Chapter 4-3: Concrete and Reinforcement

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4-3.01 General

This chapter includes guidelines for cast-in-place (CIP) concrete, including corresponding reinforcing steel, used for building projects. It also contains information for related items of work that are unique to building construction (such as exposed aggregate finish, new wall openings, and precast concrete tilt-up panels), as well as related items of work that are not unique to building construction but have special requirements when they are incorporated into building construction (such as drill and grout dowels and drill and bond dowels).

Review any applicable Standard Special Provisions (SSPs) from Section 99[1], *Building Construction*, Division 03, *Concrete*, that have been included in the project *Special Provisions*, since much of the information therein typically will not be repeated in the following sections of this chapter.

Additional information related to inspection of concrete placement and installation of reinforcing steel is provided in Bridge Construction Memos (BCMs) corresponding to *Standard* Specifications Sections 51-1.03D, *Concrete Structures – General – Construction – Placing Concrete*, 52, *Reinforcement*, and 90, *Concrete*, as well as the *Concrete Technology Manual* and the *Reinforced Concrete Construction Manual*. Make sure to review these documents, as applicable.

4-3.02 Cast-in-Place Concrete

Before any work related to cast-in-place concrete (including the reinforcing steel that will be encased by it) is performed, it is critically important to verify the location of all utilities to determine whether there will be any conflicts regarding their entrance to the building in relation to the building's foundation. The size and location of penetrations may require the placement of sleeves for passage through the foundation. Placement of pipe, conduit, and blockouts for specialty items is commonly shown on the Mechanical, Electrical, Water, and Wastewater Plans, and these items may not have been coordinated with the Architectural and Structural Plans. Review, discuss, and coordinate the location of these penetrations with the various designers of record. An example of conduit being placed prior to a concrete pour for a building's foundation is shown in Figure 4-3.1 below (in which conduit openings are taped so that no concrete can enter, and vertical sections of conduit are braced). An example of conduit and various pipes penetrating through the building's foundation and slab after concrete placement is shown in Figure 4-3.2 below.

[1] Caltrans internal use only



Figure 4-3.1. Conduit Penetrations Through a Building's Foundation Prior to Concrete Placement



Figure 4-3.2. Utility Penetrations Through a Building's Slab After Concrete Pour

4-3.02A Reinforcing Steel

Follow BCMs corresponding to *Standard Specifications* Section 52, *Reinforcement*, for inspection guidelines for reinforcing steel. Additionally, the following special considerations are emphasized:

1. Deformed bars complying with American Society for Testing and Materials (ASTM) A615/A615M, Grade 60, are allowed.
2. Plastic supports for reinforcing steel are allowed in lieu of dobies or bar chairs. However, product data must be submitted by the Contractor, and these submittals must be authorized before the plastic supports can be incorporated into the work.

3. Verify that bar reinforcing steel (rebar) is isolated from dissimilar metals (for example, galvanized components such as conduit) to prevent galvanic corrosion. This can be accomplished by using tape to electrically isolate the metals from one another, or by simply checking that they are separated by the minimum clearance specified in the contract documents.
4. Embedded items must be securely anchored in place. This includes anchor bolts, pipes and pipe sleeves, conduits, boxes, weld plates, etc.
5. Verify that pipe and conduit are not located below the rebar mat, or in the foundations of load-bearing walls.

4-3.02B Concrete

4-3.02B(1) General

Reserved

4-3.02B(2) Concrete Material Requirements

Mix designs are required to be submitted and authorized for all concrete used in building construction work just like they are for bridge work. Review the mix designs to verify that:

1. The cementitious material (CM) content meets or exceeds the minimum amount specified,
2. Penetration values as determined via California Test 533, *Method of Test for Ball Penetration in Fresh Portland Cement Concrete*, or slump values as determined by CA Test 556, *Method of Test for Slump of Hydraulic-Cement Concrete* (ASTM C143), are within the specified range,
3. Other submittal requirements (refer to *Standard Specifications* Section 90-1.01C, *Concrete – General – Submittals*) have been met.

A minimum 505 lb/cu yd CM (equivalent to a 5-sack mix) is typically specified for minor work including concrete curbs, sidewalks, driveways, gutter depressions, new door openings, and collars. A minimum 590 lbs/cy CM (equivalent to a 6-sack mix) is typically specified for structural work including footings, foundation walls, floor slabs, building frame members, and building walls, with two exceptions:

- If the project is located in District 11, then the minimum CM content is 630 lb/cy, and
- If the concrete is designated by compressive strength, then the maximum CM content is 800 lb/cy.

