Chapter 4 Construction Details

Section 40 Concrete Pavement

4-4001 General

4-4002 Before Work Begins

4-4002A General

4-4002B Submittals

4-4002C Training

4-4002D Concrete Field Qualification and Pavement Test Strip

4-4003 During the Course of Work

4-4003A Prepaving

4-4003B Paving

4-4003C Finishing Pavement

4-4003D Post-Paving

4-4003E Measurement of Pavement Thickness

4-4003E (1) Location of Primary Cores

Table 4-40.1. Calculation Factors to Locate Cores

4-4003E (2) Location of Secondary Cores

4-4003E (3) Thickness Variation

4-4003F Calculation of Deductions in Payment to the Contractor for Deficient Thickness

4-4003F (1) When None of the Primary Cores are Deficient in Thickness by More Than 0.05 Foot

4-4003F (2) When One or More of the Primary Cores are Deficient in Thickness by More Than 0.05 Foot

Figure 4-40.1. Primary Cores

Figure 4-40.2. Secondary Cores

4-4003F (3) Contractor's Requests for Additional Thickness Measurements

4-4003G Handling of Skips in the Original Day's Pour and Secondary Areas to Be Removed and Replaced

4-4003H Handling Deficient Areas Not Cored

4-4003I Administration

4-4004 Level of Inspection

4-4005 Quality Control

4-4006 Payment

Chapter 4 Construction Details

Section 40 Concrete Pavement

4-4001 General

This section covers concrete pavement including:

- Preparation of concrete pavement subgrade
- Production of the concrete
- Concrete pavement equipment requirements
- Placing, finishing, and curing of the concrete pavement
- Construction of joints
- Protection of the pavement
- Noncompliant pavement work

Plant inspection specialists and testing personnel usually perform inspection and testing duties at the concrete batch plant. However, in addition to onsite inspection, mix design authorization and plant inspection are part of the resident engineer's responsibility. Good communication between plant and inspection specialists and assistant resident engineers is essential. Inspectors and assistants must inform the resident engineer of test results in a timely manner.

This section covers mostly onsite inspection duties. For information on producing and transporting concrete, refer to Section 4-90, "Concrete," of this manual.

4-4002 Before Work Begins

4-4002A General

- Review the plans and specifications to determine the requirements for concrete pavement, including submittals, quality assurance, materials, construction, and payment provisions.
- Coordinate and hold a preconstruction meeting with the specified contractor's personnel before paving activities, including any test strips. Refer to Section 36-1.01D(2), "Preconstruction Meetings," of the *Standard Specifications*. Discuss the contractor's methods for performing each element of the work, including those identified in the quality control plan. For jointed plain concrete pavements, include discussions on the contractor's methods for ensuring proper dowel and tie bar placement relative to constructed contraction joints and their early age crack mitigation system.
- Decide if crossings will be necessary for the convenience of public traffic and whether rapid strength concrete should be used for such crossings. Advise the contractor accordingly.

- When long hauls are involved, review the contractor's proposed placement method to verify that adequate time will be available.
- Discuss pavement areas to receive tapered edge with the contractor and construction methods to be used.
- For concrete pavement widenings placed adjacent to existing pavements, make sure the existing pavement lane or shoulder is ground before new concrete is placed. New concrete pavement must match the grounded existing surfaces and meet specified smoothness requirements.
- Arrange for plant inspection and testing personnel to be present at the plant before startup.

4-4002B Submittals

- Verify that Form CEM-3101, "Notice of Materials to Be Used," includes concrete pavement materials. Refer to Section 6-202, "Responsibilities for Acceptance of Manufactured or Fabricated Materials and Products," of this manual for additional information.
- Review the contractor's proposed concrete mix design for conformance with specification requirements. The contractor's mix design submittal is to include a copy of their American Association of State Highway and Transportation Officials (AASHTO) accreditation for their laboratory determining the mix proportions and laboratory test reports including modulus of rupture information and shrinkage test data. AASHTO laboratory accreditation can be verified at the AASHTO re:source website:

  http://aashtoresource.org/aap/accreditation-directory
- Determine the pavement climate region for your project by reviewing the pavement design information located on the typical cross section sheet, which may trigger additional concrete mix requirements such as required air entrainment. Refer to Section 4-90, "Concrete," of this manual for information on concrete mix designs. Assistance with the concrete mix design review may be obtained from the district materials engineer.
- Verify that the aggregate material source complies with Section 7-103H (2), "Surface Mining and Reclamation Act," of this manual.
- Obtain the contractor's quality control plan that details the methods the contractor will use to ensure the quality of the work. Review the quality control plan for conformance with specification requirements. Check that the quality control plan has met or exceeded the quality control testing requirements specified in the contract. Make sure that individual suspension limits do not exceed specified acceptance criteria. If requested by the contractor or desired by the resident engineer, hold a separate meeting to discuss the quality control plan that addresses each element affecting pavement quality, including those specified in Section 40-1.01D(3), "Quality Control Plan," of the *Standard Specifications*. For jointed plain concrete pavements, pay extra attention to the contractor's plan for ensuring proper placement of contraction joints, dowel bars, and tie bars, as well

as their planned early age crack mitigation system. The district materials engineer may be available to provide subject matter expertise at this meeting.

