Chapter 4 Construction Details

Section 83 Railings and Barriers

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4-8301 General

Railings and barriers are used to reduce the severity of run-off-the-road accidents, to prevent out-of-control vehicles from crossing the median, and to slow errant vehicles. Construction personnel involved in the installation of railings, barriers, and other traffic safety systems should be familiar with *Traffic Safety Systems Guidance*, which supersedes Chapter 7, "Traffic Safety Systems," of the *Traffic Manual*:

https://dot.ca.gov/programs/traffic-operations

The following paragraphs discuss some of the details considered during design and construction. The details center on metal beam guard railing but can be applied to other types of railings and barriers. The district traffic safety device coordinator should be consulted if questions arise or changes are needed.

The design of guardrail contains many subtle details, the basis for which may not be readily apparent. Pay special attention to all connection details.

Guardrail must be anchored at both ends, in the same way a railing of rope would need to be anchored to function properly. Guardrail is normally anchored with a terminal system, an end anchor, such as a steel foundation tube or a buried post end anchor, or anchored to a structure using a transition detail.

Crash testing shows that the specified height of 30 to 32 inches for Midwest Guardrail System (MGS) is the optimal height to prevent errant vehicles from climbing over the guardrail. Spacing posts 6 feet 3 inches apart provides resistance to guardrail deflection on impact and lessens the tendency of the guardrail to form a pocket during impact.

If there is less than 4 feet, but at least 3 feet of clearance from the face of the guardrail to a fixed object, a strengthened rail section as shown in the *Standard Plans* should be used. This detail uses a combination of longer, heavier posts and closer post spacing to stiffen the rail gradually to reduce the deflection of an impact. If there is less than 3 feet of clearance, concrete guardrail should be considered.

A block attached to the post adds space between the rail element and the post. As a result, the guardrail is farther from the post and decreases the possibility of a vehicle snagging on the post. The block allows the guardrail to rise slightly on initial impact, reducing a vehicle's potential for rolling.

When timber shrinks, it introduces enough slack in the mounting bolts to allow the timber blocks to rotate. Toenailing the blocks to wood posts prevents this rotation. Plastic blocks used with steel posts have tabs that don't allow the block to rotate and are not nailed.

Do not allow use of washers on the rail face unless otherwise shown. Without washers, bolts will pull through the rail element if a vehicle strikes, releasing the rail from the post, and allowing the rail to remain elevated as the post is pushed over.

Do not allow holes to be drilled in the rail elements in the field unless shown on the plans.

The *Standard Plans* show how to transition from metal beam guardrail to concrete guardrail or bridge rail, and have a thrie beam element on the nontraffic side of the transition posts. The metal box spacer on the nontraffic side of the transition is used to match the width of the barrier to the width of the transition.

Transitions to bridge rail generally have nested thrie beam elements, one thicker 10-gauge under a thinner 12-gauge element. The difference in thickness can be seen when side by side or when calipers are used to check the thickness.

Frequently, when guardrail ends within the clear recovery zone, the plans and special provisions specify use of a proprietary end terminal system. The allowable alternatives are shown in the project special provisions. When the terminal system is required, verify that the system is installed in accordance with the manufacturer's instructions. Check that the contractor submits a certificate of compliance.

4-8302 Before Work Begins

Before work begins, take the following steps:

- Carefully review the required details to make sure that construction conforms to them. Review the locations in the field and decide whether changes are necessary. Contact the district traffic safety device coordinator and the design project engineer to concur with any changes. Verify that the Revised *Standard Plans* showing minor concrete vegetation control are indicated in the contract plans and are appropriate for the newly constructed or existing guardrail or thrie beam barrier.
- Verify the receipt and proper distribution of form CEM-3101, "Notice of Materials to be Used," which lists all fabricated materials. Examine the material as it arrives on the project to verify that it meets specifications. Refer to Table 6-2.1, "Inspection of Fabricated and Manufactured Materials," of this manual.
- Look for the identification tags or markings that indicate Materials Engineering and Testing Services (METS) inspected the materials. If the materials are properly identified as inspected, project personnel do not need the certificates of compliance or mill test reports. Normally, the METS inspector will have obtained these documents.
- Verify that markers and delineators for railings and barriers are the correct type and are covered by a certificate of compliance in accordance with the section titled "Prequalified and Tested Signing and Delineation Materials" in the special provisions. Refer to the Authorized Material List for signing and delineation materials:

