

Section 90 Concrete

4-9001 General

4-9001A Before Work Begins

4-9001A (1) Materials

4-9001A (1a) *Cementitious Materials*

4-9001A (1b) *Aggregates*

4-9001A (1c) *Admixtures*

4-9001A (2) Check of Mix Design

4-9001A (2a) *Checking Proportions*

4-9001A (2a) 1 Cementitious Material Content

4-9001A (2a) 2 Water Content

4-9001A (2a) 3 Aggregates

4-9001A (2a) 4 Admixtures

4-9001A (2a) 5 Volume

4-9001A (3) Proportioning

4-9001A (4) Curing Concrete

4-9001A (5) Compressive Strength

4-9001B During the Course of Work

4-9001B (1) Proportioning and Mixing Operations

4-9001B (2) Mixing and Transporting

4-9001B (3) Curing Concrete

4-9001B (4) Protecting Concrete

4-9001C Level of Inspection

4-9001D Payment

4-9002 Minor Concrete

4-9003 Rapid Strength Concrete

4-9003A Before Work Begins

4-9003B During the Course of Work

4-9003C Payment

4-9004 Precast Concrete

4-9004A Before Work Begins

4-9004B During the Course of Work

4-9004C Payment

4-9005 Self-Consolidating Concrete

4-9005A Before Work Begins

4-9005B During the Course of Work

4-9006 Lightweight Concrete

4-9006A Before Work Begins

4-9006B During the Course of Work

Section 90 Concrete

4-9001 General

Section 90, “Concrete,” of the *Standard Specifications* provides material requirements for concrete with the following descriptions:

- General
- Minor concrete
- Rapid strength concrete
- Precast concrete
- Self-consolidating concrete
- Lightweight Concrete

For a complete discussion on various items using concrete, refer to Sections 40, “Concrete Pavement”; 41, “Existing Concrete Pavement”; 50, “Prestressing Concrete”; 51, “Concrete Structures”; 72, “Slope Protection”; and 73, “Concrete Curbs and Sidewalks,” among other sections of the *Standard Specifications*. Also, refer to the corresponding Sections 4-40, 4-41, 4-50, 4-51, 4-72, and 4-73 of this manual. The resident engineer should contact Materials Engineering and Testing Services (METS), and the district materials engineer for additional guidance on specialty concretes. Additional information on concrete is available in Structure Construction’s *Concrete Technology Manual* and the *Bridge Construction Records and Procedures Manual*:

<https://dot.ca.gov/programs/engineering-services/manuals>

Regardless of the type of concrete to be used, recycled concrete may not be used on Caltrans contracts unless specifically allowed by the specifications. Recycled concrete includes use of plastic concrete combined with fresh concrete, use of recycled concrete materials from unhardened concrete, and use of materials from crushed concrete.

4-9001A Before Work Begins

In general, the *Standard Specifications* require the contractor to determine the mix proportions for all concrete. To determine the various types of concrete that will be required, review the contract provisions. Pay particular attention to concrete information, such as “cementitious material content,” “compressive strength,” “minor concrete,” “rapid strength concrete,” “precast concrete,” “self-consolidating concrete,” or “lightweight concrete.” Also, note the type of cement to be used and any special requirements for the aggregate and use of admixtures. Projects in corrosive environments or freeze-thaw areas will contain additional concrete requirements. Make a list of the various mix designs the contractor will need to submit and a note of the concrete that needs to be prequalified before use. To avoid

potential project delays and aid in the review process, encourage the contractor to submit the mix designs early in the project.

Review the mix designs for compliance with the special provisions, *Standard Specifications*, and contract plans, or forward the mix designs to the district Materials Unit for review. Before the contractor places any concrete, the district Materials Unit will need an authorized copy of the mix design for the unit's plant inspectors. If the concrete is designated by compressive strength, obtain certified test data or trial batch test results in advance of the concrete use to avoid delays. Refer to Section 90-1.01D(5)(b), "Prequalification," of the *Standard Specifications* for additional information. Review the data and results for contract compliance.

Review the current certifications of Caltrans field staff who will perform acceptance sampling and testing of the concrete. Verify that staff is certified for sampling and testing required for items of concrete work included in the project. Following are common test methods:

- California Test 125, "Method of Test for Sampling Highway Materials and Products Used in the Roadway Pavement Structure Sections."
- California Test 504, "Method of Test for Determining Air Content of Freshly Mixed Concrete by the Pressure Method," if air entrainment in concrete is required.
- California Test 518, "Method of Test for Density (Unit Weight) of Fresh Concrete."
- California Test 521, "Method of Test for Compressive Strength of Cylindrical Concrete Specimens."
- California Test 523, "Method of Test for Flexural Strength of Concrete (Modulus of Rupture)."
- California Test 524, "Method of Test for Flexural Strength of Rapid Strength Concrete," if using rapid strength concrete in pavement applications.
- California Test 533, "Method of Test for Ball Penetration in Fresh Portland Cement Concrete."
- ASTM C143, "Standard Test Method for Slump of Hydraulic-Cement Concrete," if specified in the applicable concrete application.
- California Test 539, "Method of Test for Sampling Freshly Mixed Concrete."
- California Test 540, "Method of Test for Making and Curing Concrete Test Specimens in the Field."
- California Test 556, "Method of Test for Slump of Hydraulic-Cement Concrete."
- California Test 557, "Method of Test for Temperature of Freshly Mixed Hydraulic-Cement Concrete."

