Chapter 4 Construction Details

Section 19 Earthwork

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Section 19 Earthwork

4-1901 General

Earthwork includes operations connected with roadway excavation, repair of slope failures, blasting, structure excavation, backfill, ditch excavation, compaction, embankment construction, grading, borrow excavation, placement of subgrade enhancement geosynthetic (SEG), placement of shoulder backing, and removal of unsuitable material or a buried man-made object. For earthwork requirements, refer to Section 19, "Earthwork," of the *Standard Specifications*. Also refer to Sections 10-5, "Dust Control," and 17-2, "Clearing and Grubbing," of the *Standard Specifications*.

Potential problems are discovered during all phases of construction staking, so it is essential that the resident engineer and assistant resident engineers maintain good lines of communication with the survey party chief. For the same reason, assistant resident engineers should also maintain good communication with the contractor's grade checkers and supervisory personnel.

4-1902 Before Work Begins

Resident engineers and assistant resident engineers must do the following to prepare for earthwork operations:

4-1902A Roadway Excavation

- Review right-of-way agreements, environmental reports, and other data about earthwork. Advise the contractor of any features that may require special handling. Take steps to ensure that environmentally sensitive areas are protected.
- Before any excavation, under California Government Code, Section 4216, "Regional Notification Center System," the contractor must notify the regional Underground Service Alert (USA) notification center by calling 811 or submitting an electronic ticket request at least 2 days before excavating. To ensure that the contractor has notified the regional USA notification center, request the contractor provide the ticket number issued by the USA center. Caltrans is not affiliated with USA, so Caltrans is not notified to mark out Caltrans underground facilities. To ensure that existing Caltrans underground facilities are identified before allowing the contractor to excavate, contact the local electrical maintenance regional manager for help in locating Caltrans facilities. To help identify any Caltrans facilities within the right-of-way, such as irrigation systems, signal and lighting systems, ramp metering systems, traffic monitoring stations and communication conduits, obtain the latest utility "as-built" from the Electrical Maintenance Unit.
- Review the information handout regarding permits; hazardous waste, asbestos or lead investigation reports; and optional disposal sites.

- Make a preliminary check of earthwork quantities. Decide how quantities will be measured for partial payments. Refer to Section 4-1906, “Payment” of this manual.
- Review the status of utility relocation work. Advise the contractor of any changes that may affect the work. Refer to Section 3-518C, “Nonhighway Facilities,” of this manual for more details on utilities.
- Ensure the clear marking of features and facilities that are to be preserved.
- Review and verify the contractor’s submitted list of existing irrigation system deficiencies. For more information, refer to Section 20-10.02C(2), “Check and Test Existing Irrigation Systems,” of the *Standard Specifications*.
- When the contract requires trench excavation, obtain from the contractor a detailed plan showing the design of shoring, bracing, sloping, or other provisions for worker safety. Ensure either that a licensed civil or structural engineer signs the plan or that it conforms to the shoring system standards established by the *Construction Safety Orders* (CSOs) of the Department of Industrial Relations, Division of Occupational Safety and Health (Cal/OSHA).
- Plans submitted by the contractor of the shoring details for excavations on or affecting railroad property must be satisfactory to the railroad company involved. To meet this requirement, an engineer who is licensed as a civil or structural engineer in the State of California must sign the plans (whether or not such plans deviate from Cal/OSHA standards). Submit the plans to Structure Construction in the same manner as for falsework drawings. Structure Construction will obtain the railroad company’s approval and notify the resident engineer. For additional details, refer to Structure Construction’s *Bridge Construction Records and Procedures* manual, Vol. 2, and the Caltrans *Trenching and Shoring Manual*. After review by Structure Construction and approval by the railroad company, return one set of the plans to the contractor with a written statement that, “The plans are approved under Section 5-1.23B(2), “Shop Drawings,” of the *Standard Specifications*. Structure Construction manuals are available at:

  https://dot.ca.gov/programs/engineering-services/manuals
- Discuss with the contractor the schedule of earthwork operations, sources of materials, equipment capacities, and any potential hauling problems involving public traffic. Ensure that the contractor’s plan of operation complies with any specified order of work, environmental agreements, and pollution control requirements.
- Verify that the contractor’s plan to control water pollution has been approved and implemented before beginning work. Refer to Section 13, “Water Pollution Control,” of the *Standard Specifications*.

4-1902B Blasting

4-1902B (1) Safety Considerations

All blasting work must be conducted in strict accordance with the CSOs or a properly approved alternate safety plan. An alternate safety plan is required when a 45-foot clear zone cannot be maintained around the loading area, such as a blasting area adjacent to traffic. The CSOs contain the required elements of an alternate safety plan. These elements include low-sensitivity explosive materials, initiation systems that cannot be affected by stray current or radio frequency energy, a system to detect lightning and electric storms, and barriers to prevent entry by vehicular traffic.

