

**SECTION 32 05 23**  
**CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
1. Subbase for concrete pavements.
  2. Curbs and gutters
  3. Pedestrian Pavement: Walks, pedestrian crossings, wheelchair curb ramps,

**1.2 RELATED REQUIREMENTS**

- A. Field Testing: Section 01 45 29, TESTING LABORATORY SERVICES.
- B. Subgrade Preparation and Subbase Compaction: Section 31 20 00, EARTHWORK.

**1.3 APPLICABLE PUBLICATIONS**

- A. Comply with references to extent specified in this section.
- B. American Association of State Highway and Transportation Officials (AASHTO):
1. M147-65-UL-04 - Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.
  2. M233-86 - Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
- C. American Concrete Institute (ACI):
1. 305R-10 - Guide to Hot Weather Concreting.
  2. 306R-10 - Guide to Cold Weather Concreting.
- D. American National Standards Institute (ANSI):
1. B101.3 - Wet DOCF of Common Hard Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values).
- E. ASTM International (ASTM):

1. A615/A615M-16 - Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
2. A996/A996M-15 - Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
3. A1064/A1064M-16 - Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
4. C33/C33M-16 - Concrete Aggregates.
5. C94/C94M-16 - Ready Mixed Concrete.
6. C143/C143M-15a - Slump of Hydraulic Cement Concrete.
7. C150/C150M-16 - Portland Cement.
8. C171-16 - Sheet Materials for Curing Concrete.
9. C260/C260M-10a - Air Entraining Admixtures for Concrete.
10. C309-11 - Liquid Membrane Forming Compounds for Curing Concrete.
11. C494/C494M-15a - Chemical Admixtures for Concrete.
12. C618-15 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
13. C979/C979M-16 - Pigments for Integrally Colored Concrete.
14. C989/C989M-14 - Slag Cement for Use in Concrete and Mortars.
15. C1240-15 - Silica Fume Used in Cementitious Mixtures.
16. D1751-04(2013)e1 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
17. D5893/D5893M-10 - Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
18. D6690-15 - Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

#### **1.4 PREINSTALLATION MEETINGS**

- A. Conduct preinstallation meeting at project site minimum 30 days before beginning Work of this section.

1. Required Participants:
  - a. Contracting Officer's Representative.
  - b. Inspection and Testing Agency.
  - c. Contractor.
  - d. Installer.
  - e. Other installers responsible for adjacent and intersecting work, including excavation, plantings, traffic markings.
2. Meeting Agenda: Distribute agenda to participants minimum 3 days before meeting.
  - a. Installation schedule.
  - b. Installation sequence.
  - c. Preparatory work.
  - d. Protection before, during, and after installation.
  - e. Installation.
  - f. Terminations.
  - g. Transitions and connections to other work.
  - h. Inspecting and testing.
  - i. Other items affecting successful completion.
3. Document and distribute meeting minutes to participants to record decisions affecting installation.

## **1.5 SUBMITTALS**

- A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submittal Drawings:
  1. Show size, configuration, and fabrication and installation details.
  2. Show reinforcing.
  3. Include jointing plan for concrete pavements, curbs and gutters.
- C. Manufacturer's Literature and Data:
  1. Description of each product.
  2. Installation instructions.
- D. Samples:

1. Exposed Aggregate Concrete Panel: 0.4 sq. m by 50 mm (4 sq. ft. by 2 inches) thick, 2 required, each color and finish.
  2. Colored Concrete Panel: As specified in Section 09 06 00, SCHEDULE FOR FINISHES, with mix data.
- E. Test reports: Certify products comply with specifications.
1. Concrete materials.
  2. Select subbase materials.
  3. Field test reports.
- F. Certificates: Certify products comply with specifications.
1. Expansion joint filler.
  2. Reinforcement.
  3. Curing materials.
  4. Concrete protective coating.
- G. Qualifications: Substantiate qualifications comply with specifications.
1. Installer with project experience list.
  2. Land surveyor.
- H. Concrete mix design.
- I. Select subbase job-mix design.
- J. Proposed hot and cold weather concreting methods.
- K. Land surveyor's construction staking notes, before placing concrete.
1. Identify discrepancies between field conditions and Drawings.

