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PART 1 - GENERAL

1.01 SCOPE

- A. Specific details of vehicular pavements, exterior slabs, sidewalks, and curbs constructed of Portland Cement Concrete (PCC) are also addressed in WSU Design Standard 32 13 13 "Concrete Paving."

1.02 Design Criteria

- A. Concrete Strength: The Engineer of Record shall specify the required concrete strength for all applications. Specify the following 28-day compressive strengths, at a minimum:
1. Interior Concrete: 3000 psi minimum
 2. Exterior Concrete Exposed to Freeze/Thaw: 4500 psi minimum
 - i. Water Cement Ratio ≤ 0.45 for exterior concrete exposed to freeze/thaw
- B. Air Entrainment: Specify air entrainment 5 – 8% for all exterior concrete.
1. For color-dyed concrete, Engineer of Record shall specify the air entrainment required.
- C. Joints:
1. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
 2. Control Joints:
 - i. Install control joints as close to square as possible. Score at least one-quarter the depth of the concrete pavement. Joints may be sawcut or tooled, but sawcutting shall be done within 24 hours of concrete placement.
 3. Construction Joints: The Architect or Engineer of Record shall indicate or approve locations. Install so strength and appearance of concrete are not impaired.
 - i. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise specified by the Engineer of Record.

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- ii. Horizontal Joints: Locate in walls and columns at the underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 - iii. Vertical Joints: Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
 - iv. Bonded Joints: Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces. The hardened concrete surface shall first be roughened in a manner that exposes sound aggregate uniformly without damaging the concrete.
 - v. Waterstops: Install in Construction Joints to form a continuous diaphragm. Install in longest lengths possible.
4. Expansion Joints: Engineer of Record shall indicate locations, distances, and depths.
- i. Place expansion joints, at a minimum:
 - 1) At intersections between different paving materials,
 - 2) Where concrete paving abuts structures (buildings, retaining walls, etc.).
 - ii. Discontinue reinforcement at Expansion Joints unless otherwise indicated by the Engineer of Record.
 - iii. Joint-Filler Strips: Install full width and depth of joint, terminating flush with the finished concrete surface. Install joint-filler strips in lengths as long as possible. Where more than one strip is required, lace or clip sections together.
5. Doweled Joints: Engineer of Record shall indicate locations.
- i. Lubricate or asphalt coat half the dowel length to prevent concrete bonding to one side of the joint.
- D. Finishes:
- 1. The finish surface of all concrete shall be uniform in texture, smooth, and free of hollows, depressions, and surface cracks.
 - 2. Finish Requirements for Exterior Walks, Stairs, Ramps: Provide with heavy broom finish, with the broom texture perpendicular to traffic flow. Top flat flange marks of scoring tools and edgers shall be obliterated with

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broom strokes, leaving only a rounded edge. Limit surface working to maintain air entrainment. Curbs shall not be broom finished.

E. Stair Nosing and/or Slip Resistance

1. Interior Stairs: All interior concrete stairs treads shall contain an embedded abrasive nosing.
 - i. Preferred manufacturer: Wooster Products, Inc., or approved equivalent.
 - 1) Type 231 Supergrit for concrete stairs.
 - 2) Type 23 Supergrit for steel pan concrete-filled stairs.
2. Exterior Stairs

F. Exposed aggregate concrete surfaces are not acceptable.

PART 2 - PRODUCTS

2.01 PRODUCTS

1. Cement: ASTM Designation C-150, Type I or Type II. Type III may be used for cold-weather applications. Engineer of Record is responsible for specifying and approving the proper cement type and supplements.
 - i. High-early strength cement may be used when it is necessary to open the area to traffic after 7 days of curing, but shall require the same strength as regular concrete at 28 days of curing.
2. Aggregates: Aggregates shall be composed of clean, natural-crushed gravels complying with ASTM Designation C-33. In general (unless otherwise specified by the Engineer of Record), maximum size of coarse aggregate shall not exceed:
 - i. Three-fourths of the minimum clear spacing between reinforcing bars or between reinforcing bars and forms
 - ii. One-fifth of the narrowest dimension between the sides of the forms
 - iii. One-third of the thickness of the slab or toppings
3. Form-Release Agent: Specify commercially formulated water-based form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatment of concrete surfaces.

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- i. Specify form-release agent with rust inhibitor for steel form-facing materials.
- 4. Horizontal Expansion Joint Sealant
 - i. Pre-Approved Manufacturer: Sikaflex 1c SL
- 5. PCC Rehabilitation Material:
 - i. Pre-Approved Manufacturers: MasterEmaco T545; Kwik Bond PPC-1121

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- 1. Reinforcing Bars: Deliver, store, and handle steel reinforcement to prevent bending or damage. Keep reinforcement off the ground using pallets, dunnage, or other supports.
- 2. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

3.02 FORMWORK

- 1. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

3.03 CONCRETE MIXING

- 1. Ready-Mix: Measure, batch, mix, and deliver concrete according to ASTM C-94 / C-94M.
 - i. When air temperature is between 85-90° F, limit mixing and delivery time to 75 minutes. When air temperature is above 90° F, limit mixing and delivery time to 60 minutes.
- 2. Project-Site Mixing: Measure, batch, mix, and deliver concrete according to ASTM C-94 / C-94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - i. For mixer capacity of 1 cu. yd. or smaller, continue mixing 1½ - 5 minutes after ingredients are in the mixer before any part of the mixture is released.

