

## **SECTION 27**

### **CONCRETE**

#### 27-1 General

##### 27-1.01 Scope

This section describes the requirements for concrete including, but not limited to, materials to be used, forms and details of construction, workmanship, and measurement and payment.

##### 27-1.02 Description of Work

Work under this section shall include, but not be limited to, furnishing and placing all materials for mass concrete and reinforced concrete, reinforcing steel and supports, expansion joint fillers, waterstops, floor hardener, bonding agents, packing and nonshrink grout, epoxy anchors; constructing and removing form work, measuring, mixing and transporting concrete; placing, conveying, and vibrating concrete; installing construction and expansion joints, removing the forms, curing and protecting the concrete, finishing the concrete; placing concrete fillets, topping and equipment pads; and testing for quality and watertightness.

##### 27-1.03 Sequence of Work

The type of forming system must be approved by the District Engineer prior to starting work on the forms. Forms, reinforcement, inserts, and attachments must be completed and approved by the District Engineer prior to placing concrete. The strength or class of concrete and the curing methods must also be approved by the District Engineer prior to placing concrete. Prior to starting backfill or repair operations, all formed surfaces must be inspected by the District Engineer.

##### 27-1.04 Submittals

Submittals supplied by the Contractor are described in detail in each subsection herein and generally include: samples and catalog data of materials used, a written description of the proposed forming methods, reinforcing steel shop drawings, and concrete mix design(s). The Contractor's attention is directed to the General Conditions of this Contract under "Submittals".

##### 27-1.05 Storage

Cement and aggregates to be used for concrete mixed on the job site shall be stored in such a manner as to prevent deterioration of their quality or intrusion of foreign matter. Reinforcing steel shall be stored on pallets, off the ground, and kept free of dirt and oils. All other materials, except forms, shall be stored in dry, clean containers. Any materials which have been deteriorated or damaged shall not be used and shall be removed from the job site.

##### 27-1.06 Lines and Grades

Offset lines or coordinates, and grades shall be established for the Contractor, as necessary, for accurate location of concrete structures, all as described in the Special Conditions of this Contract. The Contractor shall, at his own expense and responsibility, transfer offset lines and coordinates, and grade and set batter boards and string lines, and make all necessary measurements and sightings, all from the construction staking provided, and all as necessary to accurately place the structures.

### 27-1.07 Excavation

Clearing and grubbing operations for concrete work shall conform in all respects to Clearing and Grubbing described elsewhere in these specifications. Dust control and excavation for concrete work shall conform in all respects to Dust Control and Pipe Trench Excavation for Water Mains described elsewhere in these specifications.

### 27-1.08 Backfill

Backfill around structures shall not begin until the concrete has reached sufficient strength, as determined by the Contractor, but not earlier than 7 days after the pour. All forms shall be removed, all repairs made, and all concrete shall pass inspection prior to beginning the backfill operation. The type of backfill shall be as shown on the plans. For areas requiring backfill, but the type is not shown on the plans, the area shall be backfilled with a Class 4 Material. Backfill of areas with intruding ground water shall be with a permeable material. Backfilling operations, Class 4 Material, and Permeable Backfill Material shall comply in all respects to Pipe Trench Backfill for Water Mains described elsewhere in these specifications.

### 27-1.09 Inspection

The Contractor shall make all material stock piles available for inspection by the District Engineer. Plants used to produce ready mix concrete shall be subject to periodic inspection by the District Engineer. The Contractor shall make available, for testing purposes, samples of all materials and samples of the concrete being placed.

Each phase of work shall pass inspection by the District Engineer before commencing work on the next phase. The phases shall consist of, but not be limited to, clearing and grubbing, excavation, construction of forms, placing reinforcing steel and inserts, final inspection of forms, reinforcement, and inserts, prior to placing concrete, placing concrete, grouting, installing anchors, curing, removing forms, finishing concrete, backfilling, and testing.

## 27-2 Materials

### 27-2.01 General

Materials furnished for concrete and reinforced concrete shall include, but not be limited to, concrete and its constituents, reinforcing steel and supports, expansion joint filler, waterstops, floor hardeners, curing aids, bonding agents, patching grout, non-shrink grout, and epoxy anchors.

### 27-2.02 Submittals

Submittals supplied by the Contractor for materials include: samples of coarse and fine aggregate; and catalog data for admixtures, reinforcing supports, expansion joint filler, waterstops, floor hardener, curing aids, bonding agent, non-shrink grout and epoxy anchors, reinforcing steel, and welded wire fabric.

### 27-2.03 Concrete

The materials furnished for concrete shall include, but not be limited to, Portland cement, water, coarse and fine aggregates, fly ash, and admixtures.

#### 27-2.03-A Portland Cement

Portland Cement shall be Type II Modified conforming to Type II cement, as specified in ASTM C150. If high-early strength cement is allowed by the District Engineer, it shall conform to Type III cement as specified in ASTM C150.

#### 27-2.03-B Water

Water for washing aggregates and for mixing and curing concrete shall be clean, free from oil, acid, alkalis, vegetable matter, or other deleterious substances. No salt or sea water or water containing excessive amount of sodium sulfate, magnesium sulfate or magnesium chloride shall be used.

#### 27-2.03-C Coarse Aggregate

The coarse aggregate shall consist of clean, hard, dense, tough and durable natural gravel, crushed gravel, or crushed rock. It shall be free from oil, organic matter or other deleterious substances and shall conform to ASTM C33.

#### 27-2.03-D Fine Aggregate

Fine aggregate shall consist of hard, durable, uncoated natural sand or other approved material. It shall be free from oil or other deleterious substances.