## **1.6 QUALITY ASSURANCE**

- A. Installer Qualifications:
1. Regularly installs specified products.
  2. Installed specified products with satisfactory service on five similar installations.
    - a. Project Experience List: Provide contact names and addresses for completed projects.
- B. Land Surveyor: Professional land surveyor or engineer registered to provide land surveys in jurisdiction where project is located.
- C. Preconstruction Testing:

1. Engage independent testing laboratory to perform tests and submit reports.
  - a. Deliver samples to laboratory in number and quantity required for testing.
2. Concrete mix design.
3. Select subbase job-mix design. Report the following:
  - a. Material sources.
  - b. Gradation.
  - c. Plasticity index.
  - d. Liquid limit.
  - e. Laboratory compaction curves indicating maximum density at optimum moisture content.

#### **1.7 DELIVERY**

- A. Deliver steel reinforcement to prevent damage.
- B. Before installation, return or dispose of distorted or damaged steel reinforcement.
- C. Bulk Products: Deliver bulk products away from buildings, utilities, pavement, and existing turf and planted areas. Maintain dry bulk product storage away from contaminants.

#### **1.8 STORAGE AND HANDLING**

- A. Store products indoors in dry, weathertight facility.
- B. Protect products from damage during handling and construction operations.

#### **1.9 FIELD CONDITIONS**

- A. Hot Weather Concreting Procedures: ACI 305R.
- B. Cold Weather Concreting Procedures: ACI 306R.
  1. Use non-corrosive, non-chloride accelerator admixture.
  2. Do not use calcium chloride, thiocyanates or admixtures containing more than 0.05 percent chloride ions.

## 1.10 WARRANTY

- A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

## PART 2 - PRODUCTS

### 2.1 CONCRETE MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type I or II.
- B. Pozzolans:
  - 1. Fly Ash: ASTM C618, Class C or F including supplementary optional physical requirements.
  - 2. Slag: ASTM C989/C989M; Grade 80, Grade 100.
  - 3. Silica Fume: ASTM C1240.
- C. Coarse Aggregate: ASTM C33/C33M; size to suit application .
- D. Fine Aggregate: ASTM C33/C33M.
- E. Mixing Water: Fresh, clean, and potable.
- F. Air-Entraining Admixture: ASTM C260/C260M.
- G. Chemical Admixtures: ASTM C494/C494M.
- H. Reinforcing Steel: ASTM A615/A615M or ASTM A996/A996M, Grade 280 (40deformed).
- I. Expansion Joint Filler: ASTM D1751.
- J. Sheet Materials for Curing Concrete: ASTM C171.
- K. Color Pigment: ASTM C979/C979M, colored and white powder pigments.
  - 1. AGGREGATE BASE Aggregate base for concrete paving shall be in conformance with Caltrans Standard Specifications, section 26-1.02, Class 2, 3/4" maximum aggregate size.

### 2.2 FORMS

- A. Forms: Wood, plywood, metal, or other materials, approved by Contracting Officer's Representative, of grade or type suitable to obtain type of finish specified.
  - 1. Plywood: Exterior grade, free of defects and patches on contact surface.

2. Lumber: Sound, grade-marked, S4S stress graded softwood, minimum 50 mm (2 inches) thick, free from warp, twist, loose knots, splits, or other defects.
  3. Form Coating: As recommended by Architect/Engineer.
- B. Provide forms suitable in cross-section, depth, and strength to resist springing during depositing and consolidating concrete.
1. Do not use forms varying from straight line more than 3 mm in 3000 mm (1/8 inch in 10 feet), horizontally and vertically.
- C. Provide flexible or curved forms for forming radii.

**2.3 CONCRETE CURING MATERIALS**

- A. Concrete curing materials, conform to one of the following:
1. Burlap: Minimum 233 g/sq. m (7 ounces/sq. yd.) dry.
  2. Sheet Materials for Curing Concrete: ASTM C171.
  3. Curing Compound: ASTM C309, Type 1 clear; liquid membrane forming type, without paraffin or petroleum.

**2.4 CONCRETE MIXES**

- A. Design concrete mixes according to ASTM C94/C94M, Option C.
- B. Concrete Type Air-entrained. See Table I.

TABLE I - CONCRETE TYPES					
Concrete Type	Minimum 28 Day Compressive Strength f'c MPa (psi)	Non-Air-Entrained		Air-Entrained	
		Min. Cement kg/cu. m (lbs./cu. yd.)	Max. Water Cement Ratio	Min. Cement kg/cu. m (lbs./cu. yd.)	Max. Water Cement Ratio
A	35 (5000)1,3	375 (630)	0.45	385 (650)	0.40
B	30 (4000)1,3	325 (550)	0.55	340 (570)	0.50
C	25 (3000)1,3	280 (470)	0.65	290 (490)	0.55
D	25 (3000)1,2	300 (500)	*	310 (520)	*
Footnotes:					

If trial mixes are used, achieve compressive strength 8.3 MPa (1,200 psi) in excess of f'c. For concrete strengths greater than 35 MPa (5,000 psi), achieve compressive strength 9.7 MPa (1,400 psi) in excess of f'c.

