

SECTION 83: RAILINGS AND BARRIERS

83-1 RAILINGS

83-1.01 DESCRIPTION

- This work shall consist of constructing pipe handrailing, metal beam guard railing, steel bridge railing, cable railing, concrete railing, metal railing or chain link railing at the locations and in conformance with the details shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The type of railing to be constructed will be specified in the special provisions or shown on the plans.

83-1.02 MATERIALS AND CONSTRUCTION

- Materials and construction for the various types of railings shall conform to the provisions in this Section 83-1.02.
- At locations where public traffic is adjacent to metal beam guard railing work, all materials required to complete the guard railing construction at any one location shall be available before beginning the guard railing work at that location.
- Welding shall conform to the requirements in AWS D1.1. Welds on exposed surfaces shall be ground flush with the adjacent surfaces.
- All completed steel components and hardware for railings shall be galvanized in conformance with the requirements in AASHTO Designation: M 180 and Section 75-1.05, "Galvanizing."
- After galvanizing, all elements of the railing shall be free of fins, abrasions, rough or sharp edges and other surface defects and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by the Engineer. Kinks, twists or bends in railing elements may be cause for rejection of the railing elements.
- Abraded or damaged galvanized surfaces of steel railing and posts, and ends of steel railing cut after galvanizing, shall be cleaned and regalvanized as specified for galvanizing, except if permitted by the Engineer, repairs to the surfaces may be made in conformance with the provisions in Section 75-1.05, "Galvanizing."
- *Mortar shall conform to the provisions in Section 51-1.135, "Mortar," and shall consist of one part by volume of cementitious material and 3 parts of clean sand.*
- Mortar shall be cured by either the water method or the curing compound method using curing compound (6) as provided in Section 90-7, "Curing Concrete."

83-1.02A Pipe Handrailing

- Pipe handrailing shall consist of handrailing elements supported by metal brackets (wall type) or handrailing elements supported by tubular steel posts (post type).
- Handrailing elements shall be either structural tubing as specified herein for tubular steel posts or commercial quality standard steel pipe. Tubular steel posts shall be round, seamless or welded structural tubing conforming to the requirements in ASTM Designation: A 501 and shall have a wall thickness not less than that of standard steel pipe of the same nominal size.
- Brackets, bolts, threaded studs, nuts, washers and other fittings shall be commercial quality structural steel, except that standard steel pipe fittings may be used where shown on the plans.
- Mechanical expansion anchors for attaching the railing to supporting concrete members shall conform to the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal."
- The railing shall be carefully erected true to line and grade. Posts shall be vertical within a tolerance not to exceed 0.02-foot in 10 feet. Posts shall be set in sockets or on mortar pads as shown on the plans.

83-1.02B Metal Beam Guard Railing

- The rail elements, backup plates, terminal sections, end and return caps, bolts, nuts and other fittings shall conform to the requirements in AASHTO Designation: M 180, except as modified in this Section 83-1.02B and as specified in Section 83-1.02. The rail elements, backup plates, terminal sections, end and return caps shall conform to Class A, Type 1 W-Beam guard railing as shown in AASHTO Designation: M 180. The edges and center of the rail element shall contact each post block. Rail element joints shall be lapped not less than 12¹/₂ inches and bolted. The rail metal, in addition to conforming to the requirements in AASHTO Designation: M 180, shall withstand a cold bend, without cracking, of 180 degrees around a mandrel of a diameter equal to 2.5 times the thickness of the plate.
- Workmanship shall be equivalent to good commercial practice and all edges, bolt holes and surfaces shall be free of torn metal, burrs, sharp edges and protrusions.
- Two certified copies of mill test reports of each heat from which the rail element is formed shall be furnished to the Engineer.
- Bolts shall have shoulders of such shape that will prevent the bolts from turning. Holes in rail elements shall be of similar shape as the bolt shoulder.
- Rail elements shall be spliced at intervals not to exceed 12.5 feet and the splices shall be made at posts, unless otherwise shown on the plans.
- The rail elements at joints shall have full bearing. When the radius of curvature is 150 feet or less, the rail elements shall be shaped in the shop. The radius of curvature shall be stenciled on the back of each section of rail elements in numerals 2¹/₂ inches in height.