Review specifications for specific concrete acceptance sampling and testing requirements and determine if additional certifications will be required for field staff performing acceptance sampling and testing. Contact the district materials engineer for assistance in obtaining any specialty certifications.

4-9001A (1) Materials

Before work begins, verify that Form DOT CEM-3101, "Notice of Materials to Be Used," includes concrete materials such as cement, fly ash, and aggregate. Refer to Section 6-202, "Responsibilities for Acceptance of Manufactured or Fabricated Materials and Products," of this manual for additional information.

4-9001A (1a) Cementitious Materials

Cementitious materials are normally accepted based on certificate of compliance, so initial samples are not taken. Cementitious materials are required to be on the Authorized Materials List at the time of mix design submittal. Refer to:

<https://dot.ca.gov/programs/engineering-services/>

If special requirements exist for the cementitious materials, initial testing should be considered. For more details about cementitious materials sampling and testing, refer to Chapter 6, "Sampling and Testing," of this manual.

4-9001A (1b) Aggregates

From the contractor, obtain in writing the primary aggregate nominal sizes to be furnished and their source pit locations. Verify that aggregate material sources comply with Section 7-103H (2), "Surface Mining and Reclamation Act," of this manual. Note that for concrete aggregate to be considered innocuous, both coarse aggregate and fine aggregate sources must be listed on the Authorized Materials List. Refer to:

<https://dot.ca.gov/programs/engineering-services/>

Aggregate sources not on this list will affect cementitious material calculations as discussed in Section 4-9001A (2a) 1, "Cementitious Material Content."

- Verify with the district Materials Unit that current tests have been performed on aggregates as listed in Section 6-1, "Sample Types and Frequencies," of this manual.
- You may omit initial sampling and testing if the specified aggregate is currently being used on another Caltrans contract with acceptable testing results. In the daily report, record any reasons for not taking initial samples.
- If aggregate test data is not available, obtain initial samples of aggregate to be used and have them tested for all specified attributes. For reference, refer to the table in Section 6-1 of this manual. Indicate whether oversized material will be crushed or if any special blends are contemplated. To prevent unnecessary expense and delay, send samples that can be evaluated against the specification gradation without further processing.

When the type or amount of concrete work doesn't require furnishing the proposed gradation, advise the contractor and note such a decision in the daily report.

4-9001A (1c) Admixtures

Before work begins, do the following for admixtures:

- Verify that admixtures are a type allowed by the *Standard Specifications* or special provisions. Admixtures must be on the Authorized Materials List maintained by METS, available at:
<https://dot.ca.gov/programs/engineering-services/>
- Accept admixtures by certificate of compliance from the admixture manufacturer.
- If more than one admixture is proposed for use, admixtures must be compatible with each other.
- Even when a contract specifically allows or requires admixtures, check the proposed dosage rate for each specific product other than air-entraining agents.
- Refer to Section 2-26, "Concrete Admixtures," in Structure Construction's *Concrete Technology Manual* for additional information on admixtures.

4-9001A (2) Check of Mix Design

Before use of any concrete, the contractor is required to submit in writing a copy of their mix designs. Likewise, revisions in proportions of a previously authorized mix design will require a new mix design submittal. An integral part of quality assurance is the review of the submitted concrete mix designs for compliance with contract requirements. Attention must be paid to concrete requirements within the plans and specifications because, on most projects, there will be a need for multiple concrete mix designs for different uses, locations, and exposures. While it is the contractor's responsibility to design their concrete mixes using ingredients in compliance with contract requirements, it is critical that any submitted mix design that does not meet contract requirements be brought immediately to the contractor's attention. Once the submitted mix design, including required supporting documentation and qualifications, has been reviewed and determined to comply with contract requirements, notify the contractor of mix design authorization for the specific intended use. Make sure a copy of the authorization letter is filed in the project records.

For concrete in pavement, approach slabs, and bridge decks, or when other concrete shrinkage limitations are specified, make sure shrinkage test data under AASHTO T 160, "Standard Method of Test for Length Change of Hardened Hydraulic Cement Mortar and Concrete," is submitted and reviewed with the mix design.

Concrete mixes should generally be designed with proportions that will produce concrete with the following qualities:

- The stiffest consistency, or lowest penetration, that can be placed efficiently
- Adequate mortar content to provide the required finish
- The lowest water demand consistent with the aggregate specified

4-9001A (2a) *Checking Proportions*

Structure Construction's *Concrete Technology Manual* contains multiple examples of concrete mix design reviews. The following narrative identifies key elements to consider during the mix design review process.