#### 27-2.03-E Fly Ash

Fly ash shall conform to ASTM A618, Class F or N, except that the loss on ignition shall be limited to 1%.

#### 27-2.03-F Admixtures

Water-reducing agents such as Pozzolith, WRDA, or equal shall be used in all concrete. The admixture shall conform to ASTM Specifications C494. Proportioning and mixing shall be as recommended by the manufacturer.

Admixtures causing accelerated setting of cement in concrete shall not be used.

Air-entraining admixtures compatible with the concrete mix shall be used, as required, as a moderate addition to the water-reducing agent, to obtain the specified percent air in the resultant concrete. The Contractor shall submit data verifying that the admixtures are compatible with the mix. Air-entraining admixture shall conform to ASTM Specification C260.

### 27-2.04 Reinforcement

#### 27-2.04-A Steel Bars

All steel bars shall have a deformed surface and shall conform to ASTM A615, including Supplementary Requirement S1, Grade 60, free from dirt, rust, scale, oil, and frost. No. 3 bars may be Grade 40.

#### 27-2.04-B Epoxy-coated Steel Bars

Where shown on the plans, bars shall be epoxy coated in conformance with ASTM A775, Section 2.02A.

#### 27-2.04-C Welded Wire Fabric

Welded wire fabric shall be of gauge and mesh size shown on the plans and shall meet the requirements of ASTM A185 or ASTM A497 for smooth wire fabric. Wire fabric shall be free from dirt, rust, scale, oil, and frost.

#### 27-2.05 Reinforcing Supports

Reinforcement supported from form work shall rest on Class E (stainless steel protected) bar supports, as specified in "Manual of Standard Practice" by the Concrete Reinforcing Steel Institute (CRSI).

Reinforcement supported from the ground shall rest on 3-inch-high precast concrete blocks not less than 4 inches square, and having a compressive strength equal to the specified compressive strength of the concrete being placed. The precast blocks shall have been cured as specified for concrete and shall contain soft steel wires imbedded therein for fastening to the reinforcing.

Epoxy-coated reinforcing bars supported from form work shall rest on coated wire bar supports, or on bar supports made of dielectric materials or other acceptable materials. Wire bar supports shall be coated with dielectric material, compatible with concrete, for a minimum distance of 2-inches from the point of contact with the epoxy-coated reinforcing bars. Reinforcing bars used as support bars shall be epoxy-coated.

#### 27-2.06 Expansion Joint Filler

Filler for expansion joints shall be ½-inch thick pre-molded type conforming to ASTM D1751.

#### 27-2.07 Waterstops

Waterstops shall be neoprene or PVC conforming to State Specifications paragraph 51-1.14. Waterstops shall be of the size and type shown on the plans and shall have a hollow bulb in the center.

#### 27-2.08 Floor Hardener

Compounds used for floor hardener shall be Lapidolith, non-metallic consisting of quartz aggregate, dispersing agent and Portland cement. The hardener shall be manufactured, not field mixed, and compatible with the curing method used.

#### 27-2.09 Curing Aids

Aids for curing concrete shall be either a cover or applied spray. Covers shall be white or reflective 4-mil polyethylene, or moist burlap or rugs. Spray-applied curing compounds shall be white-pigment membrane type conforming to ASTM C309.

#### 27-2.10 Bonding Agent

Agents used for bonding concrete fillets, topping slabs, equipment pads, or similar applications, shall be Concessive 1001-LPL, or approved equal.

#### 27-2.11 Patching Grout

Grout used for patching small surface blemishes shall consist of neat portland cement, water, and fine sand passing a No. 30 mesh sieve with an approved acrylic modifier.

### 27-2.12 Non-shrink Grout

Non-shrink grout shall be Masterflow 713 by Master Builders Co., or approved equal.

### 27-2.13 Epoxy Anchors

Compounds used for poured epoxy-grouted anchors shall be Concessive Epoxy Adhesives, or approved equal. The type used for each application, as shown on the plans, shall be as recommended by the manufacturer.

Systems used for injected epoxy for anchors shall be HVA adhesive anchors by HILTI Fastening Systems, or approved equal.

## 27-3 Form Work

### 27-3.01 General

The materials and installation requirements for form work shall include, but not be limited to, furnishing submittals, forming systems, tolerances, and chamfers.

### 27-3.02 Submittals

The type of forming systems must be approved by the District Engineer prior to starting work. The Contractor shall provide a written description of the proposed forming methods including form materials, shop drawings, catalog data, and other manufacturer's information.

Form work shop drawings shall be submitted for all form work and supports showing form plywood pattern, form work, ties, beams, walers, columns, struts; vertical limits of concrete placements, horizontal lifts, and construction joints.

### 27-3.03 Forming Systems

The forming system used by the Contractor shall allow for proper sequencing of the work and removal of the forms without damage to the concrete. Symmetrical panels shall be arranged with a minimum number of joints.

Form systems may be lumber, prefabricated wood panels, metal, or plastic-lined panels, all sound and free from any defects that will mar or detract from the surface of the finished concrete. Construction forms shall be placed sufficiently tight to prevent loss of mortar. The forms shall be designed to withstand vibrator action.

The forms shall be treated with a nonstaining material to eliminate absorption of water and to act as a form release agent.

Where the bottom of an area between forms is inaccessible from within, the forming system shall provide access panels to permit thorough and complete removal of extraneous material before placing concrete.

Walls and footings below existing and final grades may use earth trench walls as forms, provided the widths shown on the plans shall be increased two (2) inches, if approved after inspection of the trenches, provided the sides are clean, even, vertical, true, and further provided the bottoms are level, clean, and without fill.