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- At the option of the Contractor, metal beam guard railing shall be constructed using either steel posts or wood posts, both with wood blocks, for line posts. Only one type of line post shall be used for any one continuous length of guard railing.
- Steel posts shall be fabricated from steel conforming to the requirements in ASTM Designation: A 36/A 36M, unless otherwise specified. Two certified copies of mill test reports of each heat of steel from which steel posts are formed or fabricated shall be furnished to the Engineer.
- The grades and species of wood posts and blocks shall be No. 1 timbers (also known as No. 1 structural) Douglas fir or No. 1 timbers Southern yellow pine. Wood posts and blocks shall be graded in conformance with the provisions in Section 57-2, "Structural Timber," of the Standard Specifications, except allowances for shrinkage after mill cutting shall in no case exceed 5 percent of the American Lumber Standards minimum sizes, at the time of installation.
- Wood posts and blocks shall be rough or S4S, at the option of the Contractor. Only one type of post and block shall be used for any one continuous length of guard railing. The size tolerance of rough sawn blocks in the direction of the bolt holes shall be not more than $\pm 1/4$ inch.
- After fabrication, wood posts and blocks shall be pressure treated in conformance with Section 58, "Preservative Treatment of Lumber, Timber and Piling," and AWPAs Use Category System: UC4A, Commodity Specification A.
- If copper naphthenate, ammoniacal copper arsenate, chromated copper arsenate, ammoniacal copper zinc arsenate, ammoniacal copper quat or copper azole is used to treat the wood posts and blocks, the bolt holes shall be treated as follows:
 - A. Before the bolts are inserted, bolt holes shall be filled with a grease, recommended by the manufacturer for corrosion protection, which will not melt or run at a temperature of 149° F.
- Breakaway wood guard rail terminal posts may be field bored to provide the 2³/₈-inch diameter hole as shown on the plans.
- Where field cutting or boring is performed after treatment, all cuts and holes shall be thoroughly swabbed, sprayed or brushed with 2 applications of the same type of preservative as initially used, or treated with copper naphthenate as specified in AWPAs Standard M4. Application of preservative in the field shall conform to the provisions in the last paragraph in Section 58-1.04, "Wood Preservative for Manual Treatment."
- Wood posts shall be driven, with or without pilot holes, or shall be placed in drilled holes, at the option of the Contractor. Any space around wood posts shall be backfilled with selected earth, free of rock, placed in layers approximately 0.33-foot thick and each layer shall be moistened and thoroughly compacted.
- Steel posts shall be driven. If ground conditions are such that pilot holes are necessary to prevent damage to posts during driving, any space around steel posts after driving shall be filled with dry sand or pea gravel.
- At the Contractor's option, steel foundation tubes with soil plates attached, shall be either driven, with or without pilot holes, or placed in drilled holes. Any space around the steel foundation tubes shall be backfilled with selected earth, free of rock, placed in layers approximately 4 inches thick and each layer shall be moistened and thoroughly compacted. Wood terminal posts shall be inserted into the steel foundation tubes by hand. Before the wood terminal posts are inserted, the inside surfaces of the steel foundation tubes to receive the wood posts shall be coated with a grease which will not melt or run at a temperature of 149° F or less. The edges of the wood terminal posts may be slightly rounded to facilitate insertion of the post into the steel foundation tubes.
- Posts shall be placed at equal intervals, as shown on the plans, except that the end posts may be spaced closer to adjacent posts if directed by the Engineer.
- The bolted connection of the rail element to the post shall withstand a 5,000-pound pull at right angles to the line of the railing.
- All metal work shall be fabricated in the shop, and no punching, cutting or welding will be permitted in the field. Rail elements shall be lapped so that the exposed ends will not face approaching traffic.
- Terminal sections shall be installed in conformance with the manufacturer's recommendations.
- Components built up from structural steel plates welded together may be substituted for the rolled steel components shown on the plans provided that the depth, width and average thicknesses are at least equal to those of the rolled section; and further provided that, for the welded section, the steel plates conform to the requirements in ASTM Designation: A 36/A 36M, and the flanges are welded to the web with continuous fillet welds on each side of the web.
- Metal beam guard railing shall be connected to bridge railings, barriers, retaining walls, abutments and other flat concrete surfaces in conformance with the details shown on the plans and the following provisions:

Metal rail posts, box spacers and plate washers shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M.

