

SECTION 03 30 00
CAST-IN-PLACE CONCRETE

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PART 1 - GENERAL

1.1 SUMMARY

- A. In general, the work includes the following:
1. Footings
 2. Stoops (at doors)
 3. Aprons (at overhead doors, including concrete infill between stoops and aprons)
 4. Cast-in-place concrete work
 5. Interior slabs on grade
 6. Vapor retarder (barrier)
 7. Recessed slab, below-slab drain containment and other concrete work below the floor slabs.
 8. Floor trenches or utility trenches
 9. Cast-in-place concrete, including concrete materials, mixture design, placement procedures, and finishes.
- B. Related Requirements:

1. Section 031000 "Concrete Forming and Accessories" for form-facing materials, form liners, insulating concrete forms, and waterstops.
2. Section 032000 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.
3. Section 079200 "Joint Sealant"
4. Section 321313 "Concrete Paving" for concrete pavement and walks.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.
- B. Water/Cement Ratio (w/cm): The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **Project site**.
 1. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Concrete Subcontractor.
 2. Review the following:
 - a. Construction joints, control joints, isolation joints, and joint-filler strips.
 - b. Semirigid joint fillers.
 - c. Vapor-retarder installation.
 - d. Anchor rod and anchorage device installation tolerances.
 - e. Cold and hot weather concreting procedures.
 - f. Concrete finishes and finishing.
 - g. Curing procedures.
 - h. Forms and form-removal limitations.
 - i. Methods for achieving specified floor and slab flatness and levelness.
 - j. Floor and slab flatness and levelness measurements.
 - k. Concrete repair procedures.
 - l. Concrete protection.
 - m. Initial curing and field curing of field test cylinders (ASTM C31/C31M.)
 - n. Protection of field cured field test cylinders.

1.4 ACTION SUBMITTALS

- A. Product Data: For each of the following.
 1. Portland cement.
 2. Fly ash.
 3. Slag cement.
 4. Aggregates.
 5. Admixtures:
 - a. Include limitations of use, including restrictions on cementitious materials, supplementary cementitious materials, air entrainment, aggregates, temperature at time of concrete placement, relative humidity at time of concrete placement, curing conditions, and use of other admixtures.
 6. Fiber reinforcement.
 7. Vapor retarders.
 8. Floor and slab treatments.
 9. Liquid floor treatments.
 10. Curing materials.
 - a. Include documentation from color pigment manufacturer, indicating that proposed methods of curing are recommended by color pigment manufacturer.
 11. Joint fillers.
 12. Repair materials.
- B. Design Mixtures: For each concrete mixture, include the following:
 1. Mixture identification.
 2. Minimum 28-day compressive strength.

- 1 3. Durability exposure class.
- 2 4. Maximum w/cm.
- 3 5. Slump limit.
- 4 6. Air content.
- 5 7. Nominal maximum aggregate size.
- 6 8. Indicate amounts of mixing water to be withheld for later addition at Project site if permitted.
- 7 9. Intended placement method.
- 8 10. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test
- 9 results, or other circumstances warrant adjustments.
- 10 C. Shop Drawings:
- 11 1. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
- 12 a. Location of construction joints is subject to approval of the Architect.
- 13 D. Samples: For **vapor retarder**.
- 14 E. Concrete Schedule: For each location of each Class of concrete indicated in "Concrete Mixtures" Article, including
- 15 the following:
- 16 1. Concrete Class designation.
- 17 2. Location within Project.
- 18 3. Exposure Class designation.
- 19 4. Formed Surface Finish designation and final finish.
- 20 5. Final finish for floors.
- 21 6. Curing process.
- 22 7. Floor treatment if any.

1.5 INFORMATIONAL SUBMITTALS

- 25 A. Material Certificates: For each of the following, signed by manufacturers:
- 26 1. Cementitious materials.
- 27 2. Admixtures.
- 28 3. Fiber reinforcement.
- 29 4. Curing compounds.
- 30 5. Floor and slab treatments.
- 31 6. Bonding agents.
- 32 7. Adhesives.
- 33 8. Vapor retarders.
- 34 9. Semirigid joint filler.
- 35 10. Joint-filler strips.
- 36 11. Repair materials.
- 37 B. Material Test Reports: For the following, from a qualified testing agency:
- 38 1. Portland cement.
- 39 2. Fly ash.
- 40 3. Slag cement.
- 41 4. Aggregates.
- 42 5. Admixtures:
- 43 C. Floor surface flatness and levelness measurements report, indicating compliance with specified tolerances.
- 44 D. Research Reports:
- 45 1. For concrete admixtures in accordance with ICC's Acceptance Criteria AC198.
- 46 2. For sheet vapor retarder/termite barrier, showing compliance with ICC AC380.
- 47 E. Preconstruction Test Reports: For each mix design.
- 48 F. Field quality-control reports.
- 49 G. Minutes of preinstallation conference.

1.6 QUALITY ASSURANCE

- 52 A. Laboratory Testing Agency Qualifications: A testing agency qualified in accordance with ASTM C1077 and
- 53 ASTM E329 for testing indicated and employing an ACI-certified Concrete Quality Control Technical Manager.
- 54 1. Personnel performing laboratory tests to be an ACI-certified Concrete Strength Testing Technician and
- 55 Concrete Laboratory Testing Technician, Grade I. Testing agency laboratory supervisor to be an ACI-certified
- 56 Concrete Laboratory Testing Technician, Grade II.
- 57 B. Field Quality-Control Testing Agency Qualifications: An independent agency, **acceptable to authorities having**
- 58 **jurisdiction**, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.

1. Personnel conducting field tests to be qualified as an ACI Concrete Field-Testing Technician, Grade 1, in accordance with ACI CPP 610.1 or an equivalent certification program.

C. Mockups: Before casting architectural concrete, build mockups, using the same procedures, equipment, materials, finishing procedures, and curing procedures that will be used for producing architectural concrete, to verify selections made under Sample submittals and to demonstrate typical joints, surface finish, color, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed work:

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by architect.
2. Build mockups of typical wall of cast-in-place architectural concrete as shown on drawings, including vertical and horizontal rustication joints, and any sculptured features.
3. Construct mockups to include at least two lifts having heights equal to those anticipated for construction.
4. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.
5. In presence of architect, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair to match adjacent undamaged surfaces.
6. In presence of architect, demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
7. Obtain architect's approval of mockups before casting architectural concrete.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on each concrete mixture.
1. Include the following information in each test report:
 - a. Admixture dosage rates.
 - b. Slump.
 - c. Air content.
 - d. Seven-day compressive strength.
 - e. 28-day compressive strength.
 - f. Permeability.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with ASTM C94/C94M and ACI 301.

1.9 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with ACI 301 and ACI 306.1 and as follows.
1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 2. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
 3. Do not use frozen materials or materials containing ice or snow.
 4. Do not place concrete in contact with surfaces less than 35 deg F, other than reinforcing steel.
 5. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- B. Hot-Weather Placement: Comply with ACI 301 and ACI 305.1, and as follows:
1. Maintain concrete temperature at time of discharge to not exceed 95 deg F.
 2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement sheet vapor retarder/termite barrier material and accessories for sheet vapor retarder/ termite barrier and accessories that do not comply with requirements or that fail to resist penetration by termites within specified warranty period.
1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

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

2.2 FORM-FACING MATERIALS

- A. Form-Facing wood forms:

1. Finishes: As cast.
 - a. Exterior-grade rough sawn board form planks, that will provide continuous, true, and pattern architectural concrete surfaces, Douglas Fir, construction grade, or better, mill-applied release agent and edge sealed, complying with DOC PS 1.
2. Location: Where noted on drawings.
3. Size: 4-inch nominal height

2.3 CONCRETE MATERIALS

- A. Source Limitations:

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

- B. Cementitious Materials:

1. Portland Cement: ASTM C150/C150M, **Type I/II, gray.**
2. Fly Ash: ASTM C618, Class C or F.

- C. Normal-Weight Aggregates: ASTM C33/C33M, **Class 3S** coarse aggregate or better, graded. Provide aggregates from a single source.

1. Maximum Coarse-Aggregate Size: **1-1/2 inches** nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

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

- E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride **in steel-reinforced concrete.**

1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
2. Retarding Admixture: ASTM C494/C494M, Type B.
3. Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
5. High-Range, Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
7. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C494/C494M, Type C.
8. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.

- F. Superplasticizer shall be used in all interior flatwork and any pumped concrete unless otherwise approved in writing by the Architect. All concrete with W/C of 0.48 or less, and where pumping equipment is used, requires this admixture. In general, concrete shall be delivered to the site with a slump of 3" to 3 1/2". Admixture shall be site added in lieu of any additional water.

- G. Water and Water Used to Make Ice: ASTM C94/C94M, potable **or complying with ASTM C1602/C1602M, including all limits listed in Table 2 and the requirements of paragraph 5.4**

2.4 FIBER REINFORCEMENT

- A. Synthetic Macro-Fiber: Synthetic macro-fibers engineered and designed for use in concrete, complying with ASTM C1116/C1116M, Type III, [**1 to 2-1/4 inches**] <Insert dimensions> long.

2.5 VAPOR RETARDERS

- A. Sheet Vapor Retarder, Class A: ASTM E1745, Class A; not less than 15 mils thick. Include manufacturer's recommended adhesive or pressure-sensitive tape.

2.6 LIQUID FLOOR TREATMENTS (SC-1)

- A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.
 - 1. Provide Prosoco SLX100 Water and Oil Repellent or equal.

2.7 CURING MATERIALS (SC-2)

- 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. when dry.
- C. Moisture-Retaining Cover: ASTM C171, polyethylene film burlap-polyethylene sheet.
 - 1. Color:
 - a. Ambient Temperature Below 50 deg F: Black.
 - b. Ambient Temperature between 50 deg F and 85 deg F: Any color.
 - c. Ambient Temperature Above 85 deg F: White.
- D. Water: Potable or complying with ASTM C1602/C1602M.
- E. Clear, Waterborne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A.

2.8 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: **ASTM D1751, asphalt-saturated cellulosic fiber.**
- B. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade and class to suit requirements, and as follows:
 - 1. **Types I and II, nonload bearing**, for bonding hardened or freshly mixed concrete to hardened concrete.

2.9 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
 - 2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand, as recommended by underlayment manufacturer.
 - 4. Compressive Strength: Not less than **5000 psi** at 28 days when tested in accordance with ASTM C109/C109M.
- B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
 - 2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
 - 4. Compressive Strength: Not less than **5000 psi** at 28 days when tested in accordance with ASTM C109/C109M.

2.10 CONCRETE MIXTURES, GENERAL

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301.
 - 1. Use a qualified testing agency for preparing and reporting proposed mixture designs, based on laboratory trial mixtures.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
 - 1. Fly Ash or Other Pozzolans: 20 percent by mass.
 - 2. Slag Cement: 35 percent by mass.

- C. Admixtures: Use admixtures in accordance with manufacturer's written instructions.
1. Use **water-reducing** admixture in concrete, as required, for placement and workability.
 2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 3. Use water-reducing admixture in **pumped concrete, concrete for heavy-use industrial slabs.**

2.11 CONCRETE MIXTURES

- A. Class **A**: Normal-weight concrete used for footings.
1. Exposure Class: ACI 318 **F1-S0-W0-C0**.
 2. Minimum Compressive Strength **4000 psi** at 28 days.
 3. Maximum w/cm: 0.55.
 4. Slump Limit: **4 inches, plus or minus 1 inch.**
 5. Air Content:
 - a. Exposure Class F1: **4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch nominal maximum aggregate size.**
- B. Class **B**: Normal-weight concrete used for foundation walls and piers.
1. Exposure Class: ACI 318 **F1-S0-W0-C0**.
 2. Minimum Compressive Strength: **4000 psi** at 28 days.
 3. Maximum w/cm: **0.45**
 4. Slump Limit: **4 inches, plus or minus 1 inch.**
 5. Air Content:
 - a. Exposure Class F1: **5.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch nominal maximum aggregate size**
 6. Limit water-soluble, chloride-ion content in hardened concrete to **1.00** percent by weight of cement.
- C. Class **C**: Normal-weight concrete used for interior slabs-on-ground.
1. Exposure Class: ACI 318 **F0-S0-W0-C0**.
 2. Minimum Compressive Strength: **3500 psi** at 28 days.
 3. Maximum w/cm: **0.40**.
 4. Slump Limit: **5 inches, plus or minus 1 inch.**
 5. Air Content:
 - a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished floors.
 6. Synthetic Macro-Fiber: Where indicated on plans, uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of **5 lb/cu. yd.**

2.12 CONCRETE MIXING

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

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions:
1. Before placing concrete, verify that installation of concrete forms, accessories, and reinforcement, and embedded items is complete and that required inspections have been performed.
 2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:
1. Daily access to the Work.
 2. Incidental labor and facilities necessary to facilitate tests and inspections.
 3. Secure space for storage, initial curing, and field curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.
 4. Security and protection for test samples and for testing and inspection equipment at Project site.

3.3 INSTALLATION OF EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining Work that is attached to or supported by cast-in-place concrete.
 - 1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of ANSI/AISC 303.