#### 27-3.04 Tolerances

The Contractor shall be responsible for setting and maintaining concrete forms sufficiently so as to insure that the completed work will be within the tolerance limits shown on the plans, or specified herein. Concrete work that exceeds these tolerance limits shall be remedied or removed at the discretion of and upon order of the District Engineer, and shall be replaced at the expense of the Contractor.

Tolerance limits for concrete:

1. Variations in Lines:

In the line and position of a structure as a unit; 1 inch.

2. Variations in Footings:

a. In dimensions in plan: minus, 1/2 inch; plus, 2 inches.

b. In misplacement or eccentricity: 2 percent of the footing width in the direction of misplacement but not more than 2 inches.

c. In reduction in thickness: minus 5 percent of specified thickness.

3. Variation from the Level, Grades, or Slopes:

a. In floors, slabs, walkways, ceilings, top of walls or beams, and beam soffits: in 10 feet, 1/4 inch; in any bay or 20 feet maximum, 3/8 inch; in 40 feet or more, 3/4 inch; in floors to receive tile, maximum of 1/8 inch in 10 feet.

b. For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines; in any bay or 20 feet maximum, 1/4 inch; in 40 feet or more, 1/2 inch.

c. In sidewalks, plazas, outdoor concrete slabs, curb and gutter sections: In 1 foot, 1/8 inch; in 10 feet, 1/4 inch.

4. Variation from Plumb:

a. In the lines and surfaces of columns, piers, and walls; in 10 feet, 1/4 inch; in any story or 20 feet maximum, 3/8 inch; in 40 feet or more, 3/4 inch.

b. For exposed corners and other conspicuous lines: in any bay or 20 feet maximum, 1/4 inch; in 40 feet or more, 1/2 inch.

5. Variation of Linear Structure Lines:

In plan and related established position of columns, walls and partitions: In any bay or 20 feet maximum, 1/2 inch; in 40 feet or more, 1 inch.

6. Variations in Cross-section:

In columns, beams, piers, slabs, and walls: Minus 1/4 inch; plus 1/2 inch.

7. Variations in Openings:

In the size and location of sleeves, floor and wall openings: 1/4 inch.

## 8. Variation in Steps:

- a. In a flight of stairs: total rise, 1/8 inch; total run, 1/4 inch.
- b. In consecutive individual steps: rise, 1/16 inch; tread, 1/8 inch.

### 27-3.05 Chamfers

All exposed horizontal and vertical edges or other corners, both interior and exterior of structures, shall be chamfered 3/4 inch minimum, measured on the sides, not hypotenuse. If shown on the plans, larger chamfers shall be used for specific corners or structures.

## 27-4 Placing Reinforcement

### 27-4.01 General

The requirements for placing reinforcement shall include, but not be limited to, furnishing submittals, bending, storage and protection, placement, splicing, welding, minimum concrete cover, and repair of epoxy coated bars.

### 27-4.02 Submittals

Prior to starting shop fabrication or field placement, the Contractor shall submit and receive approval of reinforcing steel shop drawings. The drawings shall comply with the requirements of ACI 318, detailed in accordance with ACI SP66, and adapted to the proposed placement schedule, showing size, dimension, bending, placing, and construction joint details and placement. The Contractor shall also submit the type, size, and location of all wire and bar supports.

### 27-4.03 Bending

Bending of the reinforcing steel shall be in accordance with the Concrete Reinforcing Steel Institute, Manual of Standard Practice, Chapter 7.

### 27-4.04 Storage and Protection

Reinforcing steel shall be stored off the ground and protected from oil, or other deleterious materials. Epoxy-coated reinforcing bars shall be stored on protective wood cribbing.

### 27-4.05 Placement

All reinforcing bars shall be accurately cut, bent and placed as shown on the drawings; they shall be securely tied at all intersections, and shall be firmly supported in the proper locations so that placing of concrete will not cause displacement of the reinforcing, all in conformance with Concrete Reinforcement Steel Institute, Manual of Standard Practice, Chapter 8. Other methods must be approved by the District Engineer. Concrete or steel chairs may be used to support reinforcing bars above subgrade.

Tolerance limits for placing reinforcing steel:

#### 1. Variation of Protective Covering:

- a. With 2.5-inch cover or less; ¼-inch.

b. With 3-inch cover or more; 1/2 inch.

2. Variation From Indicated Spacing:

Between any two bars, but not accumulative; 1 inch.

Horizontal wall bars in double layer walls shall be staggered.

In walls reinforced with epoxy-coated bars, spreader bars where required, shall be epoxy-coated. Proprietary combination barclips and spreaders used in walls with epoxy-coated reinforcing bars shall be made of corrosion-resistant material or coated with dielectric material. Epoxy-coated reinforcing bars shall be tied with plastic-, epoxy-, or nylon-coated tie wire, or other acceptable materials.

27-4.06 Splices

Splices shall be placed as shown on the plans. For any splices not shown, the bars shall be overlapped a minimum of 30-bar diameters. Splices in adjacent bars shall be staggered a minimum of 5 feet center to center. All laps forming splices shall be securely wired.

27-4.07 Welding

All welding of reinforcing steel shall be done by properly certified welders and operators, and shall be continuously inspected, at the Contractor's expense, by a qualified laboratory. The Contractor must furnish to the laboratory mill certificates showing the chemical analysis of the steel. All inspection reports shall be sent to the District Engineer. All preheating and welding shall be done in accordance with American Welding Society Standard D1.4. Tack welding of rebar is strictly prohibited.