  https://dot.ca.gov/programs/traffic-operations

- When reviewing the installations in the field, decide if any changes are required. For existing guardrail or thrie beam barrier, determine if erosion of the soil beneath or behind the guardrail will require backfill prior to placing forms to assure a maximum 3½-inch depth of minor concrete. Backfilling at existing guardrail locations is change order work.
- For minor concrete mix design check that:
  - Reinforcing fibers are included.
  - 28-day compressive strength test results are in the range specified.
  - The mix design has been authorized.

4-8302A Metal Beam Guard Railing, Thrie Beam Barrier, and Midwest Guardrail System

- If drainage inlets or other underground obstructions conflict with the planned locations for guardrail posts, consider using long-span MGS to omit as many as three guardrail posts. This design uses breakaway posts on either side of the omitted posts to minimize pocketing of the rail. This design should not be used at fixed objects because it allows greater deflections of the rail. Refer to Topic No. 3.6, "Guardrail Design Considerations," and Figure 7-12a, "Long Span MGS," of the *Traffic Safety Systems Guidance*. If using metal beam guard railing, refer to Figure 7-12b, "Long Span Nested MBGR," of the *Traffic Safety Systems Guidance*. Consult with the district traffic engineer for information. If the contract does not provide for long-span MGS or nested MBGR, a change order will be necessary.
- Review the contractor's stakes and layout work. Ascertain that offsets and flares for guardrail will be installed as shown on the plans.
- When connections to structures are required, coordinate with the Structures representative and Structure Construction for the review of shop plans for metal railing on structures.

4-8302B Concrete Barriers

- Verify that all concrete mix designs have been approved before use.
- To avoid possible conflicts, verify scupper, side drain, pull box, and conduit locations.

4-8303 During the Course of Work

Once work begins, take the steps below for each type of railing and barrier.

4-8303A Metal Beam Guard Railing, Thrie Beam Barrier, and Midwest Guardrail System

- Measure all post types at the job site to verify that they conform to specifications.

- When required, verify that bolt holes in treated posts are filled with grease. Note this inspection in the daily report.
- Verify that the backfilling of postholes conforms to specifications. Posts should be set to the full depth shown on the plans. When spread footings or other underground obstructions interfere with placing at full depth, refer to the *Traffic Safety Systems Guidance* and the district traffic safety device coordinator for alternatives.
- Periodically measure the spacing of posts. The slots manufactured into the rail are spaced for standard spacing. Do not allow additional holes or slots to be cut in the rail at the job site. If a post must be moved to a location that does not have a slot, bolt only the block to the post, not the rail to the block.
- Check that wood blocks for metal beam guard railing are toenailed to timber posts. Wood blocks for steel posts are routered to set into the post to prevent rotation and do not require nails.
- Verify that rail elements are lapped so that the exposed ends will not face approaching traffic. Check bolts for tightness, and check threaded rods for proper trimming. A light tap on the rail element with a hammer or wrench will reveal loose bolts, which will rattle or buzz as the rail is tapped.
- Measure the height of the guardrail and barrier above the ground or finished grade to verify that the height conforms to the plans.
- Make sure that connections to bridge railings, retaining walls, abutments, or other flat surfaces comply with specifications. When high-strength bolts are required, check markings on the bolts to verify that they match specifications. When necessary, consult with district laboratory personnel about the proper markings.
- Verify that anchor assemblies are constructed as specified and the cable clips installed in the proper direction and tightened to the required torque. When a sample cable is required for testing, the METS inspector will normally have obtained one with swaged fitting. If cable is properly identified as previously inspected, there is no need to obtain a sample.
- When posts are installed in loose soil or near embankment edges, longer posts or some design modifications may be necessary to assure a barrier with adequate strength. Refer to Sheet A77N3 in the *Standard Plans*. If longer posts are not specified for the project, a change order will be needed.
- Immediately before placing concrete, check that holes for concrete anchors and footings are excavated to the dimensions shown on the plans.
- Verify that anchor cables are tight enough to prevent any obvious slack in the cable once the footing concrete has cured for the required period.
- All anchor cables, including end anchors and terminal systems, must be tight to function properly. Cables should not be able to deflect more than 1 inch when pulled on by hand.