In addition to reviewing any blasting plan the contract requires, discuss the planned blasting operation with the contractor. Address the following areas of concern before blasting begins:

- Blast area security—Review the procedures the contractor proposes to ensure security plans are adequate to protect the public from unauthorized entry into the blast area during the loading, arming, and detonating of the explosives. Often this review will require the contractor to consider more than automobile traffic. Consideration should include recreational activities such as boating, hiking, and biking, or production activities such as farming and ranching. Some activities may use unusual entry routes.
- Electrical storms—No explosive can be considered “safe” should lightning strike directly or nearby. Always consider lightning when planning to use explosives. During a review of the electrical storm section of the contractor’s safety plan, include an evaluation of the plan’s objective and the procedures and equipment to be used.
- Radio transmissions—Review the contractor’s proposal for controlling or eliminating the possibility of a premature detonation due to radio transmissions (including transmissions from cellular telephones).
- Warnings and signals—Review the warnings and signals to be used and, if an unsafe condition should be observed, the method by which the blast can be stopped.
    1. Audible signals (as shown in the CSOs) are a widely used standard and intended to inform workers in the area that blasting is in progress. These signals are not intended to be meaningful to the public. The use of these signals is the preferred method of communication within the work area.
    2. Signs, guards, and flaggers should be used for public communications. The contractor may need a separate means of communication and control for public traffic. If radio communications will be used for site monitoring or traffic control, ensure the contractor adheres to the safe distance tables in the CSOs. Adhering to safe distances becomes critical when “rolling roadblocks” or “traffic breaks” are to be used.
- Onsite authority—Cal/OSHA regulations require that all blasting operations be under the direct control of a licensed blaster. The contractor should identify this

person as the person who has final authority over the blasting and who will be responsible for giving the “all clear” following a post-detonation inspection of the blast area.

- The relationship between the resident engineer and the licensed blaster is different from the relationships normally encountered on most contracts. By law and regulation, the licensed blaster is responsible for and is the final authority on the conduct of blasting operations. The resident engineer may only intervene in the case of a violation of the CSOs or public safety. When intervening, the resident engineer may only suspend the operation until the hazards are abated or the contractor (blaster) conforms to the safety orders.
- Misfires—Misfires are very unusual occurrences, but when they occur, they pose serious safety problems. These problems have the potential to escalate rapidly when public traffic is involved. Ensure the adequacy of the contractor’s contingency plan for misfires.

4-1902B (2) Routine Duties

Review the special provisions for additional requirements or restrictions related to blasting. Sometimes presplitting of rock excavation is required, and considerable detail covering this work is included in the contract. The special provisions may also include other requirements such as ground motion limits and preblast surveys of nearby buildings.

The resident engineer should also perform the following routine duties, among others:

- Ensure the blaster understands the survey stakes sufficiently to avoid placing explosives beyond slope tolerances.
- Order the discontinuance of any method of blasting that leads to overshooting or destruction of property or natural features.
- Ensure that all legally required warning signs are in place.

4-1902C Ditch Excavation

Before ditch excavation, review the plans and the site to determine if original ground needs to be cross-sectioned. Most ditches will require slope stakes and, on even ground, you can use slope stake information alone to calculate quantities. If cross sections are necessary, the survey party can accomplish that work at the same time as slope staking.

4-1902D Structure Excavation and Backfill

To ensure the integrity of a structure, resident engineers and assistant resident engineers must pay considerable attention to structure excavation and backfill. Various categories of structure excavation and backfill and various methods of measurement and payment exist. Often, the payment limits will not match the physical limits used in the construction of a facility. Also, take the following steps:

- Before excavation, review the plans and stakes to determine the following:
  1. Whether the structure will clear other facilities.
  2. Whether the structure will function as planned in this location or should be adjusted.
  3. Whether sufficient data is available for quantity calculations.
- To install culverts in an embankment, ensure the embankment is at the elevation specified.
- Decide whether a camber is required in a culvert or other drainage structure. If so, give the survey crew or the contractor, or both, the necessary data.
- Before backfilling, inspect structures and ensure that any required strutting or bracing, as shown on the plans, is in place.
- Test backfill material for compliance with specifications and test compaction.

4-1902E Embankment Construction

Carefully examine areas upon which embankments are to be constructed. Include a review of the information handout and an onsite observation during clearing.

Review permits, environmental studies, and requirements to ensure that the contractor meets all commitments, including any measures pertaining to providing necessary access roads. Where work will affect areas beyond those approved for construction purposes or involves an environmentally sensitive area, consult with the district or regional environmental office.

Look for the following:

- Lush vegetative growth in local areas, seepage, and springs indicating groundwater.
- Trees, brush, or fences leaning downhill, indicating slippage of the surface material.
- Rolling, hummocky terrain, twisted trees, or lack of vegetation in otherwise timbered areas, indicating a large slide.