The metal box spacer shall be either fabricated from separate plates and welded or press-formed and welded.

High strength bolts shall conform to the requirements in ASTM Designations: A 325, A 325M or A 449, or the bolts may be fabricated from steel rod conforming to the requirements in ASTM Designation: A 449. The bolts or rods shall conform to the mechanical requirements in ASTM Designation: A 325 or A 325M after galvanizing. Nuts and washers shall conform to the requirements in ASTM Designation: A 325 or A 325M.

For the connection of guard railing to new bridge railing or barriers, anchor bolt holes shall be formed in the concrete parapet by the use of metal sleeves.

For the connection of guard railing to existing bridge railing or barriers, anchor bolt holes shall be drilled in the concrete parapet as shown on the plans. Areas around the holes spalled or otherwise damaged during drilling, as determined by the Engineer, shall be repaired with a mixture of commercial quality epoxy adhesive and sand. The proportions of epoxy adhesive to sand shall be from 1:4 to 1:6, the exact proportion to be determined by the Engineer. The cementing agent shall consist of a 2-component epoxy adhesive manufactured especially for the making of epoxy-sand mortar. The 2 components and the epoxy-sand mixture shall be mixed in conformance with the manufacturer's instructions.

Footings for railing posts shall be constructed of Class 3 or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete." Reinforcement shall conform to the provisions in Section 52, "Reinforcement."

Concrete shall be placed against undisturbed material of the excavated holes for footings.

- End anchor assemblies and rail tensioning assemblies for metal beam guard railing shall be constructed as shown on the plans and shall conform to the following provisions:

An end anchor assembly (Type SFT) for metal beam guard railing shall consist of an anchor cable, an anchor plate, a wood post, a steel foundation tube, a steel soil plate and hardware.

An end anchor assembly (Type CA) for metal beam guard railing shall consist of an anchor cable, an anchor plate, a single anchor rod or double anchor rods, hardware and one concrete anchor.

A rail tensioning assembly for metal beam guard railing shall consist of an anchor cable, an anchor plate, and hardware.

The anchor plate, metal plates, steel foundation tubes and steel soil plate shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M.

The anchor rods shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M, A 441 or A 572, or ASTM Designation: A 576, Grades 1018, 1019, 1021 or 1026. The eyes shall be hot forged or formed with full penetration welds. After fabrication, anchor rods with eyes that have been formed with any part of the eye below 1,600° F during the forming operation or with eyes that have been closed by welding shall be thermally stress relieved prior to galvanizing. The completed anchor rod, after galvanizing, shall develop a strength of 50,000 pounds.

In lieu of built-up fabrication of anchor plates as shown on the plans, anchor plates may be press-formed from steel plate, with or without welded seams.

All bolts and nuts shall conform to the requirements in ASTM Designation: A 307, unless otherwise specified in the special provisions or shown on the plans.

Anchor cable shall be 3/4 inch preformed, 6 x 19, wire strand core or independent wire rope core (IWRC), galvanized in conformance with the requirements in Federal Specification RR-W-410, right regular lay, manufactured of improved plow steel with a minimum breaking strength of 23 tons.

Two certified copies of mill test reports of each manufactured length of cable used shall be furnished to the Engineer. The overall length of each cable anchor assembly shall be as shown on the plans, but shall be a minimum of 6.5 feet.

Where shown on the plans, cable clips and a cable thimble shall be used to attach cable to the anchor rod. Thimbles shall be commercial quality, galvanized steel. Cable clips shall be commercial quality drop forged galvanized steel.

The swaged fitting shall be machined from hot-rolled bars of steel conforming to AISI Designation: C 1035, and shall be annealed suitable for cold swaging. The swaged fitting shall be galvanized before swaging. A lock pin hole to accommodate a 1/4-inch, plated, spring steel pin shall be drilled through the head of the swage fitting to retain the stud in proper position. The manufacturer's identifying mark shall be stamped on the body of the swage fitting.

