Ready-Mixed Concrete."
 - 11. ASTM C 109, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)."
 - 12. ASTM C 138, "Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete."
 - 13. ASTM C 143, "Standard Test Method for Slump of Hydraulic Cement Concrete."
 - 14. ASTM C 150, "Standard Specification for Portland Cement."
 - 15. ASTM C 157, "Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete."
 - 16. ASTM C 171, "Standard Specification for Sheet Materials for Curing Concrete."
 - 17. ASTM C 172, "Standard Practice for Sampling Freshly Mixed Concrete."
 - 18. ASTM C 173, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method."
 - 19. ASTM C 231, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method."
 - 20. ASTM C 260, "Standard Specification for Air-Entraining Admixtures for Concrete."
 - 21. ASTM C 309, "Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete."
 - 22. ASTM C 311, "Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete."
 - 23. ASTM C 330, "Standard Specification for Lightweight Aggregates for Structural Concrete."
 - 24. ASTM C 457, "Standard Test Method for Microscopical Determination of Air-Void Content and Parameters of the Air-Void System in Hardened Concrete."
 - 25. ASTM C 494, "Standard Specifications for Chemical Admixtures for Concrete."
 - 26. ASTM C 567, "Standard Test Method for Determining the Density of Structural Lightweight Concrete."
 - 27. ASTM C 595, "Standard Specification for Blended Hydraulic Cements."

- E. American Welding Society (AWS):

- F. US Army Corps of Engineers (CE):
 - 1. CE CRD-C 513 "Specifications for Rubber Waterstops."
 - 2. CE CRD-C 572 "Specifications for Polyvinyl Chloride Waterstops."
 - 3. CE CRD-C 662 "Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar Bar Method)."
- G. Contractor shall have following ACI publications at Project construction site:
 - 1. ACI SP-15, "Field Reference Manual: Standard Specifications for Structural Concrete ACI 301 with selected ACI References."
 - 2. ACI 302.1R, "Guide for Concrete Floor and Slab Construction."
 - 3. ACI 305R, "Hot Weather Concreting."
 - 4. ACI 306.1, "Cold Weather Concreting."
- H. Accessibility Requirements:
 - 1. "Americans with Disabilities - Act Accessibility Guidelines for Buildings and Facilities", as published by U.S. Architectural & Transportation Barriers Compliance Board, 1331 F Street, N.W., Suite 1000, Washington, DC 20004-1111, 1-800-872-2253, <http://www.access-board.gov/adaag/ADAAG.pdf>

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store all formwork and formwork materials clear of ground, protected, to preclude damage.
- B. Deliver reinforcement to Project site bundled, tagged and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings shown on placement diagrams.
- C. Store concrete reinforcement materials at site to prevent damage and accumulation of dirt or excessive rust.
- D. Concrete transported by truck mixer or agitator shall be completely discharged within one and one half-hours (one hour for hot weather concreting) after water has been added to cement or cement has been added to aggregates. Schedule deliveries to allow for delays due to weather, traffic, etc.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

- A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
 - 1. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
 - a. High-density overlay, Class 1 or better.

- b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
- B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Forms for Textured Finish Concrete: Unit of face design, size, arrangement, and configuration to match control sample. Provide solid backing and form supports to ensure stability of textured form liners.
- D. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.
- E. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
 - 1. Products include all corrugated cardboard void forms that temporarily support concrete walls, grade beams, structural concrete slabs and top portion of concrete piers; includes filling the circular section where required.
 - a. Related accessory products include seam caps, end caps and protective cover boards or any other product to maintain above general products.
 - b. Submit all product data and manufacturer's installation instructions under provisions of this Section, based on the design loads specified in contract documents and depth and width indicated.
- F. Form Coatings: Provide commercial formulation form-coating compounds with a maximum VOC of 350 grams/liter that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces, including but not limited to water-curing, curing compound, stains or paints.
- G. Form Ties: Factory - fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units that will leave no metal closer than 1.5 in. to exposed surface.
 - 1. Provide ties that, when removed, will leave holes not larger than 1 in. diameter in concrete surface.
- H. Chamfer strips: Wood, metal, PVC, or rubber strips. 0.75 in. by 0.75 in. min. unless noted otherwise.
- I. Nails for P-T Anchors: Stainless steel ring shank nails.
 - 1. Clendenin Brothers, Baltimore, MD.
 - 2. Or Equal.

2.2 STEEL REINFORCEMENT

- A. Provide in Bid 20 additional tons of placed reinforcement bars or welded wire reinforcement for inclusion in Project as Engineer directs. Return cost of unused portion to Owner. Submit to Engineer breakdown of use each month.
- B. Reinforcement Bars: ASTM A 615, deformed, yield strength: as noted on Drawings.

- C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706, deformed.
- D. Post-tensioned Reinforcement: See Section [“Post Tensioned Concrete – Parking Garage Unbonded Post-Tensioned Concrete.”](#)
- E. Steel Bar Mats: ASTM A 184, assembled with clips.
 - 1. Steel Reinforcement: ASTM A 615, Grade 60, deformed bars.
- F. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
 - 1. Welded wire reinforcement: provide in mats only. Roll stock prohibited.
- G. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 60 percent.

2.3 REINFORCEMENT ACCESSORIES

- A. Bar supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from all plastic of greater compressive strength than concrete, and as follows:
 - 1. In manner acceptable to Engineer solely, bar and welded wire reinforcement supports shall be color-coded to visually differentiate supports by height and shall be fabricated to resist overturning during construction operations.
 - 2. For slabs on ground, use all-plastic supports with sand plates or horizontal runners where base materials will not support chair legs. All supports shall have sufficient surface area in contact with ground so that they shall not allow clearance loss when reinforcement installed or concrete placed.
 - 3. For concrete surfaces exposed to view where bar supports contact forms, supports shall have minimal contact, shall not cause voids and shall not cause damage to surrounding concrete. Use all-plastic supports conforming to CRSI Class 1 protection requirements.
 - 4. Chairs shall be sized and spaced to prevent cover loss during construction operations.
 - 5. Acceptable manufacturers:
 - a. Aztec Concrete Accessories, Inc.
 - b. General Technologies, Inc.
 - c. Accepted equivalent.
 - 6. For welded wire reinforcement, provide continuous bar supports spaced at 2 feet o.c., maximum."
- B. For mechanical tension splices of reinforcement:
 - 1. All splices to develop 125 percent of specified yield strength of bars, or of smaller bar in transition splices. Acceptable products:
 - a. Bar-Lock Rebar Coupler, by Dayton Superior.
 - b. Bar-Grip or Grip-Twist, by Barsplice Products, Inc.
 - c. Extender Coupler, by Headed Reinforcement.
 - d. Splice Sleeve, by NMB.
 - e. LENTON Splices, by Erico.

- C. Compression splices: Mechanically coupled splices in accordance with ACI 318, Chapter 12.

2.4 CONCRETE MATERIALS

- A. Ready Mixed Concrete: Obtain concrete from plant with current certification from:
1. Concrete Materials Engineering Council.
 2. Florida Department of Transportation.
 3. National Ready Mixed Concrete Association.
- B. Portland Cement (ACI 301, Section 4 header "Cementitious Materials"):
1. Portland cement, Type I, ASTM C 150. Use one cement supplier throughout project. No change in brand or supplier without prior written acceptance from Engineer.
 2. Blended cement, ASTM C 595, Type IP only with prior written acceptance from Engineer.
- C. Coal Fly Ash:
1. Permitted in all parts of structure.
 2. ASTM C 618, Class C or F.
 3. Testing: ASTM C311.
 4. Percentage of fly ash in Mixture Proportion shall be by weight, not by volume. Water/cement ratio will be calculated as water/cementitious (total cement and fly ash) ratio.
 5. If project contains post-tensioned members, see Section "Post Tensioned Concrete – Parking Garage~~Unbonded Post Tensioned Concrete~~," for high early strength requirements for concrete to be post-tensioned.
 6. Prohibited: Fly ash in same mix with Type IP blended cement.
 7. If strength or air content varies from value specified by more than specified tolerances, Engineer or designated representative shall reject that concrete.
 8. Submit all fly ash concrete Mixture Proportions per ACI 301.
- D. Slag – (Ground Granulated Blast-Furnace Slag – GG-BFS):
1. ASTM C 989, Grade 100 or higher.
 2. Percentage of GGBF slag in Mixture Proportion shall be by weight, not by volume. Water-cement ratio shall be calculated as water-cementitious (total portland cement + GGBF slag) ratio.
 3. If strength or air content varies from value specified by more than specified tolerances, Engineer or designated representative shall reject that concrete.
 4. Submit all GGBF slag concrete mixture proportions per ACI 301.
- E. Normal Weight Aggregates (ACI 301, Section 4 header "Aggregates"):
1. Normal weight concrete aggregates:
 - a. Coarse aggregate: Crushed and graded limestone or approved equivalent conforming to ASTM C33 except as noted here, minimum class designations as listed below:
 - 1) Below grade construction and below frost line: Class 1N.
 - 2) Walls not exposed to public view: Class 1N.
 - 3) Walls exposed to public view: Class 1N.
 - 4) Slabs on ground: Class 1N.
 - 5) All other concrete: Class 1N.

- b. No deleterious materials such as, but not limited to, chert or opaline.
 - c. Fine aggregate: Natural or Manufactured sand conforming to ASTM C 33 and having preferred grading shown for normal weight aggregate in ACI 302.1R, Table 5.1.
 - d. Coarse Aggregate shall not contain crushed hydraulic-cement concrete.
 - 2. Coarse aggregate: Nominal maximum sizes indicated below, conforming to ASTM C 33, Table 2:
 - a. Footings/Foundations: Size number 57 or 357.
 - b. Slab on grade: Size number 57.
 - c. All other members: Size number 67.
 - 3. Chloride Ion Level: ASTM C 1218. Chloride ion content of cement, aggregates and all other ingredients: tested by laboratory making trial mixes.
- F. Water: Comply with ASTM C 1602.
- G. Storage of Materials (ACI 301, Section 4 header "Materials Storage and Handling").

2.5 ADMIXTURES

- A. Use water-reducing admixture, mid-range water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete as required for placement and workability.
- B. Use non-chloride accelerating admixture in concrete slabs placed at ambient temperatures below 50 deg. F as required for schedule.
- C. Use high-range water-reducing admixture (HRWR) in pumped concrete, and for concrete with water/cementitious ratio of less than or equal to 0.45. Use high-range or mid-range water-reducing admixtures in pumped concrete and normal or mid-range water reducing admixtures for concrete with water/cementitious ratios greater than 0.45.
- D. Self-consolidating concrete (SCC) may be used where placement due to either dense reinforcement or form design requires both a high level of workability (horizontal slump flow greater than 24 in. diameter) and the water/cementitious ratio is less than or equal to 0.45.
- E. Only admixture manufacturers listed acceptable. Do not submit alternate manufacturers.
- F. Concrete supplier and manufacturer shall verify via trial mixes and certify compatibility (no adverse effect on workability, strength, durability, entrained air content, etc.) of all ingredients in each Mixture. Use admixtures in strict accordance with manufacturer's recommendations.
- G. Prohibited Admixtures: Calcium chloride or admixtures containing intentionally added chlorides shall not be used.
- H. Normal Water-Reducing Admixture: ASTM C 494, Type A.
 - 1. Products: Subject to compliance with requirements, provide one of following:

- a. "Eucon Series," Euclid Chemical Co.
 - b. "WRDA Series," GCP Applied Technologies (Grace)
 - c. "Pozzolith Series," or "PolyHeed Series," BASF Construction Chemicals.
 - d. "Plastocrete Series", Sika Corporation.
- I. Mid Range Water-Reducing Admixture: ASTM C 494, Type A.
- 1. Subject to compliance with requirements, provide one of following:
 - a. "Eucon MR" or "Eucon X-15 and X-20," Euclid Chemical Co.
 - b. "Daracem Series" or "MIRA Series," GCP Applied Technologies (Grace)
 - c. "PolyHeed Series," BASF Construction Chemicals.
 - d. "Sikaplast Series" or "Plastocrete Series", Sika Corporation.
 - e. "Catexol 2000 NI," Axim Concrete Technologies.
 - f. "Polychem 1000" or "KB Series," General Resource Technology.
 - g. "Finishease-NC," Russ Tech Admixtures, Inc.
- J. High Range Water-Reducing Admixture (Superplasticizer): ASTM C 494, Type F.
- 1. Products: Subject to compliance with requirements, provide one of following:
 - a. "Eucon 37" or "Eucon SP-Series" or "Plastol Series," Euclid Chemical Co.
 - b. "Daracem Series" or "ADVA Series," GCP Applied Technologies (Grace)
 - c. "Rheobuild 1000", "PS 1466" or "Glenium Series," BASF Construction Chemicals.
 - d. "Sikament Series" or "Sika ViscoCrete Series," Sika Corporation.
 - e. "Catexol 1000 SP-MN," Axim Concrete Technologies.
 - f. "Melchem Series," General Resource Technology.
 - g. "Superflo 443" or "Superflo 2000 Series," Russ Tech Admixtures, Inc.
- K. High-Range Water-Reducing Admixture (Superplasticizer) for Self-Consolidating Concrete, ASTM C 494 Type F.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. "Plastol Series" or "Eucon SPC or SPJ," Euclid Chemical Co.
 - b. "ADVA Series," GCP Applied Technologies (Grace)
 - c. "Glenium Series" or "PS1466," BASF Construction Chemicals.
 - d. "Sika ViscoCrete Series" or "Sikament Series", Sika Corporation.
- L. Viscosity Modifying Admixture for Self-consolidating Concrete:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. "Visctrol" or "Eucon ABS," Euclid Chemical Co.
 - b. "Rheomac VMA Series," BASF Construction Chemicals.
 - c. "Sika Stabilizer Series," Sika Corporation.
- M. High Range water reducing retarding (superplasticizer), ASTM C 494 Type G:
- 1. Products: Subject to compliance with requirements, provide one of following:
 - a. "Eucon 537 or RD2," Euclid Chemical Co.
 - b. "Daracem 100," GCP Applied Technologies (Grace)
- N. Non-Chloride, Non-Corrosive Water-Reducing, Accelerating Admixture: ASTM C 494, Type C or E.
- 1. Products: Subject to compliance with requirements, provide one of following:

- a. "Eucon AcN-Series," "Accelguard 80," "Accelguard NCA," or "Accelguard 90," Euclid Chemical Co.
 - b. "DCI," "PolaraSet," "Lubricon NCA," or "Gilco," GCP Applied Technologies (Grace)
 - c. "Pozzutec 20+" or "Pozzolith NC 534," BASF Construction Chemicals.
 - d. "Sika Set NC," "Plastocrete 161FL," or "Sika Rapid-1," Sika Corporation.
 - e. "Catexol 2000 RHE," Axim Concrete Technologies.
- O. Water-Reducing or retarding Admixture: ASTM C 494, Type D or B.
1. Products: Subject to compliance with requirements, provide one of following:
 - a. "Eucon Retarder-75," "Eucon DS" or "Eucon W.O." Euclid Chemical Co.
 - b. "Daratard-17" or "Recover," GCP Applied Technologies (Grace)
 - c. "Pozzolith Series" or "Delvo Series," BASF Construction Chemicals.
 - d. "Sikatard Series," or "Plastiment Series" or "Plastocrete Series," Sika Corporation.
 2. Products:
 - a. "ASRx 30LN," BASF Construction Chemicals.
 - b. "Eucon Integral ARC," Euclid Chemical Co.
 - c. "Sika Control ASR," Sika Corporation.
 - d. "Rasir," GCP Applied Technologies (Grace)
 3. Include water content in admixture when calculating water-to-cement ratio.
 4. Provide satisfactory CE CRD-C667 results with lithium admixture as defined in "Alkali-Aggregate Reactivity Resistance" paragraph below.
- P. Shrinkage Reducing Admixture:
1. Design requires using materials with combined drying shrinkage characteristic of 0.04 percent maximum at 28 days. Proposed concrete Mixture(s), using actual aggregates, admixtures and cement of the proposed mix for Project as detailed herein and in Drawings, shall meet criteria. Submit ASTM C 157 (may be modified by curing period duration) results for at least 3 specimens. Test takes 28 days minimum. Begin tests as soon as possible so final test results available for submittal to Engineer.
 2. Products: Subject to compliance with requirements, provide one of following:
 - a. If calcium nitrite is present in the original concrete mixture:
 - 1) "Eclipse 4500," GCP Applied Technologies (Grace)
 - 2) "Eucon SRA +" Euclid Chemical Company.
 - 3) "Sika Control 40," Sika Corporation.
 - b. If calcium nitrite is not present in the original concrete mixture:
 - 1) "Eucon SRA," or "Eucon SRA+," Euclid Chemical Company.
 - 2) "Eclipse Plus," GCP Applied Technologies (Grace)
 - 3) "Tetraguard AS 20," BASF Construction Chemicals.
 - 4) "Sika Control 40," Sika Corporation.
 - 5) "SRA-157," Russ Tech Admixtures, Inc.

2.6 FIBER REINFORCEMENT:

- A. Polypropylene fibers for plastic shrinkage control in concrete members.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. "Fiberstrand 100," Euclid Chemical Co.

- b. "Mighty-Mono," Forta Corp.
 - c. "Polymesh," General Resource Technology.
 - d. "Gilco," or "Grace Fibers," or "Grace Microfibers," GCP Applied Technologies (Grace), Inc.
 - e. "Durafiber," Industrial Systems, Ltd.
 - f. "MasterFiber F or M Series," BASF Construction Chemicals.
 - g. "Fibermesh 150," Propex Concrete Systems.
 - h. "Sika Fibers," or "Sika Microfibers," Sika Corporation.
2. Additional requirements:
- a. Collated fibrillated materials: Dosage rate 1.0 lb/cu. yd. of concrete minimum, containing at least 3 million individual fibers.
 - b. Multifilament (microfilament) fibers: Dosage rate 0.5 lb/cu. yd. of concrete minimum, containing at least 25 million individual fibers. Minimum length 0.75 in.
 - c. Meet requirements of ASTM C 1116, "Standard Specification for Fiber-Reinforced Concrete and Shotcrete," designation Type III,
 - d. Meet minimum plastic shrinkage crack reduction of 70 percent when tested in accordance with ICBO ES, Appendix B (7-92).
- B. Use shall not change water requirement of mix. Slump loss due to addition of fiber shall be offset by addition of superplasticizer.
- C. Conform to manufacturer's recommendations for quantity of fiber. See paragraph "Additional Requirements" above for minimums.
- D. See Drawings for locations of allowable use.
- E. Fiber manufacturer or approved distributor: Provide services of qualified representative at pre-construction meeting, concrete pre-installation meeting and first concrete placement containing fibers.

2.7 WATERSTOPS

- A. Flexible Rubber Waterstops: CE CRD-C 513, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
- 1. Profile: Flat, dumbbell without center bulb.
- B. Flexible PVC Waterstops: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
- 1. Profile: Flat, dumbbell without center bulb.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Rubber Waterstops:
 - a. Greenstreak.
 - b. Progress Unlimited Inc.
 - c. Williams Products, Inc.
 - 2. PVC Waterstops:
 - a. Greenstreak.

- b. Meadows: W.R. Meadows, Inc.
 - c. Progress Unlimited Inc.
 - d. Sternson Group.
- D. Self-Expanding Strip Waterstops: Manufactured rectangular or trapezoidal strip, butyl rubber with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Superstop; Tremco Inc.
 - b. Volclay Waterstop-RX; Colloid Environmental Technologies Co.
 - c. Hydrotite; Greenstreak.
 - d. Mirastop; Miradri, Div. Of Royal Ten Cate (USA), Inc.
 - e. Superstop; Progress Unlimited Inc.
 - f. SikaSwell Profile; Sika Corporation.

2.8 VAPOR BARRIERS

- A. Vapor Barrier: Provide vapor barrier which conforms to ASTM E 1745, Class A. The membrane shall have a water-vapor transmission rate less than or equal to 0.008 gr./ft²/hr when tested, in accordance with ASTM E96. Vapor barrier shall be no less than 15 mils thick. The vapor barrier shall be placed over prepared base material where indicated below slabs on ground.
- 1. New ISO certified virgin resins, polyolefin based maximum.
 - 2. Available Product: Subject to compliance with requirements, a product that may be incorporated into the Work includes, but is not limited to "Griffolyn Vaporguard" by Reef Industries, Inc., Stego Wrap (15-Mil) Vapor Barrier by Stego Industries LLC, or Perminator (15 Mil) Underground Vapor Barrier by W.R. Meadows,.
- B. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

2.9 CURING MATERIALS

- A. Evaporation Reducer: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- 1. Evaporation Retarder:
 - a. Cimfilm; Axim Concrete Technologies.
 - b. Aquafilm; Conspec Marketing & Manufacturing Co., Inc.
 - c. Eucobar; Euclid Chemical Co.
 - d. E-Con; L&M Construction Chemicals, Inc.
 - e. Confilm; BASF Construction Chemicals, LLC.
 - f. SikaFilm; Sika Corporation.
 - g. Sure-Film (J-74); Dayton Superior Corporation.
 - h. "EVRT", Russ Tech Admixtures, Inc.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.

- C. Moisture-Retaining Cover: Polyethylene coated burlap comprised of a minimum 4 mil polyethylene extruded onto 10- ounce burlap with components complying with AASHTO M171, AASHTO M182 Class II and ASTM C-171. The cover shall be suitable for multiple uses. Acceptable products:
 - 1. Hydracure M5 by Hydracure Covers
 - 2. Bur Lene by Max Katz Bag Co. Inc
 - 3. Curelap-Poly Coated Burlap by Midwest Canvas Corp.
 - 4. UltraCure DOT by Sika Corporation..
- C. Water: Potable.
- D. Curing Compound (VOC Compliant, less than 350 g/l): Comply with ASTM C 309, Type 1, Class A or B. Moisture loss shall be not more than 0.55 kg/m² when applied at 200 sq. ft/gal. Manufacturer's certification is required. Silicate based compounds prohibited.
 - 1. Subject to project requirements provide one of the following products:
 - a. "Kurez DR VOX" or "Kurez RC," or "Kurez RC Off," Euclid Chemical Company.
 - b. "RxCure WB," or "RxCure VOC" or "W.B. Cure VOC," Conspec Marketing & Manufacturing.
 - c. "Kure N Seal W" or "Kure N Seal WB" BASF Construction Chemicals, LLC.
 - 2. Additional requirements:
 - a. With product submittal provide plan and procedures for removal of residual curing compound prior to application of sealers, coatings, stains, pavement markings and other finishes.
 - b. Provide a summary of testing to show adequate surface preparation for successful application of sealers, coatings, stains, pavement markings, and other finishes.

2.10 RELATED MATERIALS

- A. Bonding Additive: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- B. Epoxy-Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements, and as follows:
 - 1. Type II, non-load bearing, for bonding freshly mixed concrete to hardened concrete.
 - 2. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- C. Reglets: Fabricate reglets of not less than 0.0217-inch- thick galvanized steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
- D. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

- E. Mechanical and chemical anchors as specified on the drawings or used for attaching supports for miscellaneous electrical, plumbing and mechanical components along with repairs for missing embedded anchor bolts shall be manufactured by Hilti Fastening Systems, Tulsa Oklahoma, ITW Ramset/Red Head, Wood Dale, IL, Simpson Anchor Systems, Columbus, OH, Powers Fasteners, Brewster, NY, SimpsonStrong-Tie Co., Inc., Pleasanton, CA, Powers Fasteners, Brewster, NY, or accepted equivalent. Anchor bolt composition shall be from one or more of carbon steel and stainless steel, lead, Zamac alloy, nylon, plastic, polypropylene, and jute fiber.
1. Strength of all anchors shall comply with ICC-ES-AC 193 or ICC-ES AC308 and ACI 318-11 Appendix D.
 2. Carbon steel anchors shall be either zinc plated in accordance with ASTM B 633, or hot-dipped galvanized in accordance with ASTM A-153-78. Provide mill test reports and manufacturer's quality control certification upon Engineer's request.
 3. Stainless steel anchors shall be manufactured from ASTM A304, or A663 stainless steel. Provide mill test reports and manufacturer's quality control certification upon Engineer's request.
 4. Plastic, lead, or Zamac alloy anchors shall not be used for overhead applications. Chemical anchors shall not be used to resist pullout forces in overhead and wall installations unless proper consideration is given to fire conditions. For chemical anchors, consult with manufacturer's engineer.
 5. Safety Factors: Static load safety factors shall be per manufacturer's published data. Critical load (vibratory, overhead, etc. or more) safety factors shall be 10:1 minimum. Chemical anchors are not permitted for critical loads and where resistance to direct sustained tension is required.
 - a. If necessary for purposes of determining tensile and/or shear capacity in questionable base material, testing shall be done prior to actual anchor installation. Proof load, load duration and ASTM procedures will be provided for the testing procedure. A maximum of five tension and/or shear tests shall be performed by manufacturer's engineer. Anchors shall be proof loaded in tension and/or shear to assure that working load capacity is within specified allowable load limit as published by manufacturer.
 6. Anchor spacing and edge distance per manufacturer's limits. Loading and cluster spacing shall be as established by minimum industry standards for anchors, except as follows: Anchor loading, cluster spacing and edge distances shall be as published in manufacturer's literature. Consult with manufacturer's engineer for specific requirements.
 7. Anchor installation shall be as required by manufacturers written instructions.
 8. Refer to the general notes for additional information on "Post-Installed Anchors".
- F. Inserts and Coil Rods:
1. Yield strength: 65,000 psi minimum.
 2. Galvanizing: Where indicated, electrodeposited zinc coating, ASTM B 633, Service condition 1, Type III.
 3. Acceptable manufacturers:
 - a. Dayton/Richmond Concrete Accessories, Inc., Miamisburg, OH.
 4. Details shown on drawings are based on Dayton/Richmond Concrete Accessories, Inc. products and their respective capacities. Other products may

be used only if contractor submits calculations, sealed by professional engineer or structural engineer licensed in Florida, substantiating strength of connection with other product. Calculations are subject to Engineer's acceptance before fabrication is to proceed.

G. Joint Filler:

1. Joint filler in slabs and curbs: Asphalt impregnated fiber board; as shown on Drawings. Acceptable products:
 - a. "Flexcell," Knight-Celotex Corp.
 - b. "Fibre Expansion Joint," W.R. Meadows, Inc.
2. Joint filler used vertically to isolate walls from columns or other walls: White molded polystyrene beadboard type.
3. Joint cover used to bridge gap between columns and grade walls, retaining walls, or basement walls: Minimum width: Gap width plus 4 in. For gaps over 3 in. wide, protect cover with protection board sized to span gap satisfactorily. Acceptable products:
 - a. "Sealtight Melgard," W.R. Meadows, Inc., Elgin, Illinois and shall be applied according to manufacturer's instructions.
 - b. Acceptable substitute.

H. Slide Bearing System at Expansion Joints:

1. Provide slide bearing system as shown and detailed on Drawings:
 - a. Beam slide bearings shall be reinforced PTFE: 100 percent virgin tetrafluoroethylene polymer and ground glass fiber reinforcing aggregate, prebonded to stainless steel. Acceptable slide bearing systems:
 - ~~a. Beam and double tee bearings shall be reinforced PTFE: 100 percent virgin tetrafluoroethylene polymer and ground glass fiber reinforcing aggregate, prebonded to stainless steel and/or preformed fabric (Section "Plant Precast Structural Concrete," Part 2 Article "Materials," paragraph "Bearing Pads") bearing pads. Acceptable slide bearing systems:~~
 - 1) "Fluorogold," Seismic Energy Products, L.P. Pine Brook, New Jersey.
 - 2) "Balco," Balco, Inc., Wichita, Kansas.
 - 3) "Alert 15175 Shock Pads with TFE," Alert Manufacturing and Supply Co. Chicago, Illinois.
 - 4) "Dura-Slide," Tobi Engineering, Inc., Elk Grove Village, Illinois.
 - 5) "Dynalon Slide Bearings with Masticord," JVI, Inc., Skokie Illinois.
 - b. Slab slide bearings shall be ultrahigh molecular weight, high-density polyethylene resin: Acceptable material:
 - ~~b. Slab and plank bearings shall be ultrahigh molecular weight, high-density polyethylene resin: Acceptable material:~~
 - 1) "Korolath PE," Korolath Corporation, Hudson, Mass.
 - 2) "Tivar-1000," Poly-Hi/Menasha Corporation, Fort Wayne, Indiana.
 - 3) "UHMW Econ-o-Shim," Deslausiers, Inc., Bellwood IL.
2. Backing materials for reinforced PTFE slide bearing systems as shown on Drawings:
 - a. Galvanized steel.
 - b. Stainless steel.
 - c. Reinforced elastomer, having durometer hardness of 90 +/- 5 and meeting requirements of Article 2.10.3(L) of AASHTO Standard Specifications for Highway Bridges (1983).

2.11 REPAIR MATERIALS

A. Acceptable repair materials:

1. Extended Open Time Epoxy Bonding Agent: Three-component, water based, epoxy modified portland cement bonding agent and corrosion inhibitor coating providing the recommended Manufacturer's open time in which to apply repair mortar. Product shall be capable of achieving bond strength of 2,700 psi per ASTM C 882.
 - a. "Duralprep A.C.", by The Euclid Chemical Company, Cleveland, OH.
 - b. "Emaco P24", by BASF Building Systems, Shakopee, MN.
 - c. "Sika Armatec 110 EpoCem", by Sika Corporation, Lyndhurst, NJ.
 - d. "Planibond 3-C" or "Mapefer 1K", by Mapei Corporation, Deerfield Beach, FL.
2. Epoxy Adhesive: 2 or 3 component, 100 percent solids, 100 percent reactive compound suitable for use on dry or damp surfaces:
 - a. "Euco #452 Epoxy Series", or "Duralcrete Epoxy Series", by The Euclid Chemical Company, Cleveland, OH
 - b. "Emaco P24", or "Concresive Liquid LPL", by BASF Building Systems, Shakopee, MN.
 - c. "Sikadur 32 Hi-Mod LPL" by Sika Corporation, Lyndhurst, NJ.
3. Trowel Applied Repair Mortar: Shall be prepackaged polymer-modified cementitious repair mortar capable of vertical/overhead application by trowel achieving a minimum 3,000 psi compressive strength at 7 days and 5,000 psi compressive strength at 28 days per ASTM C 109 as certified by manufacturer. All patches shall be squared or rectangular in shape with $\frac{1}{2}$ " deep sawcut edges, except at locations of reinforcement or tendons. Minimum repair thickness shall be $\frac{1}{2}$ " unless specified greater by the manufacturer and maximum lift thickness according to manufacturer requirements.
 - a. "EMACO R Series", "Thorite Rapid Vertical", or HBA or HB2 Repair Mortars", by BASF Building Systems, Shakopee, MN.
 - b. "Duraltop Gel", "Speedcrete PM", or "Verticoat", by The Euclid Chemical Company, Cleveland, OH.
 - c. "SikaRepair 223 with Latex R", "SikaRepair SHB with Latex R", or SikaRepair SHA with Latex R", by Sika Corporation, Lyndhurst, NJ.
 - d. "Planitop 23" by MAPEI Corporation, Deerfield, FL.
4. Horizontal Repair Mortar: Shall be prepackaged polymer-modified, cementitious repair mortar capable of horizontal, pour and screed, form and pour, partial depth, partial and full depth, or full depth applications. Material shall achieve a minimum 3,000 psi compressive strength at 7 days and 5,000 psi compressive strength at 28 days per ASTM C109 if neat and ASTM C39 if extended as certified by manufacturer. Manufacturer shall submit volume and size of SSD aggregate used for mix extension. All patches shall be squared or rectangular in shape with $\frac{1}{2}$ " deep sawcut edges, except at locations of reinforcement or tendons. Minimum thickness shall be $\frac{1}{2}$ " and maximum thickness of placement according to manufacturer requirements.
 - a. "Duraltop Flowable Mortar", by The Euclid Chemical Company, Cleveland, OH.
 - b. "Emaco S66 CI", or "Emaco R310 CI", by BASF Building Systems, Shakopee, MN.