When foundation problems are known during the project's design, normally the contract will address treatment of such areas. However, when serious problems exist that the contract has not addressed, consult with the district materials engineer, the geotechnical engineer, or both.

The following are some of the most common major foundation problems and the types of solutions frequently recommended:

- The weight of the embankment displaces or consolidates material in the foundation causing settlement. This condition is corrected by the following:
  1. Removing the plastic material if it is economically feasible.

2. Placing strut fills or buttress fills on either or both sides of the embankment to act as a counterweight. The fills resist any upward movement of the foundation material adjacent to the embankment.
3. Constructing the embankment at a controlled rate so that any anticipated settlement will take place over time and allow hydrostatic pressures to dissipate.
4. Constructing surcharges on the completed embankment to accelerate settlement. Settlement platforms or piezometers, or both, monitor rates of settlement. They may be installed and used under the direction of the district Materials Unit.

- Loss of stability may occur when the embankment forms a dam and impounds water, causing saturation. This may result in sloughing of part or all of the fill. This condition is corrected by the following:
  1. To provide drainage, placing a filter material blanket over the area that is to receive embankment. Stripping foundation material may be necessary.
  2. Constructing ditches or underdrains at the upper side of the fill to intercept water. This method is effective only if the underdrain or ditch intercepts and removes all the seepage water.
- The weight of a sidehill embankment causes movement on a slippage plane in the underlying foundation. This type of embankment failure is characterized by the mass movement of a large portion of the fill. This condition is corrected by the following:
  1. Constructing a stabilization trench through the slippage plane. Stabilization trenches, located beneath the embankment, are constructed in wet areas to intercept and remove water from deep, unstable embankment areas. These trenches may be major installations involving large quantities of excavation, filter material, and drainage pipe.
  2. Installing horizontal drains to drain water from the slippage plane.
  3. Changing a line or grade so that the roadway is in cut or on a smaller embankment, thus reducing the load on the slippage plane.

The contractor may often need to use combinations of the above methods for the most troublesome foundation problems.

Before the construction of embankments, also do the following:

- When consolidation of the embankment's foundation can be estimated and will be appreciable, adjust the width to be staked. When applicable, remember to include any such change in quantity calculations.
- If the foundation material will be displaced and consolidated, undertake additional measures. Place a line of "telltale" or "heave" stakes 9 to 24 feet outside of and generally parallel to the toe of the fill slope. Set these stakes to line and elevation by normal survey methods so that they will indicate both vertical and horizontal movement of the ground. In addition, inclinometers or slope indicators and

settlement platforms may be used. For installing these devices, contact the district Materials Unit. Ensure that adequate cover is placed to protect settlement platforms from damage by the grading equipment. Schedule regular monitoring and recording.

4-1902F Borrow Excavation

If the contractor requests that import borrow be measured and paid for based on borrow site cross sections, verify that the source of borrow is used exclusively for the project. Coordinate testing and survey of the imported borrow material site prior to opening.

Review the contract for specific types of borrow the contractor will use. Also, in the resident engineer's pending file, review environmental and other requirements and commitments. This includes compliance with the Surface Mining and Reclamation Act, permits and right-of-way agreements, and other items that may affect borrow excavation.

4-1902G Shoulder Backing

Review the contract documents to determine the type of shoulder backing and the locations where shoulder backing will be placed. Verify the locations in the field for accessibility and applicability.

4-1902H Subgrade Enhancement Geosynthetic

Review the contract for the specific type of SEG. The layout plans should show the limits of SEG (width and length). The typical cross sections should clearly show the location of SEG within the pavement or embankment section. If separation geotextile is used with an SEG, the pavement cross section should show the location of separation geotextile that is typically placed at the subgrade interface (below the SEG). To determine SEG material compliance, refer to Section 96-1.02O, "Subgrade Enhancement Geotextile," of the *Standard Specifications.* For further information on SEG, refer to the *Subgrade Enhancement Geosynthetic Design and Construction Guide* at:

https://dot.ca.gov/programs/maintenance/pavement/concrete-pavement-and-pavement-foundations/pavement-foundations

4-1903 During the Course of Work

Inspect the earthwork operations identified below during the work.

4-1903A Roadway Excavation

Consider the following areas when inspecting roadway excavation:

4-1903A (1) Hauling Material

For the requirements for hauling material, refer to various sections of the contract and to Section 3-519B, "Load Limits,'' of this manual. Section 7-1.04, "Public Safety,"

of the *Standard Specifications* further covers the hauling of earth, specifically with respect to spillage of material.