- When just-in-time (JIT) training is specified, obtain the contractor's JIT training submittal containing the instructor's name and qualifications, training location, course syllabus, handouts, and presentation materials. You may wave JIT training requirements for individuals who have attended equivalent JIT training within the last 12 months and have provided certification of completion documentation.
- Obtain certificates of compliance when tie bars, threaded tie bar splice couplers, dowel bars, tie bar baskets, dowel bar baskets, joint filler material, and epoxy powder coating items are to be used in concrete pavement.
- For jointed plain concrete pavements, check that the early age crack mitigation system information is provided a minimum of 24 hours in advance of each paving shift and based on predicted weather conditions for the site, including wind speed, ambient temperatures, humidity, and cloud cover. The system assists the contractor in predicting concrete stresses and strength during the initial 72 hours after paving for constructing contraction joints, cure application, and crack mitigation. Verify that the contractor employs the specified portable weather station at the paving site to monitor, update, and report predictions.
- Obtain calibration documentation and operational guidelines for frequency measuring devices for concrete consolidation vibrators.
- For cold weather conditions, obtain the contractor's plan for protecting concrete pavement.
- Obtain the name of the contractor's independent third-party air content testing laboratory when the project is located in a pavement climate region requiring air entrainment (that is, freeze-thaw area).
- Obtain the manufacturer's recommendations and instructions for storage and installation when threaded tie bar splice couplers and joint filler material items are to be used in concrete pavement.
- For continuously reinforced concrete pavements, obtain a plastic chair submittal and plastic chair sample if their use is proposed by the contractor. Refer to Section 40-2.01C, "Submittals," of the *Standard Specifications* for additional information.
- Obtain physical specimens used for the contractor's testing of coefficient of thermal expansion. Make sure the contractor provides test data at field qualification and throughout production as specified. The contractor is also required to submit this test data electronically to the specified website. Note that for continuously reinforced concrete pavements, there is specified acceptance criteria for coefficient of thermal expansion at field qualification; otherwise this is provided for information only.

4-4002C Training

- Make sure that JIT training is conducted in conformance with contract provisions.

4-4002D Concrete Field Qualification and Pavement Test Strip

- Verify that field qualification of proposed mix proportions is performed by an American Concrete Institute-certified Concrete Laboratory Technician, Grade 1. Obtain copies of certifications for project records. Review concrete field qualification data and certified test reports for conformance with contract requirements.
- Verfiy that the contractor performs coefficient of thermal expansion sampling, specimen fabrication, and testing as specified. For continuously reinforced concrete pavements, make sure the coefficient of thermal expansion test values meet acceptance criteria as a condition of qualification. Contractor submitted test specimens may be used to verify test results.
- For projects with concrete pavement volumes exceeding 2,000 cubic yards, make sure a test strip is constructed for evaluating compliance with specification acceptance criteria including smoothness; dowel bar and tie bar placement for jointed plain concrete pavements; vertical and lateral stability of reinforcement; and plastic chairs, if proposed, for continuously reinforced concrete pavements, thickness, and final finishing. Test strips not meeting requirements are rejected. Make sure an authorized test strip has been constructed before production paving. Additional test strips are required if the contractor changes the intended method of placement or concrete mix proportions or where a test strip has been rejected. Check that arrangements are made to evaluate the test strip within 3 business days of placement. Requests to eliminate the test strip should only be considered when the contractor can fully document that the same personnel and equipment have been successful in completing the same concrete pavement type within the last 12 months on a Caltrans project.

4-4003 During the Course of Work

4-4003A Prepaving

- Before the start of paving, check the accuracy of the final grade stakes.
- Inspect the subgrade to verify compliance with the specified tolerances for compaction and elevation requirements. Make sure that loose and extraneous materials are removed before paving. Check that any low areas are identified in a way that will result in placing additional concrete as specified. Such additional thickness is considered paid for as part of the lower layer and must not be included when calculating pavement thickness and payment. Refer to the applicable specifications for cement-treated base, lean concrete base, and treated permeable bases. Note these areas in daily reports with stationing and offset information.
- To maintain the concrete pavement at the thickness specified, the contractor may adjust the planned finished grade provided two conditions are met:

1. All lower layers have been constructed to at least the minimum required elevations.
2. Such adjustments do not result in abrupt changes in grade or adversely affect smoothness. General practice is to limit any such adjustment so that the planned finished grade does not change more than 0.04 foot in 60 feet longitudinally.

- When slip-form pavers are used, inspect the grade on which the paver will ride to determine if the grade is smooth enough to prevent abrupt vertical changes in the finished surface. When a wire controls the grade and alignment of the paver, check the wire for any obvious variations. Check that the wire is tensioned sufficiently to prevent measurable sag between supporting stakes. If you anticipate any problems, advise the contractor. Keep in mind that the contractor is responsible for the thickness and smoothness of the pavement.
- Identify where the contractor will post quality control charts.
- Check that any specified bond breaker material, curing seal, or other required treatment has been applied and maintained on the underlying material in conformance with contract requirements. Refer to Section 36-2, "Base Bond Breaker," of the *Standard Specifications* and Section 4-36, "Surfacing and Pavements—General," of this manual for additional information on base bond breakers. These materials may also be helpful for determining pavement thicknesses when examining pavement cores.
- Examine the equipment or tools to be used. When obvious inadequacies exist, advise the contractor and record the details in the daily report. Do the following in examining equipment or tools:
    1. For side-form construction:
        a. Examine the forms for specified attributes, including those for composition, weight, dimensions, and rigidity. Check that the forms are cleaned and oiled before each use.
        b. Verify that installation of the forms complies with specifications. Order any necessary corrective work before the placement of concrete.
        c. Inspect the paving equipment for specification compliance.
    2. For slip-form construction, examine the paver for the specified attributes.
    3. Regardless of which method of construction is used, check that the contractor uses proper consolidation techniques that produce uniform concrete without segregation. Where vibrators are used, make sure they are operated in conformance with contract requirements.
    4. To verify compliance with the requirements for protecting pavement, examine all equipment that will be placed on previously completed pavement.
- Check that a sufficient water supply is available for the work.

- Before concrete placement, check that the subgrade is uniformly moist, but free from standing or flowing water.
- Based on the concrete pavement climate region, verify the types of reinforcement, tie bars, dowel bars, tie bar baskets, and dowel bar baskets to be used within the concrete pavement. Refer to Section 40-1.02C, "Reinforcement, Bars, and Baskets," of the *Standard Specifications*. For continuously reinforced concrete pavements, spot check reinforcement for size, spacing, vertical positioning, clearance, and stability. For jointed plain concrete pavements using dowel bar or tie bar baskets, spot check their anchorage to the base material. If dowel bar or tie bar inserters are used, verify that the contractor is checking inserter alignment before the pour. Check that the specified dowel bar lubricant has been properly applied. Verify that the contractor's quality control methods for properly locating contraction joints, dowel bars, and tie bars are being applied.
- Verify that equipment for constructing joints is onsite and that it conforms to specifications.
- For jointed plain concrete pavement, verify that the contractor has updated their early age crack mitigation system with the most current weather forecast information and field conditions; for example, grade and concrete temperatures. Discuss any adjustment in their construction operations as a result of predicted weather.
- Determine the curing method the contractor proposes to use. When a curing compound will be used, discuss the labeling and packaging requirements for acceptance of the compound with the contractor. Obtain a certificate of compliance, including required test results, for each batch of curing compound.
- Verify that equipment and materials meeting the requirements of Section 90-1.03B(3), "Curing Compound Method," or Section 90-1.03B(4), "Waterproof Membrane Method," of the *Standard Specifications* are onsite.
- If paving or finishing operations will extend beyond daylight hours, check that adequate lighting facilities are on the project before paving begins.