- c. "SikaTop 111 Plus", "Sikatop 122 Plus", or Sika Repair 222 with Latex R", by Sika Corporation, Lyndhurst, NJ.
 - d. "LS-S6 or S10" or "LM-S6 or S10", by King Packaged Materials Company, Burlington, ON.
 - e. "Topcem Premix with Planitop AC", by MAPEI Corporation, Deerfield Beach, FL.
5. Immediate upon conclusion of finishing operation cure concrete in accordance with ACI 308 for duration of at least seven days by moisture curing or moisture retaining covering. Provide additional wet curing immediately following initial curing and as necessary before concrete has dried.
- a. Continue method used in initial curing.
 - b. Material conforming to ASTM C171.
 - c. Other moisture retaining covering as approved by Engineer.
 - d. During initial and final curing periods maintain concrete above 50°.
 - e. Prevent rapid drying at end of curing period.

2.12 CONCRETE MIXTURES

- A. Proportion mixtures determined by either laboratory trial mix or field test data bases, as follows:
 - 1. Proportion normal-weight concrete according to ACI 211.1 and ACI 301.
 - 2. Provide different mixtures as the season warrants, as well as each type and strength of concrete or for different placing methods.
- B. Use a qualified independent testing agency for preparing and reporting proposed Mixture Proportions for the laboratory trial mix basis.
- C. Requirements for normal-weight concrete mix are shown on Drawings:
 - 1. Compressive strength
 - 2. Slump
 - 3. Water-cementitious materials ratio
- D. Supplementary cementitious materials: For concrete exposed to deicers, limit percentage, by weight, of cementitious materials according to ACI 318 requirements.
- E. Supplementary cementitious materials: Maximum weight of fly ash, natural pozzolans, processed ultrafine fly ash or slag included in concrete shall not exceed percentages of total weight (see footnotes for ACI 301 Part 4 Table "Requirements for Concrete Exposed to Deicing Chemicals") of cementitious materials as follows:
 - 1. Fly Ash or other pozzolans conforming to ASTM C 618: 25 percent.
 - 2. Slag conforming to ASTM C 989: 50 percent.
 - 3. Processed ultra fine fly ash conforming to ASTM C 618: 15 percent.
 - 4. Total of fly ash or other pozzolans and slag: 50 percent.
- F. Chloride Ion Content of Mixture:
 - 1. Water soluble chloride ion content of concrete shall not exceed 0.06 percent by weight of cement for pre-stressed concrete and 0.15 percent for reinforced concrete. (ACI 318 Chapter 4 Table 4.4.1 "Maximum Chloride Ion Content for Corrosion Protection of Reinforcement") Test to determine chloride ion content shall conform to ASTM C 1218.

2. Concrete chloride ion content shall be determined by Testing Agency prior to placement. Cast samples from current production of concrete mix proposed for superstructure.
 3. Concrete not meeting the requirements of paragraph "Water soluble chloride ion content of concrete..." above, shall contain appropriate amount of calcium nitrite. Concrete supplier shall provide laboratory test results showing the amount of excess chloride ion content in the concrete mixture contributed by the aggregates. For each pound of chloride ion in excess of the amount allowed, mix shall contain calcium nitrite (30 percent, plus or minus 2 percent, solids content) on one-to-one basis (one gallon of calcium nitrite for one lb of excess chloride ion). Calcium nitrate used to offset chloride ions is in addition to calcium nitrate used as a corrosion inhibitor. Maximum of 1.5 lb of chloride ion per cubic yard may be offset in this manner.
- G. Alkali-Aggregate Reactivity Resistance: Provide one of the following:
1. Total equivalent alkali content of mixture less than 5 lb/cu. yd.
 2. ASTM C1293: Expansion less than 0.04 % after 1 year for each of the aggregates (both coarse and fine) in the proposed concrete mixture. This data shall be less than 1 year old.
 3. ASTM C1260: Expansion less than 0.1 % after 14 days for each of the aggregates (both coarse and fine) in the proposed concrete mixture.
 4. ASTM C1567: Expansion less than 0.1 % after 14 days with each of the aggregates (both coarse and fine) and the supplementary cementing materials (both source and quantity) of the proposed concrete mixture design. Alternatively, if satisfactory ASTM C1260 test results can be provided for one of the aggregates that are being used, ASTM C1567 testing does not need to be provided for that aggregate.
 5. CE CRD-C662: Expansion less than 0.1 % after 28 days with the each of the aggregates (both coarse and fine), the supplementary cementing materials (both source and quantity) of the proposed concrete mixture design and the lithium admixture source and dosage level of the proposed mixture design. Alternatively, if satisfactory ASTM C1260 test results can be provided for one of the aggregates that are being used, CRD-C662 testing does not need to be provided for that aggregate.
- H. Synthetic Fiber (collated fibrillated or monofilament): Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 1 lb/cu. yd.
- I. Admixtures: Use admixtures according to manufacturer's written instructions.
1. Consider using water-reducing admixture or high-range water-reducing admixture (Superplasticizers), OR admixtures that achieve self-consolidating concrete, as required, for placement, workability, finishing and when required, increased flowability.
 2. Consider using water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 3. Use high range water-reducing admixture in pumped concrete, concrete for parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio of 0.45 or less. Use normal or mid-range water reducing admixture for concrete with water-cementitious materials ratio greater than 0.45.
- J. Slump (ACI 301, Part 4 header "Slump"):

1. Maximum slump for concrete is indicated on Drawings. Where field conditions require slump to exceed that shown, increased slump shall be obtained by use of high range water reducers (superplasticizers) only, and Contractor shall obtain written acceptance from Engineer who may require an adjustment to mix.
 2. All concrete containing high-range water-reducing admixture (superplasticizer) shall have a verified initial slump of 2– 3 in. Final slump after the addition of the superplasticizer shall be 6–9 in. as required by the contractor to properly place the concrete. Before permission for plant addition of superplasticizer to be granted by Engineer, fulfill following requirements:
 - a. Submit letter from testing laboratory which developed original mixture proportions, for each superplasticized mixture, certifying volume of mix water which will produce specified slump and water/cement ratio, taking into account aggregate moisture content.
 - b. Submit plant computer printout of mixture ingredients for each truckload of superplasticized concrete with delivery of that truckload. Mix water volume greater than that certified shall be cause for concrete rejection.
 - c. Over-retarding or crusting of flatwork surface: cause for concrete rejection.
 - d. Segregation or rapid slump loss (superplasticizer life) due to incompatibility or under-dosing: cause for concrete rejection.
- K. Shrinkage (Length Change):
1. Determine length change of hardened concrete test specimens in accordance with ASTM C 157, except as noted in paragraph below. Existing test data from previous project with same materials may be acceptable.
 2. Test specimens shall be moist cured, including period in molds for 7 days. Then store specimens in air for period of 28 days.
 3. Utilize concrete materials and mix proportions submitted, for use in floor slab beam, in accordance with Part 1 Article "Submittals".
 4. Report length change of specimens after periods of air drying after curing of 4, 7, 14, 21, and 28 days.
 5. Average length change after 28 days shall be limited to 0.04%, unless otherwise accepted by Engineer. Values exceeding 0.04% shall be rejected.
- L. Self-Consolidating Concrete:
1. Minimum flow of 24 in. to 28 in. or as required by the successful test placement. All self-consolidating concrete shall contain the specified high-range water-reducing admixture and viscosity-modifying admixture as required.
 2. Measure slump flow using slump cone upright or inverted in accordance with ASTM C1611. Measured flow shall be greater than 24 inches and consistent with submitted mixture test parameters plus or minus 2 in.
 3. Measure passing ability in accordance with ASTM C 1621/C 1621M. Use the slump cone in the same way as in the slump flow test. Difference in average slump flow between slump flow and passing ability tests shall not exceed 2 in.
 4. Determine the static segregation (stability) in accordance with ASTM C 1610/C 1610M. Segregation factor of the mixture shall not be more than 15 percent.
- M. Engineer's acceptance of mixture proportions shall not relieve Contractor from responsibility for any variation from requirements of Contract Documents unless

Contractor has in writing called Engineer's attention to each such variation at time of submission and Engineer has given written approval of each such variation.

- N. Adjustment to Concrete Mixtures: Adjustments to mixture proportions may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Engineer. Laboratory test data for revised mixture and strength results shall be submitted to and accepted by Engineer before using in work.

2.13 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.14 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94 and ASTM C 1116, and furnish batch plant-printed ticket information at delivery to site.
 - 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Provide plant-printed batch ticket for each batch discharged and used in work, indicating project identification name and number, date, mixture identification number, date, time of batching, mixing time, quantity and details of materials, amount of water introduced and water permitted by plant to be added, if any.
- C. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least one and one-half minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For mixer capacity larger than 1 cu. yd. increase mixing time by 15 seconds for each additional 1 cu. yd.
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, mixture identification number, date, time of batching, mixing time, quantity and details of materials, and amount of water added. Record approximate location of final placement in structure.

2.15 TOOLS

- A. Slab Jointing
 - 1. Concrete groovers: For tooled joints in concrete:
 - a. For concrete not exceeding 4 in. thickness, use groover with 1 in. deep v-cut bit, 0.5 in. surface width and 3/16 in. to 1/4 in. edge radius.
 - b. For concrete exceeding 4 in. thickness, use groover with 1.5 in. deep v-cut bit, 0.5 in. surface width and 3/16 in. to 1/4 in. edge radius.

2. Saw Cut Joints:

- a. Acceptable tool: "Soff-Cut Saw Model 310" or "Model G2000," Soff-Cut International, Corona, CA.
 - 1) Cut joint as soon as concrete will support weight of operator and saw without deforming.
 - 2) Joint shall be 1 in. deep for concrete thickness of 4 in. or less. Joint shall be 1.5 in. deep for concrete exceeding 4 in. thickness. Do not cut reinforcement.
 - 3) Extend joint to adjacent vertical surface within 30 minutes of cutting.
 - 4) Retool or grind sawcut joint before installing sealant to provide equivalent dimensions, shape and volume as joint obtained by tooled joint. Surface width shall be 0.5 in. with 3/16 to 1/4 in. edge radius.
 - 5) All joints subject to acceptance by sealant installer. Rework rejected joints until acceptable to sealant installer.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads and in accordance with Article 1.5 "Contractor's Professional Services – Performance and Design Criteria".
- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117, except as modified below:
 1. Drilled Pier Caps and Pile Caps:
 - a. Variation of center from specified plan location: 0.5 in.
 - b. Variation of bearing surface from specified location: Plus or minus 0.5 in.
 - c. Variation from specified dimensions in plan: Plus 2 in. minus 0 in.
 - d. Variation decrease from specified thickness: 0.5 in.
 2. Footings:
 - a. Footings other than those to receive masonry construction: Variation of bearing surface from specified elevation: Plus or minus 0.5 in.
 - b. Footings to Receive Masonry Construction:
 - 1) Variation of center from specified location in plan: Plus or minus 0.25 in. in any 10 ft but not to exceed plus or minus 0.5 in.
 - 2) Variation of bearing surfaces for specified elevation: Plus or minus 0.25 in. in any 10 ft but not to exceed plus or minus 0.5 in.
 3. Piers, Columns, Walls, Beams, and Slabs:
 - a. Variation in cross-sectional dimensions of piers, beams and columns and in thickness of walls and slabs: 12 in. or less: Plus 0.375 in., minus 0.25 in. Greater than 12 in.: Plus 0.5 in., minus 0.375 in.
 - b. Variation in elevation from specified elevation for piers, columns and walls: Plus or minus 0.5 in.

4. Anchor bolts: concrete contractor shall place anchor bolts within tolerances stated under heading "Anchor Bolts and Bearing Plates" of PCI "Code of Standard Practice for Precast Concrete."
- C. Void Forms:
 1. Protect all forms from moisture prior to concrete placement.
 2. Install all forms and accessories in accordance with manufacturer's recommendations.
 3. Protect all forms from puncture and moisture during concrete placement including accessories such as taped joints, seam pads and end caps.
- D. Construct forms tight enough to prevent loss of concrete mortar.
- E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 1. Install keyways, reglets, recesses, and the like, for easy removal.
 2. Kerf wood inserts for easy removal.
 3. Do not use rust-stained steel form-facing material.
- F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
- G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- H. Chamfer exterior corners and edges of permanently exposed concrete.
- I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 1. Install anchor bolts, accurately located, to elevations required.
 2. Install reglets to receive top edge of foundation sheet waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.

3. Install dovetail anchor slots in concrete structures as indicated.

3.3 REMOVING AND REUSING FORMS

- A. General: Formwork, for sides of beams, walls, columns, and similar parts of the Work, that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.
- B. Leave formwork, for beam soffits, joists, slabs, and other structural elements, that supports weight of concrete in place until concrete has achieved the following:
 1. At least 70 percent of 28-day design compressive strength.
 2. For post-tensioned concrete, formwork shall remain in place until post-tensioning has been completed. Do not place additional loads on structure until concrete has been properly reshored.
 3. Specified compressive strength of 5000 psi. Determine compressive strength of in-place concrete by testing representative field cured test specimens according to ACI 301.
 4. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- C. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
- D. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.4 SHORES AND RESHORES

- A. Comply with ACI 347.2, ACI 318 and ACI 301, for design, installation, and removal of shoring and reshoring and in accordance with Article 1.5 "Contractor's Professional Services – Performance and Design Criteria".
 1. Do not remove shoring until measurement of slab tolerances is completed.
- B. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.
- C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.5 VAPOR BARRIER

- A. Vapor Barrier: Place, protect, and repair vapor-barrier or vapor sheets according to ASTM E 1643 and manufacturer's written instructions.

3.6 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
 - 1. Do not cut or puncture vapor barrier. Repair damage and reseal vapor barrier before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain specified concrete cover. Do not tack weld crossing reinforcing bars.
 - 1. Shop- or field-weld reinforcement according to AWS D1.4, where indicated.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- E. Install welded wire reinforcement in longest practicable lengths on continuous bar supports spaced at 2 ft o.c., maximum. Lap edges and ends of adjoining sheets per ACI 318 and as follows:
 - 1. Length of overlap measured between outermost cross wires of each sheet shall not be less than one spacing of cross wires plus two inches nor less than one and one-half times the development length nor 6 in. minimum where development length is calculated per section 12.8 of ACI 318.
 - 2. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
- F. Splices:
 - 1. Provide standard reinforcement splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements of ACI 318 for minimum lap of spliced bars.
 - 2. For mechanical tension splices of reinforcement:
 - a. Column bar lengths shall not exceed 30 ft between splices. In any bar, no splices shall occur at any floor level.
 - b. Exercise care to assure that no reduction of cross-sectional area of reinforcement occurs.
 - c. For all mechanical splices, perform splicing in strict accordance with manufacturer's requirements and instructions.
 - d. Stagger splices in adjacent bars.
 - e. Except where shown on Drawings, welding of reinforcement prohibited without prior written authorization by Engineer.
 - 3. Compression splices: Mechanically coupled splices in accordance with ACI 318, Chapter 12.
 - 4. Welded wire reinforcement shall not extend through contraction joints.

3.7 JOINTS

- A. Joints in Concrete (ACI 301, Section 5):
 - 1. Construction, control and isolation joints are located and detailed on Drawings:
 - a. Tool joints at time of finishing. Tool: Part 2 Article "Tools."
 - b. Saw Cut Joints:
 - 1) Cut joint as soon as concrete will support weight of operator and saw without deforming.

- 2) Joint shall be 1 in. deep for concrete thickness of 4 in. or less. Joint shall be 1.5 in. deep for concrete exceeding 4 in. thickness. Do not cut reinforcement.
 - 3) Extend joint to adjacent vertical surface within 30 minutes of cutting.
 - 4) Retool or grind saw cut joint before installing sealant to provide equivalent dimensions, shape, and volume as joint obtained by tooled joint. Surface width shall be 0.5 in. with 3/16 in. to 1/4 in. edge radius.
 - 5) All joints subject to acceptance by sealant installer. Rework rejected joints until acceptable to sealant installer.
 - c. Isolation joints: Interrupt structural continuity resulting from bond, reinforcement or keyway.
 - d. Construction and control joints in walls: Space joints at 20 ft. on center unless smaller spacing is shown on Drawings.
 - e. Construction or control joints in floor slabs on ground: Maximum slab area controlled by jointing 400 sq ft. Space joints at 20 ft. on center maximum unless different spacing is shown on Drawings.
 - f. Coordinate configuration of tooled joints with control joint sealants.
- B. Provide keyways at least 1-1/2 in. deep in construction joints in walls and slabs. Accepted bulkheads designed for this purpose may be used for slabs.
- C. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints except as otherwise indicated. Do not continue reinforcement through sides of strip placements.
- D. Use bonding grout, containing the specified bonding admixture, on existing concrete surfaces that will be joined with fresh concrete.
- E. Isolation Joints in Slabs-on-Ground: Construct isolation joints in slabs-on-ground at points of contact between slabs-on-ground and vertical surfaces, such as column pedestals, foundation walls, grade beams, and elsewhere as indicated.
1. Joint filler and sealant materials are specified in Division 7 Sections of these Specifications.
- F. Contraction (Control) Joints in Slabs-on-Ground: Construct contraction joints in slabs-on-ground to form panels of patterns as shown.
1. Tool contraction joints.
 2. If joint pattern not shown, provide joints not exceeding 20 ft in either direction and located to conform to bay spacing wherever possible (at column centerlines, half bays, third bays).
- G. Joint sealant material is specified in Division 7 Sections.

3.8 WATERSTOPS

- A. Flexible Waterstops: Install in construction joints as indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of Work. Field-fabricate joints in waterstops according to manufacturer's written instructions.

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

3.9 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. Before placing concrete, water may be added at Project site, subject to limitations of ACI 301.
 - 1. Do not add water to concrete after adding high-range water-reducing admixtures to mix.
- C. Deposit concrete continuously or in 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 specified. Deposit concrete to avoid segregation.
- D. Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.
 - 1. Consolidate placed concrete with mechanical vibrating equipment.
 - 2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically (in thin slabs vibrator may be inserted at angle or horizontally to keep vibrator head completely immersed) inserted at uniformly spaced locations no farther than 1.5 times action radius so area visibly affected by vibrator overlaps adjacent previously vibrated area by 3-4 inches. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration (usually 5 to 15 seconds) of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.
- E. 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 or motor driven vibrating screed and strike off to correct elevations.
 - 4. Slope surfaces uniformly to drains where required.
 - 5. Begin initial floating using highway bull floats or darbies to form a uniform and open-textured surface plane, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.
- F. 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 air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
 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. Use only the specified non-corrosive accelerator. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators, unless otherwise specified and approved in mixture proportions.
- G. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F 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. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.10 FINISHING FORMED SURFACES

- A. Refer to Section 033300.

3.11 FINISHING FLOORS AND SLABS

- A. Flatwork in Parking and Drive Areas (BROOM Finish, ACI 301, Section 5 header "Broom or Belt Finish":
1. Bullfloat immediately after screeding. Complete before any excess moisture or bleed water is present on surface (ACI 302.1R, Article 8.3.3). The use of power trowels is discouraged; however, if they are used the following applies:
 - a. Use minimal passes so as to not overwork the concrete.
 - b. At the contractor's expense a petrographic analysis will be required in each area where a power trowel is used to verify the air content at the slab surface is within specified limits.
 - c. After excess moisture or bleed water has disappeared and concrete has stiffened sufficiently to allow operation, give slab surfaces coarse transverse scored texture by drawing broom across surface. Texture shall be as accepted by Engineer from sample panels.
 2. Finish tolerance: ACI 301, Paragraph 5.3.4.2 and ACI 117, paragraph 4.5.7: The gap at any point between the straightedge and the floor (and between the high spots) shall not exceed 0.5 in. In addition, floor surface shall not vary more than plus or minus 0.75 in. from elevation noted on Drawings anywhere on floor surface.
 3. Before installation of flatwork and after submittal, review, and approval of concrete mixture proportions, Contractor shall fabricate two acceptable test

panels simulating finishing techniques and final appearance to be expected and used on Project. Test panels shall be minimum of 20 ft. by 30 ft. in area and shall be reinforced and cast to thickness of typical parking and drive area wearing surface in Project. (Maximum thickness of test panels need not exceed 6 in.) Test panels shall be cast from concrete supplied by similar concrete batch, both immediately after addition of superplasticizer or water-reducing admixture, and at maximum allowed time for use of admixture-treated concrete in accordance with Specifications. Intent of test panels is to simulate both high and low workability mixes, with approximate slump at time of casting of test panels to be 6 in. and 3 in., respectively. Contractor shall finish panels following requirements of paragraphs above, and shall adjust finishing techniques to duplicate appearance of concrete surface of each panel. Finished panels (one or both) may be rejected by Engineer, in which case Contractor shall repeat procedure on rejected panel(s) until Engineer acceptance is obtained. Accepted test panels shall be cured in accordance with Specifications and may be incorporated into Project. Accepted test panels shall serve as basis for acceptance/rejection of final finished surfaces of all flatwork.

4. Finish all concrete slabs to proper elevations to ensure that all surface moisture will drain freely to floor drains, and that no puddle areas exist. Contractor shall bear cost of any corrections to provide for positive drainage.
- B. Flatwork in Stairtowers and enclosed, Finished Areas (Float Finish, ACI 301, Paragraph 5.3.4.2.b):
1. Give slab floated finish. Texture shall be as accepted by Engineer from sample panels.
 2. Finishing tolerance ACI 301, Section 5 header "Measuring Tolerances for Slabs" and ACI 117, paragraph 4.5.7: The gap at any point between the straightedge and the floor (and between the high spots) shall not exceed 0.5 in. In addition, floor surface shall not vary more than plus or minus 3/8 in. from elevation noted on Drawings anywhere on floor surface.
- C. Flatwork in Stair towers and Parking Garage floor subject to pedestrian traffic:
1. Refer to Section 033300.

3.12 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 Work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still workable and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.

3.13 CONCRETE PROTECTION AND CURING

- A. General: Comply with ACI 308.1. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.
- B. Evaporation Reducer: Apply evaporation reducer to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft./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. Do not finish immediately after evaporation reducer applied. Wait until after (green, if Confilm used – pink, if Eucobar used) film disappears.
- C. Formed Surfaces: Cure formed concrete surfaces of columns, walls, and upturned beams. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing 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. Tepid (within 20 deg F of concrete temperature) water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch 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, 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.
 - 3. Curing Compound: After Moisture or Moisture-Retaining-Cover Curing, 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. Apply two separate coats with first allowed to become tacky before applying second. Direction of second application shall be at right angles to direction of first.
 - b. Curing compound prohibited when concrete has specified water-cementitious materials ratio less than or equal to 0.40 or air temperature above 80 deg F. Use moist cure instead.
- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces, 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. Tepid (within 20 deg. F of concrete temperature) water.
 - b. Continuous water-fog spray.

- c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch 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, 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 recommends for use with floor coverings.
3. Curing Compound: Where permitted, apply uniformly in continuous operation by power spray or roller immediately after final finishing and the absence of surface moisture, 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. Apply two separate coats with first allowed to become tacky before applying second. Direction of second application shall be at right angles to direction of first.
 - b. Curing compound prohibited when concrete has specified water-cementitious ratio less than or equal to 0.40 or air temperature above 80 deg F. Use moist cure instead.
 - c. Removal: If curing compounds are used on surfaces (exterior or interior, formed or unformed) that are scheduled or specified to receive surface-adhered treatment (including but not limited to cementitious toppings/overlays, adhesive applied carpet, resilient flooring, terrazzo, thin-set ceramic tile/stone, wood, coatings, paint, waterproofing, membranes, athletic flooring, epoxy overlay/adhesive, hardeners, sealers, water repellents, or other covering system adhered with water-based adhesive), then the following requirements apply:
 - 1) Remove curing compound no later than 7 days after end of curing period by mechanical bead blast process acceptable to Architect.
 - 2) Allow sufficient additional time after curing compound removal to achieve proper concrete moisture and/or water vapor limitation for successful application of subsequent surface treatment as specified in appropriate surface treatment specification Section.

3.14 CONCRETE SURFACE REPAIRS

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

- B. 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 sieve, using only enough water for handling and placing. Use this repair procedure only with Engineer/Architect approval.
- C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than ½ inch in any dimension in solid concrete but not less than 1 inch in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with specified bonding agent. Fill and compact with specified patching mortar before specified bonding agent has dried. Fill form-tie voids with specified patching mortar or cone plugs secured in place with specified bonding agent.
 2. Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area on mockup, or if none, at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Engineer/Architect.
 4. Repair isolated random cracks that have little movement and single holes not over 1 in. in diameter in accordance with procedures and materials specified in Division 7 Section "~~Concrete~~ Joint Sealants." Receive Engineer's written acceptance of methods and materials selected prior to application.
 - a. Repair isolated random horizontal cracks less than 0.01 in. wide, using silane sealer product specified in Division 7 "Water Repellants"
 - b. Repair isolated random horizontal cracks 0.01 in. to less than 0.03 in. wide, using crack sealer product specified in Division 7 "Water Repellants."
 - c. Repair isolated random horizontal cracks 0.03 in. to 0.06 in. wide: route and seal with specified sealant product in Division 7 "~~Concrete~~ Joint Sealants."
 - d. Repair isolated random vertical cracks more than 0.01 in. wide, using epoxy injection product specified in part 2 heading "Related Materials" of this section.
- D. 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, pop-outs, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch 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 localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
4. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of $\frac{1}{4}$ inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
5. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete or latex modified concrete as approved by the Engineer. Remove defective areas with clean, square cuts and expose steel reinforcement with at least $\frac{3}{4}$ inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mix as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
6. Repair single holes 1 inch or less in diameter with patching mortar. 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.
7. Repair isolated random cracks that have little movement and single holes not over 1 in. in diameter in accordance with procedures and materials specified in Division 7 Section "~~Concrete~~ Joint Sealants." Receive Engineer's written acceptance of methods and materials selected prior to application.
 - a. Repair isolated random horizontal cracks less than 0.01 in. wide, using silane sealer product specified in Division 7 "Water Repellants"
 - b. Repair isolated random horizontal cracks 0.01 in. to less than 0.03 in. wide, using crack sealer product specified in Division 7 "Water Repellants."
 - c. Repair isolated random horizontal cracks 0.03 in. to 0.06 in. wide: route and seal with specified sealant product in Division 7 "Concrete Joint Sealants."
 - d. Repair isolated random vertical cracks more than 0.01 in. wide, using epoxy injection product specified in part 2 heading "Related Materials" of this section.
- E. Perform structural repairs of concrete, subject to Engineer/Architect's approval, using epoxy adhesive and patching mortar, latex modified concrete or other materials as approved by the Engineer.
- F. Repair materials and installation not specified above may be used, subject to Engineer/Architect's approval.

3.15 FIELD QUALITY CONTROL

- A. CM At Risk will employ a testing laboratory to perform tests and to submit test reports.
- B. Sample concrete in accordance with ASTM C 172.

C. Temperature:

1. Test temperature of concrete in accordance with ASTM C 1064/C 1064M and ACI 301 each time cylinders are taken or as directed by the Engineer.

D. Slump Test:

1. Conduct one slump test in accordance with ASTM C 143/C 143M per truck load of ready-mixed concrete delivered to Project at truck for superstructure concrete.
2. Conduct slump test in accordance with ASTM C143/C 143M and ACI 301 for foundation concrete.
3. When high-range water-reducing admixture (superplasticizer) is used, initial slump must be verified by Testing Agency.

E. Slump Flow Test (SCC):

1. Conduct one slump flow test in accordance with ASTM C 1611/C 1611M per truck load of ready mixed concrete delivered to Project at truck for superstructure concrete.
2. Conduct slump flow test in accordance with ASTM C1611/C 1611M and ACI 301 for foundation concrete.

F. Water Content:

1. Water content and water-cementitious materials ratio shall be verified by use of the Microwave Test in accordance with AASHTO T 318.
2. Conduct test each time test cylinders are taken and as directed by Engineer.

G. Concrete Compressive Strength:

1. Mold test cylinders in accordance with ASTM C 31 and test in accordance with ASTM C 31 as follows:
 - a. Take minimum of six cylinders (eight for post-tensioned cast-in-place concrete) for each 100 cu yd or fraction thereof, of each Mixture of concrete placed in any one day.
 - b. Additional cylinders shall be taken under conditions of cold weather concreting per Part 3 Heading "Concrete Curing and Protection."
 - c. At Contractor's option and cost, cylinders may be taken to verify concrete strength prior to form removal.
 - d. Testing Agency: Provide and maintain site cure box for cylinders.
2. Sample plastic concrete for testing at point of final placement, in accordance with ASTM C 172. Engineer will select sampling locations which may include points where plastic concrete has already been screeded and floated. Sample concrete for test cylinders to be used to verify concrete compressive strength for post-tensioning as near as possible to actual tendon anchorages.
3. Cover specimens properly, immediately after finishing. Protect outside surfaces of cardboard molds, if used, from contact with sources of water for first 24 hours after molding.
4. Cure test cylinders per ASTM C 31 as follows:

- a. To verify compressive strength prior to post-tensioning or form removal or for additional test cylinders required due to cold weather concreting conditions:
 - 1) Store test specimens on structure as near to point of sampling as possible and protect from elements in same manner as that given to portion of structure as specimen represents.
 - 2) Transport to test laboratory no more than 4 hours before testing. Remove molds from specimens immediately before testing.
- b. To verify 28-day compressive strength:
 - 1) During first 24 hours after molding, store test specimens under conditions that maintain temperature immediately adjacent to specimens in range of 60 to 80 degrees F. and prevent loss of moisture from specimens.
 - 2) Remove test specimens from molds at end of 20 +/- 4 hours and store in moist condition at 73.4 +/- 3 degrees F. until moment of test. Laboratory moist rooms shall meet requirements of ASTM C 511.
- 5. Compression test for non-prestressed concrete:
 - a. Test 2 cylinders at 7 days.
 - b. Test 2 cylinders at 28 days.
 - c. Test 2 cylinders at 56 days for concrete strength requirement of 7000 psi or greater, otherwise hold 2 cylinders in reserve for use as Engineer/Architect directs.
- 6. Compression tests for post-tensioned concrete:
 - a. Test 2 cylinders immediately before tensioning slabs and 2 cylinders before tensioning beams. Cylinders must be field cured in accordance with paragraph "Cure test cylinders per ASTM C 31...."
 - b. Test 2 cylinders at 28 days.
- 7. Hold 2 cylinders in reserve for use as Engineer directs.
- 8. Unless notified by Engineer, reserve cylinders may be discarded without being tested after 56 days.
- H. Report all nonconforming test results to Engineer and others on distribution lists via fax or email. Follow up with colored paper copies to flag the non-conformances.
- I. Monthly, submit a graph showing distribution of compressive strength test results and air content test results. Include microwave test results for concretes with a water cementitious ratio less than or equal to 0.40 concrete.