A minimum 658 lb/cy CM (equivalent to a 7-sack mix) is typically specified for sewer structures, vehicle wash racks, and mudrinse slabs. Review the *Special Provisions* to determine the minimum cementitious material content for any particular building component, as the requirements may differ from the aforementioned values.

Air entrainment is required for all concrete used in structural work in District 11 only, and throughout the State for concrete used in sewer structures, vehicle wash racks, and mudrinse slabs. Furthermore, air entrainment is required for all concrete used on building construction projects that are located in freeze-thaw areas.

Reinforced concrete structures with sections over 12 inches thick must have a maximum 2-1/2-inch penetration (5-inch slump), and reinforced concrete structures with sections 12 inches thick or less must have a maximum 3-inch penetration (6-inch slump).

4-3.02B(3) Quality Control and Quality Assurance

Verify whether *Special Provisions* Section 90-1.01 has been included in the contract documents to add building components into the definition of "CIP structural concrete members" through the modified *Standard Specifications* (in the back of the project *Special Provisions*) Section 90-1.01B, *Concrete – General – Definitions*. If this is not the case, the contractor is not required to perform quality control for concrete used in building construction work in accordance with *Standard Specifications* Section 90-1.01D(10), *Concrete – General – Quality Assurance – Quality Control*.

Further, if the concrete building components ARE considered CIP structural concrete members as described above BUT the total volume for CIP structural concrete members on the project is less than 500 cy, then the following list of Quality Control - related standard specifications sections would not be applicable in that situation either:

- 90-1.01C(6)(b), *Concrete – General – Submittals – Mix Design – Cast-In-Place Structural Concrete Members*
- 90-1.01C(8)(b), *Concrete – General – Submittals – Testing – Cast-In-Place Structural Concrete Members*
- 90-1.01C(11), *Concrete – General – Submittals – Quality Control Plan for Cast-In-Place Structural Concrete Members*
- 90-1.01C(12), *Concrete – General – Submittals – Concrete Materials Quality Control Summary Report for Cast-In-Place Structural Concrete Members*
- 90-1.01D(7), *Concrete – General – Quality Assurance – Qualifications for Cast-In-Place Structural Concrete Members*
- 90-1.01D(8), *Concrete – General – Quality Assurance – Certifications for Cast-In-Place Structural Concrete Members*

- 90-1.01D(9), *Concrete – General – Quality Assurance – Preconstruction Meeting for Cast-In-Place Structural Concrete Members*
- 90-1.01D(10)(b), *Concrete – General – Quality Assurance – Quality Control – Cast-In-Place Structural Concrete Members*
- 90-1.01D(12)(b), *Concrete – General – Quality Assurance – Department Acceptance – Cast-In-Place Structural Concrete Members*

We would expect the specifications section 90-1.01A, *Concrete – General – Summary,* to be revised accordingly via *Special Provisions* Section 90-1.01 in that case.

Regardless of whether the contractor performs quality control sampling and testing for concrete used in building construction work, the Department must perform quality assurance sampling and testing for concrete used in building construction work as specified for concrete in the *Construction Manual* Chapter 6, *Sampling and Testing*. However, the Structure Representative may choose to reduce the sampling and testing intervals pending the Contractor's demonstration of consistent compliance with specified compressive strength figures. Use good engineering judgment to determine appropriate sampling and testing intervals.

A test panel or mockup may be required for concrete for building construction work, usually for instances where colored concrete is specified or when architectural treatment is shown.

4-3.02B(4) Formwork

There are different material requirements for formwork depending on whether the concrete will have an exposed surface finish or an unexposed surface finish. Furthermore, there are specific material requirements for formwork for cylindrical columns and supports.

Verify that the formwork provides for features such as doors, windows, and other openings, and that sufficient bracing has been installed prior to concrete pours.

Forms must not be stripped until at least 40 hours after placing concrete, except soffit forms and supports must not be released or removed until at least 10 days after placing concrete.

4-3.02B(5) Placing Concrete

Follow BCM 51-1.03C-D, *Concrete Structures – General – Construction – Preparation and Placing Concrete,* for general inspection guidelines for concrete placement for building construction work. Additionally, the following special considerations are emphasized:

1. Refer to the *Special Provisions* for surface preparation requirements for situations where fresh concrete will join existing or previously placed concrete or masonry.
2. Confirm the proper placement of underslab granular fills, waterproofing membranes, sand cushions, vapor barriers, reinforcing steel, anchor bolts, inserts and embeds, blockouts, pipe and conduit penetrations, etc. prior to the concrete pour.
3. For masonry buildings with concrete footings, refer to Section 4-4.03C, *Masonry – Masonry Wall Construction – Joints,* of this manual. Additional dowels may be required in the footing at the masonry control joint locations. Verify that this rebar is in place to avoid having to drill and bond into the new concrete surfaces after concrete placement has been completed.
4. Verify that items such as trench ducts, boxes, cleanouts, flanges, floor drains, etc., are all correctly located in relation to the finished floor surfaces and/or faces of walls.
5. Vehicles, equipment, or concentrated loads weighing more than 300 pounds individually and material stockpiles weighing more than 50 pounds per square foot will not be permitted on the concrete within 10 calendar days after placement.