4-1903A (2) Unsuitable Material

Section1-1.07, "Definitions," of the *Standard Specifications* defines unsuitable material as "Material encountered below the natural ground surface in embankment areas or below the grading plane in excavation areas. . ." For unsuitable material, the resident engineer's duties include the following:

- Examine all basement material and all natural ground upon which embankments are to be constructed. Advise the contractor of the areas and depths of material to be removed.
- Before removing unsuitable material that is not shown on the plans or specifications, determine the method of payment for excavation and disposal:
    1. If payment will be at contract prices, record adequate measurements for calculating quantities.
    2. If the contractor requests payment to be made as extra work, obtain the request in writing. Prepare and process a change order, and keep the necessary records relating to extra work.
- Normally, unsuitable material may be placed in embankment or contour areas.
- Examine areas where the contractor has removed unsuitable material, and before backfilling, decide on any necessary drainage or other corrective action.
- Advise the contractor of the type of material that will be suitable backfill. Observe the operation to ensure it complies with specifications.
- In addition to routine data, record in the daily report all pertinent discussion with and orders to the contractor regarding unsuitable material.

4-1903A (3) Slides and Slipouts

Perform the following steps when handling slides and slipouts:

- Examine slopes for areas of potential slides. Decide on any corrective action necessary. Corrective action may include any of the measures suggested in the paragraph below. For detailed analysis and recommendations for major problems, consult with the district Materials Unit and geotechnical engineers.
- Examine slides and slipouts to determine their probable cause. Decide on any corrective work necessary. Corrective action for a slide may require totally or partially removing the slide and flattening slopes or installing horizontal drains or underdrains, or both. For small areas, consider constructing bulkheads or retaining walls. For large areas, consider constructing benches to reduce traffic hazards from falling material. When benches are constructed, provide access roads for future maintenance.
- Corrective action for a slipout may require totally or partially removing and reconstructing the embankment with more suitable material. Also, consider

constructing fill struts, stabilizing trenches, and installing subsurface drainage facilities.

- When correcting slides and slipouts requires work in areas not already available for state use on the project, any or all of the following actions may be necessary before the work may proceed: 1) obtain new or revised permits; 2) conduct new environmental studies; and 3) meet new environmental compliance requirements. Review all previously identified haul roads and flattened slopes to determine if they involve impacts not disclosed by existing environmental documentation. If the needed area extends beyond that approved for construction or may affect an environmentally sensitive area, consult with the district or regional environmental office.
- Before removal or corrective operations, determine the method of payment:
    1. If the contractor requests the removal of slides and slipouts to be paid for as extra work, obtain this request in writing. When the resident engineer decides this removal should be paid as extra work, record this decision in the change order memorandum. Then process a change order for an ordered change or extra work.
    2. When payment is by item price for roadway excavation, measure the additional quantities and enter them on appropriate source documents that clearly identify the limits of the slides or slipouts.
- Any applicable method or combination of methods of compensation may be used to pay for removing slides or slipouts. Refer to Section 5-306C, “Methods of Payment,” of this manual for compensation methods.
- Decide where the contractor should deposit the material resulting from slides and slipouts. When practicable, use all the material for embankments or for flattening slopes or contour grading.
- Take before-and-after photographs of the slide area.

4-1903A (4) Slopes

The engineer responsible for earthwork must review the slope stakes and ensure missing stakes are replaced in accordance with Section 5-1.26, “Construction Surveys,” of the *Standard Specifications*. Also, refer to Section 3-5, “Control of Work,” of this manual and Chapter 12, “Construction Surveys,” in the *Surveys Manual* for more information on staking. In addition, the resident engineer must perform the following steps:

- Make sufficient measurements to verify the proper start of slopes.
- Make sufficient spot-checks to verify the correct slope tolerances.
- Check the slope rounding for compliance with the contract. While the top of the slope is still reachable with equipment, decide whether the contractor should do additional slope rounding or contour grading.

- Ensure that the construction of any special items for erosion control complies with the contract. This review must include items on the contractor's approved plan for controlling water pollution.
- Ensure that all top-of-slope or toe-of-slope ditches will drain.
- Ensure that embankment widening complies with the contract plans for installing guard railing.
- Examine slopes for material that blasting has shattered or loosened. Order the removal of this material.

4-1903A (5) Surplus Material

The resident engineer's responsibility for surplus material and related actions will vary considerably depending on the terms of a particular contract. Generally, for those contracts that include payment for embankment construction within the payment for roadway excavation, determine as early as possible whether there will be a surplus (or deficiency) of material. For contracts that provide separate payment for embankment, ensure that the contractor satisfies the conditions in Section 5-1.20B(4), "Contractor–Property Owner Agreement," of the *Standard Specifications*.

The following are some of the factors to analyze when determining whether there will be an unplanned surplus (or deficiency) of roadway excavation:

- Determine adequacy of the amount of embankment estimated for subsidence of original ground, considering different field conditions than those the design engineer anticipated.
- Calculate variations of slopes. Even within specified tolerances, slope variances can significantly affect quantities.
- Be alert to differences between pay quantities and the actual amount of roadway excavation as a result of curve correction. On some projects, this difference can significantly affect a surplus (or deficiency) of material.
- Decide whether the planned grading factors (shrinkage or swell) need to be adjusted based on actual conditions. The factors may be adjusted in any way the resident engineer judges to be appropriate. Appropriate judgments are based on the following:
  1. Previous experience.
  2. Measurement of definable portions of excavation and resulting embankment.
  3. In-place densities in excavation compared to in-place densities in embankment.