EVALUATION AND ACCEPTANCE OF CONCRETE

- J. Concrete Compression test will be evaluated by Engineer in accordance with ACI 301. If number of tests conducted is inadequate for evaluation of concrete or test results for any type of concrete fail to meet specified strength requirements, core tests may be required as directed by Engineer. Air content and parameters of air-void system shall meet requirements of this Section.
- K. Core tests, when required, in accordance with ASTM C42 and ACI 301.
- L. Should tested hardened concrete meet Specifications, Owner will pay for coring and testing of hardened concrete. Should tested hardened concrete not meet Specifications or should concrete have to be tested because Contractor did not conform to Project specifications, Contractor shall pay for coring and testing of hardened concrete and for any corrective action required for unaccepted concrete.

3.16 ACCEPTANCE OF STRUCTURE

- A. Acceptance of completed concrete Work will be according to provisions of ACI 301.
- B. "RAPIDLOAD" testing is acceptable, by Structural Preservation Systems, Baltimore, MD.

END OF SECTION

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

I. GENERAL INFORMATION:	
Project:	City:
General Contractor:	
Concrete Supplier:	
Mixture Identification No.:	Concrete Grade:
Use (Describe) ¹ :	

¹ example: Footings, interior flatwork, floor slabs, topping, columns, etc.

II. MIXTURE PROPORTIONING DATA:		
Proportioning Based on (Check only one):		
<p>Standard Deviation Analysis: _____(see section VIII)</p> <p>or Trial Mix Test Data: _____ (see Section IX)</p>		
Mixture	Density: _____ pcf;	Air: _____ % specified
Characteristics:	Slump _____ in. before superplasticizer	Slump _____ in. after superplasticizer
(see Mixtures in Drawings General Notes)	Strength: _____ psi (28 day);	Or for SCC: Spread _____ in.

WALKER SUBMITTAL STAMP

CONTRACTOR
SUBMITTAL STAMP

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

III. MATERIALS:		
Aggregates: (size; type; source; gradation report; specification)		
Coarse:		
Fine:		
Other Materials:	Type	Product-Manufacturer (Source)
Cement:		
Flyash, slag, or other pozzolan:		
Silica Fume		
Processed Ultra Fine Fly Ash		
HRM		
Air Entraining Agent:		
Water Reducer		
High Range Water Reducer (HRWR / superplasticizer)		
Non-Corrosive Accelerator		
Retarder		
Fibers		
Other(s):		

IV. <u>MIX PROPORTIONS</u> ⁽²⁾		
	WEIGHT (lbs.) (per yd ³)	ABSOLUTE VOL. (cu. ft.) (per yd ³)
Cement:		
Fine Aggregate: ⁽³⁾		
Coarse Aggregate: ⁽³⁾		
Flyash, slag, or other pozzolan:		
Silica Fume		
Processes Ultra Fine Fly Ash		

HRM		
Water: ⁽⁴⁾ (gals. & lbs)		
Entrained Air: (oz.)		
Fibers:		
(Other) _____:		

TOTALS:		
NOTES: ⁽²⁾ Mix proportions indicated shall be based on data used in section VII or IX. ⁽³⁾ Based on saturated surface dry weights of aggregates. ⁽⁴⁾ Includes ALL WATER, including added water and free water contained on aggregates.		

V. <u>RATIOS</u>		VI. SPECIFIC GRAVITIES
Water ⁽¹⁾	lb	Fine Aggregate:
= _____	=	
Cementitious Material ⁽²⁾	lb	Coarse Aggregate:
Fine Agg.	lb	
= _____	=	
Total Agg.	lb	
NOTES: ⁽¹⁾ Includes ALL water, including added water and free water contained on aggregates. ⁽²⁾ Cementitious materials include cement, fly ash, slag, silica fume, HRM, Processed Ultra Fine Fly Ash or other pozzolan.		

VII. <u>ADMIXTURES</u>				
Air Entraining Agent (A.E.A.):	___ oz.	per yd ³	___ oz.	per 100# cement
Superplasticizer	___ oz.	per yd ³	___ oz.	per 100# cement
Water Reducer	___ oz.	per yd ³	___ oz.	per 100# cement
Non-corrosive Accelerator	___ oz.	per yd ³	___ oz.	per 100# cement
Retarder	___ oz.	per yd ³	___ oz.	per 100# cement
Other	___ oz.	per yd ³	___ oz.	per 100# cement
Lithium Nitrate	___ gal.	per yd ³		

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

VIII. <u>STANDARD DEVIATION ANALYSIS:</u>		<u>Yes</u>	<u>N/A</u>
(Complete this section only if Mixture was developed using standard deviation analysis of previous project test results. If other method was used, check "N/A".)			
<u>Number of Tests Evaluated:</u> (One test is average of two cylinder breaks)		<u>Standard Deviation:</u> (Single Group)	
<u>Attach copy of test data considered:</u>		<u>Standard Deviation:</u> (Two Groups)	
Required average compressive strength: $f'_{cr} = f'_c + \underline{\hspace{2cm}}$ psi			
<p>NOTE:</p> <p>Mixture shall be proportioned in accordance with ACI 301 section 4.2.3 to achieve average compressive strength f'_{cr} equal to or greater than the larger of one of the following equations:</p> <p>(4.-3) $f'_{cr} = f'_c + 1.34ks$ [s= calculated standard deviation]</p> <p>or</p> <p>(4-4) $f'_{cr} = f'_c + 2.33ks - 500$</p> <p>or</p> <p>(4-5) $f'_{cr} = 0.9f'_c + 2.33ks$ (for $f'_c > 5,000$ psi)</p> <p>(Refer to ACI 301 for required average when data are not available to establish standard deviation. For post-tensioning projects, see also special requirements for strength required to apply initial post-tensioning.)</p>			
MIXTURE CHARACTERISTICS (As shown on drawings)			
Slump = <u> </u> in.		Air Content = <u> </u> %	
Unit Wet Wt. = <u> </u> pcf		Unit Dry Wt. = <u> </u> pcf	
MIXTURE CHARACTERISTICS (Based on proportioning data)			
Initial Slump = <u> </u> in.		Final Slump <u> </u> in.	
Unit Wet Wt.= <u> </u> pcf.		Unit Dry Wt. = <u> </u> pcf.	
Air Content = <u> </u> %			

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

IX. TRIAL MIXTURE TEST DATA:		Yes	N/A
(Complete this section only if Mixture Proportion is based on data from trial test mixture(s) batched by testing agency or Contractor. If other method was used, check "N/A".)			
Age (days)	Mix #1 (comp. str.)	Mix #2 (comp. str.)	Mix #3 (comp. str.)
7			
7			
28			
28			
28			
28 day average compressive strength, psi			
<p>NOTE:</p> <p>Mixture shall be proportioned in accordance with ACI 301 section 4.2.3 to achieve average compressive strength f'_{cr} equal to or greater than the larger of one of the following equations:</p> <p>(Less than 3000) $f'_{cr} = f'_c + 1000$</p> <p>or</p> <p>(3000 to 5000) $f'_{cr} = f'_c + 1200$</p> <p>or</p> <p>(Over 5000) $f'_{cr} = 1.1f'_c + 700$</p> <p>For post-tensioning projects, see also special requirements for strength required to apply initial post-tensioning.</p>			
MIXTURE CHARACTERISTICS (as shown on drawings)			
Slump = _____ in.		Air Content = _____ %	
Unit Wet Wt. = _____ pcf		Unit Dry Wt. = _____ pcf	
MIXTURE CHARACTERISTICS (Based on proportioning data)			
Initial Slump = _____ in.		Final Slump _____ in.	
Unit Wet Wt.= _____ pcf.		Unit Dry Wt. = _____ pcf.	
Air Content = _____ %			

CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

X. OTHER REQUIRED TESTS			
Water Soluble Chloride Ion Content of mix:	_____ % (by weight of cement)		ASTM C 1218
Hardened Air Content (per ASTM C457):			
Air content: _____%	Air void spacing Factor _____ in.	Specific surface: _____ in ² /in ³	
Chloride Ion Content of Concrete Mixture: ASTM C 1218			
Shrinkage (Length Change, Average) per ASTM C157:			
_____% @ 4 days	_____% @ 7 days	_____% @ 14 days	
_____% @ 21 days	_____% @ 28 days		

XI. Remarks:

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CONCRETE MIXTURE PROPORTIONS SUBMITTAL FORM

Mixture #

Project Name:

Ready Mix Concrete Supplier Information
Name:
Address:
Phone Number:
Date:
Main Plant Location:
Miles from Project Site:
Secondary or Backup Plant Location:
Miles from Project Site:

My signature below certifies that I have read, understood, and will comply with the requirements of this Section.

Signature _____

Typed or Printed Name

REQUIRED ATTACHMENTS	
	Coarse aggregate grading report
	Fine aggregate grading report
	Concrete compressive strength data used for calculation of required average strength and for calculation of standard deviation
	Chloride ion data and related calculations
	Admixture compatibility certification letter
	Shrinkage information per ASTM C157
	ASTM C 457
	Alkali Content Data and Calculations OR ASTM C1293, ASTM C1260, ASTM C 1567 or CE CRD-C662 Test report for each aggregate

SECTION 03 3801 - POST-TENSIONED CONCRETE - PARKING GARAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section.

1.2 SUMMARY

- A. In accordance with Contract Documents, provide all materials, labor, equipment, and supervision to fabricate and install all post-tensioning Work. Non-prestressed reinforcement shall conform to Division 03 Section, "Cast-in-Place Concrete."
- B. Meet the requirements of ACI 301, ACI 318, ACI 423.7, CRSI MSP-2, and Contract Documents. In case of a conflict, meet the more stringent requirement.
- C. Related work in other Sections related to Post-Tensioned Concrete:
 - 1. Division 01 Section "Project Management and Coordination."
 - 2. Division 03 Section "Cast-in-Place Concrete (Parking Garage)."

1.3 REFERENCES

- A. Field Reference: Keep a copy of the following reference in the Contractor's field office.
 - 1. PTI's "Field Procedures Manual for Unbonded Single Strand Tendons"
- B. American Concrete Institute (ACI):
 - 1. ACI 301, "Specification for Structural Concrete."
 - 2. ACI 318, "Building Code Requirements for Structural Concrete."
 - 3. ACI 347, "Recommended Practice for Concrete Formwork."
 - 4. ACI 362.1R-12, "Guide for the Design of Durable Parking Structures."
 - 5. ACI 423.3R, "Recommendations for Concrete Members Prestressed with Unbonded Tendons."
 - 6. ACI 423.7, "Specification for Unbonded Single-Strand Tendon Materials and Commentary."
- C. American Society for Testing and Materials (ASTM):
 - 1. ASTM A416, "Specification for Uncoated Seven-Wire Strand for Prestressed Concrete."
 - 2. ASTM E328, "Recommended Practice for Stress-Relaxation Tests for Materials and Structures."
- D. Concrete Reinforcing Steel Institute (CRSI):
 - 1. CRSI MSP-2, "Manual of Standard Practice."
- E. Post-Tensioning Institute (PTI):
 - 1. PTI, "Guide Specifications for Post-Tensioning Materials."
 - 2. PTI, "Performance Specification for Corrosion Preventive Coating."
 - 3. PTI, "Specification for Unbonded Single Strand Tendons."

- 4. PTI, "Field Procedures Manual for Unbonded Single Strand Tendons."
- F. Florida Building Commission:
 - 1. FBC, "Florida Building Code."

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the tendon and anchor locations with Work of other Sections, including "Cast-in-Place Concrete." Immediately inform Engineer/Architect of any potential interference.
- B. Sequencing:
 - 1. Deviations in the construction and stressing sequence shown on the Drawings are not permitted without written acceptance from Engineer/Architect.
- C. Make submittals in accordance with requirements of Division 01 Section, "Shop Drawings, Product Data, and Samples Submittal Procedures:"
 - 1. See requirements of Division 01 Section, "Submittal Procedures Shop Drawings, Product Data, and Samples," Part 1 heading, "Submittal Procedures," for limits to resubmittals.
 - 2. See requirements of Division 01 Section, "Shop Drawings, Product Data, and Samples Submittal Procedures," Part 2 heading, "Requests for Information," for RFI constraints.

1.5 ACTION SUBMITTALS

- A. Product Data: For each product as indicated.
 - 1. Corrosion Inhibiting Coating: Type and chemical analysis.
 - 2. Sheathing: Type, material, density and thickness.
 - 3. Anchorage Device: Type, material and size.
 - 4. Coupler Device: Type, material and size.
 - 5. Pocket Former: Type, material and size.
 - 6. Sheathing Repair Tape: Type, material and width.
 - 7. Encapsulation System: Type and materials.
- B. Shop Drawings: Include the following prepared by or under the supervision of a qualified professional engineer:
 - 1. Number, arrangement and designation of tendons.
 - 2. Tendon profile and method of tendon support. Show tendon profiles at sufficient scale to clearly indicate tendon high and low points.
 - 3. Tendon anchorage details including bundled tendon flaring.
- C. Construction Manager is expected to employ qualified personnel to review submittals before they are submitted to Engineer for review.
- D. Resubmittals: Engineer will review each of Contractor's submittals the initial time and, should resubmittal be required, again to verify that reasons for resubmittal have

- been addressed by Contractor and corrections made. Resubmittal changes/revisions/corrections shall be circled. Engineer will review only circled items and will not be responsible for non-circled changes/revisions/corrections and additions.
1. Make resubmittals in same form and number of copies as initial submittal.
 - a. Note date and content of previous submittal.
 - b. Note date and content of revision in label or title block and clearly indicate extent of revision.
 - E. Resubmit submittals until they are marked with approval notation from Engineer's and Construction Manager's action stamp
 - F. Samples: For the following products:
 1. Each anchorage assembly with a minimum of 24 inches of coated, sheathed strand.
 2. Each coupler assembly with a minimum of 24 inches of coated, sheathed strand.
 3. Encapsulation system.
 - G. Delegated-Design: For post-tensioning system.
 1. Signed and sealed calculations prepared by a qualified structural engineer in the State of Florida indicating method of elongation and determination of number of tendons. Include values used for friction coefficients, anchorage seating loss, elastic shortening, creep, relaxation, wobble and shrinkage.
 - H. Stressing Records: Same day as stressing operation.
 - I. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 1. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
 - b. Leadership Extraction Practices for Recycled Content for records

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Supplier and Installer at least 14 days prior to bid date using the forms at the end of this section.
- B. Mill Test Reports: Certified mill test reports for each coil or pack of strand used on Project, indicating that strand is low relaxation and including the following information:
 1. Heat number and identification.
 2. Minimum breaking strength.
 3. Yield strength at 1 percent extension under load.
 4. Elongation at failure.
 5. Modulus of elasticity.
 6. Diameter and net area of strand.
- C. Test and Evaluation Reports: Indicating compliance with the following requirements:
 1. Tests required by ACI 301, Section "Post-Tensioned Concrete."

2. Hydrostatic tests required by ACI 423.7 for “Anchorages and couplers in aggressive environments.”
 3. Relaxation loss tests required by ACI 423.7 for low relaxation prestressing steel.
- D. Field Quality-Control Reports: Within 72 hours of inspection.
- E. Stressing Jack Calibration: Calibration certificates for jacks and gages to be used on Project. Calibrate each jack-and-gage set as a pair.
- F. Warranty: Proposed warranty prior to the start of construction.

1.7 QUALITY ASSURANCE

- A. Supplier Qualifications:
1. Use a fabricating plant certified by PTI.
 2. Successfully provided all materials for at least 5 post-tensioning installations in parking structures in the United States with a structural system similar to Project within the previous 5 years. Provide all information requested on the form at the end of this section.
- B. Installer Qualifications:
1. Certified by PTI.
 2. Successfully performed at least 5 post-tensioning installations in parking structures in the United States with a structural system similar to Project within the previous 5 years. Provide all information requested on the form at the end of this section.
 3. Use a full-time Project superintendent that has supervised at least 5 projects of similar magnitude.
 4. Use PTI Certified Field Installers to install and stress post-tensioning system.
- C. Suppliers, who do not meet the qualification requirements above, shall meet and pay for following requirements:
1. Retain independent testing or consulting firm acceptable to Engineer/Architect.
 2. Acceptable firm shall inspect post-tensioning Supplier's plant at 1 wk intervals during production and issue report on each visit, signed and sealed by Florida Licensed Professional Engineer verifying that materials, methods, product, and quality meet all PTI Plant Certification and Project specification requirements. Sample tendon corrosion preventive coating being applied during each visit and send sample directly to Engineer/Architect-designated testing laboratory for testing.
 3. If firm's report indicates noncompliance, Engineer/Architect, at Owner's expense, may inspect and may reject any or all products produced during period of noncompliance.
- D. Comply with requirements in ACI 301, Section “Post-Tensioned Concrete.”
- E. Perform all post-tensioning Work under the supervision of a Project Superintendent who is present during all operations including installation, concrete placement, stressing and finishing.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Assign all tendons in same member the same heat number and identify accordingly.
- B. Package each tendon bundle at source to prevent physical damage to tendon during transportation and storage, and to protect strand from moisture. Use heavy padding cardboard is not permitted. Do not use wire binding or other materials that could cut the sheathing or tendon.
- C. Deliver, store and handle post-tensioning materials according to ACI 423.7. Contractor to inspect tendons and accessory items at time of delivery to Project site, prior to off-loading. Notify post-tensioning supplier of observed damage prior to off-loading.
- D. Immediately remove damaged components from Project site and replace at no cost to Owner.
- E. Do not remove sheathing on stressing end until the day of stressing.
- F. Materials Stored on Slabs:
 - 1. Prior to final stressing of beams and slabs, do not store any materials on slab.
 - 2. After final stressing of beams and slabs but before concrete has reached the specified 28-day strength, do not store materials on slab such that the weight exceeds 50 percent of the design live load.
 - 3. After final stressing of beams and slabs and concrete has reached the specified 28-day strength, do not store materials on slab such that the weight exceeds the design live load.

1.9 WARRANTY

- A. Provide a warranty from the Supplier that includes the following terms and provisions.
 - 1. Warranty period of 5 years beginning with the date of Beneficial Occupancy.
 - 2. Correct, at no expense to Owner, any defects that develop during the warranty period, which can be attributed to a defect in quality of product or workmanship.
 - 3. All materials have been manufactured in accordance with the Project specifications.
 - 4. Installation of materials, if under the control of the Supplier, has been according to the Project specifications.
 - 5. Supplier is not responsible for damage or liability caused by the actions or omissions of others.

PART 2 - PRODUCTS

2.1 DESIGN CRITERIA

- A. System described in this Section intended to satisfactorily perform in ACI 362.1R-12 zone CC-II environment without long-term corrosion or other distress.
- B. Engage a qualified professional engineer licensed in Florida to provide tendon quantity calculations and detail the tendon layout based on the following:
 - 1. Provide the final effective forces indicated on the drawings, which are the stressing forces minus both the short- and long-term losses.

2. Do not exceed the maximum tensile stress in the tendon during the stressing operation. The maximum tensile stress is the smallest of the following:
 - a. 80 percent of the specified tensile strength of the tendon.
 - b. 94 percent of the specified yield strength of the tendon.
 - c. Maximum value recommended by the tendon manufacturer.
3. Do not exceed 70 percent of the specified tensile strength after the anchors are seated.
4. Use PTI recommended values for friction and wobble coefficients unless test data is submitted to substantiate lower values.
5. Limit main slab tendon maximum spacing according to ACI 318, chapter "Pre-stressed Concrete," heading "Slab Systems."
6. For multi-span tendons, do not base the effective tendon force on the average stress for all spans. Calculate losses for each span independently.

2.2 PRESTRESSING TENDONS

- A. Prestressing Strand: ASTM A416, Grade 270, uncoated, seven-wire, low-relaxation strand with minimum ultimate strength of 270 ksi.
 1. Manufactured by a single source.
 2. Strands manufactured outside United States subject to Engineer/Architect's approval based on evidence of satisfactory performance in the United States during the previous 5 years.
 3. Use of high stress bar system instead of strand system is not permitted unless accepted in writing by the Engineer.
 4. Conform to ACI 423.7 for relaxation loss requirements.
 - 4-5. There shall be 0% recycled steel for the strands
- B. Tendon Sheathing: Seamless and extruded high density polypropylene or seamless and extruded high density polyethylene with a specific gravity greater than 0.95 conforming to ACI 423.7.
 1. Sufficient strength to withstand damage during fabrication, transport, installation, concrete placement and stressing.
 2. Minimum thickness of 50 mils (-0 mils +15 mils)
 3. Minimum inside diameter 0.03 inches greater than maximum strand diameter.
 4. Chemically stable without becoming brittle or softening over anticipated temperature range and service life of structure.
 5. Non-reactive with concrete, steel and corrosion inhibiting coating.
 6. Contrasting color of corrosion inhibiting coating to enhance visibility of damage. Black/dark colored sheathing is not acceptable.
 7. Annular space between sheathing and strand completely filled with corrosion inhibiting coating.
 8. Watertight including all connections and components over entire length.
- C. Tendon Anchor: Non-porous casting free of sand, blow holes, voids and other defects meeting the testing and material requirements of ACI 423.7.

1. Plastic coated bearing plates sized in accordance with ACI 423.7, unless certified test reports substantiate comparable or superior performance, for transfer at minimum stressing concrete strength.
 2. Capable of complying with PTI Guide Specification requirements for aggressive environments.
 3. Capable of developing at least 95% of the actual ultimate strength of tendon.
 4. Minimum wedge cavity opening of at least 0.19 inches larger than tendon diameter. Reaming of anchor wedge cavity is not permitted.
 5. Wedges capable of precluding failure of tendon due to notching or pinching effects during static and fatigue load tests stipulated in ACI 423.7.
 6. Provisions for a plastic cap which fits tightly and seals barrel end on stressing side of anchor.
 7. Provisions for a plastic sleeve which prevents moisture infiltration into anchor casting or tendon sheathing on bearing side of anchor.
- D. Coupler Assembly: Assembly of strands and wedges meeting the testing and material requirements of ACI 301.
1. Capable of complying with PTI Guide Specification requirements for aggressive environments.
 2. Capable of developing at least 95 percent of the ultimate strength of tendon.
 3. Wedges capable of precluding failure of tendon due to notching or pinching effects during static and fatigue load tests stipulated in ACI 423.7.
- E. Encapsulation System: Watertight encapsulation along the entire length of tendon, including anchorages and couplers, when subjected to hydrostatic testing required in ACI 423.7 for aggressive environments.
1. Sleeve: Translucent plastic with a positive mechanical connection to anchorages capable of resisting 100 lbs. pulling force. Minimum 10 inches long and 4 inches overlap with sheathing, completely filled with corrosion inhibiting coating.
 2. Anchor Cap: Translucent plastic with a positive mechanical connection to anchorages capable of resisting 100 lbs. pulling force. At intermediate anchorages, open to allow passage of strand.
 3. Subject to the requirements provide one of the following systems:
 - a. "Zero Void," General Technologies, Inc.
 - b. "Hayes Posi-Lock Plus," Hayes Industries, Ltd.
 - c. Accepted equivalent.

2.3 ACCESSORIES

- A. Pocket Formers: Capable of completely sealing wedge cavity from intrusion of concrete or cement slurry; sized to provide at least a 2 inch recess and allow access for cutting strand tail.
1. If Zero Void encapsulation system in used, the "Zero Void Nail-Less Pocket Former" is required.
- B. Anchorage Fasteners: Stainless-steel ring nails. Subject to the requirements use one of the following:

1. Clendenin Brothers, Baltimore, MD.
 2. Swan Secure Products, Baltimore, MD.
 3. R.J. Leahy Co., San Francisco, CA.
 4. Accepted equivalent.
- C. Sheathing Repair Tape: Elastic, self-adhesive, moisture-proof tape with a minimum width of 2 inches in contrasting color to tendon sheathing, and that is non-reactive with sheathing, corrosion inhibiting coating, or tendon. Subject to the requirements use one of the following:
1. "3M Tape No. 226," 3M, St. Paul, MN.
 2. "Polyken 826," Berry Plastics Corp, Evansville, IN
 3. "Tyco Adhesives No. 398," Tyco Adhesives, Franklin, MA
- D. Sheathing Repair Material: For nicks and cuts less than 0.25 inches use one of the following:
1. "Scotch-Weld DP-8005," by 3M.
 2. Accepted equivalent.
- E. Corrosion inhibiting coating: Capable of meeting the requirements of ACI 423.7. Subject to the requirements use one of the following
1. "Greasrex K-218," ExxonMobil Oil Corp., Irving, TX.
 2. "Red-i PT Coating Grease," Lubricating Specialties Co., Pico Rivera, CA
 3. "Renolit PTG," Fuch's Lubricant Co., Harvey, IL
 4. "Royal PT-1 and PT-2 Corrosion Inhibiting Grease," Troco Oil Co., Tulsa, OK
- F. Tendon supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening tendons in place. Use tendon supports capable of meeting the requirements in CRSI's "Manual of Standard Practice" and as follows:
1. Clearly marked to differentiate by height.
 2. Capable of resisting overturning during construction operations.
 3. Minimal contact with forms where concrete is exposed to view.
 4. Do not cause voids or damage to surrounding concrete.
 5. All-plastic supports conforming to CRSI Class 1 protection requirements and with a compressive strength higher than concrete.
 6. Acceptable manufacturers:
 - a. Aztec Concrete Accessories, Inc.
 - b. General Technologies, Inc.
 - c. Accepted equivalent.

2.4 GROUT MATERIALS

- A. Premixed, nonmetallic, noncorrosive, non-staining grout product containing selected silica sands, Portland cement, shrinkage compensating agents, plasticizing and water reducing agents, complying with ASTM C 1107, Grade B, with fluid consistency and a 30-minute working time.
- B. Non-reactive with prestressing strand, anchorage materials, or concrete and without chlorides or other chemicals known to be deleterious to prestressing strand.
- C. Subject to compliance with requirements, provide one of the following:

1. Sure Grip Grout, Dayton Superior.
2. Euco N.S., Euclid Chemical Co.
3. Masterflow 928, Master Builders, Inc.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Provide formwork for post-tensioned elements as specified in Division 03 Section, "Cast-in-Place Concrete." Design formwork to support load redistribution that may occur during stressing operation. Ensure that formwork does not restrain elastic shortening, camber or deflection resulting from application of prestressing force.
- B. Do not remove forms supporting post-tensioned elements until tendons have been fully stressed and elongations have been approved by Engineer/Architect.

3.2 TENDON INSTALLATION

- A. Tendon Supports:
 1. Support slab tendons independently of beam reinforcement.
 2. Position supports at high and low points and at intervals not exceeding 48 inches.
 3. Support tendons as required to provide the specified profile and prevent displacement during subsequent construction operations.
- B. Tendon Profile:
 1. Place tendons with a parabolic profile in a vertical plane conforming to control points shown on Drawings unless otherwise noted. Control points locate the center of gravity of tendons.
 2. Locate low point at mid-span unless otherwise noted.
 3. Maintain tendon profile with the maximum allowable deviation for corresponding member dimensions as follows:
 - a. 8 inches or less: ± 0.25 inches.
 - b. 8 to 24 inches: ± 0.375 inches.
 - c. 24 inches or more: ± 0.5 inches.
- C. Tendon Location:
 1. Obtain Engineer/Architect's approval before relocating tendons that interfere with one another.
 2. Slight deviations in horizontal spacing and location are permitted when required to avoid openings and inserts.
 3. Maintain minimum radius of curvature of 21 feet for horizontal deviations.
 4. Locate tendons parallel to grid lines unless otherwise noted.
 5. Straighten strands to produce equal stress in all tendons that are to be stressed in a concrete placement and to ensure proper positioning of anchors.

D. Anchors:

1. Install anchors perpendicular to tendon axis.
2. Install tendons straight, without vertical or horizontal curvature, for a minimum of 12 inches behind stressing-end and intermediate anchors.
3. Attach stressing-end anchors securely to bulkhead forms to prevent loosening due to construction activity or during concrete placement.

E. Tendon Bundling:

1. Limit slab tendon bundles to two tendons.
2. Do not twist or entwine tendons within a bundle.
3. Maintain a minimum of 12 inches between centers of adjacent bundles.

F. Tendon Protection:

1. Protect tendons from moisture and corrosion prior to concrete placement.
2. Protect exposed tendons from moisture and corrosion at all times.
3. Bare tendons are not permitted at any time.
4. Do not cut or remove sheathing before concrete is placed.

G. Over occupied/finished areas permanently mark tendon locations on slab soffit.

H. Do not use splices or coupler assemblies within a concrete pour unless accepted in writing by the Engineer. When coupler assemblies are used, completely fill enclosure with corrosion inhibiting coating.

I. Welding is prohibited unless shown on the drawings or accepted in writing by the Engineer.

3.3 SHEATHING INSPECTION AND REPAIR

A. Inspect sheathing for damage after installing tendons and before placing concrete.

B. Remove and replace tendons that have damaged encapsulation systems including sheathing tears or cuts over 10 percent of the length (damage need not be continuous), sheathing withdrawn from connecting sleeves, or connecting sleeves withdrawn from fixed end anchorages.

C. Repair damaged areas by restoring corrosion inhibiting coating and repairing sheathing according to the following procedure to the satisfaction of the Engineer/Architect.

1. Coat with corrosion inhibiting coating outside of sheathing for the length of damaged area plus 2 inches beyond each end of damage. For example, if sheathing tear is 6 inches long then corrosion inhibiting coated area will be 10 inches long, centered on tear.
2. Install longitudinally slit sheathing around corrosion inhibiting coating area with the slit on the side opposite the tear. Extend slit sheathing 2 inches beyond corrosion inhibiting coating area at each end. For example, if corrosion inhibiting coating area is 10 inches long, then the slit sheathing will be 14 inches long, centered on tear.
3. After removing corrosion inhibiting coating from the area to be taped, spirally wrap tape around slit sheathing to provide at least 2 layers of tape. Extend tape 2 inches beyond slit sheathing at each end. For example, if slit sheathing is 14 inches long, then taped area will be 18 inches long, centered on tear.