3.4 INSTALLATION OF VAPOR RETARDER

- A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder in accordance with ASTM E1643 and manufacturer's written instructions.
 - 1. Install vapor retarder with longest dimension parallel with direction of concrete pour.
 - 2. Face laps away from exposed direction of concrete pour.
 - 3. Lap vapor retarder over footings and grade beams not less than 6 inches, sealing vapor retarder to concrete.
 - 4. Lap joints 6 inches and seal with manufacturer's recommended tape.
 - 5. Terminate vapor retarder at the top of floor slabs, grade beams, and pile caps, sealing entire perimeter to floor slabs, grade beams, foundation walls, or pile caps.
 - 6. Seal penetrations in accordance with vapor retarder manufacturer's instructions.
 - 7. All overlapped conditions and terminations shall be sealed off and taped in a watertight manner.
 - 8. Protect vapor retarder during placement of reinforcement and concrete.
 - a. Repair damaged areas by patching with vapor retarder material, overlapping damages area by 6 inches on all sides, and sealing to vapor retarder.
- B. Bituminous Vapor Retarders: Place, protect, and repair bituminous vapor retarder in accordance with manufacturer's written instructions.

3.5 JOINTS

- A. Construct joints true to line, with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Coordinate with floor slab pattern and concrete placement sequence.
 - 1. Install so strength and appearance of concrete are not impaired, at locations indicated on Drawings or as approved by Architect.
 - 2. Place joints perpendicular to main reinforcement.
 - a. Continue reinforcement across construction joints unless otherwise indicated.
 - b. Do not continue reinforcement through sides of strip placements of floors and slabs.
 - 3. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 - 4. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 5. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Control Joints in Slabs-on-Ground: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least **one-fourth** of concrete thickness as follows:
 - 1. Sawed Joints: Form control joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random cracks.
- D. Isolation Joints in Slabs-on-Ground: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 - 1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated on Drawings.
 - 2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface, where joint sealants, specified in Section 079200 "Joint Sealants," are indicated.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items, and vapor retarder is complete and that required inspections are completed.
 - 1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.
 - 2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.

- B. Notify Architect and testing and inspection agencies 24 hours prior to commencement of concrete placement.
- C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect in writing, but not to exceed the amount indicated on the concrete delivery ticket.
- D. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301, but not to exceed the amount indicated on the concrete delivery ticket.
- E. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness.
 - 1. If a section cannot be placed continuously, provide construction joints as indicated.
 - 2. Deposit concrete to avoid segregation.
 - 3. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - 4. Consolidate placed concrete with mechanical vibrating equipment in accordance with ACI 301.
 - a. Do not use vibrators to transport concrete inside forms.
 - b. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer.
 - c. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.
 - d. At each insertion, limit duration of vibration to time necessary to consolidate concrete, and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.
- F. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
 - 1. Do not place concrete floors and slabs in a checkerboard sequence.
 - 2. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - 3. Maintain reinforcement in position on chairs during concrete placement.
 - 4. Screed slab surfaces with a straightedge and strike off to correct elevations.
 - 5. Level concrete, cut high areas, and fill low areas.
 - 6. Slope surfaces uniformly to drains where required.
 - 7. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface.
 - 8. Do not further disturb slab surfaces before starting finishing operations.
- G. After floating, begin first trowel finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with a level surface plane so that depressions between high spots do not exceed tolerances listed below. Grind smooth defects which would telegraph through applied floor covering system only in acceptable to Architect.
 - 1. Finish tolerances:
 - a. All locations except as noted:
 - 1) specified overall $F_F = 50$
 - 2) specified overall $F_L = 35$
 - 3) specified local $F_F = 30$
 - 4) specified local $F_L = 20$

3.7 FINISHING FORMED SURFACES

- A. As-Cast Surface Finishes:
 - 1. ACI 301 Surface Finish SF-1.0: As-cast concrete texture imparted by form-facing material.
 - a. Patch voids larger than 1-1/2 inches wide or 1/2 inch deep.
 - b. Remove projections larger than 1 inch.
 - c. Tie holes do not require patching.
 - d. Surface Tolerance: ACI 117 Class D.
 - e. Apply to concrete surfaces **not exposed to public view**.
 - 2. ACI 301 Surface Finish SF-2.0: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams.
 - a. Patch voids larger than 3/4 inch wide or 1/2 inch deep.
 - b. Remove projections larger than 1/4 inch.
 - c. Patch tie holes.
 - d. Surface Tolerance: ACI 117 Class B.

- e. Locations: Apply to concrete surfaces **exposed to public view**.
- 3. ACI 301 Surface Finish SF-3.0:
 - a. Patch voids larger than 3/4 inch wide or 1/2 inch deep.
 - b. Remove projections larger than 1/8 inch.
 - c. Patch tie holes.
 - d. Surface Tolerance: ACI 117 Class A.
 - e. Locations: Apply to concrete surfaces **exposed to public view**.

3.8 FINISHING FLOORS AND SLABS

- A. Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Float Finish:
 - 1. When bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
 - 2. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 tolerances for conventional concrete.
 - 3. Apply float finish to surfaces **to receive trowel finish**.
- C. Trowel Finish:
 - 1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.
 - 2. Continue troweling passes and restraighen until surface is free of trowel marks and uniform in texture and appearance.
 - 3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 - 4. Do not add water to concrete surface.
 - 5. Do not apply hard-troweled finish to concrete, which has a total air content greater than 3 percent.
 - 6. Apply a trowel finish to surfaces **exposed to view**.
 - 7. Finish surfaces to the following tolerances, in accordance with ASTM E1155, for a randomly trafficked floor surface:
 - a. Slabs on Ground:
 - 1) Finish and measure surface so gap at any point between concrete surface and an unlevelled, freestanding, 10-ft.- long straightedge resting on two high spots and placed anywhere on the surface does not exceed **1/8 inch**.

3.9 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

- A. Filling In:
 - 1. Fill in holes and openings left in concrete structures after Work of other trades is in place unless otherwise indicated.
 - 2. Mix, place, and cure concrete, as specified, to blend with in-place construction.
 - 3. Provide other miscellaneous concrete filling indicated or required to complete the Work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations:
 - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 - 2. Construct concrete bases **4 inches** high unless otherwise indicated on Drawings, and extend base not less than 6 inches in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated on Drawings, or unless required for seismic anchor support.
 - 3. Minimum Compressive Strength: **3000 psi** at 28 days.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
 - 6. Prior to pouring concrete, place and secure anchorage devices.
 - a. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - b. Cast anchor-bolt insert into bases.
 - c. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items.
 - 1. Cast-in inserts and accessories, as shown on Drawings.

2. Screed, tamp, and trowel finish concrete surfaces.

3.10 CONCRETE CURING

- A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
1. Comply with ACI 301 and ACI 306.1 for cold weather protection during curing.
 2. Comply with ACI 301 and ACI 305.1 for hot-weather protection during curing.
 3. Maintain moisture loss no more than 0.2 lb/sq. ft. x h, calculated in accordance with ACI 305.1, before and during finishing operations.
- B. Curing Formed Surfaces: Comply with ACI 308.1 as follows:
1. Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces.
 2. Cure concrete containing color pigments in accordance with color pigment manufacturer's instructions.
 3. If forms remain during curing period, moist cure after loosening forms.
 4. If removing forms before end of curing period, continue curing for remainder of curing period, as follows:
 - a. Continuous Fogging: Maintain standing water on concrete surface until final setting of concrete.
 - b. Continuous Sprinkling: Maintain concrete surface continuously wet.
 - c. Absorptive Cover: Pre-dampen absorptive material before application; apply additional water to absorptive material to maintain concrete surface continuously wet.
 - d. Water-Retention Sheeting Materials: Cover exposed concrete surfaces with sheeting material, taping, or lapping seams.
 - e. Membrane-Forming Curing Compound: Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions.
 - 1) Recoat areas subject to heavy rainfall within three hours after initial application.
 - 2) Maintain continuity of coating and repair damage during curing period.
- C. Curing Unformed Surfaces: Comply with ACI 308.1 as follows:
1. Begin curing immediately after finishing concrete.
 2. Interior Concrete Floors:
 - a. Floors to Receive Floor Coverings Specified in Other Sections: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches.
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive.
 - a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - b) Cure for not less than seven days.
 - 3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
 - b. Floors to Receive Penetrating Liquid Floor Treatments: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches.
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive.
 - a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - b) Cure for not less than seven days.
 - 3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.

- b) Continuous water-fog spray.
- c. Floors to Receive Polished Finish: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches.
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
- d. Floors to Receive Chemical Stain:
 - 1) As soon as concrete has sufficient set to permit application without marring concrete surface, install curing paper over entire area of floor.
 - 2) Install curing paper square to building lines, without wrinkles, and in a single length without end joints.
 - 3) Butt sides of curing paper tight; do not overlap sides of curing paper.
 - 4) Leave curing paper in place for duration of curing period, but not less than 28 days.
- e. Floors to Receive Urethane Flooring:
 - 1) As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - 2) Rewet absorptive cover and cover immediately with polyethylene moisture-retaining cover with edges lapped 6 inches and sealed in place.
 - 3) Secure polyethylene moisture-retaining cover in place to prohibit air from circulating under polyethylene moisture-retaining cover.
 - 4) Leave absorptive cover and polyethylene moisture-retaining cover in place for duration of curing period, but not less than 28 days.
- f. Floors to Receive Curing Compound:
 - 1) Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions.
 - 2) Recoat areas subjected to heavy rainfall within three hours after initial application.
 - 3) Maintain continuity of coating, and repair damage during curing period.
 - 4) Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer **unless manufacturer certifies curing compound does not interfere with bonding of floor covering used on Project.**
- g. Floors to Receive Curing and Sealing Compound:
 - 1) Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller in accordance with manufacturer's written instructions.
 - 2) Recoat areas subjected to heavy rainfall within three hours after initial application.
 - 3) Repeat the process 24 hours later and apply a second coat. Maintain continuity of coating, and repair damage during curing period.

3.11 TOLERANCES

- A. Conform to ACI 117.

3.12 APPLICATION OF LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment in accordance with manufacturer's written instructions.
 - 1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
 - 2. Do not apply to concrete that is less than **14** days' old.
 - 3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing.
 - 4. Rinse with water; remove excess material until surface is dry.
 - 5. Apply a second coat in a similar manner if the surface is rough or porous.

3.13 JOINT FILLING

- A. Prepare, clean, and install joint filler in accordance with manufacturer's written instructions.

1. Defer joint filling until concrete has aged at least **six** month(s).
2. Do not fill joints until construction traffic has permanently ceased.
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.
- C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints.
- D. Overfill joint, and trim joint filler flush with top of joint after hardening.

3.14 CONCRETE SURFACE REPAIRS

- A. Defective Concrete:
 1. Repair and patch defective areas when approved by Architect.
 2. Remove and replace concrete that cannot be repaired and patched to Architect's approval.
- B. Patching Mortar: Mix dry pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.
- 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 1/2 inch in any dimension to solid concrete.
 - a. Limit cut depth to 3/4 inch.
 - b. Make edges of cuts perpendicular to concrete surface.
 - c. Clean, dampen with water, and brush-coat holes and voids with bonding agent.
 - d. Fill and compact with patching mortar before bonding agent has dried.
 - e. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
 2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement, so that, when dry, patching mortar matches surrounding color.
 - a. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.
 - b. Compact mortar in place and strike off slightly higher than surrounding surface.
 3. Repair defects on concealed formed surfaces that will affect concrete's durability and structural performance as determined by Architect.
- D. Repairing Unformed Surfaces:
 1. Test unformed surfaces, such as floors and slabs, for finish, and verify surface tolerances specified for each surface.
 - a. Correct low and high areas.
 - b. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
 2. Repair finished surfaces containing surface defects, including spalls, popouts, honeycombs, rock pockets, crazing, and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
 3. After concrete has cured at least 14 days, correct high areas by grinding.
 4. Correct localized low areas during, or immediately after, completing surface-finishing operations by cutting out low areas and replacing them with patching mortar.
 - a. Finish repaired areas to blend into adjacent concrete.
 5. Correct other low areas scheduled to remain exposed with repair topping.
 - a. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations.
 - b. Prepare, mix, and apply repair topping and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 6. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete.
 - a. Remove defective areas with clean, square cuts, and expose steel reinforcement with at least a 3/4-inch clearance all around.
 - b. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
 - c. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate.
 - d. Place, compact, and finish to blend with adjacent finished concrete.
 - e. Cure in same manner as adjacent concrete.
 7. Repair random cracks and single holes 1 inch or less in diameter with patching mortar.