4-4003B Paving

- Maintain good communication between field personnel inspecting the placing portion of the paving operation and plant inspection personnel, so that problems related to mixing or hauling may be addressed and corrected effectively.
- Refer to Section 4-90, "Concrete," of this manual for a discussion of transporting concrete and receiving weighmaster certificates at the delivery point.
- Check that the contractor furnishes the required tachometer. Also, be sure the contractor does the vibrating at the locations and in the frequencies and amplitudes specified. Be alert for inoperative units, and verify that they are replaced immediately.

- Watch for improper proportions or inadequate mixing as concrete is placed. In the daily report, record the reasons for any concrete rejection and the approximate amount involved.
- Observe the operation of equipment on existing pavements to make sure no cracking or other damage occurs. If damage occurs, order immediate corrective action.
- At the start of each day's work, check that the specified date stamp is used to mark the new pavement.
- Make sure acceptance testing is performed on concrete pavement in accordance with Section 40-1.01D(8), "Department Acceptance" of the *Standard Specifications* and Section 6-1, "Sample Types and Frequencies," of this manual for the identified quality characteristics.
- For California Test 523, "Method of Test for Flexural Strength of Concrete (Modulus of Rupture)," select a location to store concrete beams. A good location is one convenient to a water source and removed from any traffic. Require the contractor to supply sufficient sand or earth for burying the beams. Arrange for the contractor also to supply labor for assistance with transporting and burying the beams. Note the safety precautions in the test method.
- Check that sufficient beam samples are molded for modulus of rupture acceptance testing based on lot size and age strength requirements. Make additional sets of beams to determine acceptable flexural strength when pavement crossings will be open to public traffic or to job traffic earlier than normally permitted. Make sure fabricated beams are properly handled, cured, and transported before testing.

  California Test 523, "Method of Test for Flexural Strength of Concrete (Modulus of Rupture)," follows ASTM C31, "Standard Practice for Making and Curing Concrete Test Specimens in the Field," for making and curing concrete test specimens.

  Beam Fabrication: For the beam fabrication, use the following information as described in ASTM C31 (Sections 6 and 9):

Minimum Cross-Sectional Dimension of Beams	
Nominal Maximum Aggregate Size (in)	**Minimum Cross-Sectional Dimension (in)**
≤ 1	4 x 4
Between 1 and 2	6 x 6

Method of Consolidation Requirements	
Slump (in)	**Method of Consolidation**
≥ 1	Rodding or vibration
< 1	Vibration

Molding Requirements	
Consolidation Method	**Number of Layers of Equal Depth**
Rodding	2
Vibration	1

Curing of beams: Initial curing, final curing for acceptance, and field curing for traffic opening are described in the following paragraphs.

Initial Curing: Store standard-cured specimens for as long as 48 hours after molding, while maintaining the temperature and moisture conditions specified in ASTM C31, Section 10.1.2.1.

Temperature range varies according to the specified concrete strength, as summarized in ASTM C31, Section 10.1.2.1.

Concrete Strength (psi)	Initial Curing Temperature Range (˚F)
<6000	60 - 80
≥6000	68 - 78

A satisfactory temperature environment can be created during the initial curing of the specimens by one or more of the following procedures: (1) use of ventilation; (2) use of ice; (3) use of cooling devices; or (4) use of heating devices, such as electrical resistance heaters or light bulbs. Other suitable methods may be used if the temperature requirements are met.

A satisfactory moisture environment can be created during the initial curing of the specimens by one or more of the following procedures: (1) immerse molded specimens with plastic lids in water; (2) store specimens in a container or enclosure; (3) place specimens in damp sand pits; (4) cover specimens with plastic lids; (5) place specimens inside plastic bags; or (6) cover specimens with wet fabric. Immersion in water may be the easiest method to maintain required moisture and temperature conditions during initial curing.

Final Curing for Acceptance: Upon completion of initial curing, transport specimens to the laboratory. During transporting, protect the specimens with suitable cushioning material to prevent damage from jarring. During cold weather, protect the specimens from freezing with suitable insulation material. Prevent moisture loss during transportation by wrapping the specimens in either plastic or wet burlap. Moisture loss during transportation can also be prevented by surrounding the specimens with wet sand or tight-fitting plastic caps on plastic molds. Transportation time must not exceed 4 hours.

Within 30 minutes of removing the specimens from their molds, cure specimens with free water maintained on their surfaces at all times at a temperature range of 70-77 degrees Fahrenheit using water storage tanks or moist rooms complying with the requirements of ASTM C511, “Standard Specification for Mixing Rooms,

Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes."

Beams must be stored in water saturated with calcium hydroxide at 70-77 degrees Fahrenheit at least 20 hours before testing. Drying of the surfaces of the beam shall be prevented between removal from water storage and completion of testing.

Field Curing for Traffic Opening: As nearly as practicable, cure beams in the same manner as the concrete in the pavement. To meet these conditions, specimens made for the purpose of determining when the pavement may be open to traffic must be removed from the molds 44-52 hours after molding. Store specimens representing pavement by placing them on the ground as molded, with their top surfaces up. Bank the sides and ends of the specimens with earth or sand that must be kept damp, leaving the top surfaces exposed to the specified curing treatment. Store concrete pavement specimens as near as possible to the pavement they represent. Provide these specimens with the same temperature protection and moisture environment as the concrete pavement they are representing. At the end of the curing period, leave the specimens in place, exposed to the weather in the same manner as the concrete pavement. Remove all beam specimens from field storage and store in water saturated with calcium hydroxide at 70-77 degrees Fahrenheit for 20-28 hours immediately before time of testing to assure uniform moisture condition.

