SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Portland Cement Concrete Pavement.
2. Cement Treated Base Course.

B. Related Sections:

1. Specification Section 321317 “Joint Sealants” for information regarding joint sealants and backer rods.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

B. Cement treated base course: A way to strengthen an aggregate base layer of material by mixing a specified amount of cement powder into aggregate base material to a certain depth with a specified amount of water.

1.4 SPECIFICATIONS

A. FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS” for the following items:

a. P-304: Cement-Treated Base Course
b. P-501: Portland Cement Concrete Pavement
c. P-605: Joint Sealing Filler
d. P-620: Taxiway Painting

The subsection for “Method of Measurement” and “Basis of Payment” shall not apply for each of the items above.

B. FAA Advisory Circular 150/5320-6D “AIRPORT PAVEMENT DESIGN AND EVALUATION”.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Action Submittals:

1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Qualification Data: For qualified ready-mix concrete manufacturer.

D. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Dowels and dowel baskets.
3. Admixtures.
4. Curing compounds.
5. Applied finish materials.
6. Bonding agent or epoxy adhesive.
7. Joint fillers.

E. Material Test Reports: For each of the following:

1. Aggregates: Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

1.6 QUALITY ASSURANCE

A. Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

D. Concrete Materials Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

E. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

F. Preinstallation Conference: Conduct conference at Project site one week prior to the first day of pavement concrete pouring.

1. Review methods and procedures related to concrete paving, including but not limited to, the following:

    a. Concrete mixture design.
    b. Quality control of concrete materials and concrete paving construction practices.

2. Require representatives of each entity directly concerned with concrete paving 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 paving subcontractor.

1.7 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 CEMENT-TREATED BASE

A. Comply with FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”. Refer to section P-304 for detailed information and specifications.

B. Portland Cement: Type I or II.

C. Aggregate: The aggregate shall be select granular materials, comprised of crushed or uncrushed gravel and/or stone, or recycled crushed and graded portland cement concrete (PCC). The material shall be free of roots, sod, and weeds. The crushed or uncrushed aggregate shall consist of hard, durable particles of accepted quality, free from an excess of soft, flat, elongated, or disintegrated pieces, and objectionable matter. The method used in producing the aggregate shall be such that the finished product is as consistent as practicable. All stones and rocks of inferior quality shall be wasted. When recycled PCC is used as the aggregate, it must meet the requirements for virgin aggregate.

The percentage of wear of the crushed aggregate retained on the No. 4 (4.75-mm) sieve shall not be greater than 40 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

When tested in accordance with ASTM C 136, the aggregate shall conform to the gradations shown in Table 1. An aggregate blend that meets the requirements of Table 1 shall be selected by the Contractor and used in the final mix design. The final aggregate blend shall be well graded from coarse to fine within the limits designated in the table and shall not vary from the low limit on one sieve to the high limit on adjacent sieves, or vice versa. The portion of final aggregate blend passing the No. 40 (425-µm) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 when tested in accordance with ASTM D 4318.

Table 1. Aggregate Gradation for CTB Material.

Sieve Size	Percentage by Weight Passing Sieves	
	Gradation A	Gradation B
2 in (51 mm)	100 [1]	100 [1]
No. 4 (4.75 mm)	45 - 100	55 - 100
No. 10 (1.80 mm)	37 - 80	45 - 100
No. 40 (450 μm)	15 - 50	25 - 80
No. 80 (210 μm)	0 - 25	10 - 35

[1] Maximum size of aggregate is 1 in (25.4 mm) when used as a base course under Item P-501, Portland Cement Concrete Pavement.

All aggregate samples required for testing shall be furnished by the Contractor at the expense of the Contractor. Sampling shall be performed by the Contractor in accordance with ASTM D 75.

D. Cementitious additives: Pozzolanic and ground granulated blast furnace (GGBF) slag may be added to the CTB mix. If used, each material must meet the following requirements:
   1. Pozzolan: Pozzolanic materials must meet the requirements of ASTM C 618, Class C, F, or N with the exception of loss of ignition, where the maximum shall be less than 6 percent for Class F or N. [The supplementary optional chemical and physical properties of tables 1A and 2A contained in ASTM C 618 shall apply].
   2. GGBF Slag. Slag shall conform to ASTM C 989, Grade 80, 100, or 120.