4-9001A (2a) 1 Cementitious Material Content

The cementitious material content is limited, and the design must conform to the specified limited amounts and requirements of Section 90-1.02B, "Cementitious Materials," of the *Standard Specifications*.

Cementitious material content minimums and maximums will generally be found in the specifications covering that item of work and not in Section 90. For example, Section 51-1.02B, "Concrete," of the *Standard Specifications* contains a table for general cementitious material content requirements for structures, though special provision requirements may modify these requirements for particular concrete structural elements.

Be aware that if the submitted mix design uses an authorized water-reducing admixture at the authorized dosage, the specified cementitious material content may be reduced up to 5 percent by weight under Section 90-1.02E(2), "Chemical Admixtures," of the *Standard Specifications*. This provision is not allowed for concrete pavements.

Once the mix design's cementitious material content has been verified, calculate whether equations 1 and 2 of Section 90-1.02B(3), "Supplementary Cementitious Materials," of the *Standard Specifications* have been met. Note that in evaluating equation 1, for aggregate to be considered innocuous, all aggregates must be innocuous.

Also, note that concrete in certain exposure areas will have special cementitious material requirements that need to be verified. Examples of these areas include Section 90-1.02H, "Concrete in Corrosive Environments," and Section 90-1.02I, "Concrete in Freeze-Thaw Areas," of the *Standard Specifications*. Concrete subject to these exposure areas will be designated in the contract.

4-9001A (2a) 2 Water Content

Section 90-1.02G(6), "Quantity of Water and Penetration or Slump," of the *Standard Specifications* provides the general requirements for maximum free water allowed in concrete mix designs. There may be specific provisions concerning water allowance for the contract item that will govern. When evaluating free water amounts, keep in mind that free water is defined as the amount of water in the mix excluding the amount of moisture in aggregates at their saturated surface dry condition. Note that if liquid admixtures are used in a cumulative amount of more than 1/2 gallon per cubic yard, the amount of liquid admixture is to be considered free water.

Nominal penetration or slump requirements or both must also be considered during the mix design review. Concrete mixes requiring prequalification under Section 90-1.01D(5)(b), "Prequalification," of the *Standard Specifications* require either certified test data or trial batch reports that include penetration or slump information. Use

caution when reviewing and authorizing concrete mix designs that indicate maximum nominal penetration or slump values or have used the maximum amount of allowable free water within the mix design. Both cases leave little in the way of adjustment if problems are encountered and may result in significant delays if new mix designs are required.

Certain concrete or exposure areas may also specify water to cementitious material ratio requirements on the concrete. These are typically based on the weight of free water to the weight of cementitious materials in the mix. Make sure any such requirements are evaluated during the mix design review.

4-9001A (2a) 3 Aggregates

Aggregates for concrete must conform to Section 90-1.02C “Aggregates,” of the *Standard Specifications* unless specified otherwise. These requirements include durability and cleanness testing requirements for coarse aggregates, and organic impurities and sand equivalent testing requirements for fine aggregates.

The mix design must be checked against coarse aggregate, fine aggregate, and combined aggregate. Note that the contractor controls a portion of the gradation requirements by proposing the “X” values within a specified allowable range for certain sieve sizes. These proposed “X” values complete the individual gradation limit requirements of Sections 90-1.02C(4)(b), “Coarse Aggregate Gradation,” and 90-1.02C(4)(c), “Fine Aggregate Gradation,” of the *Standard Specifications*. Verify that proposed “X” values are within allowable ranges for each sieve size. Check submitted gradations for coarse and fine aggregates and verify that gradations are within the specified operating range limits. Check additional individual gradation requirements at this time, including limitations on differences between total percentage passing adjacent sieve sizes.

Using a combined analysis of the gradations in the proportions of the mix design, determine if the combined gradation meets the gradation limits shown in Section 90-1.02C(4)(d), “Combined Aggregate Gradation,” of the *Standard Specifications*.

4-9001A (2a) 4 Admixtures

Verify that dosage amounts for each admixture within the mix design are within those listed on the Authorized Materials List.

Where more than one admixture is proposed in the mix design, remind the contractor that admixtures must be compatible with each other to realize effectiveness of the admixtures.

When chemical admixtures are used in combination with supplementary cementitious materials, the chemical admixture manufacturer’s written instructions must include a statement of compatibility for the types and quantities of materials being proposed.

4-9001A (2a) 5 Volume

Verify that individual mix design constituent volumes total to a cubic yard by using the weights and specific gravities of the constituents. For aggregates, use the specific gravity at saturated surface-dry condition.