The one-inch nominal diameter stud shall conform to the requirements in ASTM Designation: A 449 after galvanizing. Prior to galvanizing, a 3/8-inch slot for the locking pin shall be milled in the stud end.

The swaged fittings, stud and nut assembly shall develop the specified breaking strength of the cable.

The cable assemblies shall be shipped as a complete unit including stud and nut.

Clevises shall be drop forged galvanized steel and shall develop the specified breaking strength of the cable.

One sample of cable properly fitted with swaged fitting and right hand thread stud at both ends as specified above, including a clevis when shown on the plans, 39 inches in total length, shall be furnished the Engineer for testing.

The portion of the anchor rod to be buried in earth shall be coated with a minimum 20-mil thickness of coal tar enamel conforming to AWWA Standard: C203 or a coal tar epoxy conforming to the requirements in Steel Structures Painting Council Paint Specification No. 16, Coal-Tar Epoxy-Polyimide Black Paint or Corps of Engineers Specification, Formula C-200a, Coal-Tar Epoxy Paint.

Metal components of the anchor assembly shall be fabricated in conformance with good shop practice and shall be hot-dip galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."

Anchor cables shall be tightened after the concrete anchor has cured for at least 5 days.

Concrete used to construct anchors for end anchor assemblies shall be Class 3 or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete."

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Concrete shall be placed against undisturbed material of the excavated holes for end anchors. The top 12 inches of holes shall be formed, if required by the Engineer.

Reinforcing steel in concrete anchors for end anchor assemblies shall conform to the provisions in Section 52, "Reinforcement."

- Anchor bolts shown on the plans to be set with epoxy shall be placed in holes filled with the 2-component epoxy mixture specified in Section 95-2.01, "Binder (Adhesive), Epoxy Resin Base."
- Surplus excavated material remaining after the guard railing has been constructed shall be disposed of in a uniform manner along the adjacent roadway as directed by the Engineer.
- Railing parts furnished under these specifications shall be interchangeable with similar parts regardless of source.

83-1.02C (Blank)

83-1.02D Steel Bridge Railing

- Steel bridge railing shall include steel railing fabricated from structural shapes, pipe, formed sections, tubing, plates and bars and shall be of the type shown on the plans.
- Structural shapes, tubing, plates, bars, bolts, nuts, and washers shall be structural steel conforming to the provisions in Section 55-2, "Materials." Other fittings shall be commercial quality.
- Pipe sections shall be standard steel pipe.
- Formed sections shall be formed from mild steel and shall be true to dimensions, free from kinks, twists or bends, and uniform in appearance. Closed sections shall be made of one-piece tubing or of 2 bent plates welded together at the longitudinal joints, at the option of the Contractor. Seams in the posts, if any, shall be in the faces of the posts normal to the plane of the railing.
- Mechanical expansion anchors for attaching the railing to supporting concrete members shall conform to the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal."
- The railing shall conform closely to the horizontal and vertical lines shown on the plans or ordered by the Engineer. Railings shall conform to the curvature by means of a series of short chords, from center to center of rail posts, except that railing noted on the plans or specified in the special provisions shall be shop bent to fit the curvature. Joints shall be matchmarked. The railing shall present a smooth, uniform appearance in its final position.
- The railings shall be carefully erected true to line and grade. Posts and balusters shall be vertical within a tolerance not to exceed 0.02-foot in 10 feet. Adjacent railing panels shall align with each other within $\frac{1}{16}$ inch.
- Posts shall be either mortared in sockets, set on mortar pads, or set on steel or concrete supporting members as shown on the plans.

83-1.02E Cable Railing

- Cable railing shall consist of cables supported by pipe posts set in either concrete footings or post pockets in the tops of retaining walls or other structures, as shown on the plans.
- Pipe for posts and braces shall be standard steel pipe or pipe that conforms to the provisions in Section 80-4.01A, "Posts and Braces."
- Truss rods, post tops, cable clamps, eye bolts, thimbles and other required fittings shall be commercial quality steel, malleable iron or wrought iron. All post tops shall be watertight. The eye of the eye bolts shall be either drop forged or formed with a full penetration weld, at the Contractor's option. The eye shall develop 100 percent of the bolt strength.
- Turnbuckles shall be commercial quality, and shall have jaw or eye ends as shown on the plans. Turnbuckles shall have 2,700 pounds minimum, breaking strength. At the option of the Contractor, turnbuckles shall be steel pipe type or drop forged steel.
- Crimped sleeve clamps and stop sleeve clamps shall be nonferrous metal, shall develop the strength of the cable and shall be the color of the cable.