- a. Groove top of cracks and cut out holes to sound concrete, and clean off dust, dirt, and loose particles.
- b. Dampen cleaned concrete surfaces and apply bonding agent.
- c. Place patching mortar before bonding agent has dried.
- d. Compact patching mortar and finish to match adjacent concrete.
- e. Keep patched area continuously moist for at least 72 hours.
- E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.
- F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.15 FIELD QUALITY CONTROL

- A. Testing Agency: **Engage** a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
 1. Testing agency to be responsible for providing curing container for composite samples on Site and verifying that field-cured composite samples are cured in accordance with ASTM C31/C31M.
 2. Testing agency to immediately report to Architect, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
 3. Testing agency to report results of tests and inspections, in writing, to Owner, Architect, Contractor, and concrete manufacturer within 48 hours of inspections and tests.
 - a. Test reports to include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:
 - 1) Project name.
 - 2) Name of testing agency.
 - 3) Names and certification numbers of field and laboratory technicians performing inspections and testing.
 - 4) Name of concrete manufacturer.
 - 5) Date and time of inspection, sampling, and field testing.
 - 6) Date and time of concrete placement.
 - 7) Location in Work of concrete represented by samples.
 - 8) Date and time sample was obtained.
 - 9) Truck and batch ticket numbers.
 - 10) Design compressive strength at 28 days.
 - 11) Concrete mixture designation, proportions, and materials.
 - 12) Field test results.
 - 13) Information on storage and curing of samples before testing, including curing method and maximum and minimum temperatures during initial curing period.
 - 14) Type of fracture and compressive break strengths at seven days and 28 days.
- B. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.
- C. Concrete Tests: Testing of composite samples of fresh concrete obtained in accordance with ASTM C 172/C 172M to be performed in accordance with the following requirements:
 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C231/C231M pressure method, for normal-weight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 4. Concrete Temperature: ASTM C1064/C1064M:
 - a. One test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample.
 5. Compression Test Specimens: ASTM C31/C31M:

- 1 a. Cast and laboratory cure two sets of **two** 6-inch by 12-inch or 4-inch by 8-inch cylinder specimens
- 2 for each composite sample.
- 3 6. Compressive-Strength Tests: ASTM C39/C39M.
- 4 a. Test one set of **two** laboratory-cured specimens at seven days and one set of two specimens at 28
- 5 days.
- 6 b. A compressive-strength test to be the average compressive strength from a set of two specimens
- 7 obtained from same composite sample and tested at age indicated.
- 8 7. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders,
- 9 Contractor to evaluate operations and provide corrective procedures for protecting and curing in-place
- 10 concrete.
- 11 8. Strength of each concrete mixture will be satisfactory if every average of any three consecutive
- 12 compressive-strength tests equals or exceeds specified compressive strength, and no compressive-strength
- 13 test value falls below specified compressive strength by more than 500 psi if specified compressive strength
- 14 is 5000 psi, or no compressive strength test value is less than 10 percent of specified compressive strength if
- 15 specified compressive strength is greater than 5000 psi.
- 16 9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by
- 17 Architect but will not be used as sole basis for approval or rejection of concrete.
- 18 10. Additional Tests:
- 19 a. Testing and inspecting agency to make additional tests of concrete when test results indicate that
- 20 slump, air entrainment, compressive strengths, or other requirements have not been met, as
- 21 directed by Architect.
- 22 b. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored
- 23 cylinders complying with ASTM C42/C42M or by other methods as directed by Architect.
- 24 1) Acceptance criteria for concrete strength to be in accordance with ACI 301, Section 1.6.6.3.
- 25 11. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of
- 26 replaced or additional work with specified requirements.
- 27 12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract
- 28 Documents.
- 29 D. Measure floor and slab flatness and levelness in accordance with ASTM E1155 within **24** hours of completion of
- 30 floor finishing and promptly report test results to Architect.

3.16 PROTECTION

- 33 A. Protect concrete surfaces as follows:
- 34 1. Protect from petroleum stains.
- 35 2. Diaper hydraulic equipment used over concrete surfaces.
- 36 3. Prohibit vehicles from interior concrete slabs.
- 37 4. Prohibit use of pipe-cutting machinery over concrete surfaces.
- 38 5. Prohibit placement of steel items on concrete surfaces.
- 39 6. Prohibit use of acids or acidic detergents over concrete surfaces.
- 40 7. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use
- 41 protective methods and materials, including temporary covering, recommended in writing by liquid floor
- 42 treatments installer.
- 43 8. Protect concrete surfaces scheduled to receive surface hardener or polished concrete finish using Floor Slab
- 44 Protective Covering.

END OF SECTION

SECTION 03 33 00
ARCHITECTURAL CONCRETE

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place architectural concrete, including form facings, reinforcement accessories, concrete materials, concrete mixtures, concrete placement, and concrete finishes.
2. Requirements in Section 033000 "Cast-in-Place Concrete" apply to this Section.

1.2 DEFINITIONS

- A. Cast-in-Place Architectural Concrete: Concrete that is exposed to view, is designated as architectural concrete, and that requires special concrete materials, formwork, placement, or finishes to obtain specified architectural appearance.
- B. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.
- C. Water/Cement Ratio (w/cm): The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

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

1. Require representatives of each entity directly concerned with cast-in-place architectural 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. Cast-in-place architectural concrete Subcontractor.
2. Review the following:
 - a. Construction joints, control joints, isolation joints, and joint-filler strips.
 - b. Reinforcement accessory installation.
 - c. Cold- and hot-weather concreting procedures.
 - d. Concrete finishes and finishing.
 - e. Curing procedures.
 - f. Forms and form-removal limitations.
 - g. Shoring and reshoring procedures.
 - h. Concrete repair procedures.
 - i. Protection of cast-in-place architectural concrete.
 - j. Initial curing and field curing of field test cylinders (ASTM C31/C31M).
 - k. Protection of field-cured field test cylinders.

1.4 ACTION SUBMITTALS

- A. Product Data: For each of the following:
 1. Form-facing panels.
 2. Form liners.
 3. Form joint tape.
 4. Form joint sealant.
 5. Wood sealer.
 6. Form-release agent.
 7. Surface retarder.
 8. Form ties.
 9. Bar supports.
 10. Portland cement.
 11. Fly ash.
 12. Slag cement.
 13. Aggregates.
 14. Admixtures:
 - a. Include limitations of use, including restrictions on cementitious materials, supplementary cementitious materials, air entrainment, aggregates, temperature at time of concrete placement, relative humidity at time of concrete placement, curing conditions, and use of other admixtures.
 15. Repair materials.
- B. Design Mixtures: For each concrete mixture, include the following:
 1. Mixture identification.
 2. Minimum 28-day compressive strength.
 3. Durability exposure class.
 4. Maximum w/cm.
 5. Slump limit.
 6. Air content.
 7. Nominal maximum aggregate size.
 8. Amounts of mixing water to be withheld for later addition at Project site if permitted.
 9. Intended placement method.
 10. Alternative design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- C. Shop Drawings:
 1. Formwork: Prepared by, and signed and sealed by, a qualified professional engineer responsible for their preparation, detailing fabrication, assembly, and support of forms.
 - a. Show formwork construction, including form-liner layout, form-liner termination details, dimensioned locations of form-facing material joints, rustications, construction and contraction joints, form joint-sealant details, form-tie locations and patterns, inserts and embedments, cutouts, cleanout panels, and other items that visually affect cast-in-place architectural concrete.
 - b. ct cast-in-place architectural concrete.

- 1) Indicate proposed schedule and sequence of stripping of forms, shoring removal, and reshoring installation and removal.
 - 2) Location of construction joints is subject to approval of Architect.
- D. Samples for Verification: Architectural concrete Samples, cast vertically, approximately 18 by 18 by 2 inches (450 by 450 by 50 mm), of finishes, colors, and textures to match design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For the following:
1. Installer: Include copies of applicable ACI certificates.
 2. Ready-mixed concrete manufacturer.
- B. Material Certificates: For each of the following:
1. Cementitious materials.
 2. Admixtures.
 3. Form materials and form-release agents.
 4. Repair materials.
- C. Material Test Reports: For the following, by a qualified testing agency:
1. Portland cement.
 2. Fly ash.
 3. Slag cement.
 4. Aggregates.
- D. Research Reports: For concrete admixtures in accordance with ICC AC198.
- E. Preconstruction Test Reports: For each mix design.
- F. Concrete Repair: Submit a written, detailed description of materials, methods, equipment, and sequence of operations to be used for repairing architectural concrete, including protection of surrounding materials and Project site.
1. If materials and methods other than those indicated are proposed for any repairs to architectural concrete, add a written description of such materials and methods, including evidence of successful use on comparable projects, and demonstrations to show their effectiveness for this Project and Installer's ability to use such materials and methods properly.
 2. Project and Installer's ability to use such materials and methods properly.
- G. Minutes of preinstallation conference.

1.6 QUALITY ASSURANCE

- A. Ready-Mixed Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
1. Manufacturer certified in accordance with NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- B. Installer Qualifications: An experienced cast-in-place architectural concrete installer, as evidenced by not less than five consecutive years' experience, specializing in installing cast-in-place architectural concrete 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.
1. Provide written evidence of qualifications and experience.
 2. Include locations, descriptions, and photographs of completed projects, including name of architect, substantiating the quality of the installer's experience.
- C. Laboratory Testing Agency Qualifications: A testing agency qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated and employing an ACI-certified Concrete Quality Technical Manager.
1. Personnel performing laboratory tests to be an ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Level I.
 2. Testing agency laboratory supervisor to be an ACI-certified Concrete Laboratory Testing Technician, Level II.
- D. Field Sample Panels: After approval of verification sample and before casting architectural concrete, produce field sample panels to demonstrate the approved range of selections made under Sample submittals. Produce a minimum of three sets of full-scale panels, cast vertically, approximately 48 by 48 by 6 inches (1200 by 1200 by 150 mm) minimum, to demonstrate the expected range of finish, color, and texture variations.
1. Locate panels as indicated or, if not indicated, as directed by Architect.
 2. Demonstrate methods of curing, aggregate exposure, wood sealers, and coatings, as applicable.

3. In presence of Architect, damage part of an 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.
4. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
5. Demolish and remove field sample panels when directed.

E. Mockups: Before casting architectural concrete, build mockups, using the same procedures, equipment, materials, finishing procedures, and curing procedures that will be used for producing architectural concrete, to verify selections made under Sample submittals and to demonstrate typical joints, surface finish, color, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed work:

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by architect.
2. Build mockups of typical wall of cast-in-place architectural concrete as shown on drawings, including vertical and horizontal rustication joints, and any sculptured features.
3. Construct mockups to include at least two lifts having heights equal to those anticipated for construction.
4. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.
5. In the presence of architect, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair to match adjacent undamaged surfaces.
6. In the presence of architect, demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
7. Obtain architect's approval of mockups before casting architectural concrete.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on concrete mixtures.
1. Include the following information in each test report:
 - a. Admixture dosage rates.
 - b. Slump.
 - c. Air content.
 - d. Seven-day compressive strength.
 - e. 28-day compressive strength.
 - f. Permeability.

1.8 DELIVERY, STORAGE, AND HANDLING

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

1.9 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with Section 033000 "Cast-in-Place Concrete."
B. Hot-Weather Placement: Comply with Section 033000 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

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

2.2 FORM-FACING MATERIALS

- A. Comply with Section 031000 "Concrete Forming and Accessories" for formwork and other form-facing material requirements, and as specified in this Section.
Source Limitations: Obtain each type of form-facing material from single source from single manufacture
- B. Form-Facing wood forms:
1. Finishes: As cast.

- a. Exterior-grade rough sawn board form planks, that will provide continuous, true, and pattern architectural concrete surfaces, Douglas Fir, construction grade, or better, mill-applied release agent and edge sealed, complying with DOC PS 1.

2. Location: Where noted on drawings.

3. Size: 4-inch nominal height

2.3 REINFORCEMENT ACCESSORIES

- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire fabric in place.
1. Manufacture bar supports in accordance with CRSI's "Manual of Standard Practice."
 2. Where legs of wire bar supports contact forms, use **gray, all-plastic** bar supports.

2.4 CONCRETE MATERIALS

- A. Cementitious Materials:
1. Portland Cement: ASTM C150/C150M, **Type I/II gray.**
 2. Fly Ash: **ASTM C618, Class C or Class F.**
- B. Normal-Weight Aggregates: ASTM C33/C33M, **Class 5S** coarse aggregate or better, graded. Provide aggregates from single source from single manufacturer.
1. Maximum Coarse-Aggregate Size: **1 inch (25 mm).**
 2. Gradation: **Uniformly** graded.
- C. Normal-Weight Fine Aggregate: **ASTM C33/C33M**, manufactured or natural sand, free of materials with deleterious reactivity to alkali in cement, from same source for entire Project.
- D. Air-Entraining Admixture: As specified in Section 033000 "Cast-in-Place Concrete."
- E. Chemical Admixtures: As specified in Section 033000 "Cast-in-Place Concrete," and certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
- F. Water and Water Used to Make Ice: ASTM C94/C94M, potable.

2.5 CURING MATERIALS

- A. Comply with Section 03 30 00 "Cast-in-Place Concrete."
1. For integrally colored concrete, curing materials to be approved by color pigment manufacturer.
 2. For concrete indicated to be sealed, curing materials to be compatible with sealer.

2.6 REPAIR MATERIALS

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

2.7 CONCRETE MIXTURES, GENERAL

- A. Obtain each color, size, type, and variety of concrete mixture from single manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.
- B. Prepare design mixtures for each type and strength of cast-in-place architectural concrete proportioned on basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301 (ACI 301M).
1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs, based on laboratory trial mixtures.
- C. Admixtures: Use admixtures in accordance with manufacturer's written instructions.

2.8 CONCRETE MIXTURES

- A. Class **K**: Normal-weight concrete.
1. Exposure Class: ACI 318 (ACI 318M) **F1.**
 2. Minimum Compressive Strength: **4000 psi (27.6 MPa)** at 28 days.
 3. Maximum w/cm: 0.45.
 4. Slump Limit: **4 inches (100 mm), plus or minus 1 inch (25 mm).**
 5. Air Content:
 - a. Exposure Class **F1**: **5.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size.**
 6. Limit water-soluble, chloride-ion content in hardened concrete to **1.00** percent by weight of cement.