4-9001A (3) Proportioning

The following is primarily a guide for the Caltrans plant inspector, but anyone who needs to verify that plant operations are contract compliant can also use this guide:

- Make sure that storage of aggregates conforms to specification requirements. When various sizes are to be stored separately, require physical separation, either by space between stockpiles or some type of wall that will provide positive separation. Pay particular attention to the method used to prevent contamination of the aggregate. In general, a wood platform or hard surface, as specified in Section 90-1.02F(2), "Storage of Aggregates," of the *Standard Specifications* is required for storage of the aggregate stockpile.
- Determine whether the stockpiled aggregate is similar to material upon which the mix design was based.
- As a part of the Material Plant Quality Program (MPQP), the district weights and measures coordinator will have completed a safety inspection of the plant facilities frequented by the Caltrans plant inspector for the plant in question. Review the sampling facilities to verify that they will deliver a sample in a safe manner that accurately represents the material. For sampling requirements, refer to California Test 125, "Method of Test for Sampling Highway Materials and Products Used in the Roadway Pavement Structure Sections."
- Before use for Caltrans projects, the plant scales and meters must have a current MPQP acceptance sticker. The district weights and measures coordinator is responsible for the MPQP acceptance process. Examine the plant to determine whether weighing equipment matches the testing results. Check that scales and meters have been sealed or tested as required. Request from the district weights and measures coordinator the material plant approval report. For additional details, refer to Section 3-902E, "Weighing Equipment and Procedures," of this manual.

The county sealer of weights and measures tests and seals weighing and metering devices at commercial plants. During the sealing of these plants, the county sealer does not test the interlocks. Therefore, even though the county sealer has sealed the scales and meters, the interlocks must be tested and approved as for noncommercial plants in accordance with Section 3-2, "Testing and Approving Weighing and Measuring Devices," of the *MPQP Manual*.

- Verify that cementitious materials can be kept separate from the aggregate until they are discharged into the mixer.
- Verify that the plant or mixer has the specified automatic timing device. When automatic batching is used, the timing device must be interlocked with the mixer discharge mechanism as specified.
- Examine mixers to make sure that blades are not worn. See that mixers are free of accumulations of hard concrete or mortar.

- Check that truck mixers have the required metal plates containing the specified information. Also, check truck mixers to make sure they have the specified revolution counters.
- Make sure the contractor will not use equipment with aluminum or magnesium components if these components will contact plastic concrete.
- Check the following when the concrete to be produced is for concrete pavement:
 1. Make sure that the plant has a moisture meter. Be aware that any moisture determination is calculated “as a percent of the dry aggregate.” Commonly used moisture meters measure the total moisture in the material being tested. However, specifications for moisture content in the fine aggregate and batch proportion calculations are based on the free moisture rather than the total moisture content. Therefore, check that the moisture meter is calibrated for the absorption of the aggregate upon which it is to be used.
 2. Verify that the system contains the specified proportioning interlocks. Determine whether the proportioning system is capable of full automatic operation.
 3. Determine whether the equipment is capable of accepting changes in proportions or sequence of weighing individual sizes without delay.

4-9001A (4) Curing Concrete

Review the various methods of curing concrete contained in Section 90-1.03B, “Curing Concrete,” in the *Standard Specifications*, and discuss with the contractor the proposed methods. Before concrete work begins, verify that the contractor has the required curing materials and equipment onsite. Such materials include rugs, a water supply, or acceptable curing compound. Do not allow hand spraying except as allowed under Section 90-1.03B(3)(d), “Application,” of the *Standard Specifications*.

The curing compound must be of the type specified by the special provisions, *Standard Specifications*, or both. Obtain a certificate of compliance for the curing compound before its use.

4-9001A (5) Compressive Strength

If the 28-day compressive strength described is 3,600 pounds per square inch (psi) or greater, the concrete is designated as compressive strength. When concrete has a described 28-day compressive strength greater than 3,600 psi, or a minimum concrete compressive strength is specified as a prerequisite to applying loads or stresses to a concrete structure or member or as specified, the contractor must prequalify the concrete before its use in the work. For additional details, refer to Section 6-305D (2), “Trial Batches,” of this manual; the *Bridge Construction Records and Procedures Manual*; *Concrete Technology Manual*; and Section 90-1.01D(5), “Compressive Strength,” of the *Standard Specifications*.

4-9001B During the Course of Work

During the work, the resident engineer must do the following:

- Sample the concrete within the requirements and frequencies of Section 90, “Concrete,” and item of work sections of the *Standard Specifications*, and Chapter 6, “Sampling and Testing,” of this manual.
- Make appropriate arrangements for plant inspection.
- Review placement, protection, curing, and staging.
- Review concrete washout procedures as they apply to the water pollution control plan.

4-9001B (1) Proportioning and Mixing Operations

This section is primarily a guide for the Caltrans plant inspector, but can be used by anyone who may need to verify that plant operations comply with the contract. During proportioning and mixing operations, do the following:

- Obtain and verify that the certificates of compliance for cementitious materials are signed as specified.
- Observe the cementitious material storage facilities to make sure cementitious materials are protected from moisture.
- Obtain samples of the aggregate in accordance with California Test 125, “Method of Test for Sampling Highway Materials and Products Used in the Roadway Pavement Structure Sections,” and test them for the specified properties in accordance with the frequencies shown in Section 6-1, “Sample Types and Frequencies,” of this manual. For the surface moisture content of fine aggregate, vary the testing frequency depending on the uniformity of supply. A change of 1 percent in the moisture content of sand, if not compensated for during batching, may change the penetration of concrete as much as 3/4 inch and the compressive strength as much as 300 psi. You can use California Test 223, “Method of Test for Surface Moisture in Concrete Aggregates by the Displacement Method (Field Method),” or the oven-dry method, in which case you must consider an adjustment for absorption.
- Compare the test results with the data upon which the design was based, and verify that the contractor takes any necessary corrective actions. When cementitious content designates the concrete, make sure the contractor adjusts the design to compensate for any significant differences within the nominal sizes the contractor proposed. When the concrete is designated by compressive strength, make sure the contractor takes immediate corrective action for any significant deviations in production operations from those used during the production of trial batches.
- Observe the addition of admixtures to assure they are as shown on the authorized mix design and are dispensed in the specified manner. Obtain certificates of compliance for each admixture product.

During proportioning and mixing of materials, make sure the following occur in the quantities and by the methods specified:

1. At least twice during each shift, check that scales are balanced at zero load and inspect them for signs of sluggishness, inaccuracy, or damage. Should an apparent problem with the weighing or measurement systems exist, contact the district weights and measures coordinator for the method of correcting the problem. Also, check for sticking materials that do not discharge.
 2. Batch controllers that have the ability to provide an estimate of returned concrete for rebatching must have that feature disabled. Check that delivery trucks are completely empty, including washout water, before loading. Ready-mix trucks can be verified to be empty by spinning the mixing drum in reverse immediately before loading.
 3. Check that the entry of water into the mixer is timed to make sure some water is introduced in advance of aggregate and cement. Also, check that all water has been introduced by the end of the first one-fourth of the specified mixing time. Finally, see that no leakage exists that would affect the proper water content.
 4. Check the batch size to verify that it does not exceed the specified capacity or the limit to which the scales were tested during the MPQP.
 5. Check the mixer operation to verify that the automatic timing device is interlocked as specified and that the mixing time is as specified.
 6. Where allowed, observe the hand-mixing of concrete to check that it is being mixed in the specified manner.
- For concrete used in pavement, or when required for other types of concrete, make sure that automatic devices perform the proportioning operation as specified. Require the plant operator to demonstrate the function of interlock devices. Limit this check of proportioning interlock tolerances to a visual witnessing of the maximum tolerance settings in the batch computer.
 - Perform California Test 518, "Method of Test for Density (Unit Weight) of Fresh Concrete," to verify the unit weight, volume, and cementitious material content of concrete in accordance with the frequencies shown in Section 6-1, "Sample Types and Frequencies," of this manual. Notify the contractor when the test results do not confirm the correctness of the proportions being used.
 - Whenever California Test 518 is performed, the data for batch weights must be the actual weights as observed for the batch to be tested. Actual batch weights are available from the weighmaster certificate for each delivery load. It is not sufficiently accurate to use the ordered batch weights.
 - When the unit weight or cement factor varies considerably for no apparent reason, check the accuracy of the scales. For a quick method, weigh a loaded and unloaded truck on platform scales. With this method, you can also detect erratic weighing because of binding scales.
 - When air-entraining agents are used, perform California Test 504, "Method of Test for Determining Air Content of Freshly Mixed Concrete by the Pressure

Method,” to determine the air content of concrete in accordance with the frequencies shown in Section 6-1 of this manual.

- To determine the consistency of the concrete, perform California Test 533, “Method of Test for Ball Penetration in Fresh Portland Cement Concrete,” or ASTM C143, “Standard Test Method for Slump of Hydraulic Cement Concrete,” depending on the type of work identified in Section 90-1.02G(6), “Quantity of Water and Penetration or Slump,” of the *Standard Specifications*. When specified nominal values are exceeded, check that the contractor makes adjustments. Concrete exceeding maximum specified values is not to be used in the work.

Use the results of California Test 533, ASTM C143, and California Test 529, “Method of Test for Proportions of Coarse Aggregate in Fresh Concrete,” to determine the uniformity of concrete. When differences exceed specified values, require the contractor to improve the mixing operation.

- Periodically check the recording of data on weighmaster certificates for truck mixers or agitators to make sure that the required information is being entered, refer to Section 90-1.01C(7), “Concrete Delivery,” of the *Standard Specifications*.
- Periodically determine the concrete’s temperature to verify that it falls within the specified values.
- Obtain samples of the completed concrete mixture and perform tests in accordance with Section 6-1, “Sample Types and Frequencies,” of this manual.
- Analyze the test results continuously and remain alert to any changes in the concrete’s uniformity or consistency. Make sure the contractor complies with their quality control plan where specified and review quality control information in a timely manner. When test results indicate, verify that the contractor makes corrections in the production operation. Where necessary, make sure the contractor revises the mix design and submits for approval. Revised mix designs must be approved before use.
- Reject based on penetration or slump excessively wet batches discharged from mixers and do not use in the work. Prohibit indiscriminate additions of water to the mixer solely to increase the flow of already workable concrete.
- Record all tests and keep them in the project files. When a specific form is not used for recording test results, such as California Test 533, record the results including a cross reference to weighmaster certificate’s load number in the daily report.