D. Repair nick and cuts less than 0.25 inches long with sheathing repair material.

3.4 TENDON STRESSING

- A. Calibrate stressing jacks and gages at least every 6 months and keep copies of certificates on site and available for inspection.
- B. Use stressing jacks that are equipped with pressure gages to permit stress in the tendon to be computed at any time.
- C. Begin stressing operations as soon as concrete strength reaches 3,000 psi.
- D. Complete stressing within 96 hours after concrete placement begins unless concrete has not reached the required strength. If concrete strength has not reached minimum stressing strength within 96 hours (including weekends and holidays) apply 50 percent stress to each tendon and full stress as soon as compressive strength reaches the minimum stressing strength.
- E. If measured elongation deviates from calculated elongation by more than 7 percent, recalculate elongations based on actual modulus of elasticity of strand.
- F. If, after modulus check, measured and calculated elongations still deviate by more than 7 percent, cease stressing operations. Review section 7.3 from PTI's "Field Procedures Manual for Unbonded Single Strand Tendons" for causes for improper elongation. Proceed with stressing only after deviation cause has been determined and corrected to satisfaction of Engineer/Architect.
- G. Do not allow tendon movement greater than 0.25 inches during wedge seating.

3.5 TENDON FINISHING

- A. Do not cut tendons or cover anchorages until stressing records reviewed and accepted by Engineer/Architect.
- B. Clean tendons, anchorages and pockets of corrosion inhibiting prior to cutting tendons.
- C. Cut tendon end between 0.5 inches and 0.75 inches from wedges. Leave tendon end clean and free of burrs. Use of oxyacetylene flame to cut tendon is not permitted unless accepted in writing by Engineer before cutting begins. Use one of the following methods:
 - 1. Plasma cutting.
 - 2. Hydraulic shears.
- D. Make tendon ends accessible for inspection prior to and during cutting and grouting.
- E. Do not damage tendon, anchorage or concrete during the cutting and removal of the tendon.
- F. For encapsulated systems, cut tendon and install watertight cap with grease no more than 8 hours after acceptance of stressing records.
- G. Install a watertight assembly no more than 24 hours after stressing operations at the exposed stressing length of the intermediate anchorages.
- H. Coat pocket surface with bonding agent after sealing tendon end and wedges and before grouting tendon pocket.

- I. Grout tendon pockets no more than 24 hours after acceptance of stressing records. Finish grout flush with adjacent concrete.

3.6 FIELD QUALITY CONTROL

- A. Owner will engage a qualified testing agency approved by Engineer/Architect to perform materials testing. Inspections of stressing operations will be by the Special Inspector. Testing agency and Threshold Inspector have authority to reject work not conforming to the Contract Documents. Testing Agency shall coordinate efforts with Threshold Inspector.
- B. Before concrete placement, testing agency will inspect the following for compliance with the Contract Documents and accepted Installation Drawings.
 1. Location and number of tendons.
 2. Tendon size and grade.
 3. Tendon profile and cover.
 4. Sheathing type, thickness, damage and repair.
 5. Corrosion inhibiting coating.
 6. Anchorages, sleeves and accessories.
 7. Support methods.
 8. Encapsulation system.
 9. Requirements of "Florida Building Code," Section 109.
- C. During stressing operations testing agency will record the following and promptly submit to Engineer/Architect upon completion of stressing operations each day.
 1. Calculated tendon elongation based on actual modulus of elasticity and cross-sectional area of tendons used.
 2. Actual elongation measured for each tendon.
 3. Gage pressure required to achieve required stressing force (per calibration chart) for each tendon.
 4. Actual gage pressure for each tendon.
 5. Required concrete strength at time of stressing.
 6. Reported concrete strength at time of stressing.
 7. Range of allowable elongations for stressing force.
 8. Jack and gage identification numbers.
 9. Installer certification that stressing process and records have been reviewed and that forces specified have been provided.
- D. After stressing operations testing agency will inspect the following for compliance with the Contract Documents.
 1. Tendon cutting.
 2. Tendon end length.
 3. Anchor caps with grease.
 4. Cleaning and grouting of pockets.
- E. Testing agency will prepare test and inspections reports in an accepted format. In addition to test and inspection data, include the following.
 1. Project name and location.
 2. Date and time of inspection.
 3. Inspection location within the structure.

4. Air temperatures, weather and wind speed.
5. Testing agency's name, address and phone number.
6. Testing agency's technician's name.
7. Installer's name.

3.7 REPAIRS

- A. Submit repair procedures to Engineer/Architect for acceptance prior to starting repairs.
- B. Complete all required repairs at no cost to Owner.

END OF SECTION

POST-TENSIONING SUPPLIER QUALIFICATION FORM

GENERAL INFORMATION:	
Project:	City:
Supplier:	
General Contractor:	

SAMPLE PROJECT #1	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #2	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING SUPPLIER QUALIFICATION FORM

SAMPLE PROJECT #3	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #4	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING SUPPLIER QUALIFICATION FORM

SAMPLE PROJECT #5	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

REQUIRED ATTACHMENTS	
	Quality plan for manufacture, delivery, and detailing of post-tensioning system.
	Verification letter stating that the post-tensioning system will be manufactured in a plant with a current PTI certification and that all materials conform with ACI 301, ACI 318, and are approved by the International Code Council (International Building Code.)

POST-TENSIONING INSTALLER QUALIFICATION FORM

GENERAL INFORMATION:	
Project:	City:
Installer:	
General Contractor:	

SAMPLE PROJECT #1	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #2	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING INSTALLER QUALIFICATION FORM

SAMPLE PROJECT #3	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #4	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING INSTALLER QUALIFICATION FORM

SAMPLE PROJECT #5	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

REQUIRED ATTACHMENTS	
	Resume of Project Superintendent indicating required experience.
	Letter from post-tensioning Supplier accepting Installer.
	Verification letter stating that the Installer has a current PTI certification and that PTI Certified Field Installers will be used to install and stress post-tensioning system.

SECTION 03 3801 - POST-TENSIONED CONCRETE - PARKING GARAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section.

1.2 SUMMARY

- A. In accordance with Contract Documents, provide all materials, labor, equipment, and supervision to fabricate and install all post-tensioning Work. Non-prestressed reinforcement shall conform to Division 03 Section, "Cast-in-Place Concrete."
- B. Meet the requirements of ACI 301, ACI 318, ACI 423.7, CRSI MSP-2, and Contract Documents. In case of a conflict, meet the more stringent requirement.
- C. Related work in other Sections related to Post-Tensioned Concrete:
 - 1. Division 01 Section "Project Management and Coordination."
 - 2. Division 03 Section "Cast-in-Place Concrete (Parking Garage)."

1.3 REFERENCES

- A. Field Reference: Keep a copy of the following reference in the Contractor's field office.
 - 1. PTI's "Field Procedures Manual for Unbonded Single Strand Tendons"
- B. American Concrete Institute (ACI):
 - 1. ACI 301, "Specification for Structural Concrete."
 - 2. ACI 318, "Building Code Requirements for Structural Concrete."
 - 3. ACI 347, "Recommended Practice for Concrete Formwork."
 - 4. ACI 362.1R-12, "Guide for the Design of Durable Parking Structures."
 - 5. ACI 423.3R, "Recommendations for Concrete Members Prestressed with Unbonded Tendons."
 - 6. ACI 423.7, "Specification for Unbonded Single-Strand Tendon Materials and Commentary."
- C. American Society for Testing and Materials (ASTM):
 - 1. ASTM A416, "Specification for Uncoated Seven-Wire Strand for Prestressed Concrete."
 - 2. ASTM E328, "Recommended Practice for Stress-Relaxation Tests for Materials and Structures."
- D. Concrete Reinforcing Steel Institute (CRSI):
 - 1. CRSI MSP-2, "Manual of Standard Practice."
- E. Post-Tensioning Institute (PTI):
 - 1. PTI, "Guide Specifications for Post-Tensioning Materials."
 - 2. PTI, "Performance Specification for Corrosion Preventive Coating."
 - 3. PTI, "Specification for Unbonded Single Strand Tendons."

- 4. PTI, "Field Procedures Manual for Unbonded Single Strand Tendons."
- F. Florida Building Commission:
 - 1. FBC, "Florida Building Code."

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the tendon and anchor locations with Work of other Sections, including "Cast-in-Place Concrete." Immediately inform Engineer/Architect of any potential interference.
- B. Sequencing:
 - 1. Deviations in the construction and stressing sequence shown on the Drawings are not permitted without written acceptance from Engineer/Architect.
- C. Make submittals in accordance with requirements of Division 01 Section, "Submittal Procedures:"
 - 1. See requirements of Division 01 Section, "Submittal Procedures," Part 1 heading, "Submittal Procedures," for limits to resubmittals.
 - 2. See requirements of Division 01 Section, "Submittal Procedures," Part 2 heading, "Requests for Information," for RFI constraints.

1.5 ACTION SUBMITTALS

- A. Product Data: For each product as indicated.
 - 1. Corrosion Inhibiting Coating: Type and chemical analysis.
 - 2. Sheathing: Type, material, density and thickness.
 - 3. Anchorage Device: Type, material and size.
 - 4. Coupler Device: Type, material and size.
 - 5. Pocket Former: Type, material and size.
 - 6. Sheathing Repair Tape: Type, material and width.
 - 7. Encapsulation System: Type and materials.
- B. Shop Drawings: Include the following prepared by or under the supervision of a qualified professional engineer:
 - 1. Number, arrangement and designation of tendons.
 - 2. Tendon profile and method of tendon support. Show tendon profiles at sufficient scale to clearly indicate tendon high and low points.
 - 3. Tendon anchorage details including bundled tendon flaring.
- C. Construction Manager is expected to employ qualified personnel to review submittals before they are submitted to Engineer for review.
- D. Resubmittals: Engineer will review each of Contractor's submittals the initial time and, should resubmittal be required, again to verify that reasons for resubmittal have been addressed by Contractor and corrections made. Resubmittal changes/revisions/corrections shall be circled. Engineer will review only circled items and will not be responsible for non-circled changes/revisions/corrections and additions.

1. Make resubmittals in same form and number of copies as initial submittal.
 - a. Note date and content of previous submittal.
 - b. Note date and content of revision in label or title block and clearly indicate extent of revision.
- E. Resubmit submittals until they are marked with approval notation from Engineer's and Construction Manager's action stamp
- F. Samples: For the following products:
 1. Each anchorage assembly with a minimum of 24 inches of coated, sheathed strand.
 2. Each coupler assembly with a minimum of 24 inches of coated, sheathed strand.
 3. Encapsulation system.
- G. Delegated-Design: For post-tensioning system.
 1. Signed and sealed calculations prepared by a qualified structural engineer in the State of Florida indicating method of elongation and determination of number of tendons. Include values used for friction coefficients, anchorage seating loss, elastic shortening, creep, relaxation, wobble and shrinkage.
- H. Stressing Records: Same day as stressing operation.
- I. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 1. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
 - b. Leadership Extraction Practices for Recycled Content for records

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Supplier and Installer at least 14 days prior to bid date using the forms at the end of this section.
- B. Mill Test Reports: Certified mill test reports for each coil or pack of strand used on Project, indicating that strand is low relaxation and including the following information:
 1. Heat number and identification.
 2. Minimum breaking strength.
 3. Yield strength at 1 percent extension under load.
 4. Elongation at failure.
 5. Modulus of elasticity.
 6. Diameter and net area of strand.
- C. Test and Evaluation Reports: Indicating compliance with the following requirements:
 1. Tests required by ACI 301, Section "Post-Tensioned Concrete."
 2. Hydrostatic tests required by ACI 423.7 for "Anchorage and couplers in aggressive environments."

- 3. Relaxation loss tests required by ACI 423.7 for low relaxation prestressing steel.
- D. Field Quality-Control Reports: Within 72 hours of inspection.
- E. Stressing Jack Calibration: Calibration certificates for jacks and gages to be used on Project. Calibrate each jack-and-gage set as a pair.
- F. Warranty: Proposed warranty prior to the start of construction.

1.7 QUALITY ASSURANCE

- A. Supplier Qualifications:
 - 1. Use a fabricating plant certified by PTI.
 - 2. Successfully provided all materials for at least 5 post-tensioning installations in parking structures in the United States with a structural system similar to Project within the previous 5 years. Provide all information requested on the form at the end of this section.
- B. Installer Qualifications:
 - 1. Certified by PTI.
 - 2. Successfully performed at least 5 post-tensioning installations in parking structures in the United States with a structural system similar to Project within the previous 5 years. Provide all information requested on the form at the end of this section.
 - 3. Use a full-time Project superintendent that has supervised at least 5 projects of similar magnitude.
 - 4. Use PTI Certified Field Installers to install and stress post-tensioning system.
- C. Suppliers, who do not meet the qualification requirements above, shall meet and pay for following requirements:
 - 1. Retain independent testing or consulting firm acceptable to Engineer/Architect.
 - 2. Acceptable firm shall inspect post-tensioning Supplier's plant at 1 wk intervals during production and issue report on each visit, signed and sealed by Florida Licensed Professional Engineer verifying that materials, methods, product, and quality meet all PTI Plant Certification and Project specification requirements. Sample tendon corrosion preventive coating being applied during each visit and send sample directly to Engineer/Architect-designated testing laboratory for testing.
 - 3. If firm's report indicates noncompliance, Engineer/Architect, at Owner's expense, may inspect and may reject any or all products produced during period of noncompliance.
- D. Comply with requirements in ACI 301, Section "Post-Tensioned Concrete."
- E. Perform all post-tensioning Work under the supervision of a Project Superintendent who is present during all operations including installation, concrete placement, stressing and finishing.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Assign all tendons in same member the same heat number and identify accordingly.

- B. Package each tendon bundle at source to prevent physical damage to tendon during transportation and storage, and to protect strand from moisture. Use heavy padding cardboard is not permitted. Do not use wire binding or other materials that could cut the sheathing or tendon.
- C. Deliver, store and handle post-tensioning materials according to ACI 423.7. Contractor to inspect tendons and accessory items at time of delivery to Project site, prior to off-loading. Notify post-tensioning supplier of observed damage prior to off-loading.
- D. Immediately remove damaged components from Project site and replace at no cost to Owner.
- E. Do not remove sheathing on stressing end until the day of stressing.
- F. Materials Stored on Slabs:
 - 1. Prior to final stressing of beams and slabs, do not store any materials on slab.
 - 2. After final stressing of beams and slabs but before concrete has reached the specified 28-day strength, do not store materials on slab such that the weight exceeds 50 percent of the design live load.
 - 3. After final stressing of beams and slabs and concrete has reached the specified 28-day strength, do not store materials on slab such that the weight exceeds the design live load.

1.9 WARRANTY

- A. Provide a warranty from the Supplier that includes the following terms and provisions.
 - 1. Warranty period of 5 years beginning with the date of Beneficial Occupancy.
 - 2. Correct, at no expense to Owner, any defects that develop during the warranty period, which can be attributed to a defect in quality of product or workmanship.
 - 3. All materials have been manufactured in accordance with the Project specifications.
 - 4. Installation of materials, if under the control of the Supplier, has been according to the Project specifications.
 - 5. Supplier is not responsible for damage or liability caused by the actions or omissions of others.

PART 2 - PRODUCTS

2.1 DESIGN CRITERIA

- A. System described in this Section intended to satisfactorily perform in ACI 362.1R-12 zone CC-II environment without long-term corrosion or other distress.
- B. Engage a qualified professional engineer licensed in Florida to provide tendon quantity calculations and detail the tendon layout based on the following:
 - 1. Provide the final effective forces indicated on the drawings, which are the stressing forces minus both the short- and long-term losses.
 - 2. Do not exceed the maximum tensile stress in the tendon during the stressing operation. The maximum tensile stress is the smallest of the following:

- a. 80 percent of the specified tensile strength of the tendon.
 - b. 94 percent of the specified yield strength of the tendon.
 - c. Maximum value recommended by the tendon manufacturer.
3. Do not exceed 70 percent of the specified tensile strength after the anchors are seated.
 4. Use PTI recommended values for friction and wobble coefficients unless test data is submitted to substantiate lower values.
 5. Limit main slab tendon maximum spacing according to ACI 318, chapter "Pre-stressed Concrete," heading "Slab Systems."
 6. For multi-span tendons, do not base the effective tendon force on the average stress for all spans. Calculate losses for each span independently.

2.2 PRESTRESSING TENDONS

- A. Prestressing Strand: ASTM A416, Grade 270, uncoated, seven-wire, low-relaxation strand with minimum ultimate strength of 270 ksi.
 1. Manufactured by a single source.
 2. Strands manufactured outside United States subject to Engineer/Architect's approval based on evidence of satisfactory performance in the United States during the previous 5 years.
 3. Use of high stress bar system instead of strand system is not permitted unless accepted in writing by the Engineer.
 4. Conform to ACI 423.7 for relaxation loss requirements.
 - 4.5. There shall be 0% recycled steel for the strands
- B. Tendon Sheathing: Seamless and extruded high density polypropylene or seamless and extruded high density polyethylene with a specific gravity greater than 0.95 conforming to ACI 423.7.
 1. Sufficient strength to withstand damage during fabrication, transport, installation, concrete placement and stressing.
 2. Minimum thickness of 50 mils (–0 mils +15 mils)
 3. Minimum inside diameter 0.03 inches greater than maximum strand diameter.
 4. Chemically stable without becoming brittle or softening over anticipated temperature range and service life of structure.
 5. Non-reactive with concrete, steel and corrosion inhibiting coating.
 6. Contrasting color of corrosion inhibiting coating to enhance visibility of damage. Black/dark colored sheathing is not acceptable.
 7. Annular space between sheathing and strand completely filled with corrosion inhibiting coating.
 8. Watertight including all connections and components over entire length.
- C. Tendon Anchor: Non-porous casting free of sand, blow holes, voids and other defects meeting the testing and material requirements of ACI 423.7.
 1. Plastic coated bearing plates sized in accordance with ACI 423.7, unless certified test reports substantiate comparable or superior performance, for transfer at minimum stressing concrete strength.
 2. Capable of complying with PTI Guide Specification requirements for aggressive environments.

3. Capable of developing at least 95% of the actual ultimate strength of tendon.
 4. Minimum wedge cavity opening of at least 0.19 inches larger than tendon diameter. Reaming of anchor wedge cavity is not permitted.
 5. Wedges capable of precluding failure of tendon due to notching or pinching effects during static and fatigue load tests stipulated in ACI 423.7.
 6. Provisions for a plastic cap which fits tightly and seals barrel end on stressing side of anchor.
 7. Provisions for a plastic sleeve which prevents moisture infiltration into anchor casting or tendon sheathing on bearing side of anchor.
- D. Coupler Assembly: Assembly of strands and wedges meeting the testing and material requirements of ACI 301.
1. Capable of complying with PTI Guide Specification requirements for aggressive environments.
 2. Capable of developing at least 95 percent of the ultimate strength of tendon.
 3. Wedges capable of precluding failure of tendon due to notching or pinching effects during static and fatigue load tests stipulated in ACI 423.7.
- E. Encapsulation System: Watertight encapsulation along the entire length of tendon, including anchorages and couplers, when subjected to hydrostatic testing required in ACI 423.7 for aggressive environments.
1. Sleeve: Translucent plastic with a positive mechanical connection to anchorages capable of resisting 100 lbs. pulling force. Minimum 10 inches long and 4 inches overlap with sheathing, completely filled with corrosion inhibiting coating.
 2. Anchor Cap: Translucent plastic with a positive mechanical connection to anchorages capable of resisting 100 lbs. pulling force. At intermediate anchorages, open to allow passage of strand.
 3. Subject to the requirements provide one of the following systems:
 - a. "Zero Void," General Technologies, Inc.
 - b. "Hayes Posi-Lock Plus," Hayes Industries, Ltd.
 - c. Accepted equivalent.

2.3 ACCESSORIES

- A. Pocket Formers: Capable of completely sealing wedge cavity from intrusion of concrete or cement slurry; sized to provide at least a 2 inch recess and allow access for cutting strand tail.
1. If Zero Void encapsulation system in used, the "Zero Void Nail-Less Pocket Former" is required.
- B. Anchorage Fasteners: Stainless-steel ring nails. Subject to the requirements use one of the following:
1. Clendenin Brothers, Baltimore, MD.
 2. Swan Secure Products, Baltimore, MD.
 3. R.J. Leahy Co., San Francisco, CA.
 4. Accepted equivalent.

- C. Sheathing Repair Tape: Elastic, self-adhesive, moisture-proof tape with a minimum width of 2 inches in contrasting color to tendon sheathing, and that is non-reactive with sheathing, corrosion inhibiting coating, or tendon. Subject to the requirements use one of the following:
 - 1. "3M Tape No. 226," 3M, St. Paul, MN.
 - 2. "Polyken 826," Berry Plastics Corp, Evansville, IN
 - 3. "Tyco Adhesives No. 398," Tyco Adhesives, Franklin, MA
- D. Sheathing Repair Material: For nicks and cuts less than 0.25 inches use one of the following:
 - 1. "Scotch-Weld DP-8005," by 3M.
 - 2. Accepted equivalent.
- E. Corrosion inhibiting coating: Capable of meeting the requirements of ACI 423.7. Subject to the requirements use one of the following
 - 1. "Greasex K-218," ExxonMobil Oil Corp., Irving, TX.
 - 2. "Red-i PT Coating Grease," Lubricating Specialties Co., Pico Rivera, CA
 - 3. "Renolit PTG," Fuch's Lubricant Co., Harvey, IL
 - 4. "Royal PT-1 and PT-2 Corrosion Inhibiting Grease," Troco Oil Co., Tulsa, OK
- F. Tendon supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening tendons in place. Use tendon supports capable of meeting the requirements in CRSI's "Manual of Standard Practice" and as follows:
 - 1. Clearly marked to differentiate by height.
 - 2. Capable of resisting overturning during construction operations.
 - 3. Minimal contact with forms where concrete is exposed to view.
 - 4. Do not cause voids or damage to surrounding concrete.
 - 5. All-plastic supports conforming to CRSI Class 1 protection requirements and with a compressive strength higher than concrete.
 - 6. Acceptable manufacturers:
 - a. Aztec Concrete Accessories, Inc.
 - b. General Technologies, Inc.
 - c. Accepted equivalent.

2.4 GROUT MATERIALS

- A. Premixed, nonmetallic, noncorrosive, non-staining grout product containing selected silica sands, Portland cement, shrinkage compensating agents, plasticizing and water reducing agents, complying with ASTM C 1107, Grade B, with fluid consistency and a 30-minute working time.
- B. Non-reactive with prestressing strand, anchorage materials, or concrete and without chlorides or other chemicals known to be deleterious to prestressing strand.
- C. Subject to compliance with requirements, provide one of the following:
 - 1. Sure Grip Grout, Dayton Superior.
 - 2. Euco N.S., Euclid Chemical Co.
 - 3. Masterflow 928, Master Builders, Inc.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Provide formwork for post-tensioned elements as specified in Division 03 Section, "Cast-in-Place Concrete." Design formwork to support load redistribution that may occur during stressing operation. Ensure that formwork does not restrain elastic shortening, camber or deflection resulting from application of prestressing force.
- B. Do not remove forms supporting post-tensioned elements until tendons have been fully stressed and elongations have been approved by Engineer/Architect.

3.2 TENDON INSTALLATION

- A. Tendon Supports:
 - 1. Support slab tendons independently of beam reinforcement.
 - 2. Position supports at high and low points and at intervals not exceeding 48 inches.
 - 3. Support tendons as required to provide the specified profile and prevent displacement during subsequent construction operations.
- B. Tendon Profile:
 - 1. Place tendons with a parabolic profile in a vertical plane conforming to control points shown on Drawings unless otherwise noted. Control points locate the center of gravity of tendons.
 - 2. Locate low point at mid-span unless otherwise noted.
 - 3. Maintain tendon profile with the maximum allowable deviation for corresponding member dimensions as follows:
 - a. 8 inches or less: ± 0.25 inches.
 - b. 8 to 24 inches: ± 0.375 inches.
 - c. 24 inches or more: ± 0.5 inches.
- C. Tendon Location:
 - 1. Obtain Engineer/Architect's approval before relocating tendons that interfere with one another.
 - 2. Slight deviations in horizontal spacing and location are permitted when required to avoid openings and inserts.
 - 3. Maintain minimum radius of curvature of 21 feet for horizontal deviations.
 - 4. Locate tendons parallel to grid lines unless otherwise noted.
 - 5. Straighten strands to produce equal stress in all tendons that are to be stressed in a concrete placement and to ensure proper positioning of anchors.
- D. Anchors:
 - 1. Install anchors perpendicular to tendon axis.
 - 2. Install tendons straight, without vertical or horizontal curvature, for a minimum of 12 inches behind stressing-end and intermediate anchors.

3. Attach stressing-end anchors securely to bulkhead forms to prevent loosening due to construction activity or during concrete placement.
- E. Tendon Bundling:
 1. Limit slab tendon bundles to two tendons.
 2. Do not twist or entwine tendons within a bundle.
 3. Maintain a minimum of 12 inches between centers of adjacent bundles.
- F. Tendon Protection:
 1. Protect tendons from moisture and corrosion prior to concrete placement.
 2. Protect exposed tendons from moisture and corrosion at all times.
 3. Bare tendons are not permitted at any time.
 4. Do not cut or remove sheathing before concrete is placed.
- G. Over occupied/finished areas permanently mark tendon locations on slab soffit.
- H. Do not use splices or coupler assemblies within a concrete pour unless accepted in writing by the Engineer. When coupler assemblies are used, completely fill enclosure with corrosion inhibiting coating.
- I. Welding is prohibited unless shown on the drawings or accepted in writing by the Engineer.

3.3 SHEATHING INSPECTION AND REPAIR

- A. Inspect sheathing for damage after installing tendons and before placing concrete.
- B. Remove and replace tendons that have damaged encapsulation systems including sheathing tears or cuts over 10 percent of the length (damage need not be continuous), sheathing withdrawn from connecting sleeves, or connecting sleeves withdrawn from fixed end anchorages.
- C. Repair damaged areas by restoring corrosion inhibiting coating and repairing sheathing according to the following procedure to the satisfaction of the Engineer/Architect.
 1. Coat with corrosion inhibiting coating outside of sheathing for the length of damaged area plus 2 inches beyond each end of damage. For example, if sheathing tear is 6 inches long then corrosion inhibiting coated area will be 10 inches long, centered on tear.
 2. Install longitudinally slit sheathing around corrosion inhibiting coating area with the slit on the side opposite the tear. Extend slit sheathing 2 inches beyond corrosion inhibiting coating area at each end. For example, if corrosion inhibiting coating area is 10 inches long, then the slit sheathing will be 14 inches long, centered on tear.
 3. After removing corrosion inhibiting coating from the area to be taped, spirally wrap tape around slit sheathing to provide at least 2 layers of tape. Extend tape 2 inches beyond slit sheathing at each end. For example, if slit sheathing is 14 inches long, then taped area will be 18 inches long, centered on tear.
- D. Repair nick and cuts less than 0.25 inches long with sheathing repair material.

3.4 TENDON STRESSING

- A. Calibrate stressing jacks and gages at least every 6 months and keep copies of certificates on site and available for inspection.

- B. Use stressing jacks that are equipped with pressure gages to permit stress in the tendon to be computed at any time.
- C. Begin stressing operations as soon as concrete strength reaches 3,000 psi.
- D. Complete stressing within 96 hours after concrete placement begins unless concrete has not reached the required strength. If concrete strength has not reached minimum stressing strength within 96 hours (including weekends and holidays) apply 50 percent stress to each tendon and full stress as soon as compressive strength reaches the minimum stressing strength.
- E. If measured elongation deviates from calculated elongation by more than 7 percent, recalculate elongations based on actual modulus of elasticity of strand.
- F. If, after modulus check, measured and calculated elongations still deviate by more than 7 percent, cease stressing operations. Review section 7.3 from PTI's "Field Procedures Manual for Unbonded Single Strand Tendons" for causes for improper elongation. Proceed with stressing only after deviation cause has been determined and corrected to satisfaction of Engineer/Architect.
- G. Do not allow tendon movement greater than 0.25 inches during wedge seating.

3.5 TENDON FINISHING

- A. Do not cut tendons or cover anchorages until stressing records reviewed and accepted by Engineer/Architect.
- B. Clean tendons, anchorages and pockets of corrosion inhibiting prior to cutting tendons.
- C. Cut tendon end between 0.5 inches and 0.75 inches from wedges. Leave tendon end clean and free of burrs. Use of oxyacetylene flame to cut tendon is not permitted unless accepted in writing by Engineer before cutting begins. Use one of the following methods:
 - 1. Plasma cutting.
 - 2. Hydraulic shears.
- D. Make tendon ends accessible for inspection prior to and during cutting and grouting.
- E. Do not damage tendon, anchorage or concrete during the cutting and removal of the tendon.
- F. For encapsulated systems, cut tendon and install watertight cap with grease no more than 8 hours after acceptance of stressing records.
- G. Install a watertight assembly no more than 24 hours after stressing operations at the exposed stressing length of the intermediate anchorages.
- H. Coat pocket surface with bonding agent after sealing tendon end and wedges and before grouting tendon pocket.
- I. Grout tendon pockets no more than 24 hours after acceptance of stressing records. Finish grout flush with adjacent concrete.

3.6 FIELD QUALITY CONTROL

- A. Owner will engage a qualified testing agency approved by Engineer/Architect to perform materials testing. Inspections of stressing operations will be by the Special Inspector. Testing agency and Threshold Inspector have authority to reject work not conforming to the Contract Documents. Testing Agency shall coordinate efforts with Threshold Inspector.
- B. Before concrete placement, testing agency will inspect the following for compliance with the Contract Documents and accepted Installation Drawings.
 - 1. Location and number of tendons.
 - 2. Tendon size and grade.
 - 3. Tendon profile and cover.
 - 4. Sheathing type, thickness, damage and repair.
 - 5. Corrosion inhibiting coating.
 - 6. Anchorages, sleeves and accessories.
 - 7. Support methods.
 - 8. Encapsulation system.
 - 9. Requirements of "Florida Building Code," Section 109.
- C. During stressing operations testing agency will record the following and promptly submit to Engineer/Architect upon completion of stressing operations each day.
 - 1. Calculated tendon elongation based on actual modulus of elasticity and cross-sectional area of tendons used.
 - 2. Actual elongation measured for each tendon.
 - 3. Gage pressure required to achieve required stressing force (per calibration chart) for each tendon.
 - 4. Actual gage pressure for each tendon.
 - 5. Required concrete strength at time of stressing.
 - 6. Reported concrete strength at time of stressing.
 - 7. Range of allowable elongations for stressing force.
 - 8. Jack and gage identification numbers.
 - 9. Installer certification that stressing process and records have been reviewed and that forces specified have been provided.
- D. After stressing operations testing agency will inspect the following for compliance with the Contract Documents.
 - 1. Tendon cutting.
 - 2. Tendon end length.
 - 3. Anchor caps with grease.
 - 4. Cleaning and grouting of pockets.
- E. Testing agency will prepare test and inspections reports in an accepted format. In addition to test and inspection data, include the following.
 - 1. Project name and location.
 - 2. Date and time of inspection.
 - 3. Inspection location within the structure.
 - 4. Air temperatures, weather and wind speed.
 - 5. Testing agency's name, address and phone number.
 - 6. Testing agency's technician's name.
 - 7. Installer's name.