For Concrete Exposed to High Sulfate Content Soils: Maximum water cement ratio is 0.44.

3. Laboratory Determined according to ACI 211.1 for normal weight concrete.

C. Maximum Slump: ASTM C143/C143M. See Table II.

APPLICATION	MAXIMUM SLUMP
Curb & Gutter	75 mm (3 inches)
Pedestrian Pavement	75 mm (3 inches)
Vehicular Pavement	50 mm (2 inches) Machine Finished 100 mm (4 inches) Hand Finished

## 2.5 ACCESSORIES

- A. Equipment and Tools: Obtain Contracting Officer's Representative's, approval of equipment and tools needed for handling materials and performing work before work begins.
- B. Maintain equipment and tools in satisfactory working condition.
- C. Sealants:
  - 1. Concrete Paving Expansion Joints: ASTM D5893/D5893M, Type SL, single component, self-leveling, silicone joint sealant.
  - 2. Concrete Paving Joints: ASTM D6690, Type IV, hot-applied, single component joint sealant.
- D. Concrete Protective Coating: AASHTO M233 linseed oil mixture.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

- A. Examine and verify substrate suitability for product installation.
- B. Protect existing construction and completed work from damage.
- C. Prepare, construct, and finish subgrade. See Section 31 20 00, EARTHWORK.
- D. Maintain subgrade in smooth, compacted condition, in conformance with the required section and established grade until the succeeding operation has been accomplished.
- E. AGGREGATE BASE Placing:
  - 1. Place subbase material on prepared subgrade in uniform layer to required contour and grades, and to maximum 200 mm (8 inches) loose depth.
  - 2. When required compacted thickness exceeds 150 mm (6 inches), place subbase material in equal thickness layers.
  - 3. When subbase elevation is 13 mm (1/2 inch) or more below required grade, excavate subbase minimum 75 mm (3 inches) deep. Place and compact subbase to required grade.
- F. Compaction:
  - 1. Perform compaction with approved hand or mechanical equipment well suited to the material being compacted.
  - 2. Maintain subbase at optimum moisture content for compaction.
  - 3. Compact each subbase layer to minimum 95 percent of maximum density as specified in Section 31 20 00, EARTHWORK.
- G. Subbase Tolerances:
  - 1. Variation from Indicated Grade: Maximum 9 mm (3/8 inch).
  - 2. Variation from Indicated Thickness: Maximum 13 mm (1/2 inch).
- H. Protection:
  - 1. Protect subbase from damage until concrete is placed.
  - 2. Reconstruct damaged subbase before placing concrete.

### **3.2 SETTING FORMS**

- A. Form Substrate:
  - 1. Compact form substrate to uniformly support forms along entire length.
  - 2. Correct substrate imperfections and variations by cutting, filling, and compacting.
- B. Form Setting:
  - 1. Set forms to indicated line and grade with tight joints. Rigidly brace forms preventing movement.
  - 2. Remove forms when removal will not damage concrete and when required for finishing.
  - 3. Clean and oil forms before each use.
  - 4. Correct forms, when required, immediately before placing concrete.
- C. Land Surveyor: Establish control, alignment, and grade for forms
  - 1. Notify Contracting Officer's Representative immediately when discrepancies exist between field conditions and drawings.
  - 2. Correct discrepancies greater than 25 mm (1 inch) before placing concrete.
- D. Form Tolerances:
  - 1. Variation from Indicated Line: Maximum 6 mm (1/4 inch).
  - 2. Variation from Indicated Grade: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).

### **3.3 PLACING REINFORCEMENT**

- A. Keep reinforcement clean from contamination preventing concrete bond.
- B. Install reinforcement shown on drawings.
- C. Support and securely tie reinforcing steel to prevent displacement during concrete placement.
- D. Obtain Contracting Officer's Representative's reinforcement placement approval before placing concrete.

### **3.4 JOINTS - GENERAL**

- A. Place joints, where shown on approved submittal Drawings.

1. Conform to details shown.
  2. Install joints perpendicular to finished concrete surface.
- B. Make joints straight and continuous from edge to edge of pavement.

### **3.5 CONSTRUCTION JOINTS**

- A. Locate longitudinal and transverse construction joints between slabs of vehicular pavement as shown on approved submittal Drawings.
- B. Place transverse construction joints of type shown, where indicated, and whenever concrete placement is suspended for more than 30 minutes.
- C. Provide butt-type joint with dowels in curb and gutter at planned joint locations.
- D. Provide keyed joints with tie bars when joint occurs in middle third of planned curb and gutter joint interval.