E. Water: Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product. Water shall be tested in accordance with the requirements of AASHTO T 26. Water known to be of potable quality may be used without testing.

F. Curing Materials: Curing materials shall conform to the requirements provided below, as defined by the type of pavement surface to be placed on top of the CTB layer.

G. Portland Cement Concrete (PCC) Pavement: For curing CTB placed under PCC pavement, use white-pigmented, liquid membrane-forming compound conforming to ASTM C 309, Type 2, Class A or Class B (wax-based).

H. General Composition: The CTB material shall be composed of a mixture of aggregate, [Portland cement] [blended hydraulic cement], and water. Fly Ash or GGBF slag may be used as a partial replacement for Portland cement.

I. Mix Design: The mix design shall utilize a cement content that, when tested in the laboratory according to ASTM D 1633, produces a 7-day compressive strength meeting the following requirements:
   1. For CTB placed under PCC pavement: 500 psi (3,447 kPa) minimum and 1,000 psi (6,895 kPa) maximum.

Wet-dry and/or freeze-thaw tests shall be performed in accordance with ASTM D 559 and D 560, respectively. The weight loss for each type of test shall not exceed 14 percent after 12 cycles. However, if a 7-day compressive strength of 750 psi (5,170 kPa) is achieved, the wet-dry and freeze-thaw tests are not necessary.

An estimated cement content may be determined from Table 1, Chapter 2, of the Soil-Cement Laboratory Handbook, published by the Portland Cement Association (PCA). In designing the mixture, cement contents above and below the initial estimated amount should be tested to determine the minimum quantity of cement needed to achieve the required strength (or strength and durability where freeze-thaw resistance is deemed necessary by the Engineer).

The mix design shall include a complete list of materials, including type, brand, source, and amount of cement, fine aggregate, coarse aggregate, water, and cementitious additives, if used. It shall also contain the 7-day compressive strength test results and the results of the wet-dry and/or freeze-thaw tests.

Should a change be made in aggregate sources or type of cement, or if cementitious additives are added or deleted from the mix, production of the CTB mix shall be stopped and a new mix design shall be submitted.

J. Submittals: At least fourteen (14) days prior to the placement of the CTB, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the CTB material. Tests older than 6 months shall not be used. The certification shall show the ASTM or AASHTO specifications or tests for the material, the name of the company performing the tests, the date of the tests, the test results, and a statement that the material did or did not comply with the applicable specifications. The submittal package shall include the following:

1. Sources of materials, including aggregate, cement, cementitious additives, curing, and bond-breaking materials.

2. Physical properties of the aggregates, cement, cementitious additives, curing, and bond-breaking materials.

3. Mix design
   a. Mix identification number.
   b. Aggregate gradation.
   c. Cement content.
   d. Water content.
   e. Cementitious materials content.

4. Laboratory test results
   a. Compaction and strength testing procedures.
   b. Laboratory compaction characteristics (maximum dry density and optimum moisture content).
   c. Compressive strength at 7 days.
   d. Wet-dry and/or freeze-thaw weight loss, if applicable.

No CTB material shall be placed until the submittal is accepted in writing by the Engineer.

During production, the Contractor shall submit batch tickets for each delivered load.

K. Equipment: All equipment necessary to mix, transport, place, compact, and finish the CTB material shall be furnished by the Contractor. The equipment shall be inspected and approved by the Engineer at the job site prior to the start of construction operations.

2.2 FORMS

A. Comply with FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”. See section P-501 for more information.

B. Form Materials: Use straight side forms made of steel, having a thickness of not less than 7/32 inch and not less than 10 feet in length. Wood forms are not permitted. Forms shall have a depth equal to the prescribed edge thickness of the concrete without horizontal joint, and a base width equal to the depth of the forms. Flexible or curved forms of proper radius shall be used for curves of 100-foot radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base not less than two-thirds the height of the form. Forms with battered top surfaces and bent, twisted, or broken forms shall be removed from the work. Repaired forms shall not be used until inspected and approved. Built-up forms shall not be used. The top face of the form shall not vary from a true plane more than 1/8 inch in 10 feet, and the upstanding leg shall not vary more than ¼ inch. The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting.

C. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Comply with FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”. See section P-501 for more information.

B. Epoxy-Grouted, Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars. See drawings for more information.

C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

D. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.