Cable shall be wire strand or rope with a minimum diameter of $\frac{1}{4}$ inch, and a minimum breaking strength of at least 1,800 pounds. ***Cable shall be galvanized in conformance with the requirements in Federal Specification RR-W-410.***

- The cables shall be tensioned to provide taut railings between posts.
- Post footings shall be constructed of Class 3 or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete."

83-1.02F Concrete Railing

- Concrete railing shall consist of either an all reinforced concrete section or the reinforced concrete portion of composite railing sections, with end and intermediate posts, as shown on the plans, and shall conform to the provisions in Section 51, "Concrete Structures," and Section 52, "Reinforcement."
- Concrete railings shall present a smooth uniform appearance in their final position, conforming closely to the horizontal and vertical lines shown on the plans or ordered by the Engineer.
- When ordered by the Engineer, the height of the concrete railings shall be adjusted to compensate for the camber and dead load deflection of the superstructure. The amount of adjustment will be determined by the Engineer and will be ordered before the concrete is placed.

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83-1.02G Metal Railing

- Metal railing shall consist of metal elements mounted on concrete members as shown on the plans.

83-1.02G(1) (Blank)

83-1.02G(2) Metal Railing (Tubular)

- Metal railing (tubular), and tubular hand railing or such other types as are designated on the plans, shall consist of tubular metal rails supported by metal posts, together with anchor bolts, hardware and fittings, as shown on the plans.
- Materials for tubular rails, posts, rods, bolts and nuts shall conform to the following requirements:

Material	ASTM Designation
Tubular steel rails, and tubular handrailing	A 500, Grade B
Steel posts, rolled bars and plate washers	A 36/A 36M
Steel sleeves for tubular rails	A 36/A 36M
High strength bolts	A325 or A 325M or A 449
High strength threaded rods	A 449
Nuts and washers for high strength bolts and rods	A 325 or A 325M

- Stud bolts shall conform to the provisions for stud connectors in Section 55-2, "Materials."
- High strength bolts or threaded rods furnished in conformance with the requirements in ASTM Designation: A 449 shall comply with the mechanical requirements in ASTM Designation: A 449 after galvanizing.
- Posts for metal railing to which chain link railing will be attached shall be of such type that will fit the mounting brackets, pipe sleeves and other connection fittings.
- Metal railing shall conform closely to the horizontal and vertical lines shown on the plans or ordered by the Engineer. The railing shall present a smooth, uniform appearance in its final position.
- Shims shall be installed at posts and railings, where necessary, to provide uniform bearing and conformance with the horizontal lines and vertical grade lines. Shims at steel posts shall be commercial quality galvanized sheet steel.
- When the horizontal radius of the railing is 30 feet or less, that portion of the tubular railing may be either shop bent or built up from structural steel plates, 1/4 inch thick, conforming to the requirements in ASTM Designation: A 36/A 36M, at the option of the Contractor. Built up tubular railing shall match the seamless tubing in appearance.
- The difference between out-to-out rail sleeve dimensions and the clear inside dimensions of the tubular steel rails shall not exceed 3/16 inch after galvanizing.
- The Contractor shall submit 2 sets of anchor bolt layouts to the Engineer at the jobsite, prior to placing parapet or other structural support reinforcement.
- Materials shall be carefully handled so that no parts will be bent, broken, abraded or otherwise damaged. Fabrication, handling or installation methods which will injure or distort the members or damage the galvanizing shall not be used.
- Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the railing parts are assembled. The bases of posts shall be true and flat to provide uniform bearing on the concrete portions of the railing.
- The vertical position of the metal railing shall be adjusted to compensate for camber and dead load deflection of the superstructure. The amount of adjustment will be determined by the Engineer before the metal railing is installed.