- Verify that the contractor properly disposes of surplus material from excavation. Refer to Section 3-510B, “Contractor-Property Owner Agreement,” of this manual. When traffic uses an adjacent lane, prohibit spoil piles or windrows of material from remaining in front of guardrail or median barriers. Such material alters the effective height of the railings and barriers. Also, be sure that the disposal of material does not interfere with proper drainage.
- Check that asphalt concrete dikes are positioned under the guardrail as shown on the plans. Only 2-inch dike (Type C) is allowed in front of or 25 feet in advance of a terminal system.
- Bolts or threaded rods must be long enough so the nuts are completely threaded onto the bolt. Make sure that no more than 1/2 inch of thread is exposed on the traffic side of the guardrail as shown on the plans.
- Check that the construction of guardrail flares conforms to the plans. Maximum flare for metal beam guardrail and thrie beam guardrail is 15:1. Concrete guardrail cannot be flared at greater than 20:1.
- Longer posts may be needed if there is not enough distance from the post to the hinge point (check Revised Standard Plan A77N3). If posts longer than the standard 6-foot length are installed, identify their location and record in the project records. Incorporate this information into the as-built drawings if different from shown.
- Any post not in a terminal or transition can be moved 1 foot in either direction along the guardrail to avoid an underground obstacle. If a post is moved and there is not a slot to bolt the rail to the post, do not drill a hole, just bolt the block to the post without going through the railing.
- There are other options for omitting or moving posts to avoid obstacles, such as adding posts, as long as the maximum spacing of 6 feet 3 inches is maintained. Also, two blocks can be used on a post or series of posts to space the post farther from an obstacle.
- Metal beam guard railing and MGS can use either 8-inch or 12-inch blocks. The project plans will specify which is to be used.
- When there is a grade break in front of guardrail, measure the height of guardrail based on the distance from grade break to adjust for trajectory. Extend the superelevation plane from the grade break to the face of rail and then measure the height to that line if within 2 feet of the grade break. If the height of the rail must be more than 2 inches above the standard height, rub rail may be required. Contact your district safety devices coordinator if you have questions.
- Prior to placement of minor concrete vegetation control, inspect the forms to assure the top of the guardrail or thrie beam barrier above the proposed concrete surface is constructed as shown on the plans for the guardrail system or thrie beam barrier.

- Prior to placement of concrete, inspect the forms and subgrade to make sure that the minor concrete vegetation control thickness will be 2 inches to 3½ inches when the concrete is placed.
- Prior to placement of concrete, inspect that the block-out material (Styrofoam) is installed around the wood or steel post. The block-out material must be in contact with the ground surface and allow 3/8-inch to 5/8-inch minor concrete installed over the top of it. The block-out material must be 1½ inches to 3 inches thick.
- The final surface of the minor concrete should be flush with the finished grade, ground line, or surfacing as shown on the Revised *Standard Plans*. For existing guardrail locations, backfilling may be required adjacent to minor concrete vegetation control to prevent any blunt edges of concrete being left exposed. Backfilling around minor concrete vegetation control at existing guardrail locations is change order work.
- Verify that when minor concrete vegetation control is installed under end treatments, the final surface of the minor concrete does not cover the cable connection end plate, hole in wood post, cable clip connections, or other end treatment hardware shown in the Revised *Standard Plans*. This applies to all parts that are exposed above the pavement or ground line.
- Grading must be completed before guardrail installation begins.

4-8303B Guardrail End Terminals Inspection

- Conduct the following steps before and during the installation of in-line and flared end terminals:
- Prior to the beginning of work, the specifications require the contractor to submit a certificate of compliance for each type of end terminal to be installed.
- Before installation begins, identify the location shown for the terminal and verify the grading is adequate for the type of terminal to be installed. Verify that the layout shown on the plans will fit the actual field conditions. Identify any drainage features, dikes, or utilities that may interfere with the guardrail, terminal alignment, or post spacing. Post spacing within a terminal cannot be changed from that shown in the manufacturer's manual and drawing. Contact the district traffic safety device coordinator if changes are needed. The length or alignment of guardrail ahead of the terminal, the type of terminal, or the amount of flare may need to be adjusted to fit each location. Communicate any changes as soon as possible to the contractor.
- The flare or offset on most terminals can be varied to fit field conditions. Typically, an in-line terminal can be flared as much as 2 feet, while a flared terminal can be flared 2.5 feet to 4 feet. Flare design allows the impact head on an in-line terminal to be moved away from traffic to minimize nuisance hits. Check the manufacturer's manual for amount of allowable flare.
- Before installation begins, the ground where the end terminal will be installed must be graded and soil must be compacted in accordance with project specifications and contract plans.