27-4.08 Minimum Concrete Cover Over Reinforcement

Where not shown on the plans, the thickness of concrete over the reinforcement shall be as follows:

- A. Where concrete is deposited against ground, not less than 3-inches.
- B. Where concrete is exposed to the weather, process liquids, or exposed to the ground but placed in forms; not less than 2-inches for bars more than 5/8 inch in diameter and 1 ½-inch for bars 5/8-inch or less in diameter.
- C. In slabs and walls not exposed to the ground or to the weather; not less than ¾-inches.
- D. In all cases, the thickness of concrete over the reinforcement shall be not less than one and one-half times the bar diameter.

27-4.09 Repair of Epoxy-Coated Reinforcing Bars

Damage to the coating of epoxy-coated reinforcing bars due to bending, handling, shipment, and placing need not be repaired where the damaged area is 0.1 square inches or smaller; damaged areas larger than 0.1 square inches shall be repaired with patching material in accordance with manufacturer's printed instructions. The maximum amount of damage, including repaired and unrepaired areas, shall not exceed 2 percent of the surface area of each bar. If so, the bars shall be rejected and removed from the work.



## 27-5 Concrete Mix

### 27-5.01 General

The requirements for concrete mix shall include, but not be limited to, furnishing submittals, mix composition and designation, minimum cement content, fly ash, aggregate sizing, measuring materials, and mixing and transporting the concrete.

### 27-5.02 Submittals

The Contractor shall submit and receive approval of the proposed concrete mix design prior to pouring concrete, a copy of all load slips, and catalog information on all additives shall be included.

### 27-5.03 Concrete Mix Composition

Concrete shall consist of Portland cement, fine aggregate, coarse aggregate, a water reducing agent, an air-entraining agent, pre-approved additives, and water, all of which shall conform to CALTRANS Section 90 and these specifications

### 27-5.04 Concrete Designation

Concrete shall meet the minimum compressive strength or concrete class as shown on the plans. Concrete that is not assigned a minimum compressive strength or class on the plans shall comply with the minimum compressive strength or class using the types of uses described in this subsection. Prior to placing any concrete, the Contractor shall verify, in writing, and receive District Engineer's approval of the strength or class of concrete to be used. The allowable slump, maximum water-cement ratio, and air entrainment shall also comply with the following table:

TYPE OF USE	MIN. (1) COMPRESS L STRENGTH (PSI)	SLUMP (INCHES )	(2) MAXIMUM WATER-CEMENT RATIO	(3) ENTRAINED AIR REQUIRED*
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Liquid Containing Structures:

Slabs & Footings	A 3500	2 to 3	0.45	5 1/2% ±1%
Vertical Wall Sections & Columns	A 3500	3 to 4	0.45	5 1/2% ±1%
Mass Concrete & Unformed Slopes	A 3500	1 to 2	0.45	5 1/2% ±1%

Other Structural Concrete:

Interior & Exterior Slabs, Footings, and Caissons	A 3000	2 to 3	0.50	-----
Vertical Wall Sections & Columns	A 3000	3 to 4	0.50	-----
<u>Curbs, Gutters, Sidewalks</u>	B 2500	3 to 4	0.55	-----
<u>Thrust Blocks, Concrete Fill</u>	C 2000	3 to 4	0.60	-----

(1) Minimum compressive strength to be attained at 28 days.

(2) Maximum water/cement ratio by weight.

(3) Based on 1 ½-inch maximum aggregate size. Where 1-inch maximum aggregate size is used, increase entrained air by 1/2%.

27-5.05 Minimum Cement Content

Concrete shall contain the following minimum amount of Portland cement per cubic yard:

Class A	564 pounds
Class B	470 pounds
Class C	376 pounds

#### 27-5.06 Fly Ash

The Contractor may, at his option, substitute up to 15 percent by weight of fly ash for the Portland Cement required herein.

#### 27-5.07 Aggregate Sizing

Grading shall be as set forth in CALTRANS Section 90. In addition, the maximum size aggregate shall be no larger than one-fifth of the narrowest distance between forms, nor larger than three-quarters of the minimum clear spacing between reinforcing bars. The maximum size aggregate grading shall be 1 ½-inch.

#### 27-5.08 Measuring Materials

Materials shall be measured by weighing, except as otherwise specified or where other methods recommended by the manufacturer to be measured by volume are specifically authorized by the District Engineer. Scales shall be approved by the District Engineer and have been certified by the local Sealer of Weights and Measures within one year of use. Each size of aggregate and the cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. Cement in standard packages (sacks) need not be weighed, but bulk cement and fractional packages shall be weighed.

#### 27-5.09 Concrete Mixing and Transporting

All concrete shall be machine mixed at the site, or delivered to the site by transit mixers under conditions approved by the District Engineer.

No concrete shall be placed in the work after it has begun to set. No concrete can be placed more than one hour after the constituents were first combined.

If transit mix is used, the rate of delivery, haul time, mixing time and hopper capacity shall be such that all mixed concrete delivered shall be placed in the forms within one hour from the time of introduction of cement and water to the mixer. All concrete shall be kept continuously agitated until discharged in the hopper at the job site.

Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C94 and Chapter 7 of ACI 301. Plant equipment and facilities shall conform to the "Check List for Certification of Ready Mixed Concrete Production Facilities" of the National Ready Mixed Concrete Association.

### 27-6 Concrete Workmanship

#### 27-6.01 Preparation for Placement

Before placing concrete, all form work shall be cleaned of dirt and construction debris, water drained, reinforcement shall be cleaned of dirt, rust, scale, frost or other coatings deleterious to the bond, then securely and properly fastened in its correct position, forms at construction joints re-tightened, and all bucks, sleeves, hangers, pipes, conduits, bolts, wires, etc., installed. No concrete shall be placed before the forms, reinforcing steel and all work that is to be embedded have been set, observed and approved by the District Engineer.