3.7 REPAIRS

- A. Submit repair procedures to Engineer/Architect for acceptance prior to starting repairs.
- B. Complete all required repairs at no cost to Owner.

END OF SECTION

POST-TENSIONING SUPPLIER QUALIFICATION FORM

GENERAL INFORMATION:	
Project:	City:
Supplier:	
General Contractor:	

SAMPLE PROJECT #1	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #2	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING SUPPLIER QUALIFICATION FORM

SAMPLE PROJECT #3	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #4	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING SUPPLIER QUALIFICATION FORM

SAMPLE PROJECT #5	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

REQUIRED ATTACHMENTS	
	Quality plan for manufacture, delivery, and detailing of post-tensioning system.
	Verification letter stating that the post-tensioning system will be manufactured in a plant with a current PTI certification and that all materials conform with ACI 301, ACI 318, and are approved by the International Code Council (International Building Code.)

POST-TENSIONING INSTALLER QUALIFICATION FORM

GENERAL INFORMATION:	
Project:	City:
Installer:	
General Contractor:	

SAMPLE PROJECT #1	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #2	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING INSTALLER QUALIFICATION FORM

SAMPLE PROJECT #3	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

SAMPLE PROJECT #4	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

POST-TENSIONING INSTALLER QUALIFICATION FORM

SAMPLE PROJECT #5	Date Completed:
Project Name:	\$ Value of PT Sub-contract:
City and State:	Tonnage of PT tendons:
Engineer of Record	General Contractor
Name:	Project Manager:
Firm:	Firm:
Phone Number:	Phone Number:
Email:	Email:

REQUIRED ATTACHMENTS	
	Resume of Project Superintendent indicating required experience.
	Letter from post-tensioning Supplier accepting Installer.
	Verification letter stating that the Installer has a current PTI certification and that PTI Certified Field Installers will be used to install and stress post-tensioning system.

SECTION 03 45 00 - PRECAST ARCHITECTURAL CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections (including all sustainability requirements), apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Architectural precast concrete cladding units.
- B. Related Requirements:
 - 1. Retain subparagraphs below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.
 - 2. Section 03 30 00 "Cast-in-Place Concrete" for installing connection anchors in concrete.
 - 3. Section 05 12 00 "Structural Steel Framing" for furnishing and installing connections attached to structural-steel framing.
 - 4. Section 05 50 00 "Metal Fabrications" for kickers and other miscellaneous steel shapes.
 - 5. Section 07 19 00 "Water Repellents" for water-repellent finish treatments.

1.3 DEFINITIONS

- A. Design Reference Sample: Sample of approved architectural precast concrete color, finish and texture, preapproved by Architect.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Documentation Submittals: Refer to section 01 81 13.14 "Sustainable Design Requirements – LEED V4 BD+C".
 - 1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance
 - b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
 - b. Corporate Sustainability Reporting (CSR's)
- C. Design Mixtures: For each precast concrete mixture. Include compressive strength and water-absorption tests.

D. Shop Drawings:

1. Detail fabrication and installation of architectural precast concrete units.
2. Indicate locations, plans, elevations, dimensions, shapes, and cross sections of each unit.
3. Indicate joints, reveals, drips, chamfers, and extent and location of each surface finish.
4. Indicate details at building corners.
5. Retain subparagraphs below applicable to Project.
6. Indicate separate face and backup mixture locations and thicknesses.
7. Indicate type, size, and length of welded connections by AWS standard symbols. Detail loose and cast-in hardware and connections.
8. Indicate locations, tolerances, and details of anchorage devices to be embedded in or attached to structure or other construction.
9. Indicate locations, extent, and treatment of dry joints if two-stage casting is proposed.
10. Include plans and elevations showing unit location and sequence of erection for special conditions.
11. Indicate location of each architectural precast concrete unit by same identification mark placed on panel.
12. Indicate relationship of architectural precast concrete units to adjacent materials.
13. Indicate locations, dimensions, and details of thin-brick units, including corner units and special shapes, and joint treatment.
14. Indicate locations, dimensions, and details of stone facings, anchors, and joint widths.
15. If design modifications are proposed to meet performance requirements and field conditions, submit design calculations and Shop Drawings. Do not adversely affect the appearance, durability, or strength of units when modifying details or materials and maintain the general design concept.

E. Samples: Design reference samples for initial verification of design intent, for each type of finish indicated on exposed surfaces of architectural precast concrete units, in sets of three, representative of finish, color, and texture variations expected; approximately 12 by 12 by 2 inches.

1. When other faces of precast concrete unit are exposed, include Samples illustrating workmanship, color, and texture of backup concrete as well as facing concrete.

F. Delegated-Design Submittal: For architectural precast concrete indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Show governing panel types, connections, types of reinforcement, including special reinforcement, and concrete cover on reinforcement. Indicate location, type, magnitude, and direction of loads imposed on the building structural frame from architectural precast concrete.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Statements:

1. Fabricator:
 - a. Submit plant certification.
 - b. Submit evidence of experience and capabilities.
 - c. Submit copies of plant quality control program.
 2. Erector: Submit evidence of experience and capabilities.
 3. Welding: Submit welding certificates and field welding processes.
- B. Material Certificates: For the following items:
1. Cementitious materials.
 2. Reinforcing materials and prestressing tendons.
 3. Admixtures.
 4. Bearing pads.
 5. Structural-steel shapes and hollow structural sections.
- C. Material Test Reports: For aggregates.
- D. Preconstruction test reports.
- E. Source quality-control test reports.
- F. Field quality-control and special inspection reports.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: A precast concrete erector qualified and designated by PCI's Certificate of Compliance to erect Category A (Architectural Systems) for non-load-bearing members.
- B. Fabricator Qualifications: A firm that assumes responsibility for engineering architectural precast concrete units to comply with performance requirements. This responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
1. Designated as a PCI-certified plant for Group A, Category A1 - Architectural Cladding and Load Bearing Units at time of bidding or designated as an APA-certified plant for production of architectural precast concrete products.
- C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
- D. Quality-Control Standard: For manufacturing procedures and testing requirements, quality-control recommendations, and dimensional tolerances for types of units required, comply with PCI MNL 117, "Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products."
- E. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D.1.1M, "Structural Welding Code - Steel"; and AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."
- F. Mockups: After sample panel and range sample approval but before production of architectural precast concrete units, construct full-sized mockups to verify selections

made under Sample submittals and to demonstrate aesthetic effects and to set quality standards for materials and execution. Refer to Section 01 43 39 "Visual Mock-up Requirements" for additional requirements.

1. Build mockup as indicated on Drawings complete with anchors, connections, flashings, and joint fillers.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undamaged at time of Substantial Completion.

1.8 COORDINATION

- A. Furnish loose connection hardware and anchorage items to be embedded in or attached to other construction without delaying the Work. Provide locations, setting diagrams, templates, instructions, and directions, as required, for installation.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver architectural precast concrete units in such quantities and at such times to limit unloading units temporarily on the ground or other rehandling.
- B. Support units during shipment on nonstaining shock-absorbing material.
- C. Store units with adequate dunnage and bracing and protect units to prevent contact with soil, to prevent staining, and to prevent cracking, distortion, warping or other physical damage.
- D. Place stored units so identification marks are clearly visible, and units can be inspected.
- E. Handle and transport units in a manner that avoids excessive stresses that cause cracking or damage.
- F. Lift and support units only at designated points indicated on Shop Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 45 00 "Quality Control", to design architectural precast concrete units.
- B. Design Standards: Comply with ACI 318 and design recommendations of PCI MNL 120, "PCI Design Handbook - Precast and Prestressed Concrete," applicable to types of architectural precast concrete units indicated.
- C. Calculated Fire-Test-Response Characteristics: Provide architectural precast concrete units with fire-resistance rating indicated as calculated according to ACI 216.1 and acceptable to authorities having jurisdiction.

- D. Structural Performance: Provide architectural precast concrete units and connections capable of withstanding the following design loads within limits and under conditions indicated:
1. Retain "Loads" Subparagraph below if design loads are shown on Drawings.
 2. Loads: As indicated.
 3. Retain five loads subparagraphs below if including design loads here; revise requirements to suit Project, and insert other performance and design criteria if applicable.
 4. Dead Loads: Refer to Structural.
 5. Live Loads: Refer to Structural.
 6. Wind Loads: Refer to Structural.
 7. Seismic Loads: Refer to Structural.
 8. Project-Specific Loads: Refer to Structural.
 9. Design precast concrete units and connections to maintain clearances at openings, to allow for fabrication and construction tolerances, to accommodate live-load deflection, shrinkage and creep of primary building structure, and other building movements as follows:
 - a. Upward and downward movement of 1/2 inch.
 10. Revise "Thermal Movements" Subparagraph below to suit local conditions. Temperature data are available from National Climatic Data Center, www.ncdc.noaa.gov.
 11. Thermal Movements: Provide for in-plane thermal movements resulting from annual ambient temperature changes of 80 deg F.

2.2 MOLD MATERIALS

- A. Molds: Rigid, dimensionally stable, non-absorptive material, warp and buckle free, that provides continuous and true precast concrete surfaces within fabrication tolerances indicated; nonreactive with concrete and suitable for producing required finishes.
1. Mold-Release Agent: Commercially produced form-release agent that does not bond with, stain or adversely affect precast concrete surfaces and does not impair subsequent surface or joint treatments of precast concrete.
- B. Form Liners: Units of face design, texture, arrangement, and configuration indicated. Use with manufacturer's recommended form-release agent that does not bond with, stain, or adversely affect precast concrete surfaces and does not impair subsequent surface or joint treatments of precast concrete.
- C. Surface Retarder: Chemical set retarder, capable of temporarily delaying final hardening of newly placed concrete mixture to depth of reveal specified.

2.3 REINFORCING MATERIALS

- A. Provide Recycled Content of Steel Products: Postconsumer recycled content plus one-half of pre-consumer recycled content not less than 50 percent.
1. Refer to Section 01 81 13.14 "Sustainable Design Requirements - LEED v4 BD+C" for additional information and requirements for recycled content.

- B. Environmental Product Disclosure: Provide an Environmental Product Declarations (EPD) that conforms with one of the following:
 - 1. Product specific declarations in accordance with ISO 1404
 - 2. Environmental Product Declarations conforming to ISO 14025, 14040, 14044 and EN 15804 or ISO 21930
 - 3. Industry Wide Product Specific Type III EPD Third Party Certification
- C. Corporate Sustainability Report: Provide third-party verified Corporate Sustainability Report (CPD) including impacts of extraction operations and activities associated with the manufacturer's product and product's supply chain conforming the following:
 - 1. Global Reporting Initiative (GRI) Sustainability report
 - 2. Organization for Economic Co-operation and Development (OOECD) Guidelines for Multinational Enterprises.
 - 3. U.N. Global Compact: Communication of Progress
 - 4. ISO 26000: 2010 Guidance on Social Responsibility
 - 5. USGBC Approved Program: Other approved programs meeting the CSR criteria.
- D. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- E. Galvanized Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed bars, with ASTM A 767/A 767M, Class II zinc coating and chromate treatment.
- F. Epoxy-Coated Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed bars, ASTM A 775/A 775M or ASTM A 934/A 934M epoxy coated.
- G. Steel Bar Mats: ASTM A 184/A 184M, fabricated from ASTM A 615/A 615M, Grade 60, deformed bars, assembled with clips.
- H. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from steel wire into flat sheets.
- I. Deformed-Steel Welded Wire Reinforcement: ASTM A 497/A 497M, flat sheet.
- J. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, plain, flat sheet, Type 1 bendable coating.
- K. Supports: Suspend reinforcement from back of mold or use bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 117.

2.4 CONCRETE MATERIALS

- A. Regional Materials: Concrete shall be manufactured within 100 miles of Project site from aggregates and cementitious materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.
- B. Portland Cement: ASTM C 150/C 150M, Type I or Type III, gray, unless otherwise indicated.

1. For surfaces exposed to view in finished structure, use gray or white cement, of same type, brand, and mill source.
- C. Supplementary Cementitious Materials:
 1. Fly Ash: ASTM C 618, Class C or F, with maximum loss on ignition of 3 percent.
 2. Metakaolin: ASTM C 618, Class N.
 3. Silica Fume: ASTM C 1240, with optional chemical and physical requirement.
 4. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
 5. Blended Hydraulic Cement: ASTM C 595, [Type IS, portland blast-furnace slag] [Type IP, portland-pozzolan] [Type I (PM), pozzolan-modified portland] [Type I (SM), slag-modified portland] cement.
- D. Normal-Weight Aggregates: Except as modified by PCI MNL 117, ASTM C 33/C 33M, with coarse aggregates complying with Class 5S. Stockpile fine and coarse aggregates for each type of exposed finish from a single source (pit or quarry) for Project.
 1. Face-Mixture-Coarse Aggregates: Selected, hard, and durable; free of material that reacts with cement or causes staining; to match selected finish sample.
 - a. Gradation: To match design reference sample.
 2. Face-Mixture-Fine Aggregates: Selected, natural or manufactured sand compatible with coarse aggregate; to match approved finish sample.
- E. Lightweight Aggregates: Except as modified by PCI MNL 117, ASTM C 330/C 330M, with absorption less than 11 percent.
- F. Coloring Admixture: ASTM C 979/C 979M, synthetic or natural mineral-oxide pigments or colored water-reducing admixtures, temperature stable, and nonfading.
- G. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with chemical limits of PCI MNL 117.
- H. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.
- I. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and to not contain calcium chloride, or more than 0.15 percent chloride ions or other salts by weight of admixture.
 1. Water-Reducing Admixtures: ASTM C 494/C 494M, Type A.
 2. Retarding Admixture: ASTM C 494/C 494M, Type B.
 3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 4. Water-Reducing and Accelerating Admixture: ASTM C 494/C 494M, Type E.
 5. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 6. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 7. Plasticizing Admixture: ASTM C 1017/C 1017M, Type I.
 8. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
 9. Corrosion Inhibiting Admixture: ASTM C 1582/C 1582M.

2.5 STEEL CONNECTION MATERIALS

- A. Provide Recycled Content of Steel Products: Postconsumer recycled content plus one-half of pre-consumer recycled content not less than 50 percent.
 - 1. Refer to Section 01 81 13.14 "Sustainable Design Requirements - LEED v4 BD+C" for additional information and requirements for recycled content.
- B. Environmental Product Disclosure: Provide an Environmental Product Declarations (EPD) that conforms with one of the following:
 - 1. Product specific declarations in accordance with ISO 1404
 - 2. Environmental Product Declarations conforming to ISO 14025, 14040, 14044 and EN 15804 or ISO 21930
 - 3. Industry Wide Product Specific Type III EPD Third Party Certification
- C. Corporate Sustainability Report: Provide third-party verified Corporate Sustainability Report (CPD) including impacts of extraction operations and activities associated with the manufacturer's product and product's supply chain conforming the following:
 - 1. Global Reporting Initiative (GRI) Sustainability report
 - 2. Organization for Economic Co-operation and Development (OOECD) Guidelines for Multinational Enterprises.
 - 3. U.N. Global Compact: Communication of Progress
 - 4. ISO 26000: 2010 Guidance on Social Responsibility
 - 5. USGBC Approved Program: Other approved programs meeting the CSR criteria.
- D. Carbon-Steel Shapes and Plates: ASTM A 36/A 36M.
- E. Carbon-Steel-Headed Studs: ASTM A 108, AISI 1018 through AISI 1020, cold finished, AWS D1.1/D1.1M, Type A or Type B, with arc shields and with minimum mechanical properties of PCI MNL 117, Table 3.2.3.
- F. Carbon-Steel Plate: ASTM A 283/A 283M, Grade C.
- G. Malleable Iron Castings: ASTM A 47/A 47M, Grade 32510 or Grade 35028.
- H. Carbon-Steel Castings: ASTM A 27/A 27M, Grade 60-30.
- I. High-Strength, Low-Alloy Structural Steel: ASTM A 572/A 572M.
- J. Carbon-Steel Structural Tubing: ASTM A 500/A 500M, Grade B or Grade C.
- K. Wrought Carbon-Steel Bars: ASTM A 675/A 675M, Grade 65.
- L. Deformed-Steel Wire or Bar Anchors: ASTM A 496/A 496M or ASTM A 706/A 706M.
- M. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A or ASTM F 1554, Grade 36; carbon-steel, hex-head bolts and studs; carbon-steel nuts, ASTM A 563; and flat, unhardened steel washers, ASTM F 844.

- N. High-Strength Bolts and Nuts: ASTM A 325, Type 1, heavy hex steel structural bolts; heavy hex carbon-steel nuts, ASTM A 563; and hardened carbon-steel washers, ASTM F 436.
- O. Zinc-Coated Finish: For exterior steel items, steel in exterior walls, and items indicated for galvanizing, apply zinc coating by hot-dip process according to ASTM A 123/A 123M or ASTM A 153/A 153M.
 - 1. For steel shapes, plates, and tubing to be galvanized, limit silicon content of steel to less than 0.03 percent or to between 0.15 and 0.25 percent or limit sum of silicon and 2.5 times phosphorous content to 0.09 percent.
 - 2. Galvanizing Repair Paint: High-zinc-dust-content paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035B or SSPC-Paint 20.
- P. Shop-Primed Finish: Prepare surfaces of nongalvanized steel items, except those surfaces to be embedded in concrete, according to requirements in SSPC-SP 3 and shop-apply lead- and chromate-free, rust-inhibitive primer, complying with performance requirements in MPI 79 according to SSPC-PA 1.
- Q. Welding Electrodes: Comply with AWS standards.

2.6 BEARING PADS

- A. Provide one of the following bearing pads for architectural precast concrete units as recommended by precast fabricator for application:
 - 1. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, Type A durometer hardness of 50 to 70, ASTM D 2240, minimum tensile strength 2250 psi, ASTM D 412.
 - 2. Random-Oriented-Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. Type A durometer hardness of 70 to 90, ASTM D 2240; capable of supporting a compressive stress of 3000 psi with no cracking, splitting, or delaminating in the internal portions of pad. Test one specimen for every 200 pads used in Project.
 - 3. Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer; Type A durometer hardness of 80 to 100, ASTM D 2240; complying with AASHTO's "AASHTO LRFD Bridge Design Specifications," Division II, Section 18 .1 0.2; or with MIL-C-882E.
 - 4. Frictionless Pads: PTFE, glass-fiber reinforced, bonded to stainless or mild-steel plate, or random-oriented-fiber-reinforced elastomeric pads; of type required for in-service stress.
 - 5. High-Density Plastic: Multimonomer, nonleaching, plastic strip.

2.7 ACCESSORIES

- A. Reglets: Specified in Section 07 62 00 "Sheet Metal Flashing and Trim."
- B. Precast Accessories: Provide clips, hangers, high-density plastic or steel shims, and other accessories required to install architectural precast concrete units.

- C. Anchors: Type and size indicated, fabricated from Type 304 stainless steel complying with ASTM A 240/A 240M, ASTM A 276, or ASTM A 666.
- D. Dowels: 1/2-inch-diameter round bars, fabricated from Type 304 stainless steel complying with ASTM A 240/A 240M, ASTM A 276, or ASTM A 666.
- E. Weep/Vent Products: Use the following unless otherwise indicated:
 - 1. Round Plastic Weep/Vent Tubing: Medium-density polyethylene, 3/8-inch OD by length equal to thickness of precast concrete panel.

2.8 GROUT MATERIALS

- A. Sand-Cement Grout: Portland cement, ASTM C 150/C 150M, Type I, and clean, natural sand, ASTM C 144 or ASTM C 404. Mix at ratio of 1 part cement to 2-1/2 to 3 parts sand, by volume, with minimum water required for placement and hydration. Water-soluble chloride ion content less than 0.06 percent by weight of cement when tested according to ASTM C 1218/C 1218M.
- B. Nonmetallic, Nonshrink Grout: Packaged, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing and water-reducing agents, complying with ASTM C 1107/C 1107M, Grade A for drypack and Grades B and C for flowable grout and of consistency suitable for application within a 30-minute working time. Water-soluble chloride ion content less than 0.06 percent by weight of cement when tested according to ASTM C 1218/C 1218M.

2.9 CONCRETE MIXTURES

- A. Prepare design mixtures for each type of precast concrete required.
 - 1. Use a single design mixture for units with more than one major face or edge exposed.
 - 2. Where only one face of unit is exposed use either a single design mixture or separate mixtures for face and backup.
- B. Limit use of fly ash and ground granulated blast-furnace slag to 20 percent of portland cement by weight; limit metakaolin and silica fume to 10 percent of portland cement by weight.
- C. Design mixtures may be prepared by a qualified independent testing agency or by qualified precast plant personnel at architectural precast concrete fabricator's option.
- D. Limit water-soluble chloride ions to maximum percentage by weight of cement permitted by ACI 318 or PCI MNL 117 when tested according to ASTM C 1218/C 1218M.
- E. Normal-Weight Concrete Mixtures: Proportion [face mixtures] [face and backup mixtures] [full-depth mixture] [face and backup mixtures or full-depth mixtures, at fabricator's option] by either laboratory trial batch or field test data methods according to ACI 211.1, with materials to be used on Project, to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 5000 psi minimum.
 2. Maximum Water-Cementitious Materials Ratio: 0.45.
- F. Water Absorption: 6 percent by weight or 14 percent by volume, tested according to ASTM C 642, except for boiling requirement.
- G. Lightweight Concrete Backup Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211.2, with materials to be used on Project, to provide lightweight concrete with the following properties:
1. Compressive Strength (28 Days): 5000 psi.
 2. Unit Weight: Calculated equilibrium unit weight of 115 lb/cu. ft., plus or minus 3 lb/cu. ft., according to ASTM C 567.
- H. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content complying with PCI MNL 117.
- I. When included in design mixtures, add other admixtures to concrete mixtures according to manufacturer's written instructions.

2.10 MOLD FABRICATION

- A. Molds: Accurately construct molds, mortar tight, of sufficient strength to withstand pressures due to concrete-placement operations and temperature changes and for prestressing and detensioning operations. Coat contact surfaces of molds with release agent before reinforcement is placed. Avoid contamination of reinforcement and prestressing tendons by release agent.
1. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and supports to maintain stability of liners during concrete placement. Coat form liner with form-release agent.
- B. Maintain molds to provide completed architectural precast concrete units of shapes, lines, and dimensions indicated, within fabrication tolerances specified.
1. Form joints are not permitted on faces exposed to view in the finished work.
 2. Edge and Corner Treatment: Uniformly chamfered.

2.11 FABRICATION

- A. Cast-in Anchors, Inserts, Plates, Angles, and Other Anchorage Hardware: Fabricate anchorage hardware with sufficient anchorage and embedment to comply with design requirements. Accurately position for attachment of loose hardware, and secure in place during precasting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement.
1. Weld-headed studs and deformed bar anchors used for anchorage according to AWS D1.1/D1.1M and AWS C5.4, "Recommended Practices for Stud Welding."
- B. Furnish loose hardware items including steel plates, clip angles, seat angles, anchors, dowels, cramps, hangers, and other hardware shapes for securing architectural precast concrete units to supporting and adjacent construction.

- C. Cast-in reglets, slots, holes, and other accessories in architectural precast concrete units as indicated on the Contract Drawings.
- D. Cast-in openings larger than 10 inches in any dimension. Do not drill or cut openings or prestressing strand without Architect's approval.
- E. Reinforcement: Comply with recommendations in PCI MNL 117 for fabricating, placing, and supporting reinforcement.
 - 1. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy the bond with concrete. When damage to epoxy-coated reinforcing exceeds limits specified in ASTM A 775/A 775M, repair with patching material compatible with coating material and epoxy coat bar ends after cutting.
 - 2. Accurately position, support, and secure reinforcement against displacement during concrete-placement and consolidation operations. Completely conceal support devices to prevent exposure on finished surfaces.
 - 3. Place reinforcing steel and prestressing strands to maintain at least 3/4-inch minimum concrete cover. Increase cover requirements for reinforcing steel to 1-1/2 inches when units are exposed to corrosive environment or severe exposure conditions. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete. Direct wire tie ends away from finished, exposed concrete surfaces.
 - 4. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh spacing and wire tie laps, where required by design. Offset laps of adjoining widths to prevent continuous laps in either direction.
- F. Reinforce architectural precast concrete units to resist handling, transportation, and erection stresses and specified in-place loads.
- G. Comply with requirements in PCI MNL 117 and requirements in this Section for measuring, mixing, transporting, and placing concrete. After concrete batching, no additional water may be added.
- H. Place face mixture to a minimum thickness after consolidation of the greater of 1 inch or 1.5 times the maximum aggregate size, but not less than the minimum reinforcing cover specified.
- I. Place concrete in a continuous operation to prevent cold joints or planes of weakness from forming in precast concrete units.
 - 1. Place backup concrete mixture to ensure bond with face-mixture concrete.
- J. Thoroughly consolidate placed concrete by internal and external vibration without dislocating or damaging reinforcement and built-in items, and minimize pour lines, honeycombing, or entrapped air voids on surfaces. Use equipment and procedures complying with PCI MNL 117.
 - 1. Place self-consolidating concrete without vibration according to PCI TR-6, "Interim Guidelines for the Use of Self-Consolidating Concrete in Precast/Prestressed Concrete Institute Member Plants." Ensure adequate bond between face and backup concrete, if used.

- K. Comply with PCI MNL 117 for hot- and cold-weather concrete placement.
- L. Identify pickup points of architectural precast concrete units and orientation in structure with permanent markings, complying with markings indicated on Shop Drawings. Imprint or permanently mark casting date on each architectural precast concrete unit on a surface that does not show in finished structure.
- M. Cure concrete, according to requirements in PCI MNL 117, by moisture retention without heat or by accelerated heat curing using low-pressure live steam or radiant heat and moisture. Cure units until compressive strength is high enough to ensure that stripping does not have an effect on performance or appearance of final product.
- N. Discard and replace architectural precast concrete units that do not comply with requirements, including structural, manufacturing tolerance, and appearance, unless repairs meet requirements in PCI MNL 117 and Architect's approval.

2.12 FABRICATION TOLERANCES

- A. Fabricate architectural precast concrete units to shapes, lines, and dimensions indicated so each finished unit complies with PCI MNL 117 product tolerances as well as position tolerances for cast-in items.
- B. Fabricate architectural precast concrete units to shapes, lines, and dimensions indicated so each finished unit complies with the following product tolerances:
 - 1. Overall Height and Width of Units, Measured at the Face Exposed to View: As follows:
 - a. 10 feet or under, plus or minus 1/8 inch.
 - b. 10 to 20 feet, plus 1/8 inch, minus 3/16 inch.
 - c. 20 to 40 feet, plus or minus 1/4 inch.
 - d. Each additional 10 feet, plus or minus 1/16 inch.
 - 2. Overall Height and Width of Units, Measured at the Face Not Exposed to View: As follows:
 - a. 10 feet or under, plus or minus 1/4 inch.
 - b. 10 to 20 feet, plus 1/4 inch, minus 3/8 inch.
 - c. 20 to 40 feet, plus or minus 3/8 inch.
 - d. Each additional 10 feet, plus or minus 1/8 inch.
 - 3. Total Thickness or Flange Thickness: Plus 1/4 inch, minus 1/8 inch.
 - 4. Rib Thickness: Plus or minus 1/8 inch.
 - 5. Rib to Edge of Flange: Plus or minus 1/8 inch.
 - 6. Distance between Ribs: Plus or minus 1/8 inch.
 - 7. Variation from Square or Designated Skew (Difference in Length of the Two Diagonal Measurements): Plus or minus 1/8 inch/72 inches or 1/2 inch total, whichever is greater.
 - 8. Length and Width of Block-outs and Openings within One Unit: Plus or minus 1/4 inch.
 - 9. Location and Dimension of Block-outs Hidden from View and Used for HVAC and Utility Penetrations: Plus or minus 3/4 inch.
 - 10. Bowing: Plus or minus L/360, maximum 1 inch.
 - 11. Local Smoothness: 1/4 inch/10 feet.

12. Warping: 1/16 inch/12 inches of distance from nearest adjacent corner.
 13. Tipping and Flushness of Plates: Plus or minus 1/4 inch.
 14. Dimensions of Architectural Features and Rustications: Plus or minus 1/8 inch.
- C. Position Tolerances: For cast-in items measured from datum line location, as indicated on Shop Drawings.
1. Weld Plates: Plus or minus 1 inch.
 2. Inserts: Plus or minus 1/2 inch.
 3. Handling Devices: Plus or minus 3 inches.
 4. Reinforcing Steel and Welded Wire Reinforcement: Plus or minus 1/4 inch where position has structural implications or affects concrete cover; otherwise, plus or minus 1/2 inch.
 5. Reinforcing Steel Extending out of Member: Plus or minus 1/2 inch of plan dimensions.
 6. Tendons: Plus or minus 1/4 inch, vertical; plus or minus 1 inch, horizontal.
 7. Location of Rustication Joints: Plus or minus 1/8 inch.
 8. Location of Opening within Panel: Plus or minus 1/4 inch.
 9. Location of Flashing Reglets: Plus or minus 1/4 inch.
 10. Location of Flashing Reglets at Edge of Panel: Plus or minus 1/8 inch.
 11. Reglets for Glazing Gaskets: Plus or minus 1/8 inch.
 12. Electrical Outlets, Hose Bibs: Plus or minus 1/2 inch.
 13. Location of Bearing Surface from End of Member: Plus or minus 1/4 inch.
 14. Allowable Rotation of Plate, Channel Inserts, and Electrical Boxes: 2-degree rotation or 1/4 inch maximum over the full dimension of unit.
 15. Position of Sleeve: Plus or minus 1/2 inch.

2.13 FINISHES

- A. Exposed faces shall be free of joint marks, grain, and other obvious defects. Corners, including false joints shall be uniform, straight, and sharp. Finish exposed-face surfaces of architectural precast concrete units to match approved design reference sample and as follows:
1. Design Reference Sample: Provided by Architect.
- B. Finish exposed back surfaces of architectural precast concrete units to match face-surface finish.
- C. Finish unexposed surfaces of architectural precast concrete units with as cast finish.
- D. Finish all surfaces to receive sealant or membrane smooth and free from rock pockets, honeycombing, and other imperfections that may interfere with sealant or membrane.