4-3.02B(6) Finishing and Curing

There are different requirements for finishing work depending on whether the concrete is an unformed surface or a formed surface. Verify the correct specified finishing method is used for each building surface component. Note that walkways are commonly specified to receive a nonskid abrasive aggregate (grit) finish.

Pay close attention to Americans with Disabilities Act (ADA) requirements shown in the contract documents when finishing work for any walkable surface is being performed. Detectable warning surfaces may be specified in these cases. Refer to Chapter 4-09, *Finishes*, for more information.

All tool marks must be removed in the finishing process. Confirm that angles, joints, edges, and corners are carefully finished and that they match each other. Verify the finishing provides even, smooth, and level surfaces within the tolerance as specified, and confirm that horizontal surfaces have been sloped as specified to properly drain.

To create control joints in slabs, Type A control joint strips must be inserted into the floated concrete so that the bottom of the top flange is flush with the finish elevation. The top flange of the strips must be removed after the concrete has set and cured.

Floor slabs must be cured by the water method as specified for structures in *Standard Specifications* Section 90-1.03B, *Concrete – General – Construction – Curing Concrete*. Initial curing of floor slabs must start as soon as free water has evaporated from the concrete surface. Concrete surfaces other than floor slabs must be cured by the forms-in-place method or the water method as specified for structures in the aforementioned section of the standard specifications, except concrete curbs, sidewalks, collars, and gutter depressions may be cured by the curing compound method (curing compound no. 6 must be used in these instances).

Following completion of the curing period, application of special treatments for concrete surfaces (such as hardeners or sealers) may be required by the contract documents.

4-3.02C Other Materials

4-3.02C(1) General

Material requirements for various other items related to the placement of cast-in-place concrete for building work are discussed in the SSPs and should be included in the project *Special Provisions*. These materials include epoxies, anchor bolts and anchor rods (and corresponding nuts and washers), expansion joints, vapor barriers, bond breakers, nonskid abrasive aggregate, Type A control joints, keyed construction joint forms, divider and edger strips, mortar, concrete hardeners and sealers, splash blocks, and non-shrink grout.

4-3.02C(2) Anchor Bolts

Anchor bolts must be secured in their final position before concrete is placed; stabbing the anchor bolts into concrete (“wet-setting”) is not permitted. Exposed anchor bolts and their corresponding nuts and washers must be hot-dipped galvanized.

4-3.02C(3) Vapor Barriers

Vapor barriers (sometimes alternatively referred to as moisture barriers) are sheeting materials that are installed as a means of dampproofing building components so that moisture will not diffuse through those components, thus preventing interstitial condensation and mold growth. See Figure 4-3.3 below for an example. Vapor barriers are different than waterproofing membranes, which are intended to prevent liquid water from entering building components. For Caltrans’ building projects, vapor barriers are typically only installed under floor slabs that will receive flooring surfaces or other finishes constructed on top.

Vapor barrier sheeting material must be at least 15 mils thick and must comply with ASTM E1745, Grade A. Overlapping must be in accordance with the manufacturer’s instructions. A 3-inch layer of clean uncompacted sand cover must be placed across the entire top surface of the vapor barrier, as shown in Figures 4-3.3 through 4-3.5 below.



Figure 4-3.3. Preparing to Place Vapor Barrier Material



Figure 4-3.4. Uncompacted Sand Cover Being Spread over a Vapor Barrier



Figure 4-3.5. Uncompacted Sand Cover on Top of a Vapor Barrier

4-3.02C(4) Concrete Hardeners and Sealers

4-3.02C4(a) Concrete Hardeners

Concrete hardeners must be commercial-quality, waterborne, penetrating-type magnesium fluosilicate, zinc fluosilicate, or a combination of the two. Hardeners are used primarily to prevent dusting and to increase resistance to abrasion. Hardeners are not intended to act as sealers but are sometimes adequate in this respect. These products are shipped in a concentrated form and are diluted on the job in accordance with the manufacturer's instructions. Concrete surfaces must be clean and dry before the application of the hardener. If the concrete has been previously coated with curing compound or any type of sealer, the Contractor must prepare the surface in accordance with the manufacturer's recommendations prior to applying the hardener. After the hardener has dried, there should be a light residue of encrusted salts on the surface, which must be removed by mopping with water.