Excavations shall be kept free from water while concrete is being placed, cured and finished therein. Fresh concrete shall be protected at all times from running water.

#### 27-6.02 Conveying and Placing

Concrete shall be conveyed from the mixer to the place of final deposit as rapidly as practicable by methods, which will prevent the separation or loss of the materials. The concrete shall be deposited in the forms as nearly as practicable in its final position to avoid rehandling.

Concrete shall be placed and consolidated by methods that will not cause segregation of the aggregates and will result in a dense homogeneous concrete which is free of voids and rock pockets. All concrete shall be used while fresh and before it has taken an initial set. Re-tempering any partially hardened concrete with additional water will not be permitted.

Surfaces on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

Concrete shall not be deposited on frozen or ice-coated ground nor on ice-coated forms, reinforcing steel, embedded items or construction joints.

Where a schedule for placing concrete is shown on the plans, no deviation will be permitted therefrom unless approved in writing by the District Engineer.

Mixed concrete, after being deposited, shall be consolidated until all voids are filled and free mortar appears on the surface. The concrete shall be placed as nearly as possible in its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted.

Fresh concrete shall not be permitted to fall from a height greater than 4 feet without the use of adjustable length pipes, tubes or double belting placed to prevent segregation of the concrete. Double belting shall not be used unless the thickness of the member is less than 16 inches. Concrete shall not be permitted to fall through areas constricted by reinforcing that tends to segregate the mix.

In vertical sections, concrete shall be deposited continuously in horizontal layers of 24-inches maximum depth so as to maintain a horizontal plastic surface until the completion of the unit. No concrete shall be deposited on concrete which has hardened sufficiently to cause the formation of seams and planes of weakness within the section.

Concrete for horizontal members or sections shall not be placed until the concrete in the supporting vertical members or sections is no longer plastic and has been in place at least two hours.

In all slabs, concrete shall be deposited in a continuous or monolithic operation to the full thickness of the slab. Each batch shall be dumped against previously placed concrete and not away from it, and shall not be dumped in separate piles and then worked together.

Concrete shall not be mixed or placed while the atmospheric temperature surrounding the work is at or below 35 degrees F, or is expected to be at or below 35 degrees F, within 24 hours. The Contractor's attention is directed to Cold Weather Concrete Work in this section.

The concrete in each integral part of the structure shall be placed continuously, and work will not be allowed to commence on any such part unless sufficiently inspected and approved material for the concrete is on hand, and forces and equipment are sufficient to complete the part without interruption in the placing of the concrete.

#### 27-6.03 Concrete Vibrating

With the exception of concrete placed as slope paving and aprons, and concrete placed under water (where approved), all concrete shall be consolidated by means of high frequency internal vibrators within 15 minutes after it is deposited in the forms. The vibrators shall not be attached to or held against the forms or the reinforcing steel. Vibrating shall be done with care and in such manner so as not to displace forms, reinforcement, ducts, and embedded items.

All concrete shall be consolidated by vibration so that the concrete is thoroughly worked around the reinforcement, around embedded items, and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Internal vibrators shall be the largest size and the most powerful that can be properly used in the work, as described in Table 5.1.4 of ACI 309. They shall be operated by competent workmen. Use of vibrators to transport concrete within forms shall not be allowed. The vibrator shall be inserted vertically at uniform spacing over the entire area of the placement. The distance between insertions shall generally be about 1 ½ times the radius of action, or such that the area visibly affected by the vibrator overlaps the adjacent just-vibrated area by a few inches. In slabs, the vibrator shall be sloped toward the horizontal as necessary to operate in a fully embedded position.

The vibrator shall penetrate rapidly to the bottom of the layer, and at least 6 inches into the preceding layer if there is such. At each insertion, the vibrator shall be held stationary for a time sufficient to consolidate the concrete but not cause segregation, generally from 5 to 15 seconds. The vibrator shall then be withdrawn slowly, at the rate of approximately 3 inches per second.

A spare vibrator in good working condition shall be kept on the job site during all concrete placing operations. Where the concrete is to have an as-cast finish, a full surface of mortar shall be brought against the form by the vibration process, supplemented if necessary by spading to work the coarse aggregate back from the formed surface.

The use of external vibrators for consolidating concrete will be permitted when the concrete is inaccessible for adequate consolidation provided the forms are constructed sufficiently rigid to resist displacement or damage from external vibration. The Contractor must receive approval from the District Engineer prior to using external vibrators.

#### 27-6.04 Cold Weather Concrete Work

Concrete work may be carried on during cold weather, but only with the express permission of the District Engineer after approval of a plan of operation. Precautions shall be taken to see that the concrete is properly protected after pouring and during the cure period. In general, the requirements of the CALTRANS Section 90 in this regard will apply.

#### 27-6.05 Hot Weather Concrete Work

During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation which will impair the required strength or serviceability of the member or structure.

#### 27-6.06 Construction Joints

The Contractor shall obtain approval for joints not shown and locate them where they least impair the strength of the structure. Unless otherwise shown on the drawings, joints in walls and columns shall be at the underside of floors, slabs or grade beams, and at the top of footings or floor slabs. Place grade beams at the same time as slabs. At least two hours shall elapse after depositing concrete in columns or walls before depositing concrete in supported grade beams or slabs. As the new concrete is placed, revibration in tops of columns and walls is desirable.

Make joints perpendicular to the main reinforcement.

All horizontal construction joints in walls shall have a continuous wood screed strip at the outer face of the joint to form a true line. Screeds shall be removed and the joint thoroughly cleaned out before pouring the next portion of wall.

Exposed reinforcing steel shall be cleaned of all concrete and other unsuitable coatings.

Reinforcing steel and mesh shall continue across construction joints.