2.14 SOURCE QUALITY CONTROL

- A. Quality-Control Testing: Test and inspect precast concrete according to PCI MNL 117 requirements. If using self-consolidating concrete, also test and inspect according to PCI TR-6, ASTM C 1610/C 1610M, ASTM C 1611/C 1611M, ASTM C 1621/C 1621M, and ASTM C 1712.

- B. Construction Manager will employ an independent testing agency to evaluate architectural precast concrete fabricator's quality-control and testing methods.
 - 1. Allow Construction Manager's testing agency access to material storage areas, concrete production equipment, concrete placement, and curing facilities. Cooperate with testing agency and provide samples of materials and concrete mixtures as may be requested for additional testing and evaluation.
- C. Strength of precast concrete units is considered deficient if units fail to comply with ACI 318 requirements for concrete strength.
- D. Testing: If there is evidence that strength of precast concrete units may be deficient or may not comply with ACI 318 requirements, precaster will employ an independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C 42/C 42M and ACI 318.
 - 1. A minimum of three representative cores shall be taken from units of suspect strength, from locations directed by Architect.
 - 2. Test cores in an air-dry condition.
 - 3. Report test results in writing on same day that tests are performed, with copies to Architect, Contractor, and precast concrete fabricator. Test reports include the following:
 - a. Project identification name and number.
 - b. Date when tests were performed.
 - c. Name of precast concrete fabricator.
 - d. Name of concrete testing agency.
 - e. Identification letter, name, and type of precast concrete unit(s) represented by core tests; design compressive strength; type of break; compressive strength at breaks, corrected for length-diameter ratio; and direction of applied load to core in relation to horizontal plane of concrete as placed.
- E. Patching: If core test results are satisfactory and precast concrete units comply with requirements, clean and dampen core holes and solidly fill with precast concrete mixture that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.
- F. Defective Units: Discard and replace recast architectural concrete units that do not comply with acceptability requirements in PCI MNL 117, including concrete strength, manufacturing tolerances, and color and texture range. Chipped, spalled, or cracked units may be repaired, subject to Architect's approval. Architect reserves the right to reject precast units that do not match approved samples, sample panels, and mockups. Replace unacceptable units with precast concrete units that comply with requirements.

2.15 PRECAST CONCRETE STAIR TREADS

- A. Comply with "Concrete Materials" article to provide concrete with a minimum 28-day compressive strength of 5000 psi and a total air content not less than 4 percent or more than 6 percent.
 - 1. Flexural Strength: 2500 to 3000 psi in accordance with ASTM C 293.
 - 2. Water Absorption: 3 to 4 percent absorption in accordance with ASTM C 67.

- B. Reinforcing Bars: #3 - 3/8 inch (10mm) deformed rebar meeting the requirements of ASTM A 615, Grade 40.
- C. Embedded Stair Tread Anchor Bolts: ASTM F 1554, Grade 36.
 - 1. Provide hot-dip or mechanically deposited, zinc-coated anchor bolts with nuts for attaching and securing stair treads to stair framing.
 - 2. Stair tread manufacturer's standard "shoulder nut" anchor bolt design to resist damage due to excessive torque stress on anchor bolt nut, or normal stair movement.
- D. Water: Potable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine supporting structural frame or foundation and conditions for compliance with requirements for installation tolerances, bearing surface tolerances, and other conditions affecting performance of the Work.
- B. Do not install precast concrete units until supporting cast-in-place concrete has attained minimum allowable design compressive strength and supporting steel or other structure is structurally ready to receive loads from precast concrete units.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install clips, hangers, bearing pads, and other accessories required for connecting architectural precast concrete units to supporting members and backup materials.
- B. Erect architectural precast concrete level, plumb, and square within specified allowable tolerances. Provide temporary supports and bracing as required to maintain position, stability, and alignment of units until permanent connections are completed.
 - 1. Install temporary steel or plastic spacing shims as precast concrete units are being erected. Tack weld steel shims to each other to prevent shims from separating.
 - 2. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.
 - 3. Remove projecting lifting devices and grout fill voids within recessed lifting devices flush with surface of adjacent precast surfaces when recess is exposed.
 - 4. Unless otherwise indicated, maintain uniform joint widths of 3/4 inch.
- C. Connect architectural precast concrete units in position by bolting, welding, grouting, or as otherwise indicated on Shop Drawings. Remove temporary shims, wedges, and spacers as soon as practical after connecting and grouting are completed.
 - 1. Do not permit connections to disrupt continuity of roof flashing.

- D. Welding: Comply with applicable requirements in AWS D1.1/D1.1M and AWS D1.4/D1.4M for welding, welding electrodes, appearance, quality of welds, and methods used in correcting welding work.
1. Protect architectural precast concrete units and bearing pads from damage by field welding or cutting operations, and provide noncombustible shields as required.
 2. Welds not specified shall be continuous fillet welds, using no less than the minimum fillet as specified by AWS.
 3. Clean weld-affected metal surfaces with chipping hammer followed by brushing, and apply a minimum 4.0-mil-thick coat of galvanized repair paint to galvanized surfaces according to ASTM A 780/A 780M.
 4. Clean weld-affected metal surfaces with chipping hammer followed by brushing, and reprime damaged painted surfaces.
 5. Visually inspect welds and remove, reweld, or repair incomplete and defective welds.
- E. At bolted connections, use lock washers, tack welding, or other approved means to prevent loosening of nuts after final adjustment.
1. Where slotted connections are used, verify bolt position and tightness. For sliding connections, properly secure bolt but allow bolt to move within connection slot.
 2. For slip-critical connections, use one of the following methods to assure proper bolt pretension:
 - a. Turn-of-Nut: According to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
 - b. Calibrated Wrench: According to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
 - c. Twist-off Tension Control Bolt: ASTM F 1852.
 - d. Direct-Tension Control Bolt: ASTM F 1852.
 3. For slip-critical connections, use method and inspection procedure approved by Architect and coordinated with inspection agency.
- F. Grouting or Dry-Packing Connections and Joints: Grout connections where required or indicated. Retain flowable grout in place until hard enough to support itself. Alternatively, pack spaces with stiff dry-pack grout material, tamping until voids are completely filled. Place grout and finish smooth, level, and plumb with adjacent concrete surfaces. Promptly remove grout material from exposed surfaces before it affects finishes or hardens. Keep grouted joints damp for not less than 24 hours after initial set.

3.3 ERECTION TOLERANCES

- A. Erect architectural precast concrete units level, plumb, square, and in alignment without exceeding the noncumulative erection tolerances of PCI MNL 117, Appendix I.
- B. Erect architectural precast concrete units level, plumb, square, and in alignment, without exceeding the following noncumulative erection tolerances:
1. Plan Location from Building Grid Datum: Plus or minus 1/2 inch.

2. Plan Location from Centerline of Steel: Plus or minus 1/2 inch.
3. Top Elevation from Nominal Top Elevation: As follows:
 - a. Exposed Individual Panel: Plus or minus 1/4 inch.
 - b. Non-Exposed Individual Panel: Plus or minus 1/2 inch.
 - c. Exposed Panel Relative to Adjacent Panel: 1/4 inch.
 - d. Non-Exposed Panel Relative to Adjacent Panel: 1/2 inch.
4. Support Elevation from Nominal Support Elevation: As follows:
 - a. Maximum Low: 1/2 inch.
 - b. Maximum High: 1/4 inch.
5. Maximum Plumb Variation over the Lesser of Height of Structure or 100 Feet: 1 inch.
6. Plumb in Any 10 Feet of Element Height: 1/4 inch.
7. Maximum Jog in Alignment of Matching Edges: 1/4 inch.
8. Joint Width (Governs over Joint Taper): Plus or minus 1/4 inch.
9. Maximum Joint Taper: 3/8 inch.
10. Joint Taper in 10 Feet: 1/4 inch.
11. Maximum Jog in Alignment of Matching Faces: 1/4 inch.
12. Differential Bowing or Camber, as Erected, between Adjacent Members of Same Design: 1/4 inch.
13. Opening Height between Spandrels: Plus or minus 1/4 inch.

3.4 FIELD QUALITY CONTROL

- A. Architectural precast concrete installer shall provide field quality control by PCI certified staff and shall provide the following reports and checklists.
 1. BECxA shall provide initial BECx checklists. Contractor shall provide weekly updates verifying all locations have been inspected and are free of installation defects and damage.
 - a. BECx Checklists shall include specific locations of the work and specific location and description of any repairs.
 - b. BECx checklist shall be completed in its entirety and shall be provided weekly to the Construction Manager, Architect, and Owner.
 2. Provide field inspection reports within 5 working days of inspection.
- B. Testing Agency: Construction Manager will engage a qualified testing agency to perform tests and inspections and prepare test reports.
- C. Visually inspect field welds and test according to ASTM E 165 or to ASTM E 709 and ASTM E 1444. High-strength bolted connections are subject to inspections.
- D. Testing agency will report test results promptly and in writing to Contractor and Architect.
- E. Repair or remove and replace work where tests and inspections indicate that it does not comply with specified requirements.
- F. Additional testing and inspecting, at Contractor's expense, shall be performed to determine compliance of replaced or additional work with specified requirements.

3.5 REPAIRS

- A. Repair architectural precast concrete units if permitted by Architect. Architect reserves the right to reject repaired units that do not comply with requirements.
- B. Mix patching materials and repair units so cured patches blend with color, texture, and uniformity of adjacent exposed surfaces and show no apparent line of demarcation between original and repaired work, when viewed in typical daylight illumination from a distance of 20 feet.
- C. Prepare and repair damaged galvanized coatings with galvanizing repair paint according to ASTM A 780/A 780M.
- D. Wire brush, clean, and paint damaged prime-painted components with same type of shop primer.
- E. Remove and replace damaged architectural precast concrete units when repairs do not comply with requirements.

3.6 CLEANING

- A. Clean surfaces of precast concrete units exposed to view.
- B. Clean mortar, plaster, fireproofing, weld slag, and other deleterious material from concrete surfaces and adjacent materials immediately.
- C. Clean exposed surfaces of precast concrete units after erection and completion of joint treatment to remove weld marks, other markings, dirt, and stains.
 - 1. Perform cleaning procedures, if necessary, according to precast concrete fabricator's recommendations. Protect other work from staining or damage due to cleaning operations.
 - 2. Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes or damage adjacent materials.

END OF SECTION 03 45 00

SECTION 03 47 13 - TILT UP CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section specifies load-bearing, tilt-up concrete, including the following:
 - 1. Monolithic panels.
- B. Related Sections include the following:
 - 1. Division 03 Section "Cast-in-Place Concrete" for slab-on-grade closure strip and general concrete construction.

1.3 DEFINITIONS

- A. Face-down Surface: Concealed surface of as-cast, tilt-up panel formed against the casting slab.
- B. Face-up Surface: Exposed upper surface of as-cast, tilt-up panel.
- C. Reveal: Projection of the coarse aggregate from the matrix after exposure.

1.4 ACTION SUBMITTALS

- A. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 - 1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance
 - b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
 - b. Corporate Sustainability Reporting (CSR's)
- B. Product Data: For each type of product indicated.

- C. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- D. Shop Drawings: Detail fabrication and installation of tilt-up concrete units. Indicate panel locations, plans, elevations, dimensions, shapes, cross sections, and details of steel embedments.
 - 1. Include steel reinforcement, detailing fabrication, bending, and placing. Include material, grade, bar schedules, stirrup spacing, bent-bar diagrams, arrangement, and supports of concrete reinforcement.
 - 2. Include additional steel reinforcement to resist hoisting and erection stresses.
 - 3. Include locations and details of hoisting points and lifting devices for handling and erection.
 - 4. Casting Slab: Submit shop drawing showing size, type, and location of all casting slabs.
 - 5. Forms: Submit shop drawing showing edge forms for panels.
 - 6. Calculations: Submit complete signed and sealed engineering calculations. Include engineering analysis data of additional steel reinforcement and hoisting and erection details, signed and sealed by the qualified registered professional engineer in the state of Florida.
 - 7. Indicate welded connections by AWS standard symbols. Detail cast-in inserts, connections, and joints, including accessories.
- E. Sample: Prepare for approval of Architect/Engineer a minimum of one sample panel for each type of finish specified. Sample panel shall be 3 feet by 3 feet by 4 inches minimum thickness cast from a minimum 3 cubic yard truck load. Approved panels shall remain on the job site until the Architect gives instructions for removal and disposal. Rejected panels shall be disposed of off site.
- F. Welding certificates.
- G. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
 - 1. Aggregates.
- H. Material Certificates: For each of the following, signed by manufacturers:
 - 1. Cementitious materials.
 - 2. Admixtures.
 - 3. Steel reinforcement and accessories.
 - 4. Bondbreakers.
 - 5. Curing compounds.
 - 6. Inserts and embedments.
- I. Field quality-control test and inspection reports.
- J. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

- A. **Installer Qualifications:** A qualified installer who employs a supervisor on Project who is an ACI-certified Tilt-up Supervisor.
- B. **Manufacturer Qualifications:** 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."
- C. **Testing Agency Qualifications:** An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
 - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade I, according to ACI CP-01 or an equivalent certification program.
 - 2. Personnel performing laboratory tests shall be an ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.
- D. **Source Limitations:** Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.
- E. **Welding:** Qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
- F. **ACI Publications:** Comply with ACI 301, "Specification for Structural Concrete," Sections 1 through 5, unless modified by requirements in the Contract Documents.
- G. **Concrete Testing Service:** Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.
- H. **Mockups:** Refer to specification 01 4339 Visual Mock-Up Requirements. Cast and erect tilt-up concrete panel mockups to demonstrate typical reveals, surface finishes, texture, color, and standard of workmanship.
 - 1. Build mockup panels in the location and of the size indicated or, if not indicated, as directed by Architect.
 - 2. In presence of Architect, damage part of an exposed surface for each finish, color, and texture required, and demonstrate materials and techniques proposed for repairs to match adjacent undamaged surfaces.
- I. **Preinstallation Conference:** Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."
 - 1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require

representatives of each entity directly concerned with tilt-up concrete to attend, including the following:

- a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Tilt-up concrete subcontractor.
2. Review special inspection procedures; testing and inspecting agency procedures for field quality control; tilt-up concrete finishes and finishing; curing procedures; casting-slab construction, flatness and levelness, finish, and joint requirements; steel reinforcement installation tilt-up concrete repair procedures; and tilt-up concrete protection.

PART 2 - PRODUCTS

2.1 FORMS AND ACCESSORIES

- A. Forms: Metal, dressed lumber, or other approved materials that are nonreactive with concrete and that will provide continuous, true, and smooth concrete surfaces.
- B. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch
- C. Form Liners: Units of face design, texture, arrangement, and configuration indicated. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent surface treatments of concrete.
- D. Reveal Strips: Metal, PVC, rubber, straight dressed wood, or plywood; with sides kerfed.
- E. Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleedwater and prevent migration of set-retarding chemicals from wood or plywood.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 60 percent.
- C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- D. Plain-Steel Wire: ASTM A 82galvanized.
- E. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

- F. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.
- G. Bar Supports: Manufactured according to CRSI's "Manual of Standard Practice" of plastic or CRSI Class 1 plastic-protected steel wire or Class 2 stainless-steel wire.

2.3 CONCRETE MATERIALS

- A. Regional Materials: Concrete shall be manufactured within 100 miles of Project site from aggregates that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.
- B. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout the Project:
 - 1. Portland Cement: ASTM C 150, Type I or I Supplement with the following:
 - a. Fly Ash: ASTM C 618, Class C or F.
 - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- C. Coarse Aggregate: ASTM C 33 coarse aggregate or better, graded. Provide aggregates from a single source.
- D. Fine Aggregate: ASTM C 33 manufactured or natural sand, from same source for Project, free of materials with deleterious reactivity to alkali in cement.
- E. Exposed Coarse Aggregate: Hard and durable; washed; free of material that reacts with cementitious material or causes staining; from a single source, as follows:
 - 1. Aggregate Sizes: 1/2 to 3/4 inch (13 to 19 mm) nominal.
 - 2. Gradation: Uniformly graded.
- F. Water: Clean, fresh, drinkable, free of oils, acids or organic matter harmful to concrete.

2.4 ADMIXTURES

- A. Air-Entraining Admixture: ASTM C 260.
- B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 - 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - 2. Retarding Admixture: ASTM C 494/C 494M, Type B.
 - 3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 - 4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 - 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 - 6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

- C. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.
 - 1. Color: As selected by Architect from manufacturer's full range.

2.5 BONDBREAKERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in this Article.
- B. Products: Subject to compliance with requirements, provide one of the following products listed in this Article.
- C. Solvent-Borne, Chemically Reactive Bondbreaker: Penetrating polymerized solution containing no oils, waxes, paraffins, or silicones, and compatible with casting-slab curing compound.
 - 1. Burke by Edoco; Clean Lift 90 V.O.C.
 - 2. Conspec Marketing and Manufacturing Co., Inc., a Dayton Superior Company; Conspec CST VOC.
 - 3. Dayton/Richmond Concrete Accessories; Maxi Tilt.
 - 4. Dayton Superior Corporation; Sure Lift (J-6).
- D. Solvent-Borne, Membrane-Forming Bondbreaker: Dissipating polymerized solution containing no oils, waxes, paraffins, or silicones, and compatible with casting-slab curing compound.
 - 1. Burke by Edoco; Super Bondbreaker V.O.C.
 - 2. Conspec Marketing and Manufacturing Co., Inc., a Dayton Superior Company; Tilt-Eez VOC.
- E. Waterborne, Chemically Reactive Bondbreaker: Penetrating polymerized emulsion containing no oils, waxes, paraffins, or silicones, and compatible with casting-slab curing compound.
 - 1. Burke by Edoco; Super Tilt Bondbreaker W.B.
 - 2. Conspec Marketing and Manufacturing Co., Inc., a Dayton Superior Company; Conspec CST/WB.
 - 3. Dayton/Richmond Concrete Accessories; Maxi Tilt E.
 - 4. Dayton Superior Corporation; Sure-Lift WB (J-5).
 - 5. Nox-Crete Products Group, Kinsman Corporation; Silcoseal 2000F.
- F. Waterborne, Membrane-Forming Bondbreaker: Dissipating polymerized emulsion containing no oils, waxes, paraffins, or silicones, and compatible with casting-slab curing compound.
 - 1. Burke by Edoco; Super Bondbreaker W.B.
 - 2. Conspec Marketing and Manufacturing Co., Inc., a Dayton Superior Company; Tilt-Eez WB.
 - 3. Dayton/Richmond Concrete Accessories; Rich Tilt E.

2.6 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.
- B. 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.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

2.7 CONNECTION MATERIALS

- A. Embedded Metal Items and Loose Hardware: Materials for securing tilt-up concrete panels together and to supporting and adjacent construction are specified in Division 05 Section "Metal Fabrications."
- B. Loose Hardware: Materials for securing tilt-up concrete panels together and to supporting and adjacent construction are specified in Division 05 Section "Metal Fabrications."
- C. Carbon-Steel Shapes and Plates: ASTM A 36/A 36M.
- D. ASTM A 307 defines the term "studs" to include stud stock or threaded rods.
- E. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); carbon-steel, hex-head bolts and studs; carbon-steel nuts; and flat, unhardened steel washers.
- F. Unheaded Carbon-Steel Rods and Nuts: ASTM A 36/A 36M, threaded rods with ASTM A 563, nuts.
- G. Welded Headed Studs: AWS D1.1, Type B headed studs, and cold-finished, carbon-steel bars.
- H. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- I. Chord Bar Sleeves: Tubular sheathing, plastic or moisture-resistance-treated cardboard.
- J. Welding Electrodes: Comply with AWS standards.
- K. Hot-Dip Galvanized Finish: Apply zinc coating to steel connections by hot-dip process, complying with ASTM A 123/A 123M or ASTM A 153/A 153M as applicable.
 - 1. Zinc Repair Paint: SSPC-Paint 20.

2.8 LIFTING INSERTS AND ACCESSORIES

- A. Furnish inserts, dowels, bolts, nuts, washers, and other items to be cast in panels for tilting and lifting.
 - 1. Manufacture inserts with feet of plastic, galvanized steel wire, plastic-tipped steel wire, or stainless-steel-tipped steel wire.
- B. Furnish brace anchors and other accessories to be cast in panels and in casting slab for attaching bracing.
 - 1. Manufacture wall brace anchors and accessories with feet of galvanized steel wire, plastic-tipped steel wire, or stainless-steel-tipped steel wire.
 - 2. Manufacture floor brace anchors that will not penetrate vapor retarder under slab-on-grade.

2.9 BEARING PADS

- A. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet; Type A Shore durometer hardness of 50 to 70, ASTM D 2240; and minimum tensile strength 2250 psi (15.5 MPa), ASTM D 412.
- B. Random, Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer with a Type A Shore durometer hardness of 70 to 90, ASTM D 2240.
- C. Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded in elastomer with a Type A Shore durometer hardness of 80 to 100, ASTM D 2240.
- D. High-Density Plastic Strips: Multimonomer, nonleaching plastic.

2.10 GROUT

- A. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- B. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, and plasticizing and water-reducing agents; complying with ASTM C 1107, of consistency suitable for application.

2.11 MISCELLANEOUS MATERIALS

- A. Chemical Surface Retarder: Water-soluble, liquid set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to depth of reveal or etch required of specified finish.
- B. Form Retarder: Chemical liquid set retarder, for application on hardened horizontal concrete and capable of temporarily delaying final hardening of newly placed concrete to depth of reveal specified.

1. Mold Release: Solution specially formulated by manufacturer for use under form retarder.
- C. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch (0.85 mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.12 REPAIR MATERIALS

- A. Bonding Agent: ASTM C 1059, Type II, nonredispersible, acrylic emulsion or styrene butadiene.
- B. Patching Mortar: Dry-pack mix consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing No. 16 (1.18-mm) sieve, using only enough water for handling and placing.

2.13 CONCRETE MIXTURES

- A. Prepare design mixtures for each type and strength of concrete, proportioned on basis of laboratory trial mixture or field test data, or both, according to ACI 301.
 1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures based on laboratory trial mixtures.
- B. Proportion concrete mixture as follows:
 1. Minimum Compressive Strength: 4000 psi at 28 days unless noted otherwise.
 2. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete according to ACI 301 requirements.
- C. Admixtures: Use admixtures according to manufacturer's written instructions.
- D. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.14 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. When air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60-75 minutes.
- B. Project-Site-Produced Concrete: Measure, batch, and mix concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. Provide a batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time,

quantity, and amount of water added. Record panel locations where concrete is deposited.

PART 3 - EXECUTION

3.1 FORMS

- A. Construct and brace formwork so tilt-up concrete panels are of size, shape, alignment, elevation, and position indicated.
 - 1. Construct forms on slab-on-grade or on temporary casting slab, at Contractor's option.
 - 2. Provide for openings, offsets, recesses, reveals, rustications, reglets, and blockouts.
 - 3. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and supports to maintain stability of liners during concreting. Coat form liner with form-release agent.
- B. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Use kerfed inserts, such as those forming reglets, rustications, and recesses, for easy removal.
- C. Set edge forms for panels to achieve required panel thickness.
- D. Chamfer exposed corners and edges, unless otherwise indicated, using chamfer strips fabricated to produce uniform, smooth lines and tight edge joints.
- E. Coat contact surfaces of wood forms and chamfers with sealer before placing reinforcement.

3.2 BONDBREAKERS

- A. Uniformly and continuously apply two coats of bondbreaker to casting-slab surfaces by power spray or roller according to manufacturer's written instructions, before placing steel reinforcement. Recoat areas subjected to moisture before drying. Maintain continuity of coating until concrete placement.
- B. After placing steel reinforcement, touch up or recoat worn or damaged areas with bondbreaker. Do not splash or coat steel reinforcement and inserts.

3.3 FORM RETARDER

- A. Uniformly and continuously apply form retarder to slab surfaces by power spray, roller, or brush according to manufacturer's written instructions, before placing steel reinforcement. Recoat areas subjected to moisture before drying. Maintain continuity of coating until concrete placement.
 - 1. Uniformly apply mold release according to manufacturer's written instructions and allow to dry before applying form retarder.

- B. After placing steel reinforcement, touch up or recoat worn or damaged areas with form retarder. Do not splash or coat steel reinforcement and inserts.

3.4 REINFORCEMENT AND INSERTS

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating and placing reinforcement.
- B. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover.
 - 1. Field weld reinforcement according to AWS D1.4, where indicated.
 - 2. Do not tack-weld crossing reinforcing bars.
 - 3. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
- C. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.
- D. Accurately place and securely support embedded items, anchorages, inserts, cramps, retainers, bar chords and sleeves, and other items to be built into panels. Coordinate with other trades for installing cast-in items.

3.5 PANEL CASTING, GENERAL

- A. Comply with ACI 301 for handling, placing, and consolidating concrete.
- B. Maintain position of steel reinforcement, inserts, and anchors during concrete placement, consolidation, and finishing.
- C. Screed panel surfaces to correct level with a straightedge and strike off.
 - 1. Begin initial floating before excess moisture or bleedwater appears on the surface. Use bull floats or darbies to form a uniform and open-textured surface plane free of humps or hollows. Do not disturb panel surfaces before beginning finishing operations.
- D. Form chamfers at top edges of panel perimeters, openings, and similar locations not formed by chamfer strips, unless otherwise indicated.
- E. Surface Defects: Limit visible surface defects to those permitted by TCA's "Tilt-up Concrete Association's Guideline Specifications" for Grade A, Architectural panel surfaces.

3.6 CASTING TOLERANCES

- A. Cast tilt-up concrete panels without exceeding the following tolerances:

1. Height and Width of Panels:
 - a. For Panels up to 20 Feet (6.1 m) Tall: 1/4 inch (6 mm) wide.
 - b. For Panels 20 to 30 Feet (6.1 to 9.1 m) Tall: 3/8 inch (10 mm) wide.
 - c. Each Additional 10 Feet (3.05 m) in Excess of 30 Feet (9.1 m) Tall: 1/8 inch (3 mm) wide.
2. Thickness: 3/16 inch (5 mm).
3. Skew of Panel or Opening: Difference in length of diagonals of 1/8 inch per 72 inches (3 mm per 1830 mm) with a maximum difference of 1/2 inch (13 mm).
4. Openings Cast into Panel:
 - a. Size of Opening: 1/4 inch (6 mm).
 - b. Location of Centerline of Opening: 1/4 inch (6 mm).
5. Location and Placement of Embedded Items:
 - a. Inserts, Bolts, and Pipe Sleeves: 3/8 inch (10 mm).
 - b. Lifting and Bracing Inserts: As required by manufacturer.
 - c. Lateral Placement of Weld Plate Embedments: 1 inch (25 mm).
 - d. Tipping and Flushness of Weld Plate Embedments: 1/4 inch (6 mm).
6. Deviation of Steel Reinforcement Cover: Maintain minimum cover required by ACI 301.

3.7 FACE-UP FINISHES

- A. Float Finish: Consolidate surface of plastic concrete with power-driven floats or by hand floating. Restraighten and cut down high spots and fill low spots. Repeat float passes and restraighten until surface is left with a uniform, smooth, granular texture.
- B. Trowel Finish: After applying float finish, apply first trowel finish and consolidate plastic concrete by hand trowel or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and is uniform in texture and appearance.
- C. Trowel and Fine-Broom Finish: After applying float finish, apply a partial trowel finish to plastic concrete, stopping after second troweling. Immediately after second troweling, and when concrete is still plastic, slightly scarify the surface with a fine broom.
 1. Broom surface in a top-to-bottom direction.
- D. Brushed Exposed-Aggregate Finish: Produce exposed-aggregate finish to exterior surface of concrete by washing and brushing before panel erection, as follows:
 1. Immediately after floating, broadcast a single layer of aggregate uniformly onto panel surface. Tamp seeded aggregate into plastic concrete, and float to embed aggregate with mortar cover of 1/16 inch (1.6 mm).
 2. Spray chemical surface retarder on panel according to manufacturer's written instructions.

3. Cover panel surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
 4. Without dislodging aggregate, remove excess mortar by lightly brushing surface with stiff nylon-bristle broom.
 5. Fine spray surface with water, and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required.
- E. Abrasive-Blast, Exposed-Aggregate Finish: Produce exposed-aggregate finish to exterior surface of concrete by abrasive-blast finish before panel erection, as follows:
1. Immediately after floating, spray chemical surface retarder on panel surface according to manufacturer's written instructions.
 2. Cover with plastic sheeting, sealing laps with tape, and remove after concrete has hardened.
 3. Apply abrasive-blast finish using abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces as follows:
 - a. Light Exposure: Expose fine aggregate with occasional exposure of coarse aggregate and uniform color; maximum reveal of 1/16 inch (1.6 mm).
 - b. Medium Exposure: Generally expose coarse aggregate with slight reveal; maximum reveal of 1/4 inch (6 mm).
 - c. Heavy Exposure: Expose and reveal coarse aggregate to a maximum projection of 1/3 of its diameter; reveal of 1/4 to 1/2 inch (6 to 13 mm).
 4. Acid Cleaning: After abrasive blasting, clean surfaces with a 5 to 10 percent concentration of hydrochloric acid wash. Thoroughly neutralize and flush acid from finished surfaces with water under pressure. Protect casting slab and adjacent panels from acid wash.

3.8 FACE-DOWN FINISHES

- A. Smooth, As-Cast Finish: Cast panel to produce a surface free of pockets, sand streaks, and honeycombs. Produce a surface appearance of uniform color and texture.
- B. Form-Liner Finish: Cast panel over form liners placed, secured, and sealed over casting slab to produce a textured surface free of pockets, streaks, and honeycombs. Produce a surface appearance of uniform color and texture.
- C. Abrasive-Blast, Exposed-Aggregate Finish: Produce exposed-aggregate finish to exterior surface of concrete by abrasive-blasting after panel erection.
1. Apply abrasive-blast finish using abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces as follows:

- a. Light Exposure: Expose fine aggregate with occasional exposure of coarse aggregate and uniform color; maximum reveal of 1/16 inch (1.6 mm).
- b. Medium Exposure: Generally expose coarse aggregate with slight reveal; maximum reveal of 1/4 inch (6 mm).
- c. Heavy Exposure: Expose and reveal coarse aggregate to a maximum projection of 1/3 of its diameter; reveal of 1/4 to 1/2 inch (6 to 13 mm).
- D. Brushed Exposed-Aggregate Finish: Produce exposed-aggregate finish to exterior surface of concrete by washing and brushing after panel erection, as follows:
 - 1. After panel erection and without dislodging aggregate, remove excess mortar by lightly brushing surface with stiff nylon-bristle broom.
 - 2. Fine spray surface with water, and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required.
- E. Bushhammer Exposed-Aggregate Finish: Allow concrete to cure at least 14 days before starting bushhammer surface finish operations.
 - 1. Surface Continuity: Perform bushhammer finishing in as continuous an operation as possible, maintaining continuity of finish on each surface or area of Work. Maintain required patterns or variances of cut as shown on Drawings or to match mockup.
 - 2. Surface Cut: Maintain required depth of cut and general aggregate exposure. Use power tool with bushhammer attachments for large, flat surfaces, and use hand hammers for small areas, at corners and edges, and for restricted locations where power tools cannot reach.
- F. Sand-Bed, Exposed-Aggregate Finish: Place selected exposed aggregate on a sand bed over casting slab before placing reinforcement, embedments, and concrete. After erecting panel, remove sand to expose aggregate.