2.9 CONCRETE MIXING

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

1. Clean equipment used to mix and deliver cast-in-place architectural concrete to prevent contamination from other concrete.
2. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
3. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
4. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

C. Form-Facing wood forms:

1. Finishes: As cast.
 - a. Exterior-grade rough sawn board form planks, that will provide continuous, true, and pattern architectural concrete surfaces, Douglas Fir, construction grade, or better, mill-applied release agent and edge sealed, complying with DOC PS 1.
2. Location: Where noted on drawings.
3. Size: 4-inch nominal height

PART 3 - EXECUTION

3.1 INSTALLATION OF FORMWORK

- A. Comply with Section 031000 "Concrete Forming and Accessories" for formwork, embedded items, and shoring and reshoring, and as specified in this Section.
- B. Limit deflection of form-facing panels to not exceed ACI 301 (ACI 301M) requirements.
- C. Limit cast-in-place architectural concrete surface irregularities, as follows:
 1. Surface Finish-1.0: ACI 117 (ACI 117M) Class D, 1 inch (25 mm).
 2. Surface Finish-2.0: ACI 117 (ACI 117M) Class B, 1/4 inch (6 mm).
 3. Surface Finish-3.0: ACI 117 (ACI 117M) Class A, 1/8 inch (3.0 mm).
- D. Construct forms to result in cast-in-place architectural concrete that complies with ACI 117 (ACI 117M).
- E. Seal form joints, chamfers, rustication joints, and penetrations at form ties with form joint tape or form joint sealant to prevent cement paste leakage.
 1. Provide closure backing materials if indented rustication is used over a ribbed form line, and seal joint between rustication strip and form with joint sealant.
- F. **Chamfer** exterior corners and edges of cast-in-place architectural concrete.
- G. Coat contact surfaces of wood rustications and chamfer strips with wood sealer before placing reinforcement, anchoring devices, and embedded items.
- H. Coat contact surfaces of forms with form-release agent, in accordance with manufacturer's written instructions, before placing reinforcement, anchoring devices, and embedded items.

3.2 INSTALLATION OF REINFORCEMENT AND ACCESSORIES

- A. Comply with Section 032000 "Concrete Reinforcing" for fabricating and installing steel reinforcement and accessories.

3.3 JOINTS

- A. Construction Joints: Install construction joints true to line, with faces perpendicular to surface plane of cast-in-place architectural concrete, so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated.
 2. Form keyed joints as indicated. **Embed keys at least 1-1/2 inches (38 mm) into concrete.** Align construction joint within rustications attached to form-facing material.
 3. Locate joints for beams, slabs, joists, and girders at third points of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at top of footings or floor slabs.
 5. Space vertical joints in walls **as indicated on Drawings.** Unless otherwise indicated on Drawings, locate joints beside piers integral with walls, near corners, and in concealed locations where possible.

6. Use **bonding agent** at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

- B. Contraction Joints: Form weakened-plane contraction joints true to line, with faces perpendicular to surface plane of cast-in-place architectural concrete, so strength and appearance of concrete are not impaired, at locations indicated on Drawings or as approved by Architect.

3.4 CONCRETE PLACEMENT

- A. Comply with Section 033000 "Cast-in-Place Concrete."

3.5 FINISHING FORMED SURFACES

- A. Comply with Section 033000 "Cast-in-Place Concrete."
B. Architectural Concrete Finish: Match Architect's design reference sample, identified and described as indicated, to satisfaction of Architect.
C. As-Cast Surface Finishes: Comply with Section 033000 "Cast-in-Place Concrete" for the following:
1. ACI 301 (ACI 301M) Surface Finish-1.0 (SF-1.0).
2. ACI 301 (ACI 301M) Surface Finish-2.0 (SF-2.0).
3. ACI 301 (ACI 301M) Surface Finish-3.0 (SF-3.0).
D. Final Concrete Finish: Comply with Section 033000 "Cast-in-Place Concrete" for the following:
1. Smooth-rubbed finish.
E. Form-Liner Finish: Produce a textured surface free of pockets, streaks, and honeycombs, and of uniform appearance, color, and texture.
F. Maintain uniformity of architectural concrete finishes over construction joints unless otherwise indicated.

3.6 CONCRETE CURING

- A. Comply with Section 033000 "Cast-in-Place Concrete" using identical curing procedures to that used for **field sample panels**.

3.7 REPAIR

- A. Comply with ACI 301 (ACI 301M).
B. Repair damaged finished surfaces of cast-in-place architectural concrete when repairing is approved by Architect.
C. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved **field sample panels**.
D. Remove and replace cast-in-place architectural concrete that cannot be repaired to Architect's approval.

3.8 FIELD QUALITY CONTROL

- A. Comply with Section 033000 "Cast-in-Place Concrete."

3.9 CLEANING

- A. Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.
B. Wash and rinse surfaces in accordance with concrete finish applicator's written instructions.
1. 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 cast-in-place architectural concrete finishes.

3.10 PROTECTION

- A. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.
B. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.

3.11 FINAL ACCEPTANCE

- A. Final acceptance of completed architectural concrete Work will be determined by Architect by comparing approved **design reference sample** with installed Work, when viewed at a distance of **20 feet (6 m)**.

END OF SECTION

SECTION 27 00 05
STRUCTURED COMMUNICATIONS CABLING

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PART 1 – GENERAL

1.1. SCOPE OF WORK

- A. This Document specifies the City of Madison for product design, performance, and quality assurance, and contractor responsibilities for execution of work to install a complete Category 6 structured cabling system. Execution of work includes delivery and storage of materials, preparation, installation, field-testing, and project completion tasks. System certification and warranty submittal requirements for completed work and future moves, additions and changes (MAC's) are also specified in this document. Compliance to applicable codes, standards and regulations is required for all construction work performed.

1.2. SUMMARY

- A. Section includes products and execution requirements pertaining to Division 27 systems. Copper and fiber backbone and horizontal cabling along with support systems are covered under this document.
- B. Product specifications, general design considerations, and installation guidelines are provided in this document. Quantities for all cabling products shall be provided as required to complete cabling to all work areas as shown on floor plans.
- C. The Approved Contractor shall furnish, supply and install a complete Category 6 cabling infrastructure specified in the contract documents.
- D. The Approved Contractor shall furnish, supply and install a complete Category 6 cabling infrastructure specified in the contract documents.
- E. Work shall include all detailed execution requirements, such as preparation, installation, system certification, and project closeout activities according to the contract.

F. Substitutions: No substituted products shall be installed except with written approval by Owner.

1.3. DATA AND VOICE COMMUNICATIONS CONTRACT WORK

A. General

1. Furnish all labor, materials, tools, equipment and services for the installation in accordance with general provisions of specifications and the Contract Drawings.
2. Report percentage of work completed on a monthly basis.
3. Completely coordinate with work of all other trades.
4. Provide all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation, whether or not specifically indicated in the Contract Documents.
5. Provide labor for testing horizontal and backbone cabling.
6. Provide Firestopping.
7. Provide Telecommunications grounding and bonding.

B. Provide complete installation for Structured Telecommunications Cabling System including but not limited to:

1. Category 6 and 6A UTP horizontal cables.
2. Singlemode optical fiber backbone cables.
3. Work area telecommunication outlets.
4. Wall mounted voice outlets.
5. Equipment mounting racks and rack enclosures.
6. Category 6 and 6A modular patch panels.
7. Optical fiber patch panels.
8. Optical fiber LC connectors.
9. Wire management panels.
10. Field testing.
11. Firestopping.

1.3. SUBMITTALS

- A. Submittals shall be complete and at one time. Partial submittals will not be considered.
- B. Material lists, schedule of values, lists of subcontractors, and proof of Contractor qualifications shall be provided to Engineer upon request and shall follow the guidelines as stated in the General Requirements (Division 1 of the specification).
- C. Shop drawings shall be submitted. All communication system shop drawings shall include:
1. Manufacturer's data (specifications, "cut sheets").
 2. Wiring diagrams for all installed cabling.
 3. Equipment rack/cabinet layouts.
 4. Proposed labeling schemes and labeling method.
 5. List of cabling distances (typical and maximum) for all structured cabling
 6. Submit copies of certifications for all technicians and the project manager who will support this project. The certifications shall include:
 - a. Structured Cabling and termination equipment installation certifications for copper and optical fiber connectivity and cabling.
 - b. Approved manufacturer classes satisfactorily completed.
 7. Contractor shall submit a test plan that defines the tests required to ensure that the system meets technical, operational, and performance specifications 45 days prior to proposed test date.
 8. Work shall not proceed without the Owner's approval of the submitted items.
- D. Drawings & Inspection of Site:
1. Communications floor plan drawings are to scale and typically are not dimensioned. The Contractor shall not scale drawings for equipment placement and clearances. Dimensions given on drawings shall always take precedence over scaled drawings.
 2. Any existing wires, utilities, or equipment shown on the drawings are shown for general information and to the best knowledge of the Engineer. The Contractor shall field verify all existing wires, utilities, or equipment.
 3. The Contractor shall field verify distances and equipment placements coordinating locations with other trades, construction managers, and general Contractor prior to installation.
 4. The Contractor shall review all site conditions prior to submitting a bid on this project. Any obvious discrepancies between the site conditions and bidding documents shall be brought to the attention of the Engineer at the time of bidding so clarification can be made by addendum.

5. Change order requests for additional costs related to the contractors misunderstanding related to the amount of work involved and lack of knowledge related to the site conditions will not be allowed.
- E. Test Reports: Submit copies of complete reports of all testing performed to the General Contractor, with copies to the Architect's Electrical Engineer upon completion of job.

1.5. APPROVED CONTRACTOR QUALIFICATIONS

- A. The Contractor shall have experience in the installation and testing of similar systems as specified herein and shall have completed at least two projects of similar size and scope within the last 24 months. The Contractor shall provide references upon request (including the project name, address, date of implementation, client name, title, telephone number, and project description.)
- B. All members of the installation team must be certified by the manufacturer as having completed the necessary training to complete their part of the installation. All personnel shall be adequately trained in the used of such tools and equipment as required.
- C. The Contractor bidding on communication systems specified herein shall be certified by the connectivity Manufacturer to install, service, and warranty the specified product prior to the time of bid and throughout the duration of the installation. Manufacturer certifications shall not be project specific and should be valid for any and all projects completed by Contractor.
- D. The Contractor shall own and maintain tools, installation equipment, and test equipment necessary for successful installation and testing of optical and Category 6 & 6A premise distribution systems.
- E. The Owner reserves the right to require the Contractor to remove from the project any such employee the Owner deems to be incompetent, careless or insubordinate.
- F. The Contractor must maintain a state Contractor's license as required by the state.

1.6. APPROVED PRODUCT MANUFACTURERS

- A. The manufacturer of the Connectivity products specified in this document, as required for construction of the cabling Infrastructure per contract documents shall be:
1. Hubbell Premise Wiring
- B. The manufacturer of the Cabling products specified in this document, as required for construction of the copper cable Infrastructure per contract documents shall be:
1. Mohawk cable
- C. The manufacturer of the fiber optic cabling products specified in this document, as required for construction of the Fiber Optic cable per contract documents shall be:
1. Mohawk Cable or Equal
- D. Product substitutions are permitted under the conditions stated below. (1.7 A).

1.7. PRODUCT SUBSTITUTIONS

- A. Product substitutions from other manufacturers shall require the approval of the owner or owner's representative.

1.8. QUALITY ASSURANCE

- A. Installed category 6 balanced UTP and fiber cabling systems, pathways and distribution facilities shall adhere to manufacturer's instructions, contract drawings and specifications, and applicable codes, standards and regulations.
- B. Installed category 6 balanced UTP cabling systems and field test results shall strictly adhere to requirements of ANSI/TIA/EIA-568-C.0 and ANSI/TIA/EIA-568-C.2.
- C. Installed optical fiber cabling systems and field test results shall strictly adhere to requirements of ANSI/TIA/EIA-568-C.0 and ANSI/TIA/EIA-568C.3.
- D. Where applicable, all equipment, components, accessories and hardware shall be UL listed for the intended purpose of the installation.
- E. Installed products shall be manufactured by an ISO 9001 certified facility.
- F. Installed products shall be free from defects in material or workmanship from the manufacturer and shall be of the quality indicated.
- G. All methods of construction that are not specified in the contract documents shall be subject to control and approval by the Owner or Owner's Representative.
- H. Installed products shall be lot-traceable by date code.
- I. All critical internal manufacturing operations for installed products shall have documented in-process inspection and testing according to ISO9001.

1.9. DRAWINGS

- A. Approved or preliminary contract drawings furnished at the time of bid solicitation shall serve as the basis for product selection, creation of bills of material, and determination of labor content.
- B. Changes, additions, or deletions to contract drawings prior to awarding of the contract, shall require an amendment to the original bid.
- C. Prior to submitting the bid, in reviewing the contract drawings, the Approved Contractor shall:
 - 1. Request the attention of the Engineer, Owner, or Design Agency to clarify any materials, apparatus or work believed to be incorrect, inadequate, omitted, or in violation of applicable codes, standards or regulations.
 - 2. Note any contingencies related to unknown aspects of any drawings or specifications.
- D. Contract drawings, prior to execution of the project shall be formally approved and released by the Engineer or Design Agency and shall be approved by the Owner or Owner's Representative.
- E. Execution of work shall be according to approved drawings, in addition to applicable specifications and contractual obligations.