2.4 CONCRETE MATERIALS

A. Comply with FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”. See section P-501 for more information.

B. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C 150, gray portland cement Type I or Type II .

   a. Fly Ash: ASTM C 618, Class F. The weight of fly ash in the mix shall not exceed 15% of the total added weight of the fly ash and Portland Cement.

C. Normal-Weight Aggregates: ASTM C 33, Class 4S Class 4M or Class 1N , uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.

1. Coarse Aggregate: ASTM C 33, from a single source. Percentage of wear shall be nor more than 40 when tested in accordance with ASTM C131 for aggregate less than 1-1/2" and ASTM C535 for aggregates less than ¾". Gradation shall be a blend of the two sizes listed in Table 1:

TABLE 1: GRADATION FOR COARSE AGGREGATE		
Sieve Designations	Percentage of Weight Passing Sieves	
(inches)	1-1/2-3/4"	3/4"-No.4
2-1/2"	--	--
2"	100	--
1-1/2"	100	--
1"	25-55	100
3/4"	0-15	90-100
1/2"	--	--
3/8"	0-5	20-55
No.4	--	0-10
No.8	--	0-5

2. Fine Aggregate: ASTM C 33, from a single source. Gradation shall meet the requirements of Table

TABLE 2: GRADATION FOR FINE AGGREGATE	
Sieve Designations	Percentage of Weight Passing Sieves
(inches)	--
3/8"	100
No.4	95-100
No.8	80-100
No.16	50-85
No.30	25-60
No.50	10-30
No.100	2-10

D. Water: Potable and complying with ASTM C 94/C 94M.

E. Air-Entraining Admixture: ASTM C 260. Add to the mixer in the amount necessary to produce the specified air content. The air-entrainment agent and the water reducer admixture shall be compatible. Add air-entraining admixture in such a manner that will ensure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrained concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air entrainment in the mix shall be in accordance with Table 3 plus or minus 1-1/2 percentage points. Air content shall be determined by testing in accordance with ASTM C 231 for gravel and stone coarse aggregate.

TABLE 3: AIR ENTRAINED TOLERANCES	
Coarse Aggregate Size	Air Content Percent by Volume
1"	1.5% (natural)

F. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.5 CURING MATERIALS

A. All curing materials are subject to the review and approval of the Engineer.

B. Comply with FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”. See section P-501 for more information.

C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

2.6 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork in preformed strips.

B. Joint Sealers: See spec section 321373 “CONCRETE PAVING JOINT SEALANTS”.

2.7 CONCRETE MIXTURES

A. Comply with FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”. See section P-501 for more information.

B. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.

C. Proportions: Proportioning requirements shall be for a flexural strength of 700 psi. Flexural strength shall be specified at 28 days using test specimens prepared in accordance with ASTM C31 and tested in accordance with ASTM C78. For slip-form construction, a high degree of uniformity in the plastic concrete is required. Caution should be exercised in establishing the air-entrainment percentage, as excessive air entrainment will aggravate edge slumping and insufficient air entrainment will result in poor concrete durability. Some edge slump of the wet concrete behind the side form on the paving machine will occur, even with low slump concrete. This may continue, though very slowly, until initial set has taken place.

D. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 6000 psi.

2. Flexural strength: 700 psi.
3. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.53 by weight
4. Slump Limit: 4 inches.

E. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 4.5 to 7.5 percent.

F. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture, high-range, water-reducing admixture, high-range, water-reducing and retarding admixture, or plasticizing and retarding admixture in concrete as necessary for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

G. Cementitious Materials: Limit percentage by weight of cementitious materials other than Portland Cement according to ACI 301 (ACI 301M) requirements as follows:

1. Fly Ash or Pozzolan: 20 percent.

H. Minimum Cementitious material: 564 pounds per cubic yard of total weight of fly ash and Portland Cement combined.

2.8 CONCRETE MIXING

A. Comply with FAA Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”. See section P-501 for more information.

B. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94MFurnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 EQUIPMENT

A. The batch plant and equipment shall conform to the requirements of ASTM C94.

B. The finishing equipment shall be of sufficient weight and power for proper finishing of the concrete. The finishing machine shall be designed and operated to strike off, screed, and consolidate the concrete so that laitance on the surface is less than 1/8-inch (3 mm) thick.