4-9001B (2) Mixing and Transporting

During the work, do the following:

- Make sure that concrete is transported in accordance with the applicable specifications.
- Verify that the proper mix design is being batched and arrives at the job site. The concrete must arrive with a weighmaster certificate that contains the specified information. Make sure certificates of compliance for cementitious materials and

admixtures are provided. The weighmaster certificate must also show the actual scale weights (pounds) for the ingredients batched. Prohibit theoretical or target batch weights as substitutes for actual scale weights. Verify the specified information is actually on the weighmaster certificate. Use caution in authorizing submittal of this information in electronic media, because access to this information is needed in the field as the material is delivered and placed.

- As the concrete is placed, assure that it is homogeneous and thoroughly mixed and that no lumps or evidence of undispersed cementitious material exist.
- Check truck agitators to determine whether they are being operated at the speed designated by the manufacturer.
- Verify that nonagitating hauling equipment does not leak and self-cleans during discharge.
- Check that concrete hauled in open-top vehicles is protected as specified.
- Verify the uniformity of the concrete under Section 90-1.02A, "General," of the *Standard Specifications* through California Test 533, "Method of Test for Ball Penetration in Portland Cement Concrete"; ASTM C143, "Standard Method of Test for Slump of Hydraulic-Cement Concrete," or California Test 529, "Method of Test for Coarse Aggregate in Fresh Concrete," as applicable for the use of concrete. Record the results on the daily report. If the concrete exceeds the nominal or maximum penetration or slump allowed under Section 90-1.02G(6), "Quantity of Water and Penetration or Slump," of the *Standard Specifications*, take appropriate action.
- When authorized, water withheld during batching can be added at the delivery point to truck mixers. Make sure that withheld water is mixed as specified. Do not allow water to be added after the start of concrete discharge. Also do not allow adding of water in excess of the amount listed in the approved mix design. Verify that the proportioning is corrected if constant mixing is necessary at the discharge point.
- When adverse or difficult conditions affect concrete placement, the contractor may request that the specified penetration and free-water content limitations be exceeded under Section 90-1.02G(6), "Quantity of Water and Penetration or Slump," of the *Standard Specifications*. Where such requests are authorized, make sure that the added water and cementitious materials do not exceed the specified ratio allowance.
- Measure the temperature of the concrete periodically. You can obtain the temperature of the fresh concrete from a sample withdrawn from the mixer just before discharge or from within the forms during or immediately after discharge from the mixer.
- Temperature requirements for specialty concrete may vary. Refer to the specifications for these requirements.
- When concrete is being hauled in truck mixers or agitators, make sure the discharge is completed within 1-1/2 hours or 250 revolutions after introducing the

cementitious material to the aggregates. If the concrete temperature is 85 degrees Fahrenheit or above, determine the time (less than 1-1/2 hours) that will be allowed. Advise the contractor accordingly.

- For proper mixing, verify that the concrete delivered in truck mixers or agitators has received the minimum number of revolutions recommended by the manufacturer. However, a minimum of 70 revolutions is a good rule of thumb.
- When nonagitating equipment is used, make sure the discharge is completed within 1 hour as specified. If the concrete's temperature is 85 degrees Fahrenheit or above, or under other conditions contributing to quick stiffening of the concrete, verify that the discharge is completed within 45 minutes as specified.
- In the daily report, note the concrete's temperature and decisions relating to that measurement.
- For transit-mixed concrete, you cannot determine directly from the revolution counter the requirements for minimum and maximum revolutions of mixing at the mixing speed. However, in many instances, a simple calculation based on the total number of mixing revolutions and the hauling time will verify compliance with the specifications. If, because of the circumstances of long hauls or other reasons, such a calculation is not possible, you can ask the supplier for the schedule of time the drum will be operated at mixing speed. At the end of that time, the operator can reduce drum speed to agitating range. The number of revolutions at mixing speed is not considered to be as important as the total number of revolutions of mixing. However, at very low mixer revolutions per minute, and at the minimum number of revolutions, it is possible that inadequate mixing will result.
- Sample concrete and fabricate test cylinders in accordance with Section 6-1, "Sample Types and Frequencies," of this manual and specification requirements for acceptance sampling and testing.
- Do not allow trucks to exceed the weight limits, especially for bridges, given in Section 5-1.37B, "Load Limits," of the *Standard Specifications*, for additional information refer to Section 3-519B, "Load Limits," of this manual.

4-9001B (3) Curing Concrete

Check that the contractor applies the proper cure method in accordance with the specifications. Periodically check that the contractor is maintaining the cure through the curing period.

4-9001B (4) Protecting Concrete

Anticipate adverse weather conditions and discuss options with the contractor. Require the contractor to submit a written plan on methods to protect the concrete if adverse weather sets in or is anticipated.

Concrete needs time to attain sufficient strength to carry loads. Do not allow anyone to drive or place equipment or loads on the pavement when those loads are greater than those allowed by the contract.