1.10. APPLICABLE STANDARDS, CODES, AND REGULATIONS

- A. Installation Standards: Cable installation shall comply with the following:
 - 1. American National Standards Institute, (ANSI)
 - 2. ANSI/TIA-568-C.0, "Generic Telecommunications Cabling for Customer Premises", published 2009
 - 3. ANSI/TIA-568-C.1, "Commercial Building Telecommunications Cabling Standard", published 2009
 - 4. ANSI/TIA-568-C.2, "Balanced Twisted-Pair Telecommunication Cabling and Components Standard", published 2009
 - 5. ANSI/TIA-568-C.3, "Optical Fiber Cabling Components Standard", published 2008, errata issued in October, 2008
 - 6. ANSI/TIA-568-C.4, "Coaxial Cabling Component Standard" Published 2010
 - 7. ANSITIA/EIA-569-B, Commercial Building Standards for Telecommunications Pathways and Spaces, 2003.
 - 8. ANSI/TIA-607-B, Commercial Building Grounding and Bonding Requirements for Telecommunications, 2010.
 - 9. ANSI/TIA/EIA-942, Telecommunications Infrastructure for Data Centers, 2004.
 - 10. ANSI/ICEA S-83-596, Fiber Optic Premises Distribution Cable, 2001.
 - 11. ANSI/TIA/EIA-598, Color Coding of Optical Fiber Cables, 2001
 - 12. ANSI/ICEA S-87-640, Fiber Optic Outside Plant Distribution Cable, 1999.
 - 13. ANSI/TIA/EIA-492AAAC, Detail Specification for 850nm Laser-Optimized 50um Core Diameter/125 um Cladding Diameter Class 1A Graded Index Multimode Optical Fibers, 2003.
 - 14. ANSI/TIA/EIA-492CAAA, Detail Specification for Class Iva Dispersion-Unshifted Singlemode Optical fibers, 2002.
 - 15. ANSI/TIA/EIA-758: Customer-Owned Outside Plant Telecommunications Cabling Standard, 2004.
 - 16. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Plant: OFSTP-7, 2002.
 - 17. ANSI/TIA/EIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Plant: OFSTP-14A, 2003.
 - 18. ANSI/TIA/EIA-TSB-125, Guidelines for Maintaining Optical Fiber Polarity Through Reverse-Pair Positioning, 2001.
 - 19. ANSI/TIA/EIA-TSB-140, Additional Guidelines for Field Testing Length, Loss, and Polarity of Optical Fiber Cabling Systems, 2004.
 - 20. ANSI/TIA/EIA-606-A, Administration Standard for Commercial Telecommunications Infrastructure, 2002.
 - 21. ANSI/EIA-310-D, Cabinets, Racks, Panels, and Associated Equipment, 1992.
 - 22. ANSI/TIA/EIA-604 (Series), FOCIS Fiber Optic Connector Interchangeability Standard, 2000-2003.
 - 23. National Fire Protection Association, Inc., NFPA 70
 - 24. National Electric Code (NEC), 2005.
 - 25. NEC Article 250: Grounding
 - 26. NEC Article 386: Surface Metal Raceways
 - 27. NEC Article 388: Surface Non-Metallic Raceways
 - 28. NEC Article 800: Communications Circuits
 - 29. NEC Article 770: Optical Fiber Cables and Raceway
 - 30. Underwriter's Laboratory, Inc. (UL)
 - 31. UL-5A: Standard for Non-Metallic Raceways and Fittings
 - 32. UL-5: Standard for Surface Metal Raceways and Fittings

33. UL-5C: Standard for Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits
 34. UL-50: Standard for Enclosures for Electrical Equipment
 35. UL-94-V0: Tests for Flammability of Plastic Materials
 36. UL-498: Attachment Plugs and Receptacles
 37. UL-1479: Fire Tests of Through-penetration Firestops (in Accordance with ASTM E814).
 38. UL-1863: Standard for Safety of Communications Circuit Accessories
 39. National Electrical Manufacturer's Association (NEMA)
 40. ANSI/NEMA WD-6-2002: Wiring Devices – Dimensional Requirements
 41. NEMA 250-2003: Enclosures for Electrical Equipment
 42. ISO/IEC 11801, Ed. 2:2002, Information Technology – Generic Cabling for Customer Premises, 2002.
 43. ISO/IEC 18010, Information Technology – Pathways and Spaces for Customer Premises Cabling, 2005.
 44. ISO/IEC 14763-1, Information Technology – Implementation and Operation of Customer Premises Cabling – Part 1: Administration, 2004.
 45. CSA C22.1-06, Canadian Electric Code (CEC), 2006
 46. Federal Communications Commission (FCC) Title 47, Code of Federal Regulations, Part 68: Connection of Terminal Equipment to the Telephone Network, 1998.
 47. U.S. Public Law 336. 101st Congress, ADA: Americans with Disabilities Act of 1992.
 48. IEEE 802.3af, Data Terminal Equipment (DTE) Power Over Media Dependent Interface (MDI), 2003.
 49. IEEE 802.3at (current draft), Data Terminal Equipment (DTE) Enhanced Power Over Media Dependent Interface (MDI).
 50. IEEE 802.3ae, Specification for 10 Gbit/s Ethernet Operation over Optical Fiber.
 51. Telecommunications Distribution Methods Manual, 11th Ed., Building Industry Consulting Services International (BICSI), 2006.
 52. Information Transport Systems Installation Manual, 4th Ed., Building Industry Consulting Services International (BICSI), 2004.
- B. This document is not a substitute for any code, standard or regulation. The Approved Contractor must be aware of local codes that may impact the bid submittal or execution of the project. The current revision of any applicable code, standard, or regulation shall take precedence at the point of project execution, unless otherwise recognized by local authorities. Applicable standards or codes that affect construction, which are listed as normative references within any governing document, are also the responsibility of the Approved Contractor for compliance.
- C. Materials
1. All materials shall be UL or ETL listed and verified and shall be marked as such.
 2. Products shall be regularly catalogued items of the manufacturer and shall be supplied as a complete unit in accordance with the manufacturer's standard specifications with any optional items required for proper installation unless otherwise noted.
 3. Material shall be delivered to the site in the original packing.

1.11. MAINTENANCE

- A. All materials used on this project shall be new. Used and refurbished equipment is not permitted unless approved by CITY OF MADISON. Provide equipment to site in original packaging whenever practical.
- B. The Contractor is responsible for scheduling all deliveries and providing proper receipt, handling, and storage of all materials. Protect all equipment from physical damages (dents, scratches, dust, water, paint, chemicals, and temperature extremes) and vandalism, or theft. The Contractor shall replace any damaged or stolen equipment. The Contractor is responsible for all equipment until final project acceptance by Owner.
- C. Maintenance of the cabling infrastructure is to be done by authorized personnel only or void of manufacturer's warranty may result. It is the responsibility of the owner or end user to utilize a certified installer to maintain warranty coverage on existing or new cabling infrastructure.
- D. The telecommunications contractor shall furnish a quotation for time and material to perform maintenance and repairs. The owner has the first right of refusal of selecting suitable contractor or qualified internal personnel to perform maintenance and repairs on structured cabling.
- E. Additions of new cabling, either horizontal or backbone, shall be completed, tested, and documented into permanent building records. New cabling installations intended to be covered by the manufacturer's warranty shall adhere to the documentation submittal and system certification provisions stated above.
- F. The Contractor is responsible for cleaning the worksite every business day and remove debris from the facility.

1.12. DOCUMENTATION

- A. TEST RESULTS

1. All test results are to be saved electronically on CD. Test documentation submitted on disk shall be clearly marked on the cover with the words "Project Test Documentation", the project name, and the date of completion (month and year). For multiple buildings, the building name, including floor or wing I.D. should also be included on the test results disk.
2. File names of the test results recorded for each link shall match the official identification. Test results shall include a complete record for each link, including type of test, cable type, cable/port I.D., measurement direction, reference setup, date, and technician's name(s).
3. The test equipment name, manufacturer, model number, serial number, software version and last calibration date shall also be provided in the test results documentation.
4. When repairs and re-tests are performed, the problem cause and corrective action taken shall be noted, and both the failed and passed test data shall be documented.
5. The owner, engineer, lead project manager, or owner's representative reserve the right to request verification of test results with a re-test of installed cables, on a sampling basis. Re-testing shall be at the expense of the installer unless otherwise noted in the contract documents.
- B. AS BUILT DRAWINGS
 1. Deviations from the approved drawings, whether or not a change order is submitted, shall be clearly denoted as built on the working hard copy drawing by the telecommunications contractor. As-built drawings shall be returned promptly to the owner or design agent for completion of drafting revisions to the original design. See "Documentation – Change Orders" below. Manufacturer's warranty registrations may also require as-built drawings.
 2. Floor plan drawings shall at minimum include detailed cable and pathway layouts, exact locations of workstation outlets, and cable distribution hardware locations. Workstation outlets shall have alphanumeric identifiers on the drawings as specified by the end user or owner.
- C. CHANGE ORDERS
 1. Any deviation from the approved contract drawings or specifications shall be submitted as a written change order.
 2. Execution of work, to perform changes, shall not proceed without prior written approval. Any changes done without written approval will be at no cost to CITY OF MADISON. If the work is shown to be incorrect the contractor will have to correct the problem at no cost to CITY OF MADISON.
 3. Significant changes may require a written quotation of additional labor and materials from the telecommunications contractor.
 4. It is the responsibility of the owner or owner's representative to bear the added cost of any substantial cabling system design changes. The contractor will not proceed with any change orders without written approval by the owner's representative. Any changes not approved by the owner's representative will be responsibility of the contractor and at no cost to CITY OF MADISON.
 5. Field changes that are completed without issuance of revised drawings shall be clearly denoted on the working as-built drawing. Refer to "As-Built Drawings" above.
- D. PUNCH LISTS AND CORRECTIVE ACTION
 1. As required in the contract documents, the telecommunications contractor shall correct punch-lists items determined to be in violation of drawings, specifications, codes, standards or regulations.
 2. The contractor shall be responsible for timely re-work of faulty cabling or hardware installations.
 3. The owner reserves the right to withhold final payment until punch list items are resolved satisfactorily.

1.13. WARRANTY

- A. THE CITY OF MADISON requires a Permanent Link warranty for the project. Manufacturer requires Permanent Link Test.
- B. The length of the extended warranty shall be a minimum of twenty-five (25) years.
- C. Warranty covering all components, equipment and workmanship shall be submitted in writing with system documentation.
- D. The warranty period shall begin on the system's first use by the owner.
- E. Should the cabling system fail to perform its expected operation within this warranty period due to inferior or faulty material and/or workmanship, the contractor shall promptly make all required corrections without cost to the Owner.
- F. Upon Completion of the project the Telecommunication Contractor shall forward the signed Warranty Registration Form and warranty certificate to the Owner.
- G. The manufacturer warrants category 6 cabling, category 6A cabling, optical fiber cabling and connecting components free of defects in material or workmanship.

- H. Category 6, category 6A and optical fiber cabling and components are warranted to perform the intended application upon completion of proper installation and testing.
- I. Warranty coverage includes application assurance and compliance to applicable performance specifications.
- J. Installed category 6 and 6A cabling systems may be granted a full Channel warranty under the conditions stated below.
 - 1. A certified installer registered who has completed a Manufacturer's training program performs the construction.
 - 2. Contractors performing the certified installation are properly registered in the Manufacturer's warranty program.
 - 3. The channel components are supplied entirely by one Manufacturer, including patch cords.
 - 4. Cable used in the installation is qualified and recognized by Connectivity Manufacturer.
 - 5. Installed link systems are properly documented and tested with a "PASS" result. The county requires a link test and the use of manufacturer patch cords to receive a channel warranty.
 - 6. Field test equipment used for category 6 cabling is minimum level III classification and complies with TIA/EIA-568-B.2 requirements.
 - 7. Required test results, stored on a CD, and project documentation including as-built drawings, are to be submitted to the Manufacturer by the registered contractor.

1.14. MOVES, ADDS AND CHANGES

- A. Moves, additions and changes initiated by the owner, end user, project manager, or design agent, which are beyond the scope of work in the original contract, shall require a revised quotation by the telecommunications contractor.
- B. It is the responsibility of the owner or owner's representative to bear the added cost of any substantial cabling system design changes.
- C. Moves, additions and changes shall either be issued in revised drawings, or otherwise shall be clearly denoted on as-built drawings.
- D. Moves, additions and changes that affect installations covered in a manufacturer's warranty shall be performed by a certified contractor that is properly registered in the manufacturer's warranty program.

1.15. CLEANUP

- A. The communications Contractor shall clean up all debris related to this work on a regular basis leaving the job site in a clean, safe condition.
- B. Protect all equipment from damage during construction. Equipment not protected shall be replaced at the Contractor's expense.