Construction joints shall be made rough and all laitance removed from the surface by chipping the entire surface, sandblasting with coarse silica sand, or hosing the surface 4 to 6 hours after the pour with a fine spray, exposing solidly embedded clean aggregate. Forms shall be scraped and cleaned of drippings, debris, etc., and dusted by means of compressed air. Surfaces of the hardened concrete shall be cleaned to the satisfaction of the District Engineer and wetted as required before placing of new concrete. Just before starting the new pour, all free water shall be removed and the horizontal surfaces shall be covered with at least 4-inches thickness of concrete composed of cement and fine aggregate, omitting the coarse aggregate. Cement content of such mortar shall be increased to at least 7 ½- sacks per cubic yard, but not less than the approved concrete design mix.

#### 27-6.07 Expansion Joints

Install expansion joint fillers to within ½-inch below top of slab levels.

Where shown, load transfer dowels shall consist of plain bars with one-half coated with an approved antibond coating. The coated half shall be sleeved. No other reinforcement or metal shall extend continuously through expansion joint.

#### 27-6.08 Waterstops

The design and location of waterstops shall be as shown on the plans. Each piece of premolded waterstop shall be of maximum practicable length to minimize the number of end joints. Embed center bulb in the center of the joint.

All joints in waterstops including but not limited to, intersections and end to end joints, shall be joined following the manufacturer's instructions. Joints shall develop effective watertightness

fully equal to that of the continuous waterstop material and shall develop not less than 50 percent of the mechanical strength of the parent section. Do not lap sections of waterstop. All joints shall be butt spliced using a heat-sealing method and in conformance with the manufacturer's instructions.

Support waterstops securely against displacement by wire tie between the last rib and the end of the waterstop, or use a method specifically recommended by the manufacturer.

If the joint is not watertight after construction, the joint shall be grouted by drilling grout holes to the center of the structure unit and force epoxy grout into the joint under pressure. This shall be repeated until the leak has stopped completely.

#### 27-6.09 Nonshrink Grout

Use nonshrink grout to fill voids around embedded items, at locations shown on the plans, and as directed by the District Engineer. Grout shall be mixed and used in accordance with manufacturer's recommendations. Exposed surfaces and edges shall be smooth, straight, even, and finished with a steel trowel.

#### 27-6.10 Epoxy Anchors

These anchors shall be installed in strict conformance to the manufacturer's printed instructions. Embedded reinforcing bars shall not be damaged when drilling holes for these anchors.

#### 27-6.11 Other Embedded Items

Prior to placing concrete, all required sleeves, inserts, anchor bolts and embedded items shall be in place. Give all trades whose work is related to the concrete ample notice and opportunity to introduce embedded items before concrete is placed.

Position embedded items accurately and support them against displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with readily removable material to prevent the entry of concrete.

Anchor bolts placed in slabs, equipment pads, top of walls and similar installations, shall be held firmly in place by a plywood or similar type template to ensure accurate placement.

### 27-7 Form Removal, Curing, and Protecting

#### 27-7.01 Form Removal

Forms shall remain in place for seven days for curing purposes unless a curing method has been approved, as specified herein. When approved for removal, the forms shall be removed carefully to insure complete safety of the structure. For all portions of a structure supported by forms and shoring, the forms shall remain in place for a minimum of ten days. Beam sides, columns, or other vertical forms may be removed after 24 hours, providing the concrete will not be injured and a curing method has been approved. Do not remove supporting forms or shoring until effected members have acquired sufficient strength to safely support their weight and imposed loads.

The Contractor shall assume full responsibility for safe removal of the forms.

## 27-7.02 Curing and Protecting

The Contractor shall begin to protect the concrete immediately after placement from drying, excessively hot and cold temperatures, and mechanical injury. Measures shall be taken to keep moisture loss to a minimum until the cement has hydrated and the concrete is hard, but not less than seven days.

### 27-7.02-A Curing

For formed surfaces, keep the forms wet. Cool metal forms exposed to sun with water. Forms shall remain in place for seven days for curing purposes unless an approved curing compound, water cure process, or waterproof membrane is used, as specified below.

For surfaces not formed or formed surfaces whose forms have been removed prior to the seven day requirement, immediately apply a curing compound, water cure, or waterproof membrane. The Contractor shall consult with the District Engineer and receive approval of the curing method prior to placing the concrete.

If approved for use, curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen disappears from the surface, but before any drying shrinkage or craze cracks begin to appear.

Water curing shall keep the surfaces of the concrete wet for a period of seven (7) consecutive days by covering with water-saturated material kept wet by means of a system of perforated pipes, mechanical sprinklers, or porous hose, or by any approved methods which will keep all surfaces to be cured continuously (not periodically) wet.

Waterproof membrane curing shall be accomplished by first wetting the concrete surface with water using a nozzle that atomizes the flow into a mist, not a spray, until the concrete has set, then covering the concrete with a waterproof membrane. The waterproof membrane shall be a white or silver reflective material. All joints in the membrane shall be securely cemented together to provide a waterproof joint. The membrane shall remain in place for a minimum of 72 hours after being placed.

### 27-7.02-B Protecting

During curing period, the Contractor shall protect concrete from mechanical damage, loading, shock and vibration.

In cold weather, while curing proceeds, the Contractor shall maintain the moisture conditions, and shall maintain the temperature of the concrete between 50 degrees F and 70 degrees F for entire curing period by either heating or covering, or both.

In hot weather, the Contractor shall take immediate steps to protect newly finished concrete from drying effects of wind and sun, and maintain temperature of the air surrounding the concrete uniform within 5 degrees Fahrenheit in any one hour or 50 degrees Fahrenheit in any 24 hour period.