- During installation, use the manufacturer's checklist to check end terminal components and details as recommended by the manufacturer. Notify the installer of any issues that do not conform to the manufacturer's recommendations.
- At completion of installation, conduct a thorough quality assurance review using the manufacturer's checklist and make sure all components are used as required by the manufacturer's recommendations.
- File a copy of the completed checklist in Category 46, "Assistant Resident Engineer's Daily Reports," of the project records.
- Photographs of the completed end terminal must be taken and placed in the project record.
- Information about the type of end terminal installed must be recorded on the project as-built plans.

4-8303C Pipe Handrailing, Steel Bridge Railing, Cable Railing, Metal Railing (Tubular), and Chain Link Railing

- Verify that materials and methods used in anchorage and connections conform to the specifications and plans.
- Make sure the contractor connects, stretches, and tightens cables, chain link fabric, and tension wires as required.
- Check railings for proper alignment, appearance, and workmanship.

4-8303D Concrete Barriers and Railing

- Prohibit the placement of concrete barriers or railing on new structures until the falsework is released. Structure Construction will provide height adjustments to compensate for camber and dead load deflections.
- Review the specifications for closing temporary gaps in barriers during construction. Determine that the contractor has planned this work before removing existing barriers or constructing new barriers. Check that blunt ends exposed to traffic are adequately protected. Refer to the "Public Safety" section in the special provisions.
- Verify that forms comply with Section 51-1.03C(2), "Forms," of the *Standard Specifications.* For additional guidelines, refer to Section 4-51, "Concrete Structures," of this manual.
- When extrusion or slipform machines are used to construct concrete barriers, inspect the grade on which the machine will ride to determine if the grade is smooth enough to prevent foreseeable violations of specified tolerances. Check guide wires for obvious variations or measurable sags between supporting stakes.

- Check that the placing of bar reinforcing steel conforms to specified requirements and the details on the plans. For guidelines, refer to Section 4-52, “Reinforcement,” of this manual.
- Review applicable specifications for producing, placing, finishing, and curing portland cement concrete to be used in concrete railing and barriers. For guidelines, refer to Sections 4-51, “Concrete Structures,” and 4-90, “Concrete,” of this manual.
- Require stripping the forms from Type 50 and Type 60 series barrier early enough so the concrete surface may be given a light brush finish without resorting to tempering with grout.
- During the placing of extruded or slipform barriers, the design of the concrete and placing method should require no hand finishing other than a light brush finish. The surface of the traffic side of the concrete median barrier should be as smooth as possible. Prohibit heavy brooming or other activity that will leave a roughly textured finish.
- Observe the abrasive blast finish applied to Type 50 and Type 60 series concrete barriers. The surface should have a uniform appearance without heavy texturing.

4-8304 Level of Inspection

Suggested levels of inspection for typical railing and barrier work activities are:

- Intermittent inspection of railing post depth and post spacing.
- Benchmark inspection of completed railing or concrete barrier for each location or for a day’s production.
- Benchmark inspection of installed end terminal system using the manufacturer’s checklist, to make sure there are no deviations from intended product use. Checklists are available at Traffic Operation’s website:

  http://traffic.onramp.dot.ca.gov/safety-devices-approved-products

4-8305 Quality Control

While specific levels of quality control sampling and testing for railings and barriers are not included in Section 83, “Railings and Barriers,” 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*. Make sure the contractor is actively performing quality control on railing and barrier materials throughout production operations by reviewing copies of quality control records, including quality control test results.

4-8306 Payment

Measure railings, barriers, and terminal systems as specified and, where appropriate, to the limits shown on the plans. Also, count to determine the number of cable anchor assemblies and connections to be paid for. Keep adequate records and take sufficient measurements to support both partial and final payment.