PART 2 - PRODUCTS

2.1. WORK AREA CONNECTORS

- A. Category 6 Jacks
 - 1. Jacks shall be standard 8-position, RJ-45 style, un-keyed, FCC compliant.
 - 2. Jacks shall be designed for 4-pair, 100 ohm balanced unshielded twisted pair (UTP) cable.
 - 3. Jacks shall terminate 26-22 AWG solid or stranded conductors.
 - 4. Jacks shall include a dust cap for wire retention.
 - 5. Jacks shall accept FCC compliant 6 position plugs.
 - 6. Jacks shall have attached wiring instruction labels to permit either T568A or T568B wiring configurations.
 - 7. Category 6 jacks shall be backward compatible with existing Category 3, 5, and 5e cabling systems for fit, form, and function.
 - 8. Jacks shall be manufactured in the USA.
 - 9. Category 6 jacks shall meet or exceed Category 6 transmission requirements for connecting hardware, as specified in ANSI/TIA/EIA-568-C.2, Transmission Performance Specifications for 4-Pair 100 ohm.
 - 10. Jacks shall be UL LISTED and CSA certified.
 - 11. Colors to specified by end user
 - 12. Category 6 modular jacks, as specified in the Contract Documents, shall be:
 - a. Hubbell
 - b. HXJ6EI (Category 6 – Ivory)

2.2. FACE PLATES

- A. Rear loading w/designation window

1. Faceplates shall be constructed of high impact, UL94 V-0 rated thermoplastic.
2. Faceplates shall be compatible with standard NEMA openings and boxes.
3. Faceplates shall be 2.75" W x 4.5" H (69.8 mm x 114.3 mm) for single gang and 4.5" X 4.5" (114.3 X 114.3 mm) for double gang.
4. Port size in each faceplate shall fit the Category 6 Modular Jack or Snap-Fit fiber optic, audio, and video modules for multimedia applications.
5. Faceplates shall be provided with clear plastic and color-matched label field covers. Faceplates shall provide for ANSI/TIA/EIA-606-A compliant workstation outlet labeling.
6. #6-32 pan head Phillips/slotted mounting screws shall be included with each faceplate.
7. Faceplates shall be UL LISTED and CSA certified.
8. Work area faceplates, as specified in the Contract Documents, shall be:
 - a. Hubbell (IFP Series)
 - b. IFP14ei (4-Port Ivory)

2.3. CABLE

A. Category 6 UTP

1. Plenum - Cable construction shall be four twisted pairs of 23 AWG insulated solid conductors, with a ripcord, surrounded by a tight outer jacket.
2. Non-plenum - Cable construction shall be four twisted pairs of 24 AWG insulated solid conductors, with a ripcord, surrounded by a tight outer jacket.
3. NO minimum compliant cable will be accepted. The facility requires additional bandwidth.
4. Ripcord shall be directly underneath the outer jacket.
5. Cable shall be marked with Manufacturer and pertinent information. UL, ETL, or CSA agency certification or verification markings shall be marked on the cable jacket according to the certifying agency's requirements.
6. Color coding of the pairs shall be as follows:
 - a. Pair 1: White/Blue; Blue
 - b. Pair 2: White/Orange; Orange
 - c. Pair 3: White/Green/Green
 - d. Pair 4: White/Brown/Brown
7. Plenum or Riser rated jackets
8. Cable shall be supplied in 1000 ft spools or 1000 ft Reelex boxes.
9. Cable shall exceed Category 6 transmission requirements specified in ANSI/TIA/EIA-568-C.2.
10. Cable shall be UL and C (UL) listed.
11. Cable shall exceed the requirements of TIA/TSB-155: 10 Gb/s Ethernet Operation over 37 Meters Channel Length.
12. Category 6 UTP horizontal distribution cable, as specified in the Contract Documents, shall be:
 - a. Mohawk AdvanceNet Cable
 - b. Plenum M57193
 - c. Riser M57202

B. Backbone distribution cable – Fiber Optic

1. Singlemode fiber backbone distribution cable shall be available in multi-strand constructions for intra-building applications.
2. OFNR or OFNP will be determined at each site. The contractor will be responsible to assure that the proper type of jacketing is being used. Failure to meet the local code will be cause for replacement of cable at no expense to CITY OF MADISON.
3. Singlemode fiber shall be dispersion un-shifted fiber in compliance with ANSI/TIA/EIA-492CAAA.
4. Intra-building fiber distribution cable design shall be according to ANSI/ICEA S-83-596.
5. Singlemode backbone fiber distribution cable, when installed, shall exceed the performance requirements of ANSI/TIA/EIA-568-C.3.
6. Singlemode optical fiber Backbone Fiber distribution cable, as specified in the Contract Documents, shall be:
 - a. Mohawk Cable or equal
 - b. Singlemode Riser M9W042 (12 Strand) unless otherwise specified by the City of Madison.
 - c. Singlemode Plenum M9W048 (12 Strand) unless otherwise specified by the City of Madison.

2.4. CONNECTORS – FIBER OPTIC

- A. Pre-polished fiber connector basic design shall be a factory pre-polished lc-style optical fiber connector with a zirconium ceramic ferrule.

- B. Index-matching gel is factory-injected into the cleaved fiber stub splice to minimize connector insertion loss.
- C. LC Singlemode factory pre-polished connectors shall HAVE pre-installed fibers.
- D. Connector materials shall be designed with thermal stability to comply with environmental requirements of ANSI/TIA/EIA-568-B.3 and Telcordia GR-1081-CORE.
- E. Pre-polished lc connectors shall require no field polishing AND REQUIRE NO ADHESIVES FOR TERMINATION.
- F. Connector design and termination technique shall be independent of cable type or manufacturer, and shall be compatible for either 900 micron buffer or 250 micron buffer distribution cables.
- G. Pre-polished LC fiber connectors, when properly installed onto qualified cable, shall meet the 10 Gb/s Ethernet performance requirements of IEEE802.3.
- H. LC fiber connectors, properly installed onto qualified cable, shall exceed the mechanical and environmental performance requirements of ANSI/TIA/EIA-568-C.3.
- I. Optical fiber horizontal distribution cable, as specified in the Contract Documents, shall be:
 - 1. Hubbell ProClick
 - 2. Singlemode LC – FCLC900KSM12
 - 3. AFL (Fast)
 - 4. Singlemode LC- fast-LC-SM

2.5. PATCH PANELS – CATEGORY 6

- A. Category 6 patch panels shall be standard 8-position, RJ-45 style, un-keyed, FCC-compliant receptacle, in 24- and 48-port configurations.
- B. Panel frames shall be black powder coated 14-gage steel with rolled edges top and bottom for proper stiffness.
- C. Panels shall accommodate a minimum of 24 ports for each rack mount unit (1 RMU = 1.75 in.). 48 ports are recommended.
- D. Panels shall be designed for 4-pair, 100 ohm balanced unshielded twisted pair (UTP) cable.
- E. Panels shall terminate 26-22 AWG solid conductors.
- F. Panels shall have individual port identification numbers on the front and rear of the panel. Panels shall have the Category 6 designation, visible from the front when installed.
- G. Printed circuit boards shall be fully enclosed front and rear for physical protection.
- H. Panel contacts shall accept a minimum of 2000 mating cycles without degradation of electrical or mechanical performance.
- I. Panel termination method shall follow the industry standard 110 IDC punch-down, using a standard 110 impact termination tool.
- J. Category 6 panels shall be backward compatible with existing Category 3, 5, and 5e cabling systems for fit, form, and function.
- K. Category 6 patch panels, when installed, shall exceed the link or channel performance requirements of ANSI/TIA/EIA-568-C.2.
- L. Category 6 patch panels shall be able to accommodate 10G in a 37 meter channel per TSB-155.
- M. Category 6 patch panels, as specified in the Contract Documents, shall be:
 - 1. Hubbell (NEXTSPEED 6 Series)
 - 2. 24 Port - P6E24U
 - 3. 48 Port - P6E48U

2.6. CABINET – WALL MOUNT

- A. Rack material shall be welded steel construction with a durable black polyurethane powder coat finish.
- B. Installed racks shall have a static load capacity of 300 Lbs.
- C. Cabinet shall be 48-inch high, 23-inch wide and 30-inch depth.
- D. Tapped holes in the vertical rails for mounting of panels shall be #12-24 thread size. Coating shall not interfere with thread fit.
- E. Cabinet shall have a capacity of 26 RMU.
- F. Cabinet consist of: Cabinet & mounts to secure the cabinet, a vertical Electrical 20 amp Outlet strip (Minimum 6 receptacles) with Mounting Brackets.
- G. Wall mount cabinet and accessories, as specified in the Contract Documents, shall be:
 - 1. Hubbell (XHW series)
 - 2. Hubbell HSQ4836

2.7. CABLE MANAGEMENT –VERTICAL CABLE MANAGEMENT – NOT USED ON THIS PROJECT

- A. Z-channel design offers:
 - 1. Airflow

2. Minimizes weight
3. Maximum cable capacity with unobstructed access to cable
- B. Snap in Spools with ability to put them where they will do the most good.
- C. Rear cable management allows cable to be run on both left and right sides, while leaving the area behind the electronics and patch panels open for increased airflow.
- D. Construction:
 1. Cold Rolled steel z-channels
 2. Cold rolled steel covers
- E. Mounts to 84" Equipment racks
- F. Channel width: 6"W
- G. Vertical Cable Management and accessories, as specified in the Contract Documents, shall be:
 1. Hubbell (NEXTFRAME series)
 2. VS76

2.8. CABLE MANAGEMENT –HORIZONTAL CABLE MANAGEMENT

- A. Horizontal management will be constructed of 14 ga cold-rolled steel (CRS)
- B. Finish shall be a Durable, black powder coat.
- C. Size: 2RU
- D. Front Ring Depth: 3.5"
- E. All steel construction - rugged, non-flammable, no fasteners to wear or break, no fingers to fuss with.
- F. Modular components easily configured in field to adapt to demanding applications.
- G. Hinged Front Cover - Locks in place when completely open to prevent cover from being removed or lost.
- H. Horizontal Cable Management and accessories, as specified in the Contract Documents, shall be:
 1. Hubbell (NEXTFRAME series)
 2. HC219CE3N
- I. Enclosures – fiber rack mount
 1. Rack-mounted, powder coated formed cold rolled steel enclosure.
 2. Swing-out or pull-out inner tray shall provide access to inner cables and connections, and maintain proper cable bend radius throughout the range of motion.
 3. Fiber rack-mount enclosures shall be a 19-inch formed/welded and powder coated modular design, sized according to the cable installation.
 4. Fiber rack-mount enclosures may serve as a main, horizontal, or intermediate cross connect facility.
 5. Panel mounting brackets shall be configurable to either 19" or 23" racks per ANSI/EIA-310-D.
 6. Enclosure chassis shall have two mounting bracket locations for either flush mount or center mount on the rack.
 7. Inner tray shall have a threaded mounting boss to accept a mounting stud for splice trays. Splice tray capacity shall be (2) 10" splice trays, each with 24-splice capacities (48 splices total). Splice tray mounting boss shall also accept a stud for mounting 1-RMU blown fiber adapter brackets.
 8. Inner tray mounting posts for modular panels shall also accept 12-fiber MTP-style cassettes for "plug & play" installations.
 9. Inner tray shall have rear cable tie-down features to accept various diameter backbone cables entering the enclosure.
 10. Enclosures shall be constructed of 16 gage cold rolled steel (CRS)
 11. Fiber rack-mount enclosures and accessories, as specified in the Contract Documents, shall be:
 - a. Clearfield – Fieldsmart fiber crossover distribution system.
- J. Adapter panels – optical fiber
 1. Optical fiber Adapter panels shall be a modular design powder coated stamped metal construction.
 2. ADAPTER PANELS SHALL BE LC.
 3. High or low-density versions.
 4. Adapter panels shall have quick-release snap fasteners to fit directly into fiber enclosures.
 5. Fiber patch panels, as specified in the Contract Documents, shall be:
 - a. Clearfield – Clearview class patch only cassette.

2.9. INNER-DUCT

- A. Fiber Optic Cable shall be installed with Innerduct for protection of fiber cables in a shared pathway.
- B. The inner duct will be rated for the environment that it is being installed in. Plenum and riser rated.
- C. Three inner Ducts will be run between closets. One for current installation, two spare for future applications.

- D. Size: 1" CORRUGATED
- E. Flexible & Lightweight for ease of handling
- F. Pre-threaded with pull line

PART 3 - EXECUTION

3.1. APPROVED CONTRACTOR RESPONSIBILITIES

- A. The Approved Contractor shall assume the following responsibilities:
 - 1. Execute construction in accordance with contract drawings and specifications.
 - 2. Adhere to project schedules and job site rules.
 - 3. Adhere to the quality, regulatory, logistics, and documentation requirements.
 - 4. Adhere to the product requirements outlined in PART 2 above.
 - 5. Adhere to the Execution guidelines outlined below.
 - 6. Furnish the cabling system certification and warranty provisions outlined in this specification section.

3.2. DELIVERY, STORAGE AND HANDLING LOGISTICS

- A. Materials delivered to the construction site shall be stored in a dry, secure area, preferably indoors. Storage temperature of materials shall adhere to manufacturer's recommendations. Movement of packaged materials shall be in a manner to avoid damage of contents. On-site storage, either indoors or trailer, shall have permission by the owner, and shall not interfere with other construction activity.
- B. Installation of category 6 cable shall be within the recommended temperature range specified by the manufacturer. Cable installation temperature above 50F is recommended.