## 27-8 Finishing

### 27-8.01 General

The type of finish applied to concrete surfaces shall be as shown on the plans or as specified in the Special Conditions of this Contract. Concrete surfaces with no finish type identified on the plans or in the Special Conditions shall be classified using the general descriptions given in this subsection, and the specified finish type shall be applied. Prior to applying a finish to any surface not identified on the plans or in this section, the Contractor shall obtain the District Engineer's approval of the proposed finish type.

All concrete surfaces, including precast vaults, shall receive one of the finishes described herein.

The finish types for concrete surfaces are divided into two main categories: surfaces created by forms, and flat or inclined surfaces created by screeding. Formed surfaces include precast vaults. The type of finishes and processes required are identified in the table below. Each process is then further described in subsections that follow:

Type of <u>Finish</u>	<u>Required Processes</u>
F1	Formed and repaired
F2	Formed, repaired, and dressed
S1	Screeded, floated, and broomed
S2	Screeded, floated, and troweled
S2B	Screeded, floated, troweled, and lightly broomed
S2F	Screeded, floated, troweled, and flooring applied
S2FH	Screeded, floated, troweled, floor hardener applied
S2NS	Screeded, floated, and troweled with abrasive

The following is a general description of where to apply the different finishes if not otherwise shown on the plans or described in the Special Conditions of this Contract:

<u>Type of Finish</u>	<u>General Location Description</u>
F1	Apply to all formed concrete surfaces, including vaults, to be backfilled or covered with a facade.
F2	Apply to all formed concrete surfaces, including vaults, that are to remain exposed in the final product. Areas to be backfilled shall receive a F2 finish to a level 6-inches below final grade.
S1	Apply to slabs and walkways located at canal structures, valve box pads, and similar field sites outside of plant areas.
S2	Apply to all inside floors, such as areas inside treatment plants, pumping plants; and tank floors, topping slabs, and equipment pads.
S2B	Apply to all outside slabs, walkways, and the exposed top of structures and walls.
S2F	Apply to all floor areas to receive paint, or floor covering. Consult with the floor covering manufacturer for type of finish required.
S2FH	Apply to all floor areas of loading docks, storage and warehouse, repair shops, and tool rooms.
S2NS	Apply to all stair treads and landings.

#### 27-8.02 Formed Surfaces

Formed concrete surfaces shall be finished using the processes described herein. The degree of care in building forms, character of materials, and concrete placement techniques will be contributing factors in the amount of additional finishing required to produce smooth, even surfaces of uniform texture and appearance, free from bulges, depressions and other imperfections beyond allowable tolerances. The District Engineer shall be the sole judge in this respect.

##### 27-8.02-A Formed

The type of forms, form construction, form removal, and curing all affect the finish of formed concrete surfaces. These requirements shall be as described elsewhere in this section.

##### 27-8.02-B Repaired

Prior to beginning backfill or repair operations, all formed concrete surfaces must be inspected by the District Engineer.

If rock pockets, bulges, depressions, or other defects, in the opinion of the District Engineer, are of such extent or character as to substantially affect the strength or appearance of the structure or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the portions of the structure affected.

This phase of the finishing process shall consist of cleaning, filling holes or depressions, repairing rock pockets and honeycombed areas, removing fins, bulges, offsets, and stains, and repairing any other defects required by the District Engineer.

Patching mortar shall contain enough silica sand and white cement to result in a patch which, when cured, will match the surrounding concrete.

All small holes, including tie holes, shall be cleaned thoroughly, dampened, then filled solid with patching mortar.

All large holes, rock pockets, and honeycombed areas shall have all defective concrete removed to edges perpendicular to the surface using a mechanical bush hammer. The area shall then be thoroughly cleaned and dampened. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without adding water, until it has reached the stiffest consistency that will permit placing. After surface water has evaporated from the area to be patched, a small amount of patching grout shall be mixed to the consistency of thick cream and brushed thoroughly into the surface to be patched. When the patching grout begins to lose the water sheen, apply the premixed patching mortar. The mortar shall be thoroughly consolidated into place and struck off to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, leave the patch undisturbed for at least 1 hour before finishing it. Keep the patched area damp for 7 days. Do not use metal tools in finishing a patch in a formed wall which will be exposed.

Depressions in areas not receiving backfill shall be repaired by roughening the surface enough to expose large aggregate using a mechanical bush hammer, then cleaning and patching as required herein for rock pockets.

Bulges in areas not receiving backfill shall be bush hammered or ground to the proper dimension, the area cleaned and patched, as required herein for rock pockets.

#### 27-8.02-C Dressed

All formed concrete surfaces that require final dressing shall receive a coat of mortar. The area shall be cleaned thoroughly and dampened. The dressing mortar shall be a mixture of one part Portland cement and two parts clean silica sand with enough water to form a loose paste. The dressing mortar shall be applied with a float having a resilient rubber surface. The dressing process shall create a smooth, uniform surface, both in texture and color. After taking its initial cure, the dressing mortar shall be kept damp for 48 hours. Surfaces shall be dressed prior to installing any conduits, pipe, ducts, or equipment that would interfere with the dressing process.

#### 27-8.03 Screeded Areas

All surfaces not formed shall be screeded. This process is used to bring the concrete to near the desired level or shape. These areas are then float finished and, if required, troweled. Upon completion of this process, the finished surface shall meet the tolerances described in this section. The final finish shall be uniform in texture and appearance and done in a workmanlike manner. The District Engineer shall be the sole judge in this respect. Concrete given unsuitable finishes shall be removed and replaced.

#### 27-8.03-A Screeded

After the concrete has been thoroughly consolidated, the surface of all areas not formed shall be screeded to the desired elevation and contours by means of accurately placed edge forms and intermediate screed strips and striking off all excess concrete.