- Where air entraining admixtures are required by the project's pavement climate region, in accordance with Section 40-1.02B(4), "Air Entrainment," of the *Standard Specifications*, perform verification testing and use quality control testing for acceptance for air content of concrete pavement. Follow the contractual procedure specified in Section 40-1.01D(8)(b)(ii), "Air Content" of the *Standard Specifications*.
- Monitor the contractor's conformance with their quality control plan. Verify that control charts for required quality control tests are being updated on each day of paving and adhere to the quality control plan, including action and suspension limits. When deficiencies are observed, notify the contractor and document in the daily report. When deficiencies are not resolved or continue to occur, suspend the contractor's pavement operations until the contractor provides satisfactory assurances and written documentation of their corrective plans. Where appreciable differences are encountered between the quality control tests and acceptance tests, investigate and resolve these concerns with aid of the district materials engineer as necessary.
- Verify that the contractor performs coefficient of thermal expansion sampling and specimen fabrication and submits test results and specimens as specified.
- For jointed plain concrete pavements, check that dowel bar baskets, tie bar baskets, and the bars themselves are not being displaced during the concrete placement and paving operations. Check that the contractor is properly identifying and constructing contraction joints relative to pavement references

and bar centroids in conformance with the contract requirements and the contractor's quality control plan.

- For jointed plain concrete pavements, monitor the contractor's timelines from concrete placement to curing application and contraction joint sawing in comparison to their planned schedule from their early age crack mitigation system. Notify the contractor promptly of any deviations and record this information in the daily report along with the location of the work.
- When joints are to be formed rather than sawed, be sure joint material is placed as specified.
- Verify that the contractor constructs a transverse construction joint if the time interval between two successive concrete loads is greater than the specification allowance. Check that such joints are constructed at permissible contraction joint locations.
- Caution the contractor to construct the pavement so it will meet requirements for inertial profile, straightedge, and edge slump before final finishing to minimize corrective work. Inconsistent delivery and nonuniformity of concrete can affect paver performance and have negative effects on the paved surface. Where encountered, document these locations in the field and within the daily record.
- Measure the pavement's width at the beginning of and periodically after paving. While the required width applies to both upper and lower surfaces, the bottom width can be greater than specified to reduce edge slump.
- Check that end anchors are constructed at all required locations and to the dimensions shown on the plans. Be sure transverse contact joints are constructed and tie bars and dowels are placed as shown on the plans. When required, check that pressure relief joints are constructed as specified and shown on the plans.

4-4003C Finishing Pavement

- Make sure the contractor performs preliminary finishing according to specifications and in a way that imparts the desired surface characteristics.
- During concrete finishing observations, consider the following information:
    1. Pavement can be durable with inadequate texture or be well textured and not have enough durability to retain the texture.
    2. Mixing water with surface mortar during finishing reduces surface durability. This mixture may result from "bleed" water that had not evaporated, water that was added to the surface to make finishing easier, or water that was added to prevent hairline cracking and checking.
    3. If any of the concrete visible during finishing is more dilute than the mortar of the freshly placed concrete, too much water is being mixed into the surface. Telltale signs of the unacceptable practice include:
        a. Soupy mortar during finishing.

b. Excess laitance.

c. Small scallops in the slab's edge.

d. Areas still soft and wet in the finished surface while the surrounding area has turned firm and lost its watery sheen.

4. Standing bleed water may appear on the surface under certain conditions shortly after pavement is placed. To avoid mixing bleed water with surface grout, complete preliminary finishing before bleeding progresses to this degree.

5. Water applied for the convenience of finishing, not otherwise needed to produce the specified product, is contrary to specifications regarding water use for retempering.

- Check that the contractor performs the final finishing as specified and in a way that results in a finished surface with the desired characteristics.
- When sufficient rain may fall to damage fresh pavement, stop pavement placement or verify that other steps, such as covering, are taken to prevent damage.
- Before texturing, check that the contractor rounds the pavement edges to specified radii. Observe texturing for compliance with requirements. Verify that the contractor performs initial texturing with a broom or burlap drag to produce striations parallel to the centerline.
- Check that burlap drags are used as specified and kept sufficiently clean to avoid irregularities in the texture. Brooms used must also be kept sufficiently clean to avoid significant irregularities. Final texturing must be done with spring-steel tines that produce grooves parallel to the centerline. Grooves not straight and parallel to the centerline are unacceptable. Grooves are to be constructed over the entire pavement width with the exception of within 3 inches of pavement edges and longitudinal joints. Make sure the cross section of the steel tines complies with specifications. Inspect the pavement surface to verify that grooves meet the specified depth.
- Before and after the application of curing seal, make sure that the contractor keeps the pavement surface moist as specified.
- Verify that the contractor uses either the waterproof membrane method or curing compound method specified in Section 90-1.03B, "Curing Concrete," of the *Standard Specifications*. During observations, also note the following:

  1. Waterproof membrane:

     a. Make sure the contractor sprays the concrete with a mist of water until the concrete has set before placing the membrane. Make sure water does not flow over or wash the concrete surface.

     b. Examine the waterproof membrane to see that it meets specifications. For assistance, consult the district materials engineer.

c. Verify that membrane material is placed and secured and that any damaged sheeting is repaired as the specifications require.

d. If polyethylene sheeting is used, monitor maximum concrete temperatures during curing, checking that the maximum allowable is not exceeded.

e. Make sure the contractor adheres to the specified curing period.

2. Curing compound:

a. Check that the contractor applies the curing compound uniformly after tining. See that sawed cuts or other disturbed areas receive additional curing compound. Your inspection should verify the following attributes for the compound:

i. It is not contaminated, diluted, or altered before application.

ii. It is mixed thoroughly before application.

iii. It is applied when concrete surfaces are still visibly moist.

iv. The curing film remains unbroken for the specified duration of curing.

b. Perform measurements and calculations for the curing seal's application rate. To determine the rate, you may use California Test 535, "Determining the Application Rates of Concrete Curing Compounds in the Field." Record the measurements in the daily report.