### **3.6 CONTRACTION JOINTS**

- A. Tool or cut joints to width, depth, and radius edge shown on drawings using grooving tool, jointer, or saw.
- B. Construct joints in curbs and gutters by inserting 3 mm (1/8 inch) steel plates conforming to curb and gutter cross sections.
1. Keep plates in place until concrete can hold its shape.
- C. Finish joint edges with edging tool.
- D. Score pedestrian pavement with grooving tool or jointer.

### **3.7 EXPANSION JOINTS**

- A. Form expansion joints with expansion joint filler of thickness shown on drawings.
1. Locate joints around perimeter of structures and features abutting site work concrete.
  2. Create complete, uniform separation between structure and site work concrete.
- B. Extend expansion joint material full depth of concrete with top edge of joint filler below finished concrete surface where sealant is indicated on Drawings.

- C. Cut and shape material matching cross section.
- D. Anchor with approved devices to prevent displacing during placing and finishing operations.
- E. Round joint edges with edging tool.

### **3.8 PLACING CONCRETE - GENERAL**

- A. Preparation before Placing Concrete:
  - 1. Obtain Contracting Officer's Representative approval.
  - 2. Remove debris and other foreign material.
  - 3. Uniformly moisten substrate, without standing water.
- B. Convey concrete from mixer to final location without segregation or loss of ingredients. Deposit concrete to minimize handling.
- C. During placement, consolidate concrete by spading or vibrating to minimize voids, honeycomb, and rock pockets.
  - 1. Vibrate concrete against forms and along joints.
  - 2. Avoid excess vibration and handling causing segregation.
- D. Place concrete continuously between joints without bulkheads.
- E. Install construction joint in concrete placement suspended for more than 30 minutes.
- F. Replace concrete with cracks, chips, bird baths, and other defects to nearest joints, approved by Contracting Officer's Representative.

### **3.9 PLACING CONCRETE FOR CURB AND GUTTER, AND PEDESTRIAN PAVEMENT,**

- A. Place concrete in one layer conforming to cross section shown on Drawings after consolidating and finishing.
- B. Deposit concrete near joints without disturbing joints. Do not place concrete directly onto joint assemblies.
- C. Strike concrete surface to proper section ready for consolidation.
- D. Consolidate concrete by tamping and spading or with approved mechanical finishing equipment .
- E. Finish concrete surface with wood or metal float.

- F. Construct concrete pads and pavements with sufficient slope to drain, preventing standing water.

### **3.10 PLACING CONCRETE FOR VEHICULAR PAVEMENT**

- A. Deposit concrete as close as possible to its final position.
- B. Place concrete continuously between construction joints without cold joints.
- C. Strike and consolidate concrete with finishing machine, vibrating screed, or by hand-finishing.
- D. Finish concrete surface to elevation and crown shown on drawings.
- E. Deposit concrete near joints without disturbing joints. Do not place concrete directly onto joint assemblies.
- F. Obtain Contracting Officer's Representative's approval before placing adjacent lanes.

### **3.11 FORM REMOVAL**

- A. Keep forms in place minimum 12 hours after concrete placement. Remove forms without damaging concrete.
- B. Do not use bars or heavy tools against concrete to remove forms. Repair damage concrete found after form removal.

### **3.12 CONCRETE FINISHING - GENERAL**

- A. Follow operation sequence below, unless otherwise indicated on Drawings:
  - 1. Consolidating, floating, striking, troweling, texturing, and joint edging.
- B. Use edging tool with 6 mm (1/4 inch) radius,.
- C. Keep finishing equipment and tools clean and suitable for use.

### **3.13 CONCRETE FINISHING - PEDESTRIAN PAVEMENT**

- A. Walks AND Wheelchair Curb Ramps, :
  - 1. Finish concrete surfaces with metal float, troweled smooth, and finished with a broom moistened with clear water.
  - 2. Finish slab edges and formed transverse joints with edger.

3. Broom surfaces transverse to traffic direction.
  - a. Use brooming to eliminate flat surface produced by edger.
  - b. Produce uniform corrugations, maximum 1.5 mm (1/16 inch) deep profile.
4. Provide surface uniform in color and free of surface blemishes, form marks, and tool marks.
5. Paving Tolerances:
  - a. Variation from Indicated Plane: Maximum 5 mm in 3000 mm (3/16 inch in 10 feet).
  - b. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).
6. Replace paving within joint boundary when paving exceeds specified tolerances.