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- ii. For mixer capacity larger than 1 cu. yd., increase mixing time by 15 seconds for each additional cu. yd.
- 3. Furnish batch ticket for each batch discharged and used to the WSU Construction Manager, indicating project name and number, date, mixture type, mixture time, mixture quantity, and amount of water (include the amount of water in the batch from the plant and any additional water added at the site). Record approximate location of final batch placement at the project.

3.04 COLD-WEATHER PLACEMENT:

- A. Comply with ACI 306.1. Protect concrete from physical damage or reduced strength that may be caused by frost, freezing, or low temperatures.
- B. When air temperature is expected to fall below 40° F, uniformly heat water and aggregates before mixing to obtain a concrete temperature not less than 50° and not more than 80° F at point of placement.
- C. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
- D. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise approved in the mix design by the Engineer of Record and WSU Engineering Services.

3.05 HOT-WEATHER PLACEMENT

- A. Comply with ACI 305.1 and as follows.
- B. Maintain concrete temperature below 90° F at point of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated within the total quantity of mixing water.
- C. When temperature of steel reinforcement or forms is greater than 120° F, fog-spray reinforcement, embedments, and forms before placing concrete.
- D. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

3.06 INCLEMENT WEATHER

- A. Do not begin placing concrete while rain, sleet, or snow is falling unless adequate protection is provided. Do not allow rainwater to increase mixing water or to damage the concrete surface.

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3.07 CURING: Cure concrete according to ACI 308.1, by one of the following methods:

- A. Moisture Curing: Keep surface continuously moist for not less than seven days with the following methods:
 - 1. Water
 - 2. Continuous water-fog spray
 - 3. Absorptive cover, water-saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
- B. Moisture-Retaining Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12-inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 - 1. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
 - 2. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
- C. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - 1. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by the curing compound manufacturer, unless manufacturer certifies curing compound will not interfere with bonding of the floor covering used on the project.
- D. Curing and Sealing Compound: Apply uniformly to floors and slabs in a continuous operation by power spray or roller according to the manufacturer's instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.08 JOINT FILLING

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- A. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.09 CONCRETE SURFACE REPAIRS

- A. 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 $\frac{1}{2}$ inch in any dimension to solid concrete. Limit cut depth to $\frac{3}{4}$ inch. Make edges of cuts perpendicular to surface concrete; do not feather edge. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried.
 - 2. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
- B. Structural Repairs of Cracks: Use epoxy resin adhesive by direction injection as approved by the Engineer of Record:
 - 1. Cracks in excess of 0.01 inch (0.25mm) which extend through the full depth of a slab or wall.
 - 2. Cracks in excess of 0.015 inch (0.38mm) which do not extend through the full depth of a slab or wall.
 - 3. Cracks which are subject to allowing water leakage through the crack.

3.10 FIELD QUALITY CONTROL

- A. Contractor shall submit concrete mix design for approval by the Engineer of Record and WSU Engineering Services. Submit alternate design mixtures when project conditions or weather warrant adjustments.
- B. Inspection and Testing: WSU may retain a Special Inspector to perform on-site inspection and testing services. During the course of construction, the Inspector will advise the WSU PM in writing, with written copy to the Contractor, if any work does not appear to conform to the Contract Documents. Special Inspectors may perform inspections and tests including, but not limited to, those specified below:

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- i. Subgrade and backfill compaction tests per WSDOT Standard Specifications
- ii. Field verification of concrete mix design.
- iii. Field verification of materials, application, and installation.
- iv. Concrete slump test (inspector shall sample and test first, middle, and last concrete trucks during each placement).
- v. Concrete compressive strength test.

3.11 ACCEPTABLE TOLERANCES

A. Surface Irregularities (designated by ACI 347 as abrupt or gradual):

1. Surface Class A: $\frac{1}{8}$ inch
2. Surface Class B: $\frac{1}{4}$ inch

B. Elevation: $\frac{1}{4}$ inch

C. Thickness: Plus $\frac{3}{8}$ inch, minus $\frac{1}{4}$ inch

D. Surface Slope: Shall not vary from Construction Drawings and specifications more than $\frac{1}{4}$ inch per 10-feet.

E. Joints:

1. Spacing: 3 inches
2. Width: Plus $\frac{1}{8}$ inch, no minus
3. Control Joint Depth: Plus $\frac{1}{4}$ inch, no minus

END OF SECTION