3.9 CONCRETE PROTECTING AND CURING

- A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures according to ACI 301.
 - 1. Apply evaporation retarder in hot, dry, or windy weather to protect concrete from rapid moisture loss before and during finishing operations. Apply according to manufacturer's written instructions after screeding and bull floating concrete, but before float finishing.
- B. Begin curing immediately after finishing concrete. Cure by one or a combination of the following methods according to ACI 308.1:
 - 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.

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.

3.10 ERECTION

- A. Use erection equipment with care to prevent damage to floor slabs and panels.
- B. Lift, support, and erect panels only at designated lifting or supporting points indicated on Shop Drawings.
- C. Do not erect panels until 75 percent of 28-day compressive strength of concrete has been verified.
- D. Install tilt-up concrete panels level, plumb, square, and true. Place panels on leveled grout-setting pads or shims in correct position. Maintain joint width of 1/2 inch between panels.
 1. Install tilt-up concrete panels with face-down surfaces exposed to exterior of building.
- E. Temporarily brace and support panels securely in position against loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to panels are secured.
- F. Anchor panels in place and, if indicated, to one another.
 1. Weld steel connectors to steel supports and embedments indicated, complying with AWS D1.1.
- G. Solidly grout-fill gaps between foundation system and bottom of panels.

3.11 FIELD QUALITY CONTROL

- A. Testing and Inspecting: Owner will engage a special inspector and qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- B. Inspections:
 1. Steel reinforcement placement.
 2. Steel reinforcement welding.
 3. Headed bolts and studs.
 4. Verification of use of required design mixture.
 5. Concrete placement, including conveying and depositing.

6. Curing procedures and maintenance of curing temperature.
 7. Verification of concrete strength before erection of tilt-up panels.
- C. Testing Services: Tests shall be performed according to ACI 301.

3.12 ERECTION TOLERANCES

- A. Install tilt-up concrete panels without exceeding the following erection tolerances:
1. Joint Width Variation (Exterior Face): Without decreasing or increasing more than 50 percent from specified joint width, maintain joint width as follows:
 - a. For Panels up to 20 Feet (6.1 m) Tall: 1/4 inch (6 mm).
 - b. Each Additional 10 Feet (3.05 m) in Excess of 20 Feet (6.1 m) Tall: 1/8 inch (3 mm).
 2. Joint Taper: Maximum 3/8 inch (10 mm) over length, but not greater than the following:
 - a. For Panels up to 20 Feet (6.1 m) Tall: 1/4 inch (6 mm).
 - b. Each Additional 10 Feet (3.05 m) in Excess of 20 Feet (6.1 m) Tall: 1/8 inch (3 mm)
 3. Panel Alignment:
 - a. Alignment of Horizontal and Vertical Joints: 1/4 inch (6 mm).
 - b. Offset in Exterior Face of Adjacent Panels: 1/4 inch (6 mm).

3.13 FILLING AND REPAIRS

- A. Patch holes and voids left by erecting and bracing inserts on tilt-up panels and slabs-on-grade. Cut or chip edges of voids perpendicular to concrete surface. Fill blockouts where indicated.
1. Clean, dampen with water, and brush-coat holes, voids, and blockouts with bonding agent. Fill and compact with patching mortar of a stiff consistency before bonding agent has dried.
 2. Finish surfaces of fills and repairs to Architect's approval, with materials of same colors and textures as finishes on surrounding surfaces.
- B. Repair damaged galvanized steel surfaces of connectors by cleaning and applying a coat of zinc repair paint.
- C. Repair damage to tilt-up panels and slabs-on-grade resulting from tilt-up work, as directed by Architect.
- D. Remove and replace tilt-up panels that do not comply with requirements in this Section.
- E. Demolish and remove temporary concrete casting slabs.

END OF SECTION 03 47 13

SECTION 03 52 16 - LIGHTWEIGHT INSULATING CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections (including all sustainability requirements), apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Cast-in-place vermiculite aggregate lightweight insulating concrete.
- B. Related Requirements:
 - 1. Section 03 30 00 "Cast-in-Place Concrete" for requirements for normal-weight and structural lightweight concrete, including formwork, reinforcement, and concrete materials and mixes.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For lightweight insulating concrete.
 - 1. Include plans, sections, and details showing roof slopes, thicknesses, and embedded insulation board.
 - 2. Indicate locations of penetrations, perimeter terminations and curbs, control and expansion joints, and drains.
- C. Design Mixtures: For each lightweight insulating concrete mixture.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Certificates: For the following:
 - 1. Cementitious materials.
 - 2. Lightweight aggregates.
 - 3. Foaming agents.
 - 4. Admixtures.
 - 5. Molded-polystyrene insulation board.
- C. Evaluation Reports: For lightweight insulating concrete, from ICC-ES.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. NRDCA Installer Qualifications: A firm that has been evaluated by UL and found to comply with requirements of NRDCA's Lightweight Insulating Concrete Roof Deck Contractors Accreditation Program.
- B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1.7 FIELD CONDITIONS

- A. Do not place lightweight insulating concrete unless ambient temperature is at least 40 deg F and rising.
- B. Do not place lightweight insulating concrete during rain or snow or on surfaces covered with standing water, snow, or ice.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency.
 - 1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.
- B. FM Global Listing: Lightweight insulating concrete along with other roofing components shall comply with requirements in FM Global 4454 as part of a roof assembly, and shall be listed in FM Global's "RoofNav" for Class 1 or noncombustible construction, as applicable.

2.2 AGGREGATE LIGHTWEIGHT INSULATING CONCRETE

- A. Produce aggregate lightweight insulating concrete using the minimum amount of water necessary to produce a workable mix.
 - 1. Do not exceed maximum air content recommended by aggregate manufacturer.
- B. Vermiculite Aggregate Mix: Lightweight insulating concrete produced from cementitious materials, water, air-entraining admixture, and vermiculite mineral aggregates complying with ASTM C 332, Group I.
 - 1. Asbestos Content: No detectable asbestos as determined by method specified in 40 CFR 763, Subpart E, Appendix E, Section 1, "Polarized Light Microscopy."
 - 2. As-Cast Unit Weight: 44 to 60 lb/cu. ft. at point of placement, when tested according to ASTM C 138/C 138M.
 - 3. Oven-Dry Unit Weight: 22 to 28 lb/cu. ft., when tested according to ASTM C 495.
 - 4. Compressive Strength: Minimum 125 psi, when tested according to ASTM C 495.

5. Cement-to-Aggregate Ratio, by Volume: 1:6.

2.3 MATERIALS

- A. Cementitious Material: Portland cement, ASTM C 150/C 150M, Type I. Supplement with fly ash, ASTM C 618, Class C or F.
- B. Water: Clean, potable.
- C. Joint Filler: ASTM C 612, Class 2, glass-fiber type; compressing to one-half thickness under a load of 25 psi.
- D. Steel Wire Mesh: Cold-drawn steel wire, galvanized, 0.041-inch diameter, woven into 2-inch hexagonal mesh, and reinforced with a longitudinal 0.062-inch-diameter wire spaced 3 inches apart.
- E. Molded-Polystyrene Insulation Board: ASTM C 578, Type I, 0.90-lb/cu. ft. minimum density.
 - 1. Provide units with manufacturer's standard keying slots or holes of 3 to 4 percent of board's gross surface area.

2.4 DESIGN MIXTURES

- A. Prepare design mixtures for each type and strength of lightweight insulating concrete by laboratory trial batch method or by field-test data method. For trial batch method, use a qualified independent testing agency for preparing and reporting proposed mixture designs.
 - 1. Limit use of fly ash to not exceed 25 percent of portland cement by weight.
- B. Limit water-soluble chloride ions to the maximum percentage by weight of cement or cementitious material permitted by ACI 301.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Control Joints: Install control joints at perimeter of roof deck and at junctures with vertical surfaces, including curbs, walls, and vents, for full depth of lightweight insulating concrete. Fill control joints with joint filler.
 - 1. Provide 1-inch-wide control joints for roof dimensions up to 100 feet in length; 1-1/2-inch-wide control joints for roof dimensions exceeding 100 feet.
- B. Wire Mesh: Place steel wire mesh with longest dimension perpendicular to steel deck ribs. Cut mesh to fit around roof openings and projections. Terminate mesh at control joints. Lap sides and ends of mesh at least 6 inches.

3.2 MIXING AND PLACING

- A. Mix and place lightweight insulating concrete according to manufacturer's written instructions, using equipment and procedures to avoid segregation of mixture and loss of air content.

- B. Install insulation board according to lightweight insulating concrete manufacturer's written instructions. Place insulation board in wet, lightweight insulating concrete slurry poured a minimum of 1/8 inch over the structural substrate. Ensure full contact of insulation board with slurry. Stagger joints and tightly butt insulation boards. Allow slurry coat to set prior to placing remaining thickness of lightweight insulating concrete.
 - 1. Install insulation board in a stair-step configuration with a maximum step-down of 1 inch.
- C. Deposit and screed lightweight insulating concrete in a continuous operation until an entire panel or section of roof area is completed. Do not vibrate or work mix except for screeding or floating. Place to depths and slopes indicated.
- D. Finish top surface smooth, free of ridges and depressions, and maintain surface in condition to receive subsequent roofing system.
- E. Begin curing operations immediately after placement, and air cure for not less than three days, according to manufacturer's written instructions.
- F. If ambient temperature falls below 32 deg F, protect lightweight insulating concrete from freezing and maintain temperature recommended by manufacturer for 72 hours after placement.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to sample materials and perform tests and inspections.
- B. Testing of samples of lightweight insulating concrete obtained according to ASTM C 172/C 172M, except as modified by ASTM C 495, shall be performed according to the following requirements:
 - 1. Determine as-cast unit weight during each hour of placement, according to ASTM C 138/C 138M.
 - 2. Determine oven-dry unit weight and compressive strength according to ASTM C 495. Make a set of at least six molds for each day's placement, but not less than one set of molds for each 5000 sq. ft. of roof area.
 - 3. Perform additional tests when test results indicate that as-cast unit weight, oven-dry unit weight, compressive strength, or other requirements have not been met.
 - a. Retest cast-in-place lightweight insulating concrete for oven-dry unit weight and compressive strength.
- C. Prepare test and inspection reports.

END OF SECTION 03 52 16

SECTION 04 22 00 - CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections (including all sustainability requirements), apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Concrete masonry units.
 - 2. Mortar and grout.
 - 3. Steel reinforcing bars.
 - 4. Masonry-joint reinforcement.
 - 5. Embedded flashing.
 - 6. Miscellaneous masonry accessories.
 - 7. Masonry-cell fill.
- B. Related Requirements:
 - 1. Section 05 12 00 "Structural Steel Framing" for installing anchor sections of adjustable masonry anchors for connecting to structural steel frame.
 - 2. Section 07 19 00 "Water Repellents" for water repellents applied to unit masonry assemblies.
 - 3. Section 07 62 00 "Sheet Metal Flashing and Trim" for sheet metal flashing and for furnishing manufactured reglets installed in masonry joints.

1.3 DEFINITIONS

- A. CMU(s): Concrete masonry unit(s).
- B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Data: Refer to section 01 81 13.14 "Sustainable Design Requirements – LEED V4 BD+C" for Leadership Extraction Practices for the following:
 - a. Regional/Local Multiplier Compliance

- b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
 - b. Corporate Sustainability Reporting (CSR's) this will depend on the manufacturer sections
- B. Shop Drawings: For the following:
 - 1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.
 - 2. Reinforcing Steel: Detail bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315. Show elevations of reinforced walls.
 - 3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.
 - 4. Control joint locations corresponding with joints in cladding materials where applicable.
- C. Samples for Verification: For each type and color of the following:
 - 1. Exposed CMUs.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Material Certificates: For each type and size of the following:
 - 1. Masonry units.
 - a. Include data on material properties.
 - 2. Grout mixes. Include description of type and proportions of ingredients.
 - 3. Reinforcing bars.
 - 4. Joint reinforcement.
 - 5. Anchors, ties, and metal accessories.
- C. Mix Designs: For each type of mortar. Include description of type and proportions of ingredients.
 - 1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C 109/C 109M for compressive strength, ASTM C 1506 for water retention, and ASTM C 91/C 91M for air content.
 - 2. Include test reports, according to ASTM C 1019, for grout mixes required to comply with compressive strength requirement.
- D. Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for testing indicated.
- B. Mockups: Build mockups as indicated in Section 01 43 39 "Visual Mock-up Requirements".
 - 1. Build mockup of typical wall area as directed by Architect.
 - 2. Protect accepted mockups from the elements with weather-resistant membrane.

3. Approval of mockups is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
 - a. Approval of mockups is also for other material and construction qualities specifically approved by Architect in writing.
 - b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.
- B. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- C. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.10 FIELD CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
 1. Extend cover a minimum of 24 inches down both sides of walls, and hold cover securely in place.
- B. Do not apply uniform loads for at least 12 hours and concentrated loads for at least three days after building masonry walls or columns.
- C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
 1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
 2. Protect sills, ledges, and projections from mortar droppings.
 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
 4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- D. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.
- B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.

2.2 PERFORMANCE REQUIREMENTS

- A. Provide unit masonry that develops indicated net-area compressive strengths at 28 days.
 - 1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) according to TMS 602/ACI 530.1/ASCE 6.

2.3 UNIT MASONRY, GENERAL

- A. Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6 except as modified by requirements in the Contract Documents.
- B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work.
- C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated.
 - 1. Where fire-resistance-rated construction is indicated, units shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction.
- D. Sustainability Requirements
 - 1. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of pre-consumer recycled content not less than 10 percent.
 - a. Refer to Section 01 81 13.14 "Sustainable Design Requirements - LEED v4 BD+C" for additional information and requirements for recycled content.
 - 2. Regional Materials: Refer to section 01 81 13.14 "Sustainable Design Requirements – LEED V4 BD+C" for CMUs manufactured within 100 miles of Project site from aggregates and cement that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

2.4 CONCRETE MASONRY UNITS

- A. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.
 - 1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
 - 2. Provide bullnose units for outside corners unless otherwise indicated.
- B. Integral Water Repellent: Provide units made with integral water repellent for exposed units.

1. Integral Water Repellent: Liquid polymeric, integral water-repellent admixture that does not reduce flexural bond strength. Units made with integral water repellent, when tested according to ASTM E 514/E 514M as a wall assembly made with mortar containing integral water-repellent manufacturer's mortar additive, with test period extended to 24 hours, shall show no visible water or leaks on the back of test specimen.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) ACM Chemistries.
 - 2) BASF Corporation; Construction Systems.
 - 3) Grace Construction Products.
- C. CMUs: ASTM C 90.
 1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 1900 psi.
 2. Density Classification: Normal weight.
 3. Size (Width): Manufactured to dimensions 3/8 inch less-than-nominal dimensions.
- D. Pre-faced CMUs: Lightweight hollow concrete units complying with ASTM C 90, with manufacturer's standard smooth resinous facing complying with ASTM C 744.
 1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2150 psi (14.8 MPa).
 2. Size: Manufactured to dimensions specified in "CMUs" Paragraph but with pre-faced surfaces having 1/16-inch- (1.5-mm-) wide returns of facing to create 1/4-inch- (6.5-mm-) wide mortar joints with modular coursing.
 3. Colors and Patterns: As selected by Architect from manufacturer's full range.

2.5 MASONRY LINTELS

- A. General: Provide one of the following:
- B. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs matching adjacent CMUs in color, texture, and density classification, with reinforcing bars placed as indicated and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.

2.6 INSULATED CONCRETE MASONRY UNITS

- A. Insulated Concrete Masonry Units: Pre-assembled structural concrete masonry units composed of an inner component concrete masonry shell that is continuously thermally broken from the outer concrete shell. The thermal break is expanded polystyrene (EPS) closed cell insulation. The insulation EPS is held firmly between the two concrete block shells by dove tail slots and internal stainless-steel metal anchors molded into the EPS inserts, creating a cohesive and tightly fitting single unit.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide Northfield, an Oldcastle Company; InsulTech Insulated Concrete Masonry Units or comparable approved product meeting all requirements including sustainability requirements.

- a. Refer to Sections 01 25 00 "Substitution Procedures" and 01 60 00 "Product Requirements" for comparable product requirements.
- B. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2000 psi. Weight Classification: Medium weight with density not to exceed 125 lbs. per cubic foot concrete.
- C. Molded-Polystyrene Insulation:
 1. Rigid, cellular thermal insulation formed by the expansion of polystyrene-resin beads or granules in a closed mold to comply with ASTM C 578, Type I.
 2. Provide specially shaped insulation designed for installing in face shells of insulated masonry units and providing continuous thermal barrier across head joints, including corner units. Provide an adhesive applied to EPS insert which serves as a continuous air barrier. Provide compliant closed cell gasket material to provide air tightness and continuous insulation across the bed joints.
- D. Special Shapes:
 1. Provide special shapes as follows: Provide shapes including right and left corner and L corner units, jambs, half-size shapes, solid bottom bond beams, and other special conditions manufactured as pre-assembled units with EPS, complying with above requirements, and match exposed finish of insulated concrete masonry units.
 2. Provide square-edged units for outside corners. Provide EchelonMasonry.com separate 8" unit matching exposed finish to be installed at base of wall, above doors and windows, and other areas where flashing is required. Provide exterior face shell preassembled with 3" EPS with inside face shaved flush to be installed at base of wall, above doors and windows, and other areas where flashing is required.

2.7 THERMALLY IMPROVED CONCRETE MASONRY UNITS

- A. Thermally improved concrete masonry units: Specially formed concrete masonry units with pre-formed, molded expanded polystyrene inserts.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide Omni Block Concrete Masonry Units or comparable approved product meeting all requirements including sustainability requirements.
- B. Provide special block sizes and shapes required or as shown on Drawings.

2.7.2.8 CMU INSULATION

- A. Where indicated, units shall contain rigid, specially shaped, cellular thermal insulation units complying with ASTM C 578, Type I, designed for installing in cores of masonry units.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Concrete Block Insulating Systems.
 - b. Shelter Enterprises Inc.

2.8.2.9 MORTAR AND GROUT MATERIALS

04 22 00 - 6

- A. Portland Cement: ASTM C 150/C 150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.
- B. Hydrated Lime: ASTM C 207, Type S.
- C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.
- D. Aggregate for Mortar: ASTM C 144.
 - 1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
 - 2. For joints less than 1/4-inch-thick, use aggregate graded with 100 percent passing the No. 16 sieve.
 - 3. White-Mortar Aggregates: Natural white sand or crushed white stone.
 - 4. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.
- E. Aggregate for Grout: ASTM C 404.
- F. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with CMUs containing integral water repellent from same manufacturer.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACM Chemistries.
 - b. BASF Corporation - Admixture Systems.
 - c. Grace Construction Products.
- G. Water: Potable.

2.92.10 REINFORCEMENT

- A. Provide Recycled Content of Steel Products: Postconsumer recycled content plus one-half of pre-consumer recycled content not less than 50 percent.
 - 1. Refer to Section 01 81 13.14 "Sustainable Design Requirements - LEED v4 BD+C" for additional information and requirements for recycled content.
- B. Uncoated Steel Reinforcing Bars: ASTM A 615/A 615M or ASTM A 996/A 996M, Grade 60.
- C. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.
- D. Masonry-Joint Reinforcement, General: Ladder type complying with ASTM A 951/A 951M.
 - 1. Interior Walls: Hot-dip galvanized carbon steel.
 - 2. Exterior Walls: Stainless steel.
 - 3. Wire Size for Side Rods: 0.187-inch diameter.

4. Wire Size for Cross Rods: 0.187-inch diameter.
5. Spacing of Cross Rods: Not more than 16 inches o.c.
6. Provide in lengths of not less than 10 feet, with prefabricated corner and tee units.

2.102.11 TIES AND ANCHORS

- A. General: Ties and anchors shall extend at least 1-1/2 inches into masonry but with at least a 5/8-inch cover on outside face.
- B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:
 1. Stainless-Steel Wire: ASTM A 580/A 580M, Type 304.
- C. Partition Top Anchors: 0.105-inch-thick metal plate with a 3/8-inch-diameter metal rod 6 inches long welded to plate and with closed-end plastic tube fitted over rod that allows rod to move in and out of tube. Fabricate from steel, hot-dip galvanized after fabrication.
- D. Rigid Anchors: Fabricate from steel bars 1-1/2 inches wide by 1/4 inch thick by 24 inches long, with ends turned up 2 inches or with cross pins unless otherwise indicated.
 1. Corrosion Protection: Hot-dip galvanized to comply with ASTM A 153/A 153M.

2.142.12 EMBEDDED FLASHING MATERIALS

- A. Single-Wythe CMU Flashing
 1. System of CMU cell flashing pans and interlocking CMU web covers made from UV-resistant, high-density polyethylene. Cell flashing pans have integral weep spouts designed to be built into mortar bed joints and that extend into the cell to prevent clogging with mortar.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide Mortar Net Solutions, BlockFlash or comparable approved product meeting all requirements including sustainability requirements.
 - 1) Refer to Sections 01 25 00 "Substitution Procedures" and 01 60 00 "Product Requirements" for comparable product requirements.
 - b. Recycled Content: Postconsumer recycled content plus one-half of pre-consumer recycled content not less than 40 percent.
 - 1) Refer to Section 01 81 13.14 "Sustainable Design Requirements - LEED v4 BD+C" for additional information and requirements for recycled content.
- B. Flexible Thru-Wall Flashing
 1. Rubberized-Asphalt Flashing: Composite flashing product consisting of a pliable, adhesive rubberized-asphalt compound, bonded to a high-density, cross-laminated polyethylene film to produce an overall thickness of not less than 1.0 mm (40 mil).
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Carlisle Coatings & Waterproofing Inc.

- 2) GCP Applied Technologies Inc. (formerly Grace Construction Products).
- 3) W. R. Meadows, Inc.
- b. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.

2.122.13 MISCELLANEOUS MASONRY ACCESSORIES

- A. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene.
- B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.
- C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D 226/D 226M, Type I (No. 15 asphalt felt).
- D. Weep/Cavity Vent Products: Use the following unless otherwise indicated:
 1. Mesh Weep/Vent: Free-draining mesh; made from polyethylene strands, full height and width of head joint and depth 1/8 inch (3 mm) less than depth of outer wythe; in color selected from manufacturer's standard.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Advanced Building Products Inc.
 - 2) Keene Building Products.
 - 3) Mortar Net Solutions.
- E. Cavity Drainage Material: Free-draining mesh, made from polymer strands that will not degrade within the wall cavity.
 1. Configuration: Strips to fit within individual masonry cells.

2.132.14 MASONRY-CELL FILL

- A. Lightweight-Aggregate Fill: ASTM C 331/C 331M.

2.142.15 MORTAR AND GROUT MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
 1. Do not use calcium chloride in mortar or grout.
 2. Use portland cement-lime mortar unless otherwise indicated.
 3. For exterior masonry, use portland cement-lime mortar.
 4. For reinforced masonry, use portland cement-lime mortar.
- B. Mortar for Unit Masonry: Comply with ASTM C 270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated.
 1. For masonry below grade or in contact with earth, use Type S.

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2. For reinforced masonry, use Type S.
 3. For exterior, above-grade, load-bearing and nonload-bearing walls and parapet walls; for interior load-bearing walls; for interior nonload-bearing partitions; and for other applications where another type is not indicated, use Type N.
 4. For interior nonload-bearing partitions, Type O may be used instead of Type N.
 5. For mortar parge coats, use Type S or Type N.
- C. Grout for Unit Masonry: Comply with ASTM C 476.
1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602/ACI 530.1/ASCE 6 for dimensions of grout spaces and pour height.
 2. Proportion grout in accordance with ASTM C 476, paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi.
 3. Provide grout with a slump of 8 to 11 inches as measured according to ASTM C 143/C 143M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
 2. Verify that foundations are within tolerances specified.
 3. Verify that reinforcing dowels are properly placed.
 4. Verify that substrates are free of substances that would impair mortar bond.
- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Build chases and recesses to accommodate items specified in this and other Sections.
- B. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.
- C. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

3.3 FIELD QUALITY CONTROL

- A. Concrete unit masonry installer shall provide field quality control by staff having adequate prior experience and shall provide the following reports and checklists.

1. BECxA shall provide initial BECx checklists. Contractor shall provide weekly updates verifying all locations have been inspected and are free of installation defects and damage.
 - a. BECx Checklists shall include specific locations of the work and specific location and description of any repairs.
 - b. BECx checklist shall be completed in its entirety and shall be provided weekly to the Construction Manager, Architect, and Owner.
2. Provide field inspection reports within 5 working days of inspection.

3.4 TOLERANCES

A. Dimensions and Locations of Elements:

1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch or minus 1/4 inch.
2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch.
3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch in a story height or 1/2 inch total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet, or 1/2-inch maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2-inch maximum.
3. For vertical lines and surfaces do not vary from plumb by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2-inch maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2-inch maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2-inch maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet, or 1/2-inch maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch, with a maximum thickness limited to 1/2 inch.
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch.
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch or minus 1/4 inch.
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch.

3.5 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.
- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less-than-nominal 4-inch horizontal face dimensions at corners or jambs.
- C. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- E. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.
- F. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below, and rod mortar or grout into core.
- G. Fill cores in hollow CMUs with grout 24 inches under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.
- H. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.
 - 1. Install compressible filler in joint between top of partition and underside of structure above.
 - 2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors and push tubes down into grout to provide 1/2-inch clearance between end of anchor rod and end of tube. Space anchors 48 inches o.c. unless otherwise indicated.
 - 3. At fire-rated partitions, treat joint between top of partition and underside of structure above to comply with Section 07 84 43 "Joint Firestopping."

3.6 MORTAR BEDDING AND JOINTING

- A. Lay hollow CMUs as follows:
 - 1. Bed face shells in mortar and make head joints of depth equal to bed joints.
 - 2. Bed webs in mortar in all courses of piers, columns, and pilasters.
 - 3. Bed webs in mortar in grouted masonry, including starting course on footings.
 - 4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.
- B. Lay solid CMUs with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

- C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.
- D. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.
- E. Cut joints flush where indicated to receive waterproofing unless otherwise indicated.

3.7 MASONRY-CELL FILL

- A. Pour lightweight-aggregate fill into cavities to fill void spaces. Maintain inspection ports to show presence of fill at extremities of each pour area. Close the ports after filling has been confirmed. Limit the fall of fill to one story high, but not more than 20 feet.

3.8 MASONRY-JOINT REINFORCEMENT

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch on exterior side of walls, 1/2 inch elsewhere. Lap reinforcement a minimum of 6 inches.
 - 1. Space reinforcement not more than 16 inches o.c.
 - 2. Space reinforcement not more than 8 inches o.c. in foundation walls and parapet walls.
 - 3. Provide reinforcement not more than 8 inches above and below wall openings and extending 12 inches beyond openings in addition to continuous reinforcement.
- B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.
- C. Provide continuity at wall intersections by using prefabricated T-shaped units.
- D. Provide continuity at corners by using prefabricated L-shaped units.
- E. Cut and bend reinforcing units as directed by manufacturer for continuity at corners, returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

3.9 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

- A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:
 - 1. Provide an open space not less than 1/2-inch-wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
 - 2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
 - 3. Space anchors as indicated, but not more than 24 inches o.c. vertically and 36 inches o.c. horizontally.

3.10 CONTROL AND EXPANSION JOINTS

- A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.
- B. Form control joints in concrete masonry as follows:
 - 1. Install preformed control-joint gaskets designed to fit standard sash block.
 - 2. Install temporary foam-plastic filler in head joints, and remove filler when unit masonry is complete for application of sealant.

3.11 LINTELS

- A. Provide masonry lintels where shown and where openings of more than 12 inches for brick-size units and 24 inches for block-size units are shown without structural steel or other supporting lintels.
- B. Provide minimum bearing of 8 inches at each jamb unless otherwise indicated.

3.12 FLASHING

- A. General: Install embedded flashing at ledges and other obstructions to downward flow of water in wall where indicated.
- B. Install flashing as follows unless otherwise indicated:
 - 1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.
 - 2. At lintels, extend flashing a minimum of 6 inches into masonry at each end. At heads and sills, extend flashing 6 inches at ends and turn up not less than 2 inches to form end dams.
 - 3. Interlock end joints of ribbed sheet metal flashing by overlapping ribs not less than 3 inches or as recommended by flashing manufacturer, and seal lap with elastomeric sealant complying with requirements in Section 07 92 00 "Joint Sealants" for application indicated.
 - 4. Install metal drip edges and sealant stops with ribbed sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 07 92 00 "Joint Sealants" for application indicated.
- C. Install single-wythe CMU flashing system in bed joints of CMU walls where indicated to comply with manufacturer's written instructions. Install CMU cell pans with upturned edges located below face shells and webs of CMUs above and with weep spouts aligned with face of wall. Install CMU web covers so that they cover upturned edges of CMU cell pans at CMU webs and extend from face shell to face shell.
- D. Install reglets and nailers for flashing and other related construction where they are shown to be built into masonry.

3.13 REINFORCED UNIT MASONRY INSTALLATION

- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
 - 1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
 - 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.
- B. Placing Reinforcement: Comply with requirements in TMS 602/ACI 530.1/ASCE 6.
- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
 - 1. Comply with requirements in TMS 602/ACI 530.1/ASCE 6 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
 - 2. Limit height of vertical grout pours to not more than 60 inches.

3.14 FIELD QUALITY CONTROL

- A. Testing Prior to Construction: One set of tests.

3.15 PARGING

- A. Parge exterior faces of masonry walls, where indicated, in two uniform coats to a total thickness of 3/4 inch (19 mm). Dampen wall before applying first coat, and scarify first coat to ensure full bond to subsequent coat.
- B. Use a steel-trowel finish to produce a smooth, flat, dense surface with a maximum surface variation of 1/8 inch per foot (3 mm per 300 mm). Form a wash at top of parging and a cove at bottom.
- C. Damp-cure parging for at least 24 hours and protect parging until cured.

3.16 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:

1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
3. Protect adjacent nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
5. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.