In estimating the actual grading factor, also consider consulting with geotechnical engineers in the district Materials Unit who have local experience.

When the amount of any unplanned surplus is known, make plans for its ultimate disposal. Normally, do not order or permit any disposal before embankments are complete, and do not relieve the contractor of the obligation to complete all embankments before disposal.

The actions necessary for unplanned surplus will vary, depending on whether the project already has a planned surplus with available disposal areas, or whether the project was planned as a balanced project with no readily available or economically feasible disposal sites. Consider factors such as the location of the surplus within the project and whether the surplus can be disposed of within the right-of-way.

The contractor may place surplus material within or alongside an embankment, between an embankment and a right-of-way line, or in the loops and gores of interchange areas. Remember that such placement is subject to the requirements for constructing embankments. Also, ensure material is not disposed of above the grade of the adjacent roadbed unless the resident engineer specifically issues a written authorization. Select disposal sites that will not interfere with drainage, will benefit future development, and will improve appearance or stability.

When unplanned surplus material can be disposed of within the project, decide whether it will be economically more feasible either to order changes in earthwork immediately or to perform the disposal after all embankments have been completed.

When unplanned material will be removed from the project, immediately begin arrangements for disposal unless planned disposal sites will accommodate the excess. Such arrangements must include a review of environmental agreements to ensure compliance.

Before submitting ordered changes to the contractor, consult with the construction engineer on the proposed disposal of unplanned surplus. Consider disposing the surplus on excess parcels if such disposal will improve the parcels' value.

When appropriate, enter the cost or anticipated cost of disposal in the contract records to produce an accurate contingency balance.

4-1903A (6) Deficiency of Material

When the engineer's analysis of quantities indicates an unplanned deficiency of embankment material, determine whether to make up the shortage by obtaining local borrow, increasing excavation, or by obtaining imported borrow. Make this determination whether or not the contract includes an item of imported borrow. Also, consider factors such as economic feasibility, safety, environmental requirements, and material quality.

Obtaining material from outside the project's limits may require the processing of a "public interest finding." Refer to Section 3-6, "Control of Materials," of this manual for more information about this requirement.

Notify the project manager of any major deficiencies (or surpluses) so that adjustments can be made for future projects.

Keep adequate measurements and records to support payment.

4-1903A (7) Selected Material

The contractor cannot use selected material for any purpose other than that designated unless the resident engineer first determines ample material remains for the planned work.

If it is feasible and economically advantageous to the state, initiate a change order to substitute the selected material for planned aggregate subbase.

Do not order the contractor to stockpile the selected material unless stockpiling is planned, economical, or necessary for the movement of traffic.

4-1903A (8) Excessive Groundwater

When excessive groundwater is encountered at subgrade, the resident engineer's duties include the following:

- Contact the district hydraulics engineer, geotechnical engineer, or both, to discuss the materials information and the area's known groundwater depths. Also, discuss with these experts any viable alternatives for stabilizing the area.
- Advise the contractor of the situation, and work with the contractor to determine the payment method for implementing the desired alternative.
- Prepare and issue a change order, if necessary.

4-1903B Structure Excavation and Backfill

Consider the following when inspecting for both structure excavation and backfill.

4-1903B (1) Structure Excavation

The resident engineer's duties include the following during structure excavation:

- Observe the excavation to ensure that sloping or shoring conforms to the contractor's approved detailed plan or to the sloping or shoring requirements in the CSOs.
- To anticipate changes because of the foundation's condition, periodically inspect the excavation. When the foundation's condition is not stable and requires further investigation, contact the district geotechnical engineer to discuss the materials information and a viable foundation investigation. In consultation with the geotechnical engineer, direct the contractor to conduct a foundation investigation, which may include digging test pits, drilling test borings, and performing foundation bearing capacity tests. This additional work will be paid as extra work.
- Before fine grading begins, order any necessary additional excavation.
- Enter in the daily report any orders to increase excavation, and enter sufficient data in the appropriate records to support additional payment.
- Pay for additional quantity by measuring such quantity and including it in the appropriate contract records when no extra work is involved.
- Observe fine grading to ensure compliance with requirements for grade and culvert beddings.