3.2 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph (5 km/h).
2. Proof-roll with any pneumatic-tired vehicle weighing no less than 15 tons (13.6 tonnes).
3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch (13 mm) according to requirements in Division 31 Section "Earth Moving."

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.4 COMPACTION OF BASE LAYERS

A. General: Comply with FAA compaction requirements per Advisory Circular 150/5370-10C “STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS”.

B. Generalized compaction requirements are as follows:
   1. Cement-treated base: Compact the full section to 98% relative compaction per ASTM D1557.

3.5 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

   1. All forms shall be fully supported on the base material including any bracing or kickers. Forms shall be set sufficiently in advance of the concrete placement to ensure continuous paving operation. After the forms have been set to correct grade, the grade shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place with not less than 3 pins for each 10-foot section. A pin shall be placed at each side of every joint.
   2. Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than ¼ inch at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of concrete.
   3. The alignment and grade elevations of the forms required for any one day's production shall be checked and corrections made by the Contractor before placing any concrete that day. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.6 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch (50-mm) overlap of adjacent mats.

3.7 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 feet (15.25 m) unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Install joint filler per the drawings.
4. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
5. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction (Control) Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth as indicated on the drawings.

1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut wide joints into concrete to depths shown on the drawings when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

a. Tolerance: Ensure that sawed joints are within 3 inches (75 mm) either way from centers of dowels.

2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.8 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

F. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating dowels and joint devices.

G. Screed paving surface with a straightedge and strike off.

H. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

I. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

J. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

K. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided

water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.9 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

3.10 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

    a. Water.
    b. Continuous water-fog spray.
    c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm) and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.11 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/4 inch (19 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/2 inch (13 mm).
4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches (13 mm per 300 mm) of tie bar.
5. Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).
6. Vertical Alignment of Dowels: 1/4 inch (6 mm).
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (6 mm per 300 mm) of dowel.
8. Joint Spacing: 3 inches (75 mm).
9. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
10. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 500 cu. yd. (380 cu. m) or fraction thereof of each concrete mixture placed each day.

    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; 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. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C 231, pressure method; 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 C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.

5. FlexuralTest Specimens: ASTM C 31/C 31M.

a. Concrete samples shall be furnished by the Contractor for each sublot and shall be taken in the field to determine the consistency, air content, and strength of concrete. A lot is defined as 2000 CY and shall be divided into four equal sublots. Flexural test beams shall be made for each sublot. Each group of test beams shall be molded from the same batch of concrete and shall consist of six test beams molded from the same batch of concrete to provide two flexural strength tests at each test age and two beams to be held in reserve. Each set of beams shall be identified as to date of placement, time of day, mix and ambient temperature, batch number, slump, until weight and air content. The specimen shall be made in accordance with ASTM C 31. However, at the start of paving operations and when the aggregate source, aggregate characteristics, or mix design is changed, additional groups of test beams may be required until the Engineer is satisfied that the concrete mixture being used complies with the strength requirements of these specifications. Test ages will be 7 days and 28 days.

b. The flexural strength of the concrete for each sublot shall be tested and shall meet the following requirements: (1) the average of two strength tests for each sublot, test at the end of 28 days, shall have an average flexural strength equal to or greater than the specified flexural strength; (2) none of the beams tested at the end of 28 days shall have a flexural strength less than 700 psi. Specimens that are obviously defective shall not be considered in the determination of the strength. When it appears that the test specimens will fail to conform to the requirements for strength, the Engineer shall have the right to order changes in concrete sufficient to increase the strength to meet the established requirements. When a satisfactory relationship between 7-day and 28-day strengths has been established and approved, the 7-day test results may be used as an indication of the 28-day strengths. However, the 7-day test results will not replace the results of the 28-day tests if the 28-day results fall below the requirements. All acceptance testing will be performed by the Owner's laboratory, which will have full authority for determining compliance with the specified flexural strength shall be removed and replaced at the Contractor's expense.

C. Test results shall be reported in writing to Engineer, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

D. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.

E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer.

F. Concrete paving will be considered defective if it does not pass tests and inspections.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

H. Prepare test and inspection reports.

3.13 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Engineer.