- Verify that concrete pavement joints are constructed in conformance with Section 40-1.03B, "Joints" of the *Standard Specifications*; the contractor's quality control plan; and the contractor's early age crack mitigation system for jointed plain concrete pavements. Longitudinal and transverse contraction joints must be sawed before cracking occurs and after the concrete is hard enough to saw without spalling, raveling, or tearing. The contractor is responsible for determining the exact time of sawing. Check that concrete debris, water residue, and paste are immediately removed during saw cutting operations and that slurry from the sawing operation is immediately washed from the joint and removed. Where spalling, raveling, and tearing are observed, make sure the contractor performs repairs in conformance with Section 40-1.03N(2), "Spall and Ravel Repair," of the *Standard Specifications*.
- Check that concrete pavement temperature is maintained above 40 degrees Fahrenheit during the initial 72 hours after placement.

4-4003D Post-Paving

- Identify where core locations are to be taken by the contractor. Obtain core submittals throughout pavement operations for determining pavement thickness and air entrainment, which is required when the contractor's quality control air entrainment test results are not verified by Caltrans testing. For jointed plain concrete pavements, obtain cores for evaluating dowel and tie bar placement and concrete consolidation in these areas. Verify that specified placement

tolerances have not been exceeded relative to constructed contraction joints and orientation of pavement edges.

- For jointed plain concrete pavements, examine concrete pavement surfaces once the cure period is complete. If necessary, order the contractor to obtain concrete cores for further evaluation. Verify that partial depth cracks are treated with a high molecular weight methacrylate resin in accordance with Section 40-1.03N(3), "Crack Repair," and Section 41-3, "Crack Treatment," of the *Standard Specifications*. Check that working cracks within 0.5 foot of either side of a planned contraction joint and the adjacent unformed contraction joint are treated in accordance with Section 40-1.03N(3). Pavement slabs with full depth cracks other than working cracks require the removal and replacement of slab or slab portions. Spall or ravel areas larger than specified allowance must be repaired under Section 41-4, "Spall Repair," of the *Standard Specifications*. Slabs with combined raveled areas greater than 5 percent of the slab area or with a single area of more than 4 square feet must be removed and replaced.
- For continuously reinforced concrete pavements (CRCP), examine pavement surfaces for cracking and raveling. Any full-depth cracking with faulting exceeding specified limits will require repair in conformance with Section 40-2.03E(3), "Full-Depth Repair," of the *Standard Specifications*. High molecular weight methacrylate is not to be applied to any cracks in CRCP. Any raveled areas of specified size must be repaired in conformance with Section 40-2.03E(2), "Partial Depth Repair," of the *Standard Specifications*.
- Verify that the contractor performs inertial profiling on specified areas. Refer to Section 36-3, "Pavement Smoothness," of the *Standard Specifications* and Section 4-36, "Surfacing and Pavements—General," of this manual for additional information. Areas requiring correction for smoothness may be ground under Section 42-3, "Grinding," of the *Standard Specifications*, subject to meeting minimum pavement thickness requirements. Alternatively, these noncompliant areas may be removed and replaced. Once corrective work has been performed and the contractor's corrective inertial profile shows compliance, arrange through the district for inertial profile acceptance testing for pavement smoothness. Pavement areas not subject to inertial profiling requirements must meet specified straightedge requirements.
- Obtain contractor's inertial profiler information and reports for each day of inertial profiling of concrete pavement. Refer to Section 36-3, "Pavement Smoothness," of the *Standard Specifications* and Section 4-36, "Surfacing and Pavements—General," of this manual for additional information.
- With the district materials engineer, arrange to measure the coefficient of friction (California Test 342, "Surface Skid Resistance with the California Portable Skid Test"). Do not open pavement to traffic unless the coefficient of friction has been obtained.
- Note the following for coefficient of friction:

1. Areas with uniform surface texture require testing only at representative locations to assure that the required coefficient of friction has been provided. Test areas with visibly smoother texture as completely as necessary to verify compliance or delineate areas that must be corrected.
2. Tests made at temperatures lower than 40 degrees Fahrenheit will yield low results; therefore, do not rely on such tests as indications of failure. However, you may use values higher than the required minimum to indicate compliance even if you made measurements at temperatures lower than 40 degrees Fahrenheit.
3. To determine if the contractor's method of texturing is capable of producing the specified results, perform some tests as soon as possible after paving begins. Note that tests performed before the concrete is 7 days old are not valid for acceptance. Whenever early tests are performed, advise the contractor that such areas are subject to retesting. If the contractor has used the pavement for hauling or conducted an operation that could reduce the friction factor from the one originally determined, retest such areas before opening them to public traffic.
4. Areas not meeting coefficient of friction requirements must be corrected by grooving or grinding in conformance with Section 42, "Groove and Grind Concrete," of the *Standard Specifications*. Retest the corrected sections as necessary to verify the coefficient of friction value has been met.

- After any required corrective grinding, determine locations where coring for thickness will be performed by the contractor. Observe coring operations and obtain drilled corings in properly identified plastic bags from the contractor. Use cores to determine acceptance of concrete pavement thickness. Do not allow coring machines on fresh concrete while any danger exists of damaging the concrete. Wait at least 72 hours.
- Check that any required rumble strips are ground into the concrete pavement after the minimum specified time and strength have been obtained. Verify that the completed rumble strip conforms to the tolerances for alignment, spacing, depth, length, and width. Make sure equipment noise restrictions are met. Refer to Section 84-8, "Rumble Strips," of the *Standard Specifications* for additional information concerning rumble strips.
- Obtain contractor's plan if repair or replacement of noncompliant concrete pavement is required.

4-4003E Measurement of Pavement Thickness

Use the following procedure for determining pavement thickness and any applicable deductions:

- Cores taken in each primary unit of pavement at the minimum specified rate and cores in primary unit areas taken at the contractor's request are referred to as "primary cores."