4-1903B (2) Structure Backfill

The resident engineer's duties include the following during structure backfill:

- Inspect the backfill to ensure it is brought up uniformly and in the specified layer thickness.
- When slurry cement backfill is used, ensure that it is adequately fluid and is placed so that it completely fills the area around the culvert. One of the advantages of slurry cement backfill is that it provides adequate support on the underside of pipes where compaction of ordinary backfill material is difficult. The contractor must avoid "floating" the culvert.
- If backfilling steel culverts, reinforced concrete, or other metal products, ensure the contractor adds only nonchloride admixtures to slurry cement backfill to accelerate the setting time. Chloride-containing admixtures, used to hasten curing, increase the corrosion potential of the steel or reinforced concrete structure. In addition, slurry cement backfill or controlled low-strength material cannot be used as structure backfill for aluminum or aluminized steel pipe culverts.
- Ensure that all conditions described in the specifications are met before permitting "ponding" and "jetting." "Ponding" means flooding the backfill material for a period of time (by erecting dams or dikes) so that water will pond on the material. "Jetting" means forcing water into the layer of backfill material through a small diameter pipe. Ponding alone is not permissible because it does not give uniform or adequate consolidation. Pressure jets must be inserted at the bottom of the backfill material at close, uniform intervals.
- Prohibit the use of any compacting equipment or methods that may displace or damage structures or otherwise adversely affect foundations or adjacent embankments.
- Order compaction tests (except for slurry cement backfill) to ensure compliance with the contract. Also, determine the frequency of such testing, ensuring sufficient frequency to determine compliance with requirements. Determine frequency based on variables such as the nature of the material and the efficiency of the contractor's methods. At the beginning of backfilling, take sufficient tests to establish the amount of effort required to attain the required compaction.
- Ensure the contractor places compacted impervious material where erosion of backfill material or seepage through backfill material may occur. This approach is particularly important at culvert inlets.
- Ensure the contractor places pervious backfill material as specified.
- When imported material is used as structure backfill for metal products such as steel pipe, culverts, or reinforced concrete, the imported backfill must be at least as noncorrosive as the native soil material. Consequently, the special provisions should specify corrosive parameters for the imported fill that are less corrosive than that of the native soil. This requirement applies to imported soil, lightweight

aggregate fill, and controlled low-strength material. Contact Materials Engineering and Testing Services for assistance with corrosion recommendations.

4-1903C Ditch Excavation

Ensure ditches are excavated to the required lines and grades. Require any areas excavated below grade to be backfilled according to the specifications. When ditches are to be lined with concrete or shotcrete, require the contractor to prepare the foundation in accordance with Sections 53, “Shotcrete,” or 72, “Slope Protection,” of the *Standard Specifications*.

4-1903D Embankment Construction

The resident engineer’s duties include the following during embankment construction:

- As material is placed, verify that the thicknesses of the layers meet specifications. Also, verify that the contractor fills voids between rocks in each layer with earth or other fine material. Record such observations in the daily report.
- Ensure the contractor does not place rocks, broken concrete, or other solid materials larger than 4 inches in areas where piles are to be placed or driven.
- During hillside construction or where the section changes from embankment to excavation, ensure that benching into existing material is adequate for proper keying of embankment material to original ground. Decide whether benching should exceed 6 feet. If widening eliminates the need for end dumping from above, increase the benching width to provide room for compacting equipment. Advise the contractor accordingly, and measure the additional excavation for payment.
- Observe end dumping and prohibit its continued use as soon as normal embankment methods can be used.
- Ensure the contractor removes from embankment areas all debris from clearing, unless the special provisions allow otherwise. In heavy grading operations, small gullies and canyons may be filled with loose material during pioneering and haul road construction. During this phase, close observation is necessary so that such areas can be recorded for future correction.
- During embankment construction, measure the cross-fall to ensure it does not exceed specifications.
- Ensure embankment slopes comply with specified tolerances.
- Ensure surcharges and settlement periods comply with contract requirements.

4-1903E Compaction

Compaction directly affects the supporting strength of soil. The less the compaction, the lower the supporting power when the material is saturated. The contractor must

choose the method for achieving the required compaction, and the engineer must not direct the compaction operation.

The contractor may choose to use wetting agents, provided no detrimental effects result.

The resident engineer's and assistant resident engineer's duties include the following during compaction:

- Measure the compaction to ensure compaction meets specifications. Test at the frequency necessary for control. Take into account the uniformity of the material and the uniformity of the particular operation. Generally, if the operation is uniform and well within specifications, testing frequencies may be decreased. For nonuniform operations, borderline results, or both, increase testing frequencies.
- Observe compaction testing to ensure it complies with contract requirements. Advise testing personnel of the specific limits of the testing area.
- If the contractor chooses to excavate basement material to facilitate compaction, examine the underlying material before the area is backfilled. Decide whether the layer of material below the excavated basement material should be compacted. In general, if sufficient loose material exists to allow settlement of subsequent layers, order compaction of the underlying material by change order.

To attain the required compaction, ensure that the contractor sufficiently dries material that contains excessive moisture. Also, ensure that the resulting embankment is firm and stable.