4-9001C Level of Inspection

Levels of inspection for concrete material operations are highly dependent upon the concrete element being constructed. Levels of field inspection of concrete elements should be addressed within the corresponding section of Chapter 4, "Construction Details," of this manual. When arranging for concrete plant inspection for these elements it is important to discuss both relative importance of the element and associated sampling and testing frequencies with the plant inspector. Levels of plant inspection may also vary depending on previous performance of the mix, weather conditions, and uniformity history of constituents.

4-9001D Payment

Measurement and payment must comply with the applicable sections of this manual and the special provisions, *Standard Specifications*, and *Bridge Construction Records and Procedures Manual*.

Review and document the results of acceptance testing in accordance with Chapter 6, "Sampling and Testing," of this manual and specification requirements. Take appropriate remedial action or deductions for failing results on acceptance tests.

4-9002 Minor Concrete

The general provisions of Section 90-1, "General," of the *Standard Specifications* apply to minor concrete unless otherwise specified. Similarly, guidance contained in Section 4-9001, "General," of this manual is applicable to minor concrete unless otherwise stated.

Verify that the minor concrete mix design contains at least the minimum amount of cementitious materials specified.

Verify that mix designs for minor concrete are submitted and authorized before use on the contract. When applicable, make sure compressive strength test results are submitted with the mix design as specified in Section 90-2.01C, "Submittals," of the *Standard Specifications*.

Make sure the contractor submits a proposed combined aggregate gradation unless this requirement is waived by the resident engineer. Note that Section 90-2.02C, "Aggregate," of the *Standard Specifications* includes aggregate requirements for minor concrete and specifically excludes certain aggregate requirements in Section 90-1, "General," of the *Standard Specifications*.

Note that Section 90-2.02D, "Water," of the *Standard Specifications* includes water requirements for minor concrete and specifically excludes certain water requirements in Section 90-1, "General," of the *Standard Specifications*.

Production requirements for minor concrete are contained in Section 90-2.02E, "Production," of the *Standard Specifications*. Note that these requirements specifically exclude certain sections of proportioning, mixing, and transporting concrete requirements in Section 90-1, "General," of the *Standard Specifications*.

Verify that a certificate of compliance is provided for minor concrete and that each load is accompanied by a weighmaster certificate with the specified information. Refer to Section 90-2, "Minor Concrete," of the *Standard Specifications* for additional information on minor concrete.

Be sure to review any contract item specifications that require minor concrete, because they may have additional or modified concrete requirements.

4-9003 Rapid Strength Concrete

The general provisions of Section 90-1, "General," of the *Standard Specifications* apply to rapid strength concrete (RSC) unless otherwise specified. Similarly, guidance contained in Section 4-9001, "General," of this manual is applicable to RSC unless otherwise stated.

If RSC is proportioned volumetrically, the following additional guidance will apply:

4-9003A Before Work Begins

- Check that each volumetric mixer is calibrated before beginning production work.
- Make sure that certificates of compliance are provided for each delivery of aggregate, cementitious material and admixtures used in calibration tests and that the material sources are the same as those that will be used for the planned work.

4-9003B During the Course of Work

- Make sure that weighmaster certificates are provided for cement as required in Section 90-3.01C(4), "Weighmaster Certificate," of the *Standard Specifications*.
- Make sure that aggregate moisture test results, log of production data and test samples of freshly mixed concrete for uniformity testing are submitted.
- Verify that the contractor measures aggregate moisture under California Test 223, "Method of Test for Surface Moisture in Concrete Aggregates by the Displacement Method (Field Method)," every 2 hours during production and that the information is being submitted at the end of each production shift.
- Verify that production data is provided at the end of each production shift in the format specified.
- Make sure that the contractor maintains a witness scale at the production site throughout the production period. When concerns arise, accuracy checks can be made using the witness scale. Recalibration of proportioning devices may also be performed with the witness scales. Contact the district's weights and measure coordinator to witness the accuracy checks, recalibrations, and spot calibrations for the cement proportion system only.
- Verify that compliant volumetric mixers operate with the requirements specified in Section 90-3.02B(3), "Mixer Requirements," of the *Standard Specifications*.

- Check for uniformity by measuring penetration with California Test 533, “Method of Test for Ball Penetration in Fresh Portland Cement Concrete.” Make sure penetration comparisons are made on 2 test samples of mixed concrete from the same batch or volumetric mixer load. Any difference in readings must be within the specified tolerance.
- Check that RSC is properly cured. If using a cement other than portland cement, the RSC is to be cured as recommended by the cement manufacturer. The method of curing must be authorized before starting construction.

4-9003C Payment

If volumetric mixer calibration is performed more than 100 miles from the project limits, make sure that the specified deduction amount is taken for each calibration session.

4-9004 Precast Concrete

The general provisions of Section 90-1, “General,” of the *Standard Specifications* apply to precast concrete unless otherwise specified. Similarly, guidance contained in Section 4-9001, “General,” of this manual is applicable to precast concrete unless otherwise stated.