4-3.02C4(b) Concrete Sealers

Concrete sealers must be commercial-quality, VOC-compliant, silane-type sealer with hydrophobic and oleophobic properties. Sealers are generally used to prevent the absorption of grease and oil into the concrete. To ensure penetration, the concrete must be dry before application of the sealer. Some manufacturers recommend the use of three coats with a drying time of 24 hours between coats. The initial application is frequently diluted more than subsequent applications.

4-3.02C4(c) Anti-Graffiti Coatings

Caltrans often requires the use of approved anti-graffiti coatings on buildings, structures, bridges, and other facilities to protect against vandalism and facilitate maintenance. Check the contract documents to verify if anti-graffiti coatings are required.

If so, these coatings are included in the Caltrans Authorized Materials Lists (AML) for graffiti removal and protective products.

In addition, BCM 78-4, *Incidental Construction – Miscellaneous Coatings*, specifies the use of anti-graffiti coatings under related *Standard Specifications* Section 78-4.06, placing them alongside other incidental coatings such as concrete stain and sealers. BCM 78-4 governs submittal requirements, manufacturer qualifications, quality assurance, surface preparation, and inspection procedures for these materials. Contractors must submit product data and application plans per these AML and BCM standards, ensure proper application according to manufacturer recommendations, and comply with Caltrans' inspection protocols to maintain compliance and structural resilience.

4-3.03 Exposed Aggregate Finish

Reserved

4-3.04 New Wall Openings

Reserved

4-3.05 Precast Concrete Tilt-Up Panels

Contrary to their name, precast concrete tilt-up panels are not comprised of actual precast concrete complying with *Standard Specifications* Sections 51-4, *Concrete Structures – Precast Concrete Members*, and 90-4, *Concrete – Precast Concrete*. They are reinforced concrete wall panels that are cast at the job site on concrete casting slabs or an authorized casting facility. These panels must not be erected until 75 percent of the specified concrete compressive strength has been attained. The Contractor is required to conduct quality control testing to demonstrate that this requirement has been met. Refer to Figure 4-3.6 below for an example of a precast concrete tilt-up panel being formed on top of a casting slab at a project site.

Reinforcing embeds, which are used for lifting, setting, bracing, and securing the panels, are considered "critical points" and must be inspected carefully. Consult with the structural designer to determine exactly where these critical points are located. Review Cal/OSHA Title 8 Construction Safety Orders § 1715, *Tilt-up Concrete Panel Construction,* for applicable safety requirements. An example of bracing for an erected precast concrete tilt-up panel is shown in Figure 4-3.7 below.



Figure 4-3.6. Forming a Tilt-up Panel on a Concrete Casting Slab



Figure 4-3.7. Erecting and Bracing Tilt-up Panels

Concrete mortar, grout, or dry-pack (sand/cement mortar) must be used to fill joints between the panels and foundation system. Verify the location of connections with respect to weld plates, bolts, dowels, and other embedded items. An example of weld plates embedded into a building foundation for precast concrete tilt-up panel connection is shown in Figure 4-3.8 below.

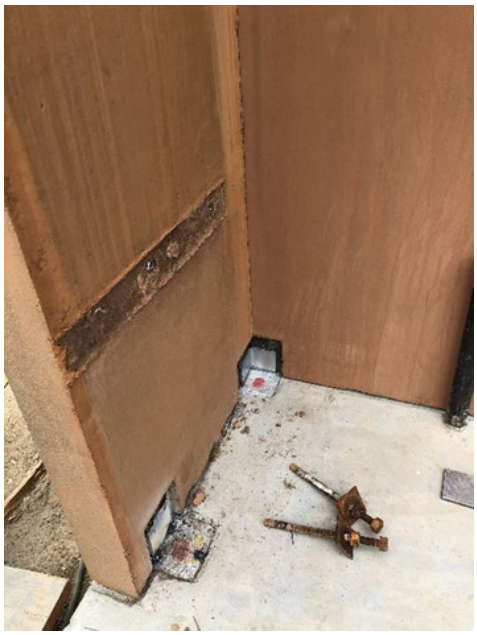


Figure 4-3.8. Embedded Weld Plates Used to Connect Concrete Tilt-up Panel to Foundation

Verify that panel and joint connections align within the specified tolerances.

Consult the project *Special Provisions* for any water-repellent treatments and protective coatings to be applied. Verify that the materials and application methods used conform to the authorized product data.

4-3.06 Drill and Grout Dowels

Reserved

4-3.07 Drill and Bond Dowels

Reserved