B. Drill test cores, where directed by Engineer, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

3.14 CEMENT TREATED BASE

A. Equipment: All equipment necessary to mix, transport, place, compact, and finish the CTB material shall be furnished by the Contractor. The equipment shall be inspected and approved by the Engineer at the job site prior to the start of construction operations.

B. Mixing: The mixer shall be a batch or continuous-flow type stationary mixer and shall be equipped with calibrated metering and feeding devices that introduce the aggregate, cement, water, and cementitious additives (if used) into the mixer in the specified quantities. If necessary, a screening device shall be used to remove oversized material greater than 2 in (51 mm) from the raw aggregate feed prior to mixing.

Free access to the plant must be provided at all times for inspection of the plant's equipment and operation and for sampling the CTB mixture and its components, as deemed necessary by the Engineer.

C. Recycled PCC: An area on-site will be designated to be used for an on-site crushing and mixing plant.

D. Hauling: The mixed CTB material shall be transported from the plant to the job site in trucks or other hauling equipment having beds that are smooth, clean, and tight. Truck bed covers shall be provided and used to protect the CTB from rain. CTB material that becomes wet during transport shall be subject to rejection.

E. Placing: CTB material shall be placed using a mechanical spreader or a machine capable of receiving, spreading, and shaping the mixture without segregation into a uniform layer or lift. The equipment shall be equipped with a strike-off plate capable of being adjusted to the specified layer thickness. It shall also be equipped with two end gates or cut off plates, so that the CTB may be spread in widths varying up to lane width.

F. Compaction: Compaction of the CTB layer shall be accomplished using one or a combination of the following pieces of equipment:

1. Tamping or grid roller.
2. Steel-wheeled roller
3. Vibratory roller.

4. Pneumatic-tire roller.
5. Vibrating plate compactor (for areas inaccessible to rollers).

The number, type, and weight of rollers and/or compactors shall be sufficient to compact the mixture to the required density.

G. Finishing: Final trimming of the compacted CTB to meet surface requirements shall be accomplished using a self-propelled grader or trimming machine, with a mold board cutting edge, which is at least 12 ft (3.7 m) wide and is automatically controlled by sensors in conjunction with an independent grade control from a taut stringline. Stringline will be required on both sides of the sensor controls for the pilot lane. For all other lanes, a single stringline on the outside and grade matching with previously completed adjacent lanes is permissible.

H. Weather Limitations:

1. Cold Weather: The CTB material shall not be mixed or placed while the air temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 35°F (2°C) within 24 hours. The CTB shall not be placed on frozen surfaces.
2. Rain: The CTB may not be placed when rainfall is occurring. If an unexpected rain event occurs during placement, the layer should be quickly compacted. CTB material that becomes wet by rain during transport or placement shall be evaluated by the Engineer, and may be subject to rejection.

I. Preparation of Underlying Course: The underlying course shall be checked by the Engineer before placing and spreading operations are started, in order to ensure that it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause, shall be corrected before the CTB mixture is placed thereon. The underlying course shall be wetted in advance of placing the CTB layer. The final prepared grade prior to placing the CTB should be in a firm and moist condition free of frost. Use of chemicals to eliminate frost will not be permitted.

To ensure proper drainage, placement of the base shall begin along the centerline of the pavement on a crowned section or on the highest elevation contour of a pavement with variable cross slope.

J. Grade Control: Grade control between the edges of the CTB shall be accomplished at intervals of 50 ft (15.2 m) or less on the longitudinal grade and at 25 ft (7.6 m) or less on the transverse grade.

K. Handling, Measuring, and Batching: The continuous flow central plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Aggregate stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials.

Aggregates that are segregated or mixed with earth or foreign material will not be accepted.

Continuous flow plants shall be equipped with feeders to proportion aggregates and bulk cement, by weight, automatically and accurately. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot or other device, to prevent loss of cement. The device shall be arranged to provide positive assurance that the cement content specified is present in each batch.

L. Mixing: Aggregate and cement may be proportioned either by weight or volume, and shall be mixed sufficiently to prevent the forming of cement balls when water is added. The mixing time shall be that

which is required to secure an intimate, uniform mixture of aggregate, cement, water, and pozzolan (if used). The minimum mixing time will be based on the uniformity and consistency of the mixture.