4-9004A Before Work Begins

- Review precast concrete specification requirements and note any special requirements including specified exceptions to those of general concrete.
- Identify the tier designations corresponding to the precast concrete members in the project, refer to Section 90-4.01D(1), “General,” of the *Standard Specifications*. The tier designation will invoke specified requirements for those precast concrete elements.
- For tiers 1 and 2 precast concrete members, make sure the contractor submits a project-specific quality control plan for authorization before performance of any precast activities. Tier 1 and tier 2 members must be produced at an authorized facility and the quality control plan must supplement the information from the authorized facility audit. The structural materials representative (SMR) from the Office of Structural Materials within METS will assist with review of this quality control plan, be knowledgeable of the authorized facility audit, arrange any inspections at the plant location, and monitor the contractor’s compliance with their quality control plan. Once the precast quality control plan has been submitted and before production, hold a quality control meeting with the SMR and contractor. Refer to Sections 90-4.01C(3), “Precast Concrete Quality Control Plan,” and 90-4.01D(2), “Quality Control,” of the *Standard Specifications*, which pertain to tiers 1 and 2 precast concrete members, for additional information
- For tiers 3 and 4 precast concrete members, a project-specific quality control plan is not required.

- Make sure that expansion test data is submitted with the mix design when required in accordance with Section 90-4.02, "Materials," of the *Standard Specifications*. Specifications for shrinkage in Section 90-1.02A, "General," of the *Standard Specifications* are not applicable to precast concrete.
- When reviewing the mix design, verify that the supplementary cementitious materials content requirements for precast concrete meet those specified in Section 90-4.02, "Materials," of the *Standard Specifications*. Note that the supplementary cementitious materials content requirements in Section 90-1.02B(3), "Supplementary Cementitious Materials," of the *Standard Specifications* do not apply to precast concrete.
- Verify that a trial batch and prequalification of the materials, mix proportions, mixing equipment and procedures are performed if precast concrete is not manufactured at an established precast concrete plant.
- Review specifications and this manual concerning precast concrete items of work to determine method of acceptance. Pay particular attention to which precast items will receive source inspection as opposed to those that will be inspected in the field. If there are questions concerning Caltrans' acceptance of precast concrete members, contact the SMR.

4-9004B During the Course of Work

Verify that certificates of compliance, signed by the concrete manufacturer, are submitted for cementitious materials used in purchased precast concrete products. For tiers 1 and 2 members, the certificate is to be signed by the quality control manager. For tier 3 members, the certificate is to be signed by the quality control inspector. The SMR will typically verify this information for tiers 1 and 2 members.

4-9004C Payment

Review payment provisions within the specifications based on the contract item number of the precast concrete element. Associated guidance may be found in this manual in the corresponding section, for example, Section 4-51, "Concrete Structures," of this manual, or *Bridge Construction Records and Procedures Manual*.

4-9005 Self-Consolidating Concrete

Self-consolidating concrete (SCC) is defined as flowing concrete that is capable of spreading to a level state without segregation and without the use of internal or external vibration.

The general provisions of Section 90-1, "General," of the *Standard Specifications* apply to SCC unless otherwise specified. Similarly, guidance contained in Section 4-9001, "General," of this manual is applicable to SCC unless otherwise stated.

SCC may only be used where the specifications allow, such as for precast concrete.

4-9005A Before Work Begins

- Verify that placement procedures are included with the proposed mix design submittal before placement of SCC. Make sure that a trial batch test report is submitted that includes test results for the tests specified in Section 90-5.01D(2)(c), "Prequalification of Mix Design," of the *Standard Specifications*.
- Check that the aggregate gradations to be used are provided as an informational submittal.
- Where the contract specifies, make sure an acceptable mock-up is placed and evaluated in accordance with Section 90-5.01D(2)(d), "Mock-up," of the *Standard Specifications* before placing SCC for production work.

4-9005B During the Course of Work

- Check that the contractor is performing specified quality control sampling and testing for the SCC throughout production operations.
- Perform acceptance testing of SCC in conformance with specified requirements.

4-9006 Lightweight Concrete

The general provisions of Section 90-1, "General" of the *Standard Specifications* apply to lightweight concrete unless otherwise specified. Similarly, guidance contained in Section 4-9001, "General," of this manual is applicable to lightweight concrete unless otherwise stated.

4-9006A Before Work Begins

- Review contract requirements and determine which concrete elements require lightweight concrete.
- Make sure that prequalification data or reports and proposed mix design are submitted far in advance of placing lightweight concrete. Discuss these requirements with the contractor early in the contract.
- Verify that test samples of lightweight aggregates for each gradation are taken and evaluated. The mix design submittal needs to include written verification that arrangements have been made for obtaining test samples of these aggregates. Coordinate aggregate sampling with the district materials engineer and METS.

4-9006B During the Course of Work

- Check that lightweight concrete acceptance sampling and testing are performed for penetration, air content, and compressive strength.
- Make sure that unit weight testing of lightweight concrete is performed as prescribed throughout production operations.