#### 27-8.03-B Floated

After the screeding process is complete, wait for the water sheen to disappear and the surface has stiffened sufficiently to start the floating process. For large flat areas, during or after the first floating, check for planeness of the surface with a 10-foot straightedge applied at not less than two different angles, and then cut down all high spots and fill all low spots to achieve a true plane within the allowable tolerances.

#### 27-8.03-C Troweled

After the floating process has been completed, the surface shall be troweled by machine or by hand using steel trowels. Additional trowelings shall be done by hand after the surface has hardened sufficiently. Final troweling shall produce a ringing sound from the trowel and the finished surface shall be free of trowel marks, uniform in texture and appearance, and shall be planed to the tolerance specified under Floated Finish.

Sidewalks and outside slabs shall be marked and scribed into rectangles of not less than 12 square feet nor more than 20 square feet with a scoring tool which will leave the edges rounded. All sidewalk and outside slab edges shall be tooled to a rounded edge.

#### 27-8.03-D Lightly Broomed

After the troweling process has been completed, the surface shall be lightly broomed perpendicular to the normal traffic pattern, if present. The Contractor shall consult with the District Engineer at the time brooming starts, to establish the texture and depth of profile created by the brooming process.

#### 27-8.03-E Flooring Applied

Where flooring is required on the plans or in these specifications, the surface shall be troweled to a finish recommended by the manufacturer for proper installation of the flooring.

#### 27-8.03-F Floor Hardener Applied

Areas to receive floor hardeners shall be troweled and the floor hardener applied using methods and amounts to produce a floor suitable for heavy to heavy-duty use, as recommended by the manufacturer.

#### 27-8.03-G Abrasive, Nonskid Applied

Areas to have nonslip finish shall incorporate 25 pounds per 100 square feet of aluminum oxide grains into the surface. Immediately before troweling begins, sprinkle two-thirds of the abrasive evenly over the surface and float. After embedment, sprinkle the remaining one-third at right angles to the previous application. Apply more heavily in areas not sufficiently covered by the first application, and trowel again immediately. Complete finishing as specified under Troweled Finish. Stairs and stair landings shall receive Nonslip Floor finish.

## 27-9 Concrete Fillets, Topping Slabs, and Equipment Pads

### 27-9.01 General

Concrete fillets, topping slabs, and equipment pads shall be placed over a bonding agent as soon as possible after completion of the curing period of the concrete. Contact surfaces shall be thoroughly cleaned to the degree recommended by the bonding agent manufacturer.

### 27-9.02 Construction

The bonding agent shall be accurately and thoroughly mixed and applied at the manufacturer's recommended coverage rate. Mix only the amount which can be used prior to expiration of the pot life. Concrete shall be immediately placed over the fresh bonding agent before the surface takes an initial set, all as recommended by the manufacturer. Bonding agent which sets up prior to placing concrete shall be removed and a fresh coat of bonding agent applied prior to placing concrete.

Concrete fillets, topping slabs, and equipment pads shall be accurately screeded to the slopes and elevations shown on the plans. Cure the concrete as specified for slabs above. Set equipment anchor bolts in pad to accommodate equipment furnished. Finish fillets the same as adjacent surfaces. Finish topping slabs and equipment pads as shown on the plans, or as specified herein.

## 27-10 Testing

### 27-10.01 General

Concrete shall be tested for quality, including slump, air entrainment, and compressive strength; and shall be tested for watertightness.

### 27-10.02 Quality Testing

Quality testing shall be done at the Contractor's expense, unless otherwise specified in the Special Conditions of this Contract. If the Contractor is required to arrange for testing, it shall be done by a certified testing laboratory and all test results shall be forwarded immediately to the District Engineer. The Contractor shall cooperate with and provide any equipment or manpower necessary to assist the District Engineer in testing the concrete.

The Contractor may, at any time, and at his own expense, perform additional testing for purposes of quality control and shall not depend on testing by other parties for such purposes. The Contractor shall, at his own expense, perform any tests necessary to acquire the strength of the concrete for the purpose of, and shall be solely responsible for, form removal and safety of the structure.

Prior to placing the concrete, each load or batch shall be tested for proper slump and air entrainment. These tests shall be taken in accordance with ASTM C172 and ASTM C143.

The acceptable strength of concrete shall be based on compressive test specimens taken and cured in accordance with ASTM C31. A minimum of three specimens shall be taken from every 20 cubic yards of concrete placed or for each major placement during the day. The District Engineer shall determine the number of specimens to be taken as he deems necessary to

ensure the concrete meets the specifications. The compressive tests shall be in accordance with ASTM C39. The standard compressive test shall be 28 days.

#### 27-10.03 Watertightness

Watertightness testing shall be done at the expense of the Contractor.

All concrete structures and channels which will later be subjected to hydrostatic pressure shall be tested for watertightness. The tests shall be made prior to application of waterproof coating, if required. Testing shall consist of filling the structure with clean water to a level of 6 inches below the top. Cells adjacent to the cell being tested shall be empty and dry. Water shall be allowed to stabilize for 12 hours, refilled, then the water level shall be measured at the beginning, middle, and end of a 24-hour test period. Allowable leakage shall not exceed 1/2 percent of the contents. The Contractor shall repair any visible leaks and shall correct the cause of any test failures. The repair procedure shall be submitted to the District Engineer for approval. After repairs are made, the District Engineer may require retesting of structures and/or channels which have been repaired.

#### 27-11 Measurement and Payment

No measurement for separate payment shall be made for any work specified in this section. All costs in connection therewith shall be included in the contract price for the item to which the work is pertinent.