4-1903F Borrow Excavation

During borrow excavation, the resident engineer's duties include the following:

- Make measurements and keep adequate records for progress and final payment.
- When material is to be paid for by the ton, ensure there is sufficient moisture testing to determine pay quantities. For more information, refer to Section 9-1.02D, "Quantities of Aggregate and Other Roadway Materials," of the *Standard Specifications*.
- Ensure the contractor submits the necessary documents covering possible local material sources. For details, refer to Section 3-6, "Control of Materials," of this manual.

4-1903G Shoulder Backing

Test the shoulder backing materials for meeting the specification. Ensure the compaction is adequate. Make sure the shoulder backing is completed within 5 days after placement of adjacent new surfacing.

4-1903H Subgrade Enhancement Geosynthetic

SEG material can be damaged easily if mishandled during construction. During placement of SEG, the resident engineer should ensure that the product has been installed correctly by adhering to the following installation requirements:

- SEG shall be placed directly on a cleared surface along the alignment to the limits shown on the plans. The surface to receive the geogrid or geotextile, immediately prior to placing, shall conform to the elevation tolerance and cross slopes as specified in the plans.
- The subgrade to receive the SEG must conform to the compaction and elevation tolerance specified in Section 25-1.03B, “Subgrade,” of the *Standard Specifications* and project special provisions and must be free of loose or extraneous material and sharp objects that may damage the SEG during installation.
- SEG must be handled and placed in accordance with the manufacturer's recommendations and pulled taut to form a wrinkle-free mat on the prepared surface.
- Borders of rolled out geogrid or geotextile must be overlapped a minimum of 2 feet in the direction as ordered by the resident engineer. All roll ends must be overlapped a minimum of 2 feet in the direction of the spreading of the aggregate subbase material. As determined by the resident engineer, an overlap larger than 2 feet may be required for lower-strength subgrade (R-value < 5).
- The geotextile or geogrid must be cut to conform to the curves. A minimum overlap of 1.5 feet shall be provided for adjacent geotextile or geogrid cut sides. The overlap must be held in place by staples, pins, or piles of fill of the materials to be placed on the geotextile or geogrid, or as directed by the resident engineer.
- Construction equipment must not operate directly on the geogrid or geotextile. A minimum of 6 inches of fill cover is required prior to operation of construction vehicles atop the geotextile or geogrid.
- The amount of SEG placed on subgrade must be limited to that which can be covered with aggregate subbase or base material within 72 hours.
- Special care must be taken in the handling of geogrids manufactured from polypropylene at temperatures at or below 0 degrees Fahrenheit.
- Stockpiling of materials directly on the SEG is not allowed. Once a sufficient working platform has been constructed, all remaining materials must be placed and compacted in accordance with special provisions and the *Standard Specifications*. A minimum of 6 inches of fill material must be maintained between the geotextile or geogrid and the equipment to prevent damage to the geotextile or geogrid. Until this sufficient working platform has been constructed, compaction must be achieved by using either smooth wheel (without vibratory action) or rubber-tired rollers. Sheepsfoot or other types of compactor equipment employing a sheepsfoot shall not be used. Excessive turning of vehicles must not be allowed on the aggregate subbase or aggregate base material placed directly over the geotextile or geogrid.
- Areas of geotextile or geogrid damaged beyond repair during placement must be covered by a new geosynthetic covering. The overlap from the edge of the damaged area must be a minimum of 3 feet.

- Geotextile or geogrid must be laid at the proper elevation and alignment as shown on the plans or as directed by the resident engineer. Geogrid must be oriented such that the roll length runs parallel to the roadway alignment.

4-1904 Level of Inspection

Suggested levels of inspection for typical earthwork activities are:

- Continuous inspection of structure excavation under Section 19-3, "Structure Excavation and Backfill," of the *Standard Specifications*.
- Intermittent inspection of grading, blasting, and compaction of roadway structural section.
- Benchmark inspection of placement of structure backfills, embankment, shoulder backing, subgrade geosynthetic and foundation preparation for embankment and roadway.
- Intermittent sampling and testing of material and compaction measurement of embankment within 150 feet of bridge abutments.
- Benchmark sampling and testing of imported borrow and relative compaction of material where specified.

4-1905 Quality Control

While specific levels of quality control sampling and testing for earthwork are not included in Section 19, "Earthwork," of the *Standard Specifications*, the contractor is responsible for providing quality control under Sections 5-1.01, "General," and 6-2.02, "Quality Control," of the *Standard Specifications*. Ensure the contractor is actively performing quality control on production and placement of structure backfills, shoulder backing, and subgrade enhancement geosynthetic.

4-1906 Payment

The following measurement and payment information covers roadway excavation, structure excavation and backfill, and ditch excavation.

4-1906A Roadway Excavation

The resident engineer's duties include the following regarding measurement and payment for roadway excavation:

- Usually, the design calculations to determine quantities of roadway excavation are suitable to be incorporated directly into the project records as source documents. Check the accuracy of these calculations. Also check whether slope rounding and quantities for contiguous ditches (as shown in the *Standard Plans*) have been included.
- Before beginning work, check the accuracy of original ground elevations using slope stake locations. It may also be necessary to take field cross sections or run profile lines to check original ground elevations.