3.3. PREPARATION

- A. Cable pathways and Firestops
 - 1. Cable pathways, including conduit, cable tray, ladder rack, raceway, slots, sleeves, etc. shall be located and mounted according to contract drawings and manufacturer's instructions. Pathways shall not be installed in wet areas.
 - 2. Cable pathway fill ratio, bend radius, run length, number of bends, and proximity to EMI sources shall be in accordance with ANSI/TIA/EIA-569-B. Maximum cable count of the initial installation shall not exceed 40% fill ratio in any pathway.
 - 3. In accordance with NEC 2005, power wiring and communications cabling shall not share the same pathway or outlet unless separated by a physical barrier.
 - 4. Cable pathways shall be secured to a structural member of the building, or permanent wall studs. Wall surfaces for raceway mounting should be finished complete.
 - 5. Metallic pathways shall be electrically continuous, free of sharp edges, and properly bonded to an approved ground. EMI sources such as ballasts, motors, and bus conductors shall be avoided by using proper separation distances.
 - 6. Pathways that penetrate fire-rated barriers shall be fire stopped according to local codes and recognized practices. Fire stop materials or devices shall be qualified to UL-1479, in accordance with ASTM E814. Fire stop method shall have P.E. approval.
 - 7. Core drilling of holes for fire-rated poke-through outlet devices shall have approval by a structural engineer or P.E. on the contract drawings prior to start of work.
 - 8. Pathways for vertical cable runs, such as slots and sleeves, shall be installed in the proper location in accordance with applicable codes and standards.
- B. Telecommunications rooms and equipment rooms
 - 1. Telecommunications room (TR) layout, location and design shall be in accordance with the guidelines of ANSI/TIA/EIA-569-B. TR's on each floor of the building should be centrally located and vertically aligned to simplify backbone cable and pathway routing. TR's shall not be installed in wet areas, or near EMI sources or caustic chemicals.
 - 2. Layout of rack, cabinet or enclosure locations shall be according to contract drawings.
 - 3. Racks and cabinets shall be secured to the floor using proper anchors and fasteners.
 - 4. Mount and assemble racks, cabinets, brackets and enclosures per manufacturer's instructions. Mount patch panels and cable management accessories in the specified locations.
 - 5. Adjoining pathways (ladder rack, cable tray, etc.) shall be properly secured and positioned to allow adequate bend radius of cables entering the rack or cabinet.
- C. Wall outlets and recessed wall boxes

1. Wall outlet and cable drop pathway location shall be according to contract drawings. Guidelines from ANSI/TIA/EIA-569-B should be followed for location with electrical outlets and outlet height above finished floor.
 2. Outlet boxes shall be fastened securely to a wall stud or structural element, in a manner to permit flush mounting of the faceplate with the finished wall.
 3. Multi-connect boxes shall be installed in a manner to comply with separation rules for power and communications wiring in close proximity.
 4. Refer to specific manufacturer's recommendations for wall outlet selection, cable deployment, and termination of jacks into faceplates.
- D. Surface housings and MUTOA outlets
1. Raceway or conduit should be deployed to the surface housing location. For through-wall cable entry, cut the wall opening to match the opening in the housing base.
 2. Lay out mounting holes onto the desired wall location. For wallboard, concrete or cinder block walls, drill to the proper depth and install anchors.
 3. Always use proper wall anchors. Installing mounting screws directly into wallboard without using anchors can cause screw pullout and detachment of the surface housing. Mounting the base plate to studs is recommended.
 4. Mount base plate of surface box or MUTOA to outlet location using proper fasteners. Note: furniture and wall outlet applications require mounting of base plate prior to cable pulling and connector termination.
 5. Install cover onto base plate.
 6. Refer to detailed manufacturer's guidelines for cable deployment and termination of jacks into surface housings. Due to the larger size of category 6 cables, proper cable bend radius must be maintained. Certain restrictions may apply when dressing category 6 cabling into surface housings.

3.4. INSTALLATION

A. Cable Support

1. This Contractor shall install all supports for cables specified in this section. Traditional Ladder rack will be used in each telecommunications room, basket tray and j-hooks will be used in the horizontal.
2. Cable supports shall be spaced randomly, but no further than 5'-0" apart.
3. Inner-ducts will be run between each closet or telecommunications room. One for current installation with three multi cells for future installations or changes. In each telecommunications room the inner-ducts entering the space will be combined, in a size appropriate metallic box that is mounted on the wall. The combined inner ducts will then be routed to the rack and the fiber bay.
4. Provide all additional cable management products, sleeves or conduit raceways as required to protect exposed cabling and complete the installation of cables in a neat manner.
5. A horizontal conduit system consists of conduits radiating from the telecommunications room to the workstation outlets in the floor, walls, ceilings, and columns of a building. When using a conduit distribution system utilize the most direct route following the building lines.
6. The size and number of conduits or sleeves used for backbone pathways depends on the usable floor space served by the backbone system. at least three 4 trade size sleeves are recommended.
7. Conduit is only required if building codes or environmental conditions necessitate it. Rigid or EMT metal conduits are deemed suitable for building installation. Adequate planning should allow for a minimum of one 1-inch conduits to each workstation location if code requires conduit for voice and data cables.
8. Conduit fill ratios shall not exceed 40%; contact your cable manufacturer to get recommendation on fill rates.
9. No conduit run should be designed with more than two (2), 90 degree bends between pull points or pull boxes. If a run requires more than two 90 degree bends, install a pull box.
 - a. Exceptions:
 - i. The total run is not longer than 33 feet.
 - ii. The conduit size is increased to next trade size.
 - iii. One of the bends is located within 12 inches of the cable end.
10. All conduits will be equipped with a contiguous length of plastic or nylon pull string with a minimum rating of 200 lbs. (90 Kg)
11. A conduit run should not be designed with continuous closed sections longer than 100 ft without pull points or pull boxes installed.
12. All conduits should terminate above or in the installed ladder racks and allow for proper cable racking. Cable waterfalls should be considered in areas that have excessive distance between the conduit and ladder rack.

13. Trays and conduits located within the ceiling shall protrude into the room a distance of 1 to 2 in without a bend and above 8 ft high. Clear, unobstructed access to the ladder rack and conduits shall be provided within telecommunications rooms.
 14. Conduits entering through the floor shall terminate at least two (2) inches above the finished floor
 15. Locate slot/sleeve systems in places where pulling and termination will be easy.
 16. If possible, locate sleeves, slots, and/or conduits on the left side of the room; this placement enhances the use of wall space from left to right.
 17. When possible, entrance conduit and distribution conduit/cable tray should enter and exit on the same wall; if this is not possible, ladder rack inside the room should be provided for distribution from wall to wall.
 18. All floor penetrations shall be core drilled with a maximum 1/4 inch size greater than the exterior dimension of the riser conduit.
 19. Conduits entering through a wall shall be reamed and bushed, and terminated as close as practicable to the terminating rack or wall.
 20. Terminating above a suspended ceiling must terminate not less 3 inches above finished ceiling and finished with bushing opening.
 21. All conduit will be labeled for easy identification.
 22. All floor penetrations shall be at columns, exterior walls or in equipment rooms.
 23. Cables shall be supported at height of bottom flange of structural beams using a rigid support method (i.e. threaded rod, beam clamps, etc.).
 24. Do not support cables from ductwork, sprinkler piping, water piping, waste piping, conduit, ceiling wire, or other system supports.
 25. The conduits or sleeve will be installed per TIA/EIA-569-B and seal all penetration with approved fire stop product.
 26. Provide independent support system for each low voltage cabling system.
- B. Cable
1. Category 6 cable will be run for data. Category 6A will be run to all Wireless access points. Category 6 Gelled filled cable will be run in the backbone for all communications applications. Certain environments may require the use of different cables and/or cable jackets.
 2. **All Terminations will utilize T568B wiring in THE CITY OF MADISON facility.** Any Contractor not complying with this wiring requirement will fix the problem at no cost to CITY OF MADISON.
 3. Maximum cable lengths to be 295 feet (90 m) including service loop. Provide all necessary installation materials, tools and equipment to perform insulation displacement type terminations at all communications outlets, patch panels.
 4. All communications cabling that has become abandoned as part of new renovation projects, previous renovation projects, or temporary communication cables used during the construction process shall be completely removed.
 5. Refer to detailed manufacturer's guidelines for deployment of category 6 cable. Certain restrictions apply, and specific techniques are recommended.
 6. All cabling shall be installed in accordance with manufacturers' written bend radius and pulling tensions. General industry guidelines recommend the following bend radius and pulling tensions:
 - a. Tensile loading on a single 4-pair copper UTP cable shall not exceed 25 lbf.
 7. Bend radius of a single 4-pair copper UTP cable shall not exceed 4 times the diameter of the cable.
 8. Bend radius of multi-pair copper UTP and optical fiber cable shall not exceed 10 times the diameter of the cable.
 9. All conduits and conduit sleeves shall have bushings or grommets shall be installed prior to the installation of communications cables to avoid damage and abrasions to cable sheathing and insulation. If bushings have are installed by the electrical Contractor, the communications cabling contract shall furnish and install bushings prior to pulling communications cabling.
 10. Horizontal cable length for 4-pair copper UTP cables shall not exceed 295 feet. Prior to bidding and installation, the contractor shall review the drawings and verify no cable run exceeds 295 feet and notify the communications designer of cable runs that may exceed 295 feet.
 11. Splices are not permitted in any voice or data cable unless other specified or shown on drawings.
 12. Avoid placing copper cables near sources of extreme heat (i.e. boilers, radiators, heat coils).
 13. Maintain cable twists for all UTP cables. For terminations cable sheathing shall be stripping back no more than 1/2" back from termination point for all Category 6 cables.
 14. All cables shall be supported by cable tray, cable runway, or J-hooks. When large quantities of cables leave trays or runways, cables shall be supported by drop-outs or cable support hardware manufactured

- specifically for the purpose of supporting cables. J-hooks shall be installed a minimum of every 5 feet and cabling shall maintain minimal deflection and strain (less than 12" deflection). Cables shall not be supported from ceiling grid wires. Cables shall not run above iron joists.
15. All cables shall be separated and bundled into like groups.
16. Service loops shall be provided at both ends of installed horizontal and backbone cabling. A 12" service loop shall be installed in the ceiling space near workstation outlets (excessive cable shall not be coiled in outlet boxes). A 10' service loop shall be provided in communication rooms and shall be installed to allow for future equipment rack/cabinet relocations without the need to re-terminate patch panels; the 10' service loop shall be neatly bundled and secured in ceiling space with large D-rings or place in cable trays. Cable slack and service coils shall be stored properly above the ceiling or under the access floor. A "figure-eight" service loop is recommended for category 6 cabling to reduce EMI coupling. Loose, random bundling is recommended.
17. Any cabling installing in equipment rooms shall be neatly placed in cabling trays, cabling runways, or horizontal and vertical rack/cabinet cable managers.
18. Velcro straps shall be utilized in the TR and inside TC enclosures for all cable bundling. Tie wraps shall be prohibited in the telecommunication rooms.
19. Separation: Maintain the following distances between cables, other system cables and other building systems:
- One (1) foot from Fluorescent Light.
 - One (1) foot from power cable in parallel.
 - One (1) foot from electrical conduits, other systems cables or other electrical equipment.
 - Four (4) feet from motors or transformers
 - Three (3) feet from hot water piping or other mechanical equipment.
 - Ten (10) Feet from Bus Conductors or high-current branch circuits.
20. All low voltage cables shall be run parallel or at right angles to building structural framework. Do not run cables diagonally across ceiling space without written authorization by the Architect's Electrical Engineer or CITY OF MADISON Representative.
21. Communications cabling that must cross power cables or conduit shall cross at a 90-degree angle, and shall not make physical contact.
22. Fire seal around all cables running through rated floors and walls. Firestop all cables and pathways that penetrate fire-rated barriers using approved methods and according to local codes.
23. Leave spare pull string with every outlet installed.
24. Do not install cable in wet areas, or in proximity to hot water pipes or boilers.
25. Cable ends for termination shall be clean and free from crush marks, cuts, or kinks left from pulling operations. Installed cable jackets shall have no abrasions with exposed conductor insulation or bare copper "shiners". The installer is responsible to replace damaged cables.
26. Backbone cables shall be installed and bundled separately from horizontal distribution cables. Backbone and horizontal cable bundles shall be loose and random.
27. Backbone cables spanning more than three floors shall be supported at the top of the cable run with a wire mesh grip and on alternating floors, unless otherwise specified by local codes or manufacturer's guidelines.
28. Vertical runs of backbone cables entering each TR shall be securely fastened along a properly prepared wall in the TR on each floor. Use of cable ladder is recommended.
- C. Communications Infrastructure
- Maximum cable lengths to be 295 feet (90 m) including service loop. Provide all necessary installation materials, tools and equipment.
 - Support and secure cables at patch panels using rear cable management bracket, spools or management device.
 - Cross-connects shall be completed as per construction schedule.
- D. Optical Fiber Cable:
- Inner-ducts of the proper rating will be run between each closet.
 - Cables for direct burial, aerial, or other outside applications shall be designed specifically for the intended purpose.
 - All optical fiber installations shall be installed using open cabling methods. Limit cable-bending radius to 20 times the cable diameter during installation, and 10 times the diameter after installation. Provide all required tools, materials, consumables, and equipment necessary for field mounting of LC connectors.
 - Do not exceed the maximum pull tension specified by the cable manufacturer. Use appropriate lubricants as required to reduce pulling friction. Avoid kinking and twisting of cables during installation.