### **3.14 CONCRETE FINISHING - VEHICULAR PAVEMENT**

- A. Align finish surfaces where new and existing pavements abut.
- B. Longitudinally float pavement surface to profile and grade indicated on drawings.
- C. Straighten surface removing irregularities and maintaining specified tolerances while concrete is plastic.
- D. Finish pavement edges and joints with edging tool.
- E. Broom finish concrete surface after bleed water dissipates and before concrete hardens.
  1. Broom surface transverse to traffic direction.
    - a. Use brooming to eliminate flat surface produced by edger.
    - b. Produce uniform corrugations, maximum 3 mm (1/8 inch) deep profile.
- F. Pavement Tolerances:
  1. Variation from Indicated Plane: Maximum 6 mm in 3000 mm (1/4 inch in 10 feet) tested parallel and perpendicular to traffic direction at maximum 1500 mm (5 feet) intervals.
  2. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).

- G. Replace paving within joint boundary when paving exceeds specified tolerances.

### **3.15 CONCRETE FINISHING - CURBS AND GUTTERS**

- A. Round edges of gutter and top of curb with edging tool.
- B. Gutter and Curb Top:
  - 1. Float surfaces and finish with smooth wood or metal float until true to grade and section and uniform color.
  - 2. Finish surfaces, while still plastic, longitudinally with bristle brush.
- C. Curb Face:
  - 1. Remove curb form and immediately rub curb face with wood or concrete rubbing block removing blemishes, form marks, and tool marks and providing uniform color.
  - 2. Brush curb face, while still plastic, matching gutter and curb top.
- D. Curb and Gutter Tolerances: Except at grade changes or curves.
  - 1. Variation from Indicated Plane and Grade:
    - a. Gutter: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).
    - b. Curb Top and Face: Maximum 6 mm in 3000 mm (1/4 inch in 10 feet).
- E. Replace curbs and gutters within joint boundary when curbs and gutters exceed specified tolerances.
- F. Correct depressions causing standing water.

### **3.16 CONCRETE CURING**

- A. Concrete Protection:
  - 1. Protect unhardened concrete from rain and flowing water.
  - 2. Provide sufficient curing and protection materials available and ready for use before concrete placement begins.
  - 3. Protect concrete to prevent pavement cracking from ambient temperature changes during curing period.
    - a. Replace pavement damaged by curing method allowing concrete cracking.

- b. Employ another curing method as directed by Contracting Officer's Representative.
- B. Cure concrete for minimum 7 days by one of the following methods appropriate to weather conditions preventing moisture loss and rapid temperature change:
  1. Burlap Mat: Provide minimum two layers kept saturated with water during curing period. Overlap Mats at least 150 mm (6 inches).
  2. Sheet Materials:
    - a. Wet exposed concrete surface with fine water spray and cover with sheet materials.
    - b. Overlap sheets minimum 300 mm (12 inches).
    - c. Securely anchor sheet materials preventing displacement.
  3. Curing Compound:
    - a. Protect joints indicated to receive sealants preventing contamination from curing compound.
    - b. Insert moistened paper or fiber rope into joint or cover joint with waterproof paper.
    - c. Apply curing compound before concrete dries.
    - d. Apply curing compound in two coats at right angles to each other.
    - e. Application Rate: Maximum 5 sq. m/L (200 sq. ft./gallon), both coats.
    - f. Immediately reapply curing compound to surfaces damaged during curing period.

### **3.17 FIELD QUALITY CONTROL**

- A. Field Tests: Performed by testing laboratory specified in Section 01 45 29, TESTING LABORATORY SERVICES.
  1. Compaction.
    - a. Pavement subgrade.
    - b. Curb, gutter, and sidewalk.
  2. Concrete:

- a. Delivery samples.
- b. Field samples.
3. Slip Resistance: Steps and pedestrian paving.

### **3.18 CLEANING**

- A. After completing curing:
  1. Remove burlap and sheet curing materials.
  2. Sweep concrete clean, removing foreign matter from the joints.
  3. Seal joints as specified.

### **3.19 PROTECTION**

- A. Protect exterior improvements from traffic and construction operations.
  1. Prohibit traffic on paving for minimum seven days after placement, or longer as directed by Contracting Officer's Representative.
- B. Remove protective materials immediately before acceptance.
- C. Repair damage.
  1. Replace concrete containing excessive cracking, fractures, spalling, and other defects within joint boundary, when directed by Contracting Officer's Representative, and at no additional cost to the Government.

**END OF SECTION 32 05 23**