- Check the roadway template and subgrade elevations. Include in the project records all documentation substantiating roadway excavation quantities. It should be easy to trace back from the total pay quantity to the source documents.
- When all roadway excavation is complete, reconcile the total quantity with the total of the partial payments. It is important to determine early in the project, and as closely as possible, the total pay quantity for roadway excavation. This early determination, coupled with the periodic adjustment of partial payment totals (as described in the following paragraph), will help prevent overpayment.
- During the work, choose a method to measure roadway excavation quantities for partial payment. One method commonly used is "load count." Load count involves determining daily production by reaching an agreement on the capacity of hauling equipment and by using the contractor's daily load tally. To make a preliminary determination of unit capacity, you can use the following methods:
  1. Using previous experience.
  2. Measuring volumes of hauling equipment.
  3. Weighing a loaded hauling unit and converting results into volume of material in the cut.
- As work progresses check actual conditions as frequently as possible. As a single cut is completed, compare volume in that cut to volume represented by load counts from the cut. It may also be possible to cross-section partially completed excavations, calculate work done, and compare the result to load count totals. When these checks indicate over- or underpayments, make up the difference in the current partial payment. Adjust the capacities of hauling equipment so that future partial payments based on load count are more accurate.
- Unless otherwise specified, payment for embankment is included in payment for other items of work. However, the quantities of material in embankments must be known to determine whether a surplus or deficiency of excavated material will exist. On a project involving significant amounts of earthwork, predicting a surplus or a deficiency of roadway excavation should be a primary concern in the early stages and throughout the project. Refer to the discussion regarding subsidence and grading factors under 4-1903A (5), "Surplus Material" of this manual. During the work, it is just as important to periodically measure the constructed embankment as it is to periodically measure the completed excavation. These periodic measurements are usually the most accurate way to determine the actual grading factor.
- When the contractor disposes of surplus material, additional haul distances may occur. It may be appropriate to pay for additional hauling cost as extra work. Use a mass diagram as a useful tool for determining haul distances.

4-1906B Structure Excavation and Backfill

To determine methods and limits for calculating structure excavation and backfill pay quantities, and payment clauses, review the special provisions, the *Standard Plans*,

and Section 19-2.04, “Payment,” of the *Standard Specifications*. Note that the payment for structure excavation and backfill is included in the payment for some structures and culverts. Before excavation, determine if it is necessary to profile or cross-section original ground in structure excavation areas.

4-1906C Ditch Excavation

To determine whether ditches and gutters are to be paid for as ditch excavation or roadway excavation, review the specifications, plans, and *Standard Plans*.

Measure the pay quantities of ditch excavation using the average end area method. Before excavation, determine if it is necessary to profile or cross-section original ground.

4-1906D Borrow Material

Before beginning work, verify the planned ground surface of excavations and the embankment area by measuring the ground surface. Determine the theoretical volume of the embankment and excavation from the planned or authorized cross sections of embankment or excavation and the verified measured ground surface. The payment quantity of imported borrow is the material deficiency calculated as the difference between the theoretical volume of the embankment (fill) and theoretical volume of excavation (cut).

In lieu of measurement of imported borrow by theoretical volume basis, the contractor may request to be paid for imported material quantity if the borrow material is from a single dedicated borrow site. Do not authorize to import borrow from multiple sites or from a single site that is not used exclusively for the project. If authorized, the contractor must inform the engineer and give Caltrans access to the site. Before beginning work, take cross-section elevations and ground surface measurements of the borrow site after any clearing, grubbing or stripping before as well as after any excavation of borrow materials. The quantity of the import borrow is measured based on the calculated volume of material from the average area and the distance between the pre-borrow excavation and post excavation cross section.

When the source of borrow material is unknown or multiple borrow sources are used, payment for imported borrow material is determined by the volume of material deficiency. The material deficiency is calculated as the difference of cut and fill based on the cross-sections of the embankment and the roadway excavation shown on the plan. If a borrow source is used exclusively for the project and borrow is paid for based on the volume, borrow material can be paid for based on the cross section of borrow areas. Before beginning work, cross-section all known borrow areas that are dedicated to the project. Calculate the volume of borrow from the cross sections average area and the distance between them before and after the excavation.

4-1906E Shoulder Backing

Measuring and paying for shoulder backing by the station is not permitted.

Shoulder backing is paid for by the ton. For payment, use the factor 145 lb/cu ft or 0.0725 ton/cu ft when volume is known. If a more accurate factor of conversion is

needed, determine the actual dry density of the shoulder backing material being used.

4-1906F Subgrade Enhancement Geosynthetic

SEG is measured and paid for by the square yard of the surface. Caltrans does not pay for additional geosynthetic used for overlaps.