- 1 5. Label each end of each cable as to source and destination. Terminate optical fibers in consistent,
2 consecutive manner at each end. Place all material in inner-duct between Label Optical Fiber raceway
3 cable with yellow "Caution - Optical Fiber Cable" tags every 10 feet. Leave 10 feet of slack at each fiber
4 termination point. Neatly coil slack optical fiber cable on top of rack above optical fiber patch panel
5 enclosure at each rack location.
- 6 6. Optical fiber cable terminations shall utilize enclosures and components in quantities consistent with the
7 required fiber counts at each end of each segment.
- 8 7. During optical fiber connector termination, visually inspect all terminations with a 200 or 400-power
9 microscope.
- 10 8. Follow all of the connector manufacturer's recommendations.
- 11 9. Unacceptable flaws in the terminations will include, but not limited to, scratches, full or partial cracks,
12 bubbles, pits, epoxy residual, dirt, dust, oil, moisture, grinding and sanding debris. The acceptable
13 termination will show a connector tip that is free of all imperfections in 100% of the core and 80% of the
14 cladding. All unacceptable connectors shall be inspected after rework.
- 15 10. During installation of optical fiber cable do not allow pulling tension to exceed cable manufacturer's
16 specification for the cable being installed. Only the strength member of the cable shall be subjected to
17 the pulling tension.
- 18 11. Clean all optical fiber connector tips prior to inserting them into matting receptacles or bulkheads. Install
19 all dust covers.
- 20 12. Using approved methods, pull cable into conduit, or place into raceway or cable tray as specified. A pull
21 cord (nylon; 1/8" minimum) shall be co-installed with all cable installed in any conduit.
- 22 13. Where cables are installed in air return plenum, riser rated cable shall be installed in metallic conduit.
- 23 14. Backbone and horizontal cables shall be installed and bundled separately in any pathway.
- 24 15. Cables above ceilings or below access floors shall be installed in cable tray or open-top cable hangers.
- 25 16. Cable slack and service coils shall be stored properly above the ceiling or under the access floor. Pathway
26 fill ratio in conduit, tray, raceway, etc. shall not exceed 40% of pathway cross-sectional area.
- 27 17. A service coil of at least 1 meter is recommended within workstation outlets, and at least 2 meters is
28 recommended for telecommunications enclosures. Main trunk and OSP cables shall also have a large
29 diameter service coil in the specified location.
- 30 18. Recommended maximum spacing of cable supports above the ceiling is 60 in.
- 31 19. Backbone cables spanning more than three floors shall be securely attached at the top of the cable run
32 with a wire mesh grip and on alternating floors or as required by local codes.
- 33 20. Vertical runs of cable shall be supported to messenger strand, cable ladder, or other approved structure
34 to support the weight of the cable. Do not exceed maximum cable vertical rise limits.
- 35 21. Cables that are damaged during installation shall be replaced by the contractor.
- 36 E. RACKS AND ENCLOSURES:
 - 37 1. Freestanding equipment racks and enclosures shall be protected free of all dust, debris and other
38 environmental elements during construction until substantial completion walk-through.
 - 39 2. Each rack, enclosure shall have a dedicated #6 AWG ground wire to a grounding buss bar or building
40 ground as defined by NEC.
 - 41 3. Secure racks and enclosures to floor using rack installation kit.
- 42 F. CATEGORY 6 JACKS
 - 43 1. Refer to specific manufacturer's guidelines for termination of jacks and dressing category 6 cables inside
44 wall outlets and surface housings. Due to the larger size of category 6 cable, service coils in outlet boxes
45 and surface housings are not recommended.
 - 46 2. Terminate jacks according to manufacturer's instructions.
 - 47 3. All jack will be wired utilizing T568B.
 - 48 4. To assure 10GBase-T performance, maintain wiring pair twists as close as possible to the point of
49 termination. Also minimize the length of exposed pairs from the jacket to the IDC termination point
50 during installation.
 - 51 5. The length of wiring pair un-twist in each termination shall be less than 0.5 inches (13 mm).
 - 52 6. Jacks shall be properly mounted in plates, frames, or housings with dust caps fully installed over IDC
53 contacts.
 - 54 7. Horizontal cables extending from mounted jacks shall maintain a minimum bend radius of at least 4 times
55 the cable diameter, unless space is restricted. Note: Refer to specific manufacturer's recommendations
56 for restricted cable bend radius.
 - 57 8. Cable terminations shall minimize tensile or bending strain on IDC contacts after assembly of faceplate or
58 housing to the wall outlet.

1 G. CATEGORY 6 PATCH PANELS

- 2 1. Properly mount patch panels into the designated rack, cabinet, or bracket locations with the #12-24
- 3 screws provided.
- 4 2. Terminate cables behind the patch panel according to manufacturer's instructions.
- 5 3. To assure performance, maintain wiring pair twists as close as possible to the point of termination. Also
- 6 minimize the length of exposed pairs from the jacket to the ICD termination point during installation.
- 7 4. The length of wiring pair un-twist in each termination shall be less than 0.5 inches (13 mm), and shall be
- 8 kept to a minimum.
- 9 5. Each terminated and dressed cable shall be maintained perpendicular to the rear cover using the
- 10 recommended cable management hardware.
- 11 6. Horizontal or backbone cables extending from the rear panel terminations shall maintain a minimum
- 12 bend radius of at least 4 times the cable diameter.
- 13 7. Cable terminations shall have minimal tensile or bending strain on panel IDC contacts in each installed
- 14 location.
- 15 8. Panels shall be properly labeled on the front and back with the cable number and port connections for
- 16 each port.

17 H. Harsh Environment Housing and Connectivity

- 18 1. Mount connector housing from front of device but Install Gasket or optional Protective Cap before
- 19 mounting connector housing into device.
- 20 2. Secure connector housing to device using supplied plastic nut. Tighten nut with 6-7 inch/pounds of
- 21 torque.
- 22 3. Ensure that mounting surface is clean and free of debris.
- 23 4. Installing the jack into the mounted connector housing.
- 24 5. Install the terminated jack into the mounted connector housing by tilting the jack and securing the fixed
- 25 latch in the connector opening. Rotate the jack, securing the spring latch.
- 26 6. Clean and remove any obstructions from the surface that the wall plate assembly will be installed against.
- 27 7. Place washers provided with HI Impact series plates onto screws. Align rubber gasket on back side of
- 28 plate prior to installing to box/wall by placing screws through plate and rubber gasket.
- 29 8. Secure the wall plate assembly to box/wall by tightening screws with 5 inch/pounds of torque.
- 30 9. Attach patch cords and field term plug assemblies (sold separately) to the mounted connector.

31 I. OPTICAL FIBER CONNECTORS, HORIZONTAL AND BACKBONE

- 32 1. Installed fiber connectors shall have proper cable support, routing and strain relief.
- 33 2. Installed connectors shall be inspected 100% for polish quality, and contamination.
- 34 3. Fusion splices for pigtail connections shall be protected in a suitable enclosure.

35 J. GROUNDING and BONDING SYSTEMS: Basic Guidelines

- 36 1. Telecommunications grounding and bonding system shall be installed in accordance with NEC
- 37 requirements, and per the guidelines of ANSI J-STD-607-A.
- 38 2. The Telecommunications Main Grounding Buss Bar (TMGB) shall be bonded to the building main
- 39 electrical service ground (Grounding Electrode Conductor or GEC), using approved lugs or exothermic
- 40 weld methods. Bonding to the GEC or TMGB with sheet metal screws is prohibited.
- 41 3. The Telecommunications Bonding Backbone shall be a minimum 6 AWG copper wire conductor. A
- 42 Telecommunications Grounding Buss Bar (TGB) shall be installed in the TR on each floor, and shall be
- 43 bonded to the TBB. All metal racks, cabinets, pathway and enclosures shall be bonded to the TGB.
- 44 4. Telecommunications equipment shall be grounded according to manufacturer's instructions and in
- 45 accordance with applicable codes.
- 46 5. All metallic pathways, including conduit, raceway ladder or cable trays shall be electrically continuous and
- 47 shall be bonded to ground on each end.
- 48 6. OSP cable entering the building or backbone cables having metal sheaths shall have isolation protection.
- 49 Isolation protectors shall be bonded to the TMGB.

50
51 3.5. LABELING

52 A. General:

- 53 1. **All labels shall be permanent, machine generated labels produced by a labeling machine.** Labels shall
- 54 be a permanent polyester material clear in color with label lettering black in color. No hand written
- 55 labels will be accepted.
- 56 2. Labeling information will be reviewed at Pre-Install Meeting, and the Owner shall approve the labeling
- 57 scheme prior to the installation of any cabling.

- 1 3. Surfaces shall be cleaned before attaching labels. All labels shall be attached firmly and vertically plumb
- 2 on equipment, faceplates, patch panels termination blocks, etc.
- 3 4. All labeling of cables, equipment, and components shall be included in as-built documentation, floor plan
- 4 drawings, and schematic designs.
- 5 B. Cabling
- 6 1. All structured cables (horizontal and backbone) shall be labeled at both ends within 6" of cable
- 7 termination point. Where voice backbone cables extend behind termination blocks, cable labels shall be
- 8 placed at a location on the cable where the labels are visible from the front of the termination blocks.
- 9 2. Labels shall have an adhesive backing and shall wrap completely around the circumference of the cable
- 10 jacket. Label and lettering sizes shall be of appropriate size in regard to cable diameter.
- 11 C. Equipment Racks, Termination Hardware, and Faceplates
- 12 1. LABELING SCHEME TO BE SPECIFIED BY OWNER.
- 13

14 3.6. TESTING

- 15 A. Category 6 and 6A Cable Testing
- 16 1. Permanent Link Testing shall be completed on all horizontal (station) cables. The Contractor will be
- 17 responsible to supply a Channel warranty, but CITY OF MADISON is requiring that the contractor supply
- 18 all manufacturer patch cords per the contract.
- 19 2. Category 6 and 6A cabling systems shall be tested as an installed horizontal permanent link configuration.
- 20 Jacks and faceplates shall be assembled complete and properly mounted into outlet boxes. Panels shall
- 21 be terminated complete and fully dressed in proper cable management.
- 22 3. All wiring shall be certified to meet or exceed the specifications as set forth in TIA-568C for Category 6
- 23 requirements for permanent link. All test will be performed to 250MHz.
- 24 4. Field Testing shall include the following parameters for each pair of each cable installed:
- 25 a. Name of the person performing the test.
- 26 b. Test equipment manufacturer and model number.
- 27 c. Cable I.D. The test sheets will be in numerical order by cable ID.
- 28 d. Date of test.
- 29 e. Wire map (pin to pin connectivity and polarity check)
- 30 f. Length (in feet)
- 31 g. Insertion Loss.
- 32 h. Near End Crosstalk (NEXT).
- 33 i. Power Sum Near End Crosstalk (PSNEXT).
- 34 k. Equal-Level Far End Crosstalk (ELFEXT).
- 35 l. Power Sum Equal-Level Far End Crosstalk (PSELFEXT).
- 36 m. Return Loss.
- 37 n. Delay Skew.
- 38 o. Attenuation to Crosstalk ratio (ACR).
- 39 5. A "PASS" indication shall be obtained for each link, using at minimum a level III tester that complies with
- 40 TIA/EIA-568-B.2 field test requirements.
- 41 6. Record test results for each cable and turn over to the General Contractor Upon completion of the job.
- 42 Correct malfunctions when detected, and re-test to demonstrate compliance. Note: Test equipment
- 43 shall be a Type III cable Tester.
- 44 B. Optical Fiber Testing:
- 45 1. Test procedures shall be as described by the TIA/EIA-568-B: Commercial Building Telecommunications
- 46 Cabling Standard, Parts 2 and 3 and TIA/EIA-526-14-A-1998 - Optical Power Loss Measurements of
- 47 Installed Multimode Fiber Cable Plant-OFSTP-14A
- 48 2. Preinstallation Testing:
- 49 a. Test each conductor of every optical fiber cable on the reel with a light source and a power meter.
- 50 b. Obtain the cable manufacturer power meter test results for each reel used on the project. Using
- 51 the attached Optical Fiber Test Form record the readings and the manufacturer's reel number.
- 52 Prior to completion of project, turn over the completed optical fiber test form, optical fiber cable
- 53 reel ID tags and optical fiber cable manufacturer's test results.
- 54 3. Acceptance Testing:
- 55 a. Each terminated fiber strand in the horizontal or backbone infrastructure shall be tested
- 56 individually as a permanent link. A fiber permanent link is defined as a length of individual fiber
- 57 strand with a connector terminated on each end.

- b. Testing for multimode shall be at 850 and 1300 nanometers. Total link insertion loss (dB) shall be within the specified link loss budget.
- c. Tier 1 testing for each installed singlemode link shall be performed as an optical power insertion loss measurement, as defined by ANSI/TIA/EIA-526-7. Testing for singlemode shall be at 1310 and 1550 nanometers. Total link insertion loss (dB) shall be within the specified link loss budget.
- d. Tier 2 testing, if required for each installed singlemode or multimode link, shall be performed as an OTDR measurement, as defined in TIA-TSB-140. We require Tier 2 testing on all fibers installed in the facility for future troubleshooting.
- e. Multimode optical fiber attenuation shall be tested on all individual fibers of each cable segment using an LED light source and power meter to determine the actual loss. These tests shall be performed at the 850nm and 1300nm windows in both directions. Test set up and performance shall be in accordance with ANSI/TIA/EIA-526-14A, Method B.
- f. A reference power measurement shall be obtained by connecting one end of test jumper 1 to the light source and the other end to the power meter. After recording the reference power measurement, test jumper 1 shall be disconnected from the power meter without disturbing the light source and attached to the cable plant. The power meter shall be moved to the far end of the cable plant and attached to the cable plant with test 2.
- g. Readings must not be higher than the "Optimal Attenuation Loss." The OAL will be calculated using the manufacturer's factory certified test results, (db/km) converted to the actual installed lengths plus the manufacturer's best published attenuation losses for the connector and/or splice installed on this project. (0.30+/-0.30 for Connectors and 0.10 for splices). The construction manager shall use the OAL for comparison with the end to end power loss test results prior to acceptance.
- h. Test Results: Must be completed and turned over to the General Contractor prior to active equipment installation. Specific due dates for optical fiber will be established at pre-install meeting.

END OF SECTION