83-1.02H (Blank)

83-1.02I Chain Link Railing

- Chain link railing shall consist of a metal frame covered with chain link fabric, including posts, horizontal members, post anchorages, stretcher bars, truss rods, tension wires and other required hardware and fittings, as shown on the plans.
- Posts and horizontal members shall be standard steel pipe, structural steel tubing or structural shapes as shown on the plans, except where metal conduit is specified in this Section 83-1.02I. Structural tubing steel shall conform to the requirements in ASTM Designations: A 500 or A 501.
- Structural shapes, plates, bars and bolts shall be structural steel conforming to the provisions in Section 55-2, "Materials."
- Stretcher bars, truss rods, post tops and other required fittings and hardware shall be steel, malleable iron or wrought iron. All post tops and other closures shall be watertight. All required fittings and hardware shall fasten to the posts and other members in proper manner.
- *Where shown on the plans, cables used in the frame shall be 5/16 inch in diameter, wire rope, with a minimum breaking strength of 5,000 pounds and shall be galvanized in conformance with the requirements in Federal Specification RR-W-410.*
- Crimped sleeve clamps and stud socket assemblies shall be ferrous or nonferrous metal, shall develop the strength of the cable and shall be the color of the cable.
- All frame members carrying electrical conductors shall be rigid metal conduit manufactured of mild steel, conforming to the requirements in UL Publication UL 6 for Rigid Metallic Conduits. The rigid metallic conduit shall have interior and exterior surfaces zinc-coated by hot-dip galvanizing.
- Tension wires shall be at least 7-gage coil spring steel.

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- Post clips shall be at least 9-gage steel.
- Wire ties or hog rings shall be 9-gage commercial quality steel wire. Wire ties shall be given at least one complete turn.
- Tension wires, post clips, wire ties and hog rings shall be galvanized in conformance with the requirements in ASTM Designation: A 116, Coating Class 3.
- Six-gage (0.1920-inch minimum diameter) aluminum wire ties, conforming to the requirements in ASTM Designation: B 211 or B 211M, Alloy 1100-H18, or 6-gage (0.1920-inch minimum diameter) aluminum hog rings, conforming to the requirements in ASTM Designation: B 211 or B 211M, Alloy 6061-T94 or Alloy 5052-H38 may be substituted for steel wire ties or hog rings.
- Ends of wire ties shall be bent away from pedestrian traffic.
- **Chain link fabric shall be 11-gage conforming to one of the following:**
 1. **AASHTO Designation: M181, Type I, Class C**
 2. **AASHTO Designation: M181, Type IV, Class A**
 3. **ASTM F 1345, Class 2**
- The color of vinyl coated chain link fabric shall be either medium green or dark green unless otherwise specified in the special provisions. The railings pertaining to any structure shall all be of the same color.
- All chain link fabric shall be woven into approximately one inch mesh.
- Truss rods and cables shall be tightened with turnbuckles or other fittings.
- The fabric shall be stretched and securely fastened to the posts, other members and tension wires. Tension wires shall be stretched tight.
- Where necessary to conform to curvature, either horizontal or vertical, the fabric shall be reworked and fitted so as to present a smooth, neat and workmanlike appearance.
- Where required by the other facilities, openings in the fabric shall be provided. The openings shall be reinforced with not less than one turn of 6-gage wire.
- Where shown on the plans, pipe handrailing shall be attached to the chain link railing. The handrailing shall conform to the provisions in Section 83-1.02A, "Pipe Handrailing."

83-1.03 MEASUREMENT

- Concrete railing will be measured by the cubic yard of concrete as provided in Section 51, "Concrete Structures."
- Except for metal beam guard railing within the pay limits of a terminal system end treatment or transition railing (Type WB), metal beam guard railing will be measured by the linear foot along the face of the rail element from end post to end post of the completed railing at each installation. The point of measurement at each end post will be the center of the bolt attaching the rail element to the end post.
- All other railing will be measured by the linear foot from end to end along the face of the railing, including end and intermediate posts, and with no deductions for gaps in railing for lighting and sign supports.
- When metal beam guard railing is connected to structures, barriers, walls or abutments, the structure, barrier, wall or abutment will