- Primary cores do not include cores taken for secondary thickness measurements. These cores and those taken to determine the limits of secondary units are referred to as secondary cores.
- Before coring begins in primary units, designate areas where coring is excluded. Limit excluded areas to the following:
  - Dig-out spots in the subgrade
  - Thickened slabs at bridge approaches
  - End anchors
  - Local areas where authorized modifications to the planned pavement thickness have been permitted
- Do not exclude portions of the primary unit where equipment had difficulty or where unauthorized deviations from planned pavement thickness occurred.

4-4003E (1) Location of Primary Cores

Do the following to locate primary cores:

- For each pavement thickness on each day's paving, determine the net area, in square yards, of pavement placed, excluding the area of structures and other areas on which pavement is not placed during that day. The resulting measurement is the area of the primary unit. Divide the area of the primary unit by 1,200 square yards and take the next highest whole number. The resulting number is the number of primary cores to be taken, unless the contractor requests additional ones.
- Divide the net length of the primary unit by the number of primary cores to be taken in that unit. The resulting distance is the primary coring interval.

Locate the first core in any primary unit by starting at either end of the unit (preferably proceeding in the direction of increasing stations), and select a lane at random. Select any factor from the longitudinal factors shown in Table 4-40.1, “Calculation Factors to Locate Cores,” and multiply the factor by the primary coring interval. The result is the distance from the beginning of the primary unit to the first core. (Any random method of selecting the longitudinal location of the first core is within the intent of the specification.) Determine the lateral location of the first core by selecting a value from the lateral column shown in Table 4-40.1, Calculation Factors to Locate Cores,” and measuring that distance from the right-hand edge (when looking ahead) of the lane selected.

Table 4-40.1. Calculation Factors to Locate Cores

Longitudinal (Factor)	Lateral (Feet)
0.6	6
0.1	10
0.2	2
0.9	9
0.5	5
0.7	7
0.4	4
0.8	8
0.3	3

- In turn, locate the remaining primary cores in the lanes. Space them uniformly, from the first core in the unit, at longitudinal intervals equal in length to the primary coring interval for the unit. Then locate them laterally within each lane as used for the first core by applying successive values from the lateral factors in Table 4-40.1. All values in the table are to be used successively for each primary unit throughout the project after the value for the first core in the unit is selected at random. The location of each core should be spotted on the pavement within "pacing accuracy" longitudinally and within about 1 foot laterally.

4-4003E (2) Location of Secondary Cores

To determine the limits of secondary units, locate cores in approximately the center of each adjacent panel. Note that for continuously reinforced concrete pavements, panel lengths are defined as 15 feet for this purpose.

4-4003E (3) Thickness Variation

For all cores, determine the pavement thickness variation by subtracting the specified thickness of pavement from the thickness determined by core measurements determined by California Test 531, "Method of Test for Length of Drilled Concrete Cores." Record excess thickness by using a plus sign and deficient thickness by using a minus sign.

4-4003F Calculation of Deductions in Payment to the Contractor for Deficient Thickness

Take these steps when calculating deductions based on deficient thickness:

4-4003F (1) When None of the Primary Cores are Deficient in Thickness by More Than 0.05 Foot

When no primary cores are deficient in thickness by more than 0.05 foot, make an adjustment as follows:

- To determine the average thickness deficiency, if any, for the primary unit, average the thickness variations of all primary cores. Record this value to the nearest 0.01 foot. If the average thickness deficiency is less than 0.01 foot, make no deficiency adjustment. If the average thickness deficiency is more than 0.01 foot, continue with the following steps.
- To obtain the deficiency adjustment in dollars per square yard, use the table in Section 40-1.01D(8)(c)(iv), "Thickness," of the *Standard Specifications*. The average thickness value is to be rounded to the nearest hundredth of a foot for averages from 0.01 foot to 0.05 foot when using the pay adjustment table.
- To obtain the total amount of payment to deduct for the primary unit, multiply the deficiency adjustment by the total area of the primary unit in square yards.

4-4003F (2) When One or More of the Primary Cores are Deficient in Thickness by More Than 0.05 Foot

When one or more cores are deficient in thickness by more than 0.05 foot, determine the limits of the deficiency by taking a secondary core in adjacent panels. Continue taking a secondary core in adjacent panels, expanding as necessary, until the deficient area is bounded by panels with deficient thickness of 0.05 foot or less. The bounded area is referred to as a secondary unit. Reject the secondary unit area for noncompliance pursuant to Section 5-1.30, "Noncompliant and Unauthorized Work," of the *Standard Specifications*. Exclude the secondary unit areas from payment and deduction calculations. In the calculation to determine average thickness of the primary unit, use the average thickness of all secondary cores outside the secondary unit to replace the thickness of the initial primary core within that secondary unit.

To determine the primary unit deduction, multiply the primary unit area, excluding any secondary unit areas, by the appropriate factor (if any) in the table titled "Deduction for Thickness Deficiency" within Section 40-1.01D(8)(c)(iv), "Thickness," of the *Standard Specifications*.

To determine the total deduction, add the deductions for primary units and the cost of all secondary cores, including those taken outside secondary unit areas.

Following is an example illustrating the procedure for measuring the pavement for thickness and calculating deductions for thickness deficiencies. The procedures and the dollar figures used for deductions from payments to the contractor used in the example are based on Section 40-1.01D(8)(c)(iv), "Thickness," of the *Standard Specifications.*