M. Placing: The CTB mixture shall be deposited on the moistened subgrade or subbase and spread into a uniform layer of such width and thickness that, following compaction and trimming, conforms to the required grade and cross-section. The Contractor may install the CTB layer in single or multiple compacted lifts; however, each compacted lift must be no greater than 6 in (152 mm) thick. In multi-lift construction, the surface of the compacted lift shall be kept moist until covered with the next lift. Successive lifts shall be placed and compacted so that the required total depth of the CTB layer is completed within 12 hours.

A single spreader may be used, provided it is capable of placing a uniform, full-depth layer of material across the full width of the base in one pass. Otherwise, two or more spreaders will be required, and shall be operated so that spreading progresses along the full width of the base in a uniform manner.

N. Compaction: Immediately upon completion of the spreading operations, the CTB material shall be thoroughly compacted using approved compaction equipment. At the start of compaction, the moisture content shall be within 2 percentage points of the specified optimum moisture.

O. Finishing: Upon completion of compaction, the surface of the CTB layer shall be shaped to the specified lines, grades, and cross-section. During the finishing process, the surface shall be kept moist by means of fog-type sprayers. Compaction and finishing shall be done in such a manner as to produce a smooth, dense surface, free of ruts, cracks, ridges, and loose material. All placement, compaction, and finishing operations shall be completed within 2 hours from the start of mixing. Material not completed within the 2-hour time limit shall be removed and replaced at the Contractor's expense.

CTB layer limits that extend beyond the edges of the new PCC surface course shall be rolled down or shaped in such a manner that the drainage is away from the new PCC surface course edge.

P. Construction Joints: At the end of each day's construction, a transverse construction joint shall be formed that is a true vertical face (perpendicular to the centerline) and is free of loose material.

Longitudinal construction joints (parallel to the centerline) shall be formed to a consistent, well-defined near vertical edge that is free of loose material. The longitudinal joints shall be located such that there is a 2-ft (0.6-m) minimum offset from planned joints in any overlying layer.

While forming construction joints, the Contractor shall make sure the material in the joint area is adequately compacted and that the joints are finished level and even with the remainder of the CTB layer.

Q. Curing: The compacted and finished CTB shall be cured with the approved curing agents as soon as possible, and in no case later than 2 hours after completion of the finishing operations. The layer shall be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied.

When asphalt emulsion is used as the curing agent, the entire surface of the CTB layer shall be uniformly sprayed with the emulsion at a rate of between 0.15 and 0.30 gal/yd^2 (0.7 and 1.4 L/m^2); the exact temperature and rate of application being that required to achieve complete and uniform coverage without runoff. Should it be necessary for construction equipment or other traffic to use the asphalt-covered surface, sufficient sand blotter cover shall be applied to prevent pick-up.

When liquid membrane-forming curing compound is used as the curing agent, the entire surface of the CTB layer shall be uniformly sprayed with the compound at the rate of 1 gal (3.8 L) to not more than 200 ft^2 (18.6 m^2). The rate of application shall be determined such that a uniform surface is obtained. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. The compound shall be thoroughly mixed with the pigment uniformly dispersed throughout the storage tank. During application, the compound shall be stirred continuously by effective mechanical means. Hand spraying of odd widths or shapes and CTB surfaces exposed by the removal of forms is permitted.

The curing seal shall be maintained and protected until the pavement is placed. Should the surface of the finished CTB and/or the curing seal become damaged, additional curing material shall be applied at the time it is damaged or when the damage is first observed.

R. Protection: The Contractor shall protect the finished CTB against traffic. Completed portions of the CTB layer can be opened immediately to low-speed traffic and to construction equipment, provided the curing material is not damaged and the CTB is sufficiently stable to resist permanent deformation. Should the CTB be damaged, it shall be replaced using full-depth patches, and sprayed with the selected curing compound as described above. The CTB shall also be protected from freezing at all times.

S. Bond-Breaker: When the CTB is to be placed directly beneath PCC, a bond-breaker selected by the Contractor shall be used. The entire surface of the CTB shall be coated with a de-bonding compound applied in a quality sufficient to prevent bonding of the PCC pavement to the base course. If an impervious membrane or asphalt emulsion is used as a curing material, additional applications of curing materials may be required. The Contractor shall be responsible for selecting the de-bonding compound and determining the necessary application rate. The de-bonding compound shall be approved by the Engineer prior to being incorporated into the work.

END OF SECTION 321313