3.17 MASONRY WASTE DISPOSAL

- A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.

END OF SECTION 04 22 00

SECTION 05 1200 - STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Structural steel.
 - 2. Field-installed shear connectors.
 - 3. Grout.
- B. Related Requirements:
 - 1. Section 053100 "Steel Decking" for field installation of shear connectors through deck.
 - 2. Section 055000 "Metal Fabrications" for miscellaneous steel fabrications and other steel items not defined as structural steel.
 - 3. Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for surface-preparation and priming requirements.

1.3 DEFINITIONS

- A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."
- B. Heavy Sections: Rolled and built-up sections as follows:
 - 1. Shapes included in ASTM A 6/A 6M with flanges thicker than 1-1/2 inches.
 - 2. Welded built-up members with plates thicker than 2 inches.
 - 3. Column base plates thicker than 2 inches.

1.4 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 - 1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance – where possible.
 - b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
 - b. Corporate Sustainability Reporting (CSR's)
- C. Shop Drawings: Show fabrication of structural-steel components.
 - 1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
 - 2. Include embedment Drawings.
 - 3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
 - 4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections.
- D. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs): Provide according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for each welded joint qualified by testing, including the following:

1. Power source (constant current or constant voltage).
 2. Electrode manufacturer and trade name, for demand critical welds.
- E. Delegated-Design Submittal: For structural-steel connections indicated to comply with design loads, include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, fabricator and shop-painting applicators.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats or fire proofing applied over shop primers, certifying that shop primers are compatible with topcoats.
- D. Mill test reports for structural steel, including chemical and physical properties.
- E. Product Test Reports: For the following:
1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
 2. Direct-tension indicators.
 3. Tension-control, high-strength, bolt-nut-washer assemblies.
 4. Shear stud connectors.
 5. Shop primers.
 6. Nonshrink grout.
 7. Rods
 8. Clevis
- F. Survey of existing conditions.
- G. Source quality-control reports.

1.8 QUALITY ASSURANCE

- A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category STD.
- B. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category ACSE for building over 200,000 sf, ASC, LST, Pedestrian Bridge. Category CSE for remaining steel structures.
- C. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P1 or to SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."

- D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- E. Comply with applicable provisions of the following specifications and documents:
 - 1. AISC 303.
 - 2. AISC 360.
 - 3. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
 - 1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
- B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
 - 1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
 - 2. Clean and relubricate bolts and nuts that become dry or rusty before use.
 - 3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Connections: Provide details of simple shear connections required by the Contract Documents to be selected or completed by structural-steel fabricator, including comprehensive engineering analysis by a qualified professional engineer, to withstand loads indicated and comply with other information and restrictions indicated.
 - 1. Select and complete connections using schematic details indicated and AISC 360.
 - 2. Use Load and Resistance Factor Design; data are given at factored-load level or Allowable Stress Design; data are given at service-load level., refer to the drawings notes for each building
- B. Moment Connections: Type FR, fully restrained.
- C. Construction: Combined system of moment frame, braced frame, and shear walls.

2.2 STRUCTURAL-STEEL MATERIALS

- A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than the following:
 - 1. W-Shapes: 60 percent.
 - 2. Channels, Angles-Shapes: 60 percent.
 - 3. Plate and Bar: 85 percent.
 - 4. Cold-Formed Hollow Structural Sections: 30 percent.
 - 5. Steel Pipe: 25 percent.
 - 6. All Other Steel Materials: 25 percent.
- B. W-Shapes: ASTM A 992, Grade 50.
- C. Channels, Angles, M-Shapes: ASTM A 36/A 36M.
- D. Plate and Bar: ASTM A 572/A 572M, Grade 50.
- E. Cold-Formed Hollow Structural Sections: ASTM A 500/A 500M, Grade C, structural tubing.
- F. Steel Pipe: ASTM A 53/A 53M, Type E or Type S, Grade B.
 - 1. Weight Class: As shown on Contract drawings
 - 2. Finish: Black except where indicated to be galvanized.
- G. Seamless Carbon and Alloy Steel Mechanical Tubing ASTM A 519 Grade 1096
- H. Steel Castings: ASTM A 216/A 216M, Grade WCB with supplementary requirement S11.
- I. Steel Forgings: ASTM A 668/A 668M.
- J. Welding Electrodes: Comply with AWS requirements.

2.3 High Strength Tension Rods System:

- A. Steel rods shall be carbon steel and shall conform to DIN EN 10025.
 - 1. For rods $\frac{1}{2}$ " in diameter or less provide S355 (51 ksi yield) steel
 - 2. For rods greater than $\frac{1}{2}$ " in diameter provide S460 (66 ksi yield) steel.
 - 3. Fabricate rods with right hand threads and left hand threads on alternate ends.
- B. Fittings shall be cast steel and shall be capable of developing 1.5 times the full breaking strength of the steel rod.
 - 1. For rods $\frac{1}{2}$ " in diameter or less material shall be forged carbon steel S355J2 DIN EN 10025
 - 2. For rods greater than $\frac{1}{2}$ " in diameter material shall be cast steel G20 Mn5+QT DIN EN 10293.

- C. Provide a complete system from one of the following or approved equal:
1. Halfen Detan rod system, Halfen, USA, Inc., 8521 FM 1976, P.O. Box 547, Converse, TX 78109
 2. Macalloy 460 rod system, Macalloy, Caxton Way, Dinnington, Sheffield, S25 3QE, UK.
 3. Pfeifer Tension Rod System Typ 860, Pfeifer Seil- und Hebetchnik GmbH, Dr.-Karl-Lenz-Strasse 66, DE-87700 Memmingen.

2.4 BOLTS, CONNECTORS, AND ANCHORS

- A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbon-steel washers; all with plain finish.
1. Retain "Direct-Tension Indicators" Subparagraph below if applicable. If using corrosion-resisting (weathering) steel, revise Type 325 to Type 325-3; ASTM F 959M does not include a designation for corrosion-resistant steel.
 2. Direct-Tension Indicators: ASTM F 959, Type 325, compressible-washer type with plain finish.
- B. High-Strength Bolts, Nuts, and Washers: ASTM A 490, Type 1, heavy-hex steel structural bolts or tension-control, bolt-nut-washer assemblies with splined ends; ASTM A 563, Grade DH, heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbon-steel washers with plain finish.
1. Direct-Tension Indicators: ASTM F 959, Type 490, compressible-washer type with plain finish.
- C. Zinc-Coated High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade DH heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbon-steel washers.
1. Finish: Mechanically deposited zinc coating] [Hot-dip or mechanically deposited zinc coating.
 2. Direct-Tension Indicators: ASTM F 959, Type 325, compressible-washer type with mechanically deposited zinc coating finish.
- D. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, heavy-hex head assemblies consisting of steel structural bolts with splined ends, heavy-hex carbon-steel nuts, and hardened carbon-steel washers.
1. Finish: Plain (interior) and Mechanically deposited zinc coating (exterior).
- E. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.

- F. Headed Anchor Rods: ASTM F 1554, Grade 55 unless shown otherwise on contract drawings, straight.
 - 1. Nuts: ASTM A 563 heavy-hex carbon steel.
 - 2. Plate Washers: ASTM A 36/A 36M carbon steel.
 - 3. Washers: ASTM F 436 Type 1, hardened carbon steel.
 - 4. Finish: Plain (interior) and Mechanically deposited zinc coating, ASTM B 695, Class 50 (exterior).
- G. Threaded Rods: ASTM A 36/A 36M.
 - 1. Nuts: ASTM A 563 heavy-hex carbon steel.
 - 2. Washers: ASTM A 36/A 36M carbon steel.
 - 3. Finish: Plain and Mechanically deposited zinc coating, ASTM B 695, Class 50.
- H. Clevises and Turnbuckles: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1035.
- I. Eye Bolts and Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1030.
- J. Sleeve Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1018.
- K. Structural Slide Bearings: Low-friction assemblies, of configuration indicated, that provide vertical transfer of loads and allow horizontal movement perpendicular to plane of expansion joint while resisting movement within plane of expansion joint. Refer to drawings.
 - 1. Provide slide bearing system from one of the following or approved equal:
 - a. Con-Serv Inc. - Con Slide
 - b. Steel Supply Company
 - 2. Mating Surfaces: PTFE and mirror-finished stainless steel.
 - 3. Coefficient of Friction: Not more than 0.05
 - 4. Design Load: Not less than 4,000 psi.
 - 5. Total Movement Capability: See architectural drawings
- L. Urethane Springs: Compression Springs machined from Urethane rod stock or precision cast. Outer diameter and length as shown on Contract drawings. Inner diameter to be an interference fit for the rod diameter shown on Contract drawings.
 - 1. Fabricate from 60A Durometer urethane, natural color.
 - 2. Provide compression springs from one of the following or approved equal:
 - a. Gallagher Corp., 3908 Morrison Dr, Gurnee, IL 60031
 - b. Precision Urethane, 612 3rd St, Hempstead, TX 77445
 - c. Century Spring Corp., 5959 Triumph Street, Commerce, CA 90040

2.5 PRIMER

- A. Primer: Comply with Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

~~B. Primer: SSPC Paint 25, Type II, zinc oxide, alkyd, linseed oil primer.~~

~~B. Galvanizing Repair Paint: ASTM A 780/A 780M.~~

~~C. Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.~~

~~C.~~

2.6 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.7 FABRICATION

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," and to AISC 360.
1. Camber structural-steel members where indicated.
 2. Fabricate beams with rolling camber up.
 3. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
 4. Mark and match-mark materials for field assembly.
 5. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
- B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.
- C. Bolt Holes: Cut, drill, mechanically thermal cut, or punch standard bolt holes perpendicular to metal surfaces.
- D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
- E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 1, "Solvent Cleaning." and SSPC-SP 2, "Hand Tool Cleaning."

- F. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.
- G. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural-steel frame. Straighten as required to provide uniform, square, and true members in completed wall framing. Build up welded framing, weld exposed joints continuously, and grind smooth.
- H. Welded Door Frames: Build up welded door frames attached to structural-steel frame. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk machine screws, uniformly spaced not more than 10 inches o.c. unless otherwise indicated.
- I. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.
 - 1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
 - 2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
 - 3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.8 SHOP CONNECTIONS

- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
 - 1. Joint Type: Snug tightened unless shown otherwise on the drawings.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 - 1. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

2.9 SHOP PRIMING

- A. Shop prime steel surfaces except the following:
 - 1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
 - 2. Surfaces to be field welded.
 - 3. Surfaces of high-strength bolted, slip-critical connections.
 - 4. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
 - 5. Galvanized surfaces.
 - 6. Surfaces enclosed in interior construction.

- B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards: As per the primer manufacturer's recommendation.
- C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
 - 1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
 - 2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

2.10 GALVANIZING

- A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123/A 123M.
 - 1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
 - 2. Galvanize lintels, shelf angles and welded door frames attached to structural-steel frame and located in exterior walls.
 - 3. Galvanize steel to be embedded in concrete or exposed to exterior.

2.11 SOURCE QUALITY CONTROL

- A. Testing Agency: Contractor will engage a qualified testing agency to perform shop tests and inspections.
 - 1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
- B. Bolted Connections: Inspect and test shop-bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- C. Welded Connections: Visually inspect shop-welded connections according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - 1. Liquid Penetrant Inspection: ASTM E 165.
 - 2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
 - 3. Ultrasonic Inspection: ASTM E 164.
 - 4. Radiographic Inspection: ASTM E 94.
- D. In addition to visual inspection, test and inspect shop-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
 - 1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.

2. Conduct tests according to requirements in AWS D1.1/D1.1M on additional shear connectors if weld fracture occurs on shear connectors already tested.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
1. Prepare a certified survey of existing conditions. Include bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Work shown on Contract drawings indicates final conditions only. The Contractor shall be responsible for insuring the stability of the construction during construction.
- B. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.
1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

- A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.
- B. Baseplates Bearing Plates and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
1. Set plates for structural members on wedges, shims, or setting nuts as required.
 2. Weld plate washers to top of baseplate.

3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- C. Maintain erection tolerances of structural steel within AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."
- D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that are in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
1. Level and plumb individual members of structure.
 2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.
- E. Splice members only where indicated.
- F. Do not use thermal cutting during erection unless approved by Engineer. Finish thermally cut sections within smoothness limits in AWS D1.1/D1.1M.
- G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
- H. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

3.4 FIELD CONNECTIONS

- A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
1. Joint Type: Snug tightened unless otherwise noted.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
 2. Remove backing bars or runoff tab, back gouge, and grind steel smooth.
 3. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," for mill material.

3.5 PREFABRICATED BUILDING COLUMNS

- A. Install prefabricated building columns to comply with AISC 360, manufacturer's written recommendations, and requirements of testing and inspecting agency that apply to the fire-resistance rating indicated.

3.6 FIELD QUALITY CONTROL

- A. Special Inspections: **Owner will engage** a qualified special inspector to perform the following special inspections:
 - 1. Verify structural-steel materials and inspect steel frame joint details.
 - 2. Verify weld materials, inspect welds and perform non-destructive testing.
 - 3. Verify connection materials and inspect high-strength bolted connections.
- B. Bolted Connections: Inspect and test bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- C. Welded Connections: Visually inspect field welds according to AWS D1.1/D1.1M. 100% visual inspection of all fillet welds including fit up and partial penetration welds with 25% subject to Liquid Penetrant or Mag Particle and 100% UT testing of full pen.
 - 1. In addition to visual inspection, test and inspect field welds according to AWS D1.1/D1.1M and the following inspection procedures.
 - a. Liquid Penetrant Inspection: ASTM E 165.
 - b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
 - c. Ultrasonic Inspection: ASTM E 164.
 - d. Radiographic Inspection: ASTM E 94.
- D. In addition to visual inspection, test and inspect field-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
 - 1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
 - 2. Conduct tests according to requirements in AWS D1.1/D1.1M on additional shear connectors if weld fracture occurs on shear connectors already tested.

3.7 REPAIRS AND PROTECTION

- A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A 780/A 780M.
- B. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.
- C. Touchup Painting: Cleaning and touchup painting are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
- D. Touchup Priming: Cleaning and touchup priming are specified in Section 099600 "High-Performance Coatings."

END OF SECTION 05 1200

SECTION 05 2100 - STEEL JOIST FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. K-series steel joists.
 - 2. KCS-type K-series steel joists.
 - 3. LH- and DLH-series long-span steel joists.
 - 4. Joist girders.
 - 5. Joist accessories.
- B. Related Requirements:
 - 1. Section 033000 "Cast-in-Place Concrete" for installing bearing plates in concrete.
 - 2. Section 042000 "Unit Masonry" for installing bearing plates in unit masonry.
 - 3. Section 051200 "Structural Steel Framing" for field-welded shear connectors.

1.3 DEFINITIONS

- A. SJI's "Specifications": Steel Joist Institute's "Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders."
- B. Special Joists: Steel joists or joist girders requiring modification by manufacturer to support nonuniform, unequal, or special loading conditions that invalidate load tables in SJI's "Specifications."

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of joist, accessory, and product.
- B. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 - 1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance
 - b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:

- a. Environmental Product Declarations (EPD's)
 - b. Corporate Sustainability Reporting (CSR's)
- C. Shop Drawings:
 - 1. Include layout, designation, number, type, location, and spacing of joists.
 - 2. Include joining and anchorage details; bracing, bridging, and joist accessories; splice and connection locations and details; and attachments to other construction.
 - 3. Indicate locations and details of bearing plates to be embedded in other construction.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer
- B. Welding certificates.
- C. Manufacturer certificates.
- D. Mill Certificates: For each type of bolt.
- E. Comprehensive engineering analysis of special joists signed and sealed by the qualified professional engineer responsible for its preparation.
- F. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A manufacturer certified by SJI to manufacture joists complying with applicable standard specifications and load tables in SJI's "Specifications."
 - 1. Manufacturer's responsibilities include providing professional engineering services for designing special joists to comply with performance requirements.
- B. Welding Qualifications: Qualify field-welding procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle joists as recommended in SJI's "Specifications."
- B. Protect joists from corrosion, deformation, and other damage during delivery, storage, and handling.

1.8 SEQUENCING

- A. Deliver steel bearing plates to be built into cast-in-place concrete and masonry construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers:
 - 1. Canam Steel Corporation
 - 2. Nucor, Vulcraft
 - 3. Or approved substitution

2.2 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide special joists and connections capable of withstanding design loads indicated.
 - 1. Use ASD; data are given at service-load level.
 - 2. Design special joists to withstand design loads with live-load deflections no greater than the following:
 - a. Roof Joists: Vertical deflection of 1/240 of the span.
- B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 60 percent.

2.3 K-SERIES STEEL JOISTS

- A. Manufacture steel joists of type indicated according to "Standard Specification for Open Web Steel Joists, K-Series" in SJI's "Specifications," with steel-angle top- and bottom-chord members, underslung ends, and parallel top chord.
 - 1. Joist Type: K-series steel joists and KCS-type K-series steel joists.
- B. Provide holes in chord members for connecting and securing other construction to joists.
- C. Top-Chord Extensions: Extend top chords of joists with SJI's Type S top-chord extensions where indicated, complying with SJI's "Specifications."
- D. Extended Ends: Extend bearing ends of joists with SJI's Type R extended ends where indicated, complying with SJI's "Specifications."
- E. Do not camber joists.
- F. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches.

2.4 LONG-SPAN STEEL JOISTS

- A. Manufacture steel joists according to "Standard Specification for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series" in SJI's "Specifications," with steel-angle top- and bottom-chord members; of joist type and end and top-chord arrangements as follows:
 - 1. Joist Type: LH-series steel joists and DLH-series steel joists.
 - 2. End Arrangement: Underslung unless noted otherwise.
 - 3. Top-Chord Arrangement: Parallel and Pitched, as noted on the drawings
- B. Provide holes in chord members for connecting and securing other construction to joists.
- C. Camber long-span steel joists as indicated.
- D. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches.

2.5 JOIST GIRDERS

- A. Manufacture joist girders according to "Standard Specification for Joist Girders" in SJI's "Specifications," with steel-angle top- and bottom-chord members; with end and top-chord arrangements as follows:
 - 1. End Arrangement: Underslung or Underslung with bottom-chord extensions unless noted otherwise.
 - 2. Top-Chord Arrangement: As shown on the drawings
- B. Provide holes in chord members for connecting and securing other construction to joist girders.
- C. Camber joist girders as indicated.
- D. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches.

2.6 PRIMERS

- A. Primer: SSPC-Paint 15, or manufacturer's standard shop primer complying with performance requirements in SSPC-Paint 15.
- B. Primer: Provide shop primer that complies with Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

2.7 JOIST ACCESSORIES

- A. Bridging: Provide bridging anchors and number of rows of horizontal or diagonal bridging of material, size, and type required by SJI's "Specifications" for type of joist,

- chord size, spacing, and span. Furnish additional erection bridging if required for stability.
- B. Fabricate steel bearing plates from ASTM A 36/A 36M steel with integral anchorages of sizes and thicknesses indicated. Shop prime paint
 - C. Furnish ceiling extensions, either extended bottom-chord elements or a separate extension unit of enough strength to support ceiling construction. Extend ends to within 1/2 inch of finished wall surface unless otherwise indicated.
 - 1. Finish: Plain, uncoated.
 - D. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy hex steel structural bolts; ASTM A 563 heavy hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers.
 - 1. Finish: Plain.
 - E. Welding Electrodes: Comply with AWS standards.
 - F. Galvanizing Repair Paint: ASTM A 780/A 780M.
 - G. Furnish miscellaneous accessories including splice plates and bolts required by joist manufacturer to complete joist assembly.

2.8 CLEANING AND SHOP PAINTING

- A. Clean and remove loose scale, heavy rust, and other foreign materials from fabricated joists and accessories by hand-tool cleaning, SSPC-SP 2 or power-tool cleaning, SSPC-SP 3.
- B. Do not prime paint joists and accessories to receive sprayed fire-resistive materials.
- C. Apply one coat of shop primer to joists and joist accessories to be primed to provide a continuous, dry paint film not less than 1 mil thick.
- D. Shop priming of joists and joist accessories is specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine supporting substrates, embedded bearing plates, and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Do not install joists until supporting construction is in place and secured.
- B. Install joists and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Specifications, joist manufacturer's written instructions, and requirements in this Section."
 - 1. Before installation, splice joists delivered to Project site in more than one piece.
 - 2. Space, adjust, and align joists accurately in location before permanently fastening.
 - 3. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.
 - 4. Delay rigidly connecting bottom-chord extensions to columns or supports until dead loads are applied.
- C. Field weld joists to supporting steel bearing plates and framework. Coordinate welding sequence and procedure with placement of joists. Comply with AWS requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
- D. Bolt joists to supporting steel framework using high-strength structural bolts. Comply with RCSC's "Specification for Structural Joints Using ASTM A 325 or ASTM A 490 Bolts" for high-strength structural bolt installation and tightening requirements.
- E. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.

3.3 FIELD QUALITY CONTROL

- A. The following requirements are intended to supplement GOAA's specification 01 4529 Structural Testing and Inspection. Where conflict exist specification 01 4529 Structural Testing and Inspection shall govern.
- B. Testing Agency: **Contractor will engage** a qualified testing agency to perform tests and inspections.
- C. Visually inspect field welds according to AWS D1.1/D1.1M.
 - 1. In addition to visual inspection, test field welds according to AWS D1.1/D1.1M and the following procedures, at testing agency's option:
 - a. Liquid Penetrant Inspection: ASTM E 165/E 165M.
 - b. Magnetic Particle Inspection: ASTM E 709.
 - c. Ultrasonic Testing: ASTM E 164.
 - d. Radiographic Testing: ASTM E 94.
- D. Visually inspect bolted connections.
- E. Prepare test and inspection reports.

3.4 PROTECTION

- A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780/A 780M and manufacturer's written instructions.
- B. ~~Touchup~~ Touchup Painting: After installation, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted joists, bearing plates, abutting structural steel, and accessories.
 - 1. Clean and prepare surfaces by hand-tool cleaning according to SSPC-SP 2 or power-tool cleaning according to SSPC-SP 3.
 - 2. Apply a compatible primer of same type as primer used on adjacent surfaces.
- C. Touchup Painting: Cleaning and touchup painting are specified in Section 099123 "Interior Painting." Section 099600 "High-Performance Coatings."

END OF SECTION 05 2100

SECTION 053100 - STEEL DECKING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Roof deck.
 - 2. Composite floor deck.
 - 3. Noncomposite form deck.
- B. Related Requirements:
 - 1. Section 033000 "Cast-in-Place Concrete" for normal-weight and lightweight structural concrete fill over steel deck.
 - 2. Section 051200 "Structural Steel Framing" for shop- and field-welded shear connectors.
 - 3. Section 055000 "Metal Fabrications" for framing deck openings with miscellaneous steel shapes.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of deck, accessory, and product indicated.
- B. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C".
 - 1. Product Data: Documentation for Leadership Extraction Practices in the following:
 - a. Regional/Local Multiplier Compliance
 - b. Leadership Extraction Practices for Recycled Content
 - 2. Product Certificates: Provide the following:
 - a. Environmental Product Declarations (EPD's)
- C. Shop Drawings:
 - 1. Include layout and types of deck panels, anchorage details, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Product Certificates: For each type of steel deck.
- C. Product Test Reports: For tests performed by a qualified testing agency, indicating that each of the following complies with requirements:
 - 1. Power-actuated mechanical fasteners.
- D. Evaluation Reports: For steel deck, from ICC-ES.
- E. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. The following requirements are intended to supplement GOAA's specification 01 4529 Structural Testing and Inspection. Where conflict exist specification 01 4529 Structural Testing and Inspection shall govern.
- B. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
- D. FM Global Listing: Provide steel roof deck evaluated by FM Global and listed in its "Approval Guide, Building Materials" refer to drawings for building ratings.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.
- B. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. AISI Specifications: Comply with calculated structural characteristics of steel deck according to AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."
- B. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.
- C. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 30 percent.

2.2 ROOF DECK

- A. Manufacturers:
1. Canam Steel Corporation
 2. Nucor, Vulcraft
 3. Epic Metals
 4. Roof Deck Inc.
 5. Or approved substitution
- B. Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with "SDI Specifications and Commentary for Steel Roof Deck," in SDI Publication No. 31, and with the following:
1. Galvanized-Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 80, G90 zinc coating.
 2. Deck Profile: Type WR wide rib or As indicated on the drawings.
 3. Dove Tail Deck Profile: As indicated on drawings.
 - a. Manufactures:
 - 1) Metal Dek Group – Versa Dek 3.5LS Acoustical
 - 2) Verco Deck – 3 ½" Dove Tail Acoustical
 - 3) Epicore – ~~3.5ERAToris4A~~
 4. Profile Depth: 1-1/2 inches or as indicated on the drawings (2", 3" and 3 ½")
 5. Design Uncoated-Steel Thickness: 0.0358 inch or as indicated on the drawings.
 6. Span Condition: Double span.
 7. Side Laps: Overlapped or interlocking seam at Contractor's option. The contractor shall follow FM Global for side lap installation

2.3 COMPOSITE FLOOR DECK

- A. Manufacturers:
1. Canam Steel Corporation
 2. Nucor, Vulcraft
 3. Or approved substitution
- B. Composite Floor Deck: Fabricate panels, with integrally embossed or raised pattern ribs and interlocking side laps, to comply with "SDI Specifications and Commentary for Composite Steel Floor Deck," in SDI Publication No. 31, with the minimum section properties indicated, and with the following:
1. Galvanized-Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 50, G90 zinc coating.
 2. Profile Depth: 2 inches, 3 inches or as indicated on the drawings.

3. Design Uncoated-Steel Thickness: 0.0474 inch or as indicated on the drawings.
4. Span Condition: ~~Double span~~ As indicated on the drawings.

2.4 NONCOMPOSITE FORM DECK (Refer to drawings)

- A. Manufacturers:
 1. Xanam Steel Corporation
 2. Nucor, Vulcraft
 3. Or approved substitution
- B. Noncomposite Form Deck: Fabricate ribbed-steel sheet noncomposite form-deck panels to comply with "SDI Specifications and Commentary for Noncomposite Steel Form Deck," in SDI Publication No. 31, with the minimum section properties indicated, and with the following:
 1. Galvanized-Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 40, G90 zinc coating.
 2. Profile Depth: 2 and 3 inches.
 3. Design Uncoated-Steel Thickness: 0.0358 inch or as indicated on the drawings.
 4. Span Condition: Double span or as indicated on the drawings.
 5. Side Laps: Overlapped or interlocking seam at Contractor's option.

2.5 ACCESSORIES

- A. General: Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.
- B. Mechanical Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws.
- C. Side-Lap Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 10 minimum diameter.
- D. Flexible Closure Strips: Vulcanized, closed-cell, synthetic rubber.
- E. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi, not less than 0.0359-inch design uncoated thickness, of same material and finish as deck; of profile indicated or required for application.
- F. Pour Stops and Girder Fillers: Steel sheet, minimum yield strength of 33,000 psi, of same material and finish as deck, and of thickness and profile recommended by SDI Publication No. 31 for overhang and slab depth.
- G. Column Closures, End Closures, Z-Closures, and Cover Plates: Steel sheet, of same material, finish, and thickness as deck unless otherwise indicated.

- H. Flat Sump Plates: Single-piece steel sheet, 0.0747 inch thick, of same material and finish as deck. For drains, cut holes in the field.
- I. Galvanizing Repair Paint: ASTM A 780/A 780M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine supporting frame and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install deck panels and accessories according to applicable specifications and commentary in SDI Publication No. 31, manufacturer's written instructions, and requirements in this Section.
- B. Install temporary shoring before placing deck panels if required to meet deflection limitations.
- C. Locate deck bundles to prevent overloading of supporting members.
- D. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract side-lap interlocks.
- E. Place deck panels flat and square and fasten to supporting frame without warp or deflection.
- F. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.
- G. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of deck, and support of other work.
- H. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.
- I. Mechanical fasteners may be used in lieu of welding to fasten deck. Locate mechanical fasteners and install according to deck manufacturer's written instructions.
 - 1. Roof fasteners have to be FM Global approved

3.3 ROOF-DECK INSTALLATION

- A. Fasten roof-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated or arc seam welds with an equal perimeter that is not less than 1-1/2 inches long, and as follows:
 - 1. Weld Spacing: As indicated on drawings
- B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of one-half of the span or 18 inches, or as indicated on the drawings and as follows:
 - 1. Mechanically fasten with self-drilling, No. 10 diameter or larger, carbon-steel screws.
- C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 2 inches, with end joints as follows:
 - 1. End Joints: Lapped 2 inches minimum.
- D. Roof Sump Pans and Sump Plates: Install over openings provided in roof deck and mechanically fasten flanges to top of deck. Space mechanical fasteners not more than 12 inches apart with at least one mechanical fastener at each corner.
 - 1. Install reinforcing channels or zees in ribs to span between supports and weld or mechanically fasten.
- E. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels according to deck manufacturer's written instructions. Weld or mechanically fasten to substrate to provide a complete deck installation.
 - 1. Weld cover plates at changes in direction of roof-deck panels unless otherwise indicated.
- F. Flexible Closure Strips: Install flexible closure strips over partitions, walls, and where indicated. Install with adhesive according to manufacturer's written instructions to ensure complete closure.

3.4 FLOOR-DECK INSTALLATION

- A. Fasten floor-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated and as follows:
 - 1. Weld Diameter: 5/8 inch or as indicated on drawings, nominal.
 - 2. Weld Spacing: Weld edge ribs of panels at each support. Space additional welds an average of 12 inches apart, but not more than 18 inches apart.
 - 3. Weld Spacing: Space and locate welds as indicated.
- B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of one-half of the span or 36 inches, and as follows:

1. Mechanically fasten with self-drilling, No. 10 diameter or larger, carbon-steel screws.
 2. Mechanically clinch or button punch.
 3. Fasten with a minimum of 1-1/2-inch- long welds.
- C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 2 inches, with end joints as follows:
1. End Joints: Lapped.
- D. Pour Stops and Girder Fillers: Weld steel sheet pour stops and girder fillers to supporting structure according to SDI recommendations unless otherwise indicated.
- E. Floor-Deck Closures: Weld steel sheet column closures, cell closures, and Z-closures to deck, according to SDI recommendations, to provide tight-fitting closures at open ends of ribs and sides of deck.

3.5 FIELD QUALITY CONTROL

- A. The following requirements are intended to supplement GOAA's specification 01 4529 Structural Testing and Inspection. Where conflict exist specification 01 4529 Structural Testing and Inspection shall govern.
- B. Testing Agency: **Contractor will engage** a qualified testing agency to perform tests and inspections.
- C. Field welds will be subject to inspection.
- D. Prepare test and inspection reports.

3.6 PROTECTION

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on both surfaces of deck with galvanized repair paint according to ASTM A 780/A 780M and manufacturer's written instructions.

END OF SECTION 05 3100