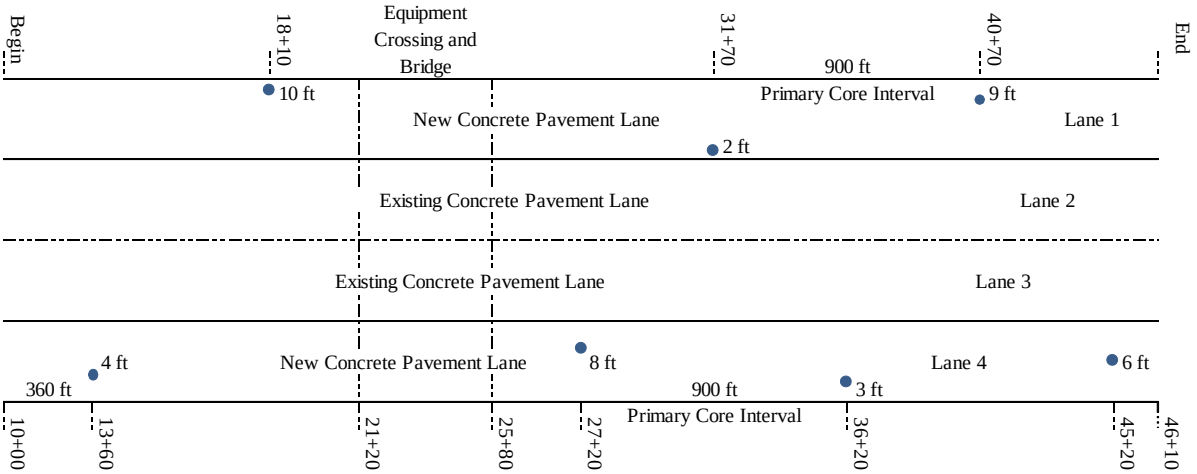
Assume the following:

The contractor paved two lanes (1 and 4) from Station 10+00 to Station 46+10. An equipment crossing and a bridge within the limits of the day's run caused "skips" in the length paved totaling 460 feet (from Station 21+20 to Station 25+80). The actual length paved was 6,300 feet (3,150 feet x 2 lanes). The total area paved on this date was 8,400 square yards.

The engineer calculated the number of cores required for thickness measurements in the primary unit (8,400/1,200 = 7) and the core interval (6,300/7 = 900). To determine the location of the first core, the engineer chose the outside lane (4), at random and used the seventh set of numbers at random, from Table 4-40.1, "Calculation Factors to Locate Cores." The first core was taken at a longitudinal distance of 360 feet from the beginning and at a lateral distance of 4 feet from the right edge of the lane. Subsequent cores were taken at a core interval of 900 feet, excluding skip areas, proceeding from lane 4 to lane 1. Figure 4-40.1, "Primary Cores," illustrates the primary unit and the locations of all the primary cores.

Figure 4-40.1. Primary Cores

The core thickness variations for the respective numbered cores were determined as follows:



a. Length of primary unit = 6300 ft {[(4610-1000) - (2580-2120)]*2}
b. Number of cores = Area/Core Frequency = (6300 ft x 12 ft x 1 sqyd/ 9 sf) / (1200 sqyd/core) = 7 cores
c. Primary core interval = 6300 ft / 7 cores = 900 ft/core
d. Location of the first primary core:
In this example the outside lane (4) is chosen (at random), and the seventh set of numbers (at random) from Table 4-40.1 is used. The first core is taken at a longitudinal distance from the beginning of 360 ft (0.4 x 900 ft). The first core is taken 4 ft from the right edge of the lane.

Core Number	Stationing and Lane	Core Offset	Thickness Variation
1.	Sta. 13+60 Lane 4	4 ft off right edge	-0.03 ft
2.	Sta. 27+20 Lane 4	8 ft off right edge	+0.02 ft
3.	Sta. 36+20 Lane 4	3 ft off right edge	+0.03 ft (use +0.02 ft)
4.	Sta. 45+20 Lane 4	6 ft off right edge	-0.03 ft
5.	Sta. 18+10 Lane 1	10 ft off right edge	-0.04 ft
6.	Sta 31+70 Lane 1	2 ft off right edge	-0.00 ft
7.	Sta 40+70 Lane 1	9 ft off right edge	-0.07 ft

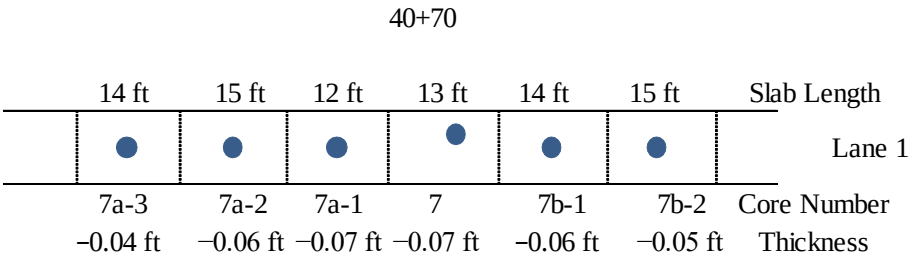
Core 3 is more than 0.02 foot greater than the specified thickness, so + 0.02 foot was used in the calculation to determine thickness deficiency in the primary unit in accordance with Section 40-1.01D(8)(c)(iv), “Thickness,” of the *Standard Specifications*.

Core 7 was deficient by more than 0.05 foot. Because of this deficiency, the next step was to determine the dimensions of the secondary unit from secondary thickness measurements.

To determine the limits of the secondary unit, the resident engineer ordered secondary thickness measurements in the panels adjacent to the panel where Core 7 was taken. Subsequent thickness measurements were in panels adjacent to panels with thickness deficiencies of more than 0.05 foot. This process continued until the secondary unit was bounded by panels in which the secondary measurements were deficient in thickness by 0.05 foot or less. Cores in each of these panels were taken in the center of the panel.

Figure 4-40.2, “Secondary Cores,” illustrates the thicknesses of the secondary cores taken.

Figure 4-40.2. Secondary Cores



Core Number	Thickness Variation
7a-1	-0.07 ft
7a-2	-0.06 ft
7a-3	-0.04 ft
7b-1	-0.06 ft
7b-2	-0.05 ft

The panels in the secondary unit area represented by cores 7, 7a-1, 7a-2 and 7b-1 were measured and found to be 54 feet in length and represent 72 square yards.

The engineer averaged thickness variations of the secondary thickness measurements outside the secondary unit area. The resulting value was used in the calculation instead of the thickness variation for Core 7 to determine the average thickness deficiency of the primary unit area. The core thickness variations in the panels surrounding the secondary unit are tabulated below.

Core Number	Thickness Variation
7a-3	-0.4 ft
7b-2	-0.5 ft

The average of the thickness variations in the preceding table is -0.045 feet. This average was rounded to -0.05 foot, and used for the thickness variation for Core 7 in the primary unit.

Using -0.05 foot for the Core 7 thickness deficiency, the engineer calculated the average thickness deficiency (cores 1 through 7) for the primary area to be -0.016 foot. This average was rounded to -0.02 foot and used for the thickness deficiency for the primary unit.

The remaining area of the primary unit, after the area of the secondary unit was subtracted, was as follows:

8,400 - 72 = 8,328 square yards.

The deduction from payment to the contractor for thickness deficiency in the primary area in accordance with Section 40-1.01D(8)(c)(iv), "Thickness," of the *Standard Specifications* was calculated as follows:

8,328 square yards x $2.30/square yard = $19,154.40

The secondary unit area was later removed, reworked, and replaced. A single core was then taken to determine thickness variation and found to be -0.01 foot. A deduction was then taken on the remedied secondary unit as follows:

72 square yards x $0.90/square yard = $64.80

In addition to the deductions for pavement thickness deficiencies in the primary and secondary units, a deduction from payment to the contractor was made for the cost of all secondary thickness measurements. The cost of secondary thickness measurements was the cost of cores 7a-1 through 7a-3, 7b-1 through 7b-2, and 7c-1 (core taken after replacement of secondary unit).

4-4003F (3) Contractor's Requests for Additional Thickness Measurements

If, after the primary coring is performed, the contractor requests additional thickness measurements in any primary unit, treat the request as a request for doubling the frequency of coring in the primary unit area. Locate the additional cores in a manner similar to that used for locating the primary cores. This approach will halve the interval distance between primary cores. To calculate the deficiency adjustment, do not separately consider additional cores that are deficient in thickness by no more than 0.05 foot. Instead, include these cores with the original primary cores. If additional cores are deficient in thickness by more than 0.05 foot, determine the limits of the secondary areas.

Do not grant permission to a request from the contractor for selective coring. However, if the contractor requests additional thickness measurements before the performance of any of the primary coring, you may shorten the length of the coring interval for the primary unit accordingly. For example, the contractor may request a

rate of one core for each 600 feet of traffic lane rather than one core for each 900 feet. The request will have the effect of increasing, not necessarily doubling the number of cores.

Deduct from the payment to the contractor the cost of additional thickness measurements that resulted from the contractor's request.

If a contractor requests more than one round of additional cores, consult with the construction field coordinator before granting permission.

4-4003G Handling of Skips in the Original Day's Pour and Secondary Areas to Be Removed and Replaced

Skips, such as gaps left for traffic or equipment crossing, short distances between adjacent bridges, and secondary areas to be removed and replaced, are ultimately poured at a later date. The net area of such pavement placed in any one day technically becomes a primary unit area and, as such, is subject to the specifications regarding thickness measurements. Use judgment regarding which of these areas warrant thickness coring. In general, any area excluded from final coring should be small, and you must have other measurements to confirm that the thickness of the pavement is not deficient.

4-4003H Handling Deficient Areas Not Cored

When you have specific knowledge of areas deficient in thickness and you have records of the extent of such deficiency, exclude these areas from the random coring. Make the deficiency adjustment on the average thickness deficiency in the same manner as for areas that have been cored.

4-4003I Administration

Notify the contractor in writing of the date and place where coring will be performed. Follow up orally, if necessary, to be certain the contractor knows when and where coring will take place.

After measuring and recording pavement thickness, retain the cores until final agreement is reached on payment for the concrete pavement, usually after the contractor returns the proposed final estimate.

The personnel who measure core thickness prepare the coring records, which include information about core location (include sketches) and measured thickness. The original records and one copy are given to the resident engineer, who retains the original and forwards the copy to the contractor. Personnel from the district materials laboratory will keep one copy; another copy goes to METS in Sacramento.

Separate reports should be prepared and identified for secondary area measurements. These reports will help determine the cost to the contractor for secondary coring and provide a clear record of secondary areas. Follow the same distribution of copies described for primary unit reports.

Coring for determining acceptance of dowel bars and tie bar placement is to be conducted in a similar manner as that of thickness, except use revised lot sizes

based on the specified frequencies. If dowel or tie bars are placed outside the specified tolerances, or cores show air voids around the bars, obtain additional cores to determine the limits of unacceptable work. Determine the areas that will require removal as specified in Section 40-1.03N, "Correcting Noncompliant Pavement Work," and Section 40-4.03B, "Correcting Noncompliant Pavement Work," of the *Standard Specifications*.

4-4004 Level of Inspection

Suggested levels of field inspection for typical concrete pavement activities are:

- Benchmark inspection of subgrade for compaction and elevation requirements.
- Benchmark inspection of forms and paving equipment.
- Intermittent inspection of reinforcement, dowel bars, tie bars, dowel bar baskets, and tie bar baskets.
- Benchmark inspection of the contractor's early age crack mitigation system for jointed plain concrete pavements.
- Continuous inspection of concrete delivery, placement, finishing, curing, and contraction joint operations.
- Continuous acceptance sampling and testing of fresh concrete.
- Intermittent monitoring of the contractor's adherence to their quality control plan.
- Benchmark evaluation of pavement for cracking, faulting, spalling, and raveling.
- Benchmark inspection of dowel and tie bar placement through coring.
- Benchmark inspection for coefficient of friction, smoothness, and thickness.

4-4005 Quality Control

Guidance for quality control activities included in this section is summarized as follows:

- Review contractor's quality control plan.
- Make sure the contractor submits a copy of the AASHTO accreditation for the laboratory performing the mix design.
- Review control charts, verify that results for quality characteristics are in compliance, and check that copies of control charts are posted at designated location.
- For jointed plain concrete pavements, check that the contractor performs quality control methods to properly locate contraction joints, dowel bars, and tie bars.
- For jointed plain concrete pavements, review the contractor's early age crack mitigation analysis. As necessary, verify contractor's analysis by performing an independent simulation using high performance concrete paving software.

4-4006 Payment

Using the dimensions shown on the plans, calculate the quantity of concrete pavement to be paid for. Use curve corrections to make sure that calculations account for curves in alignment.

Make deductions from contract payments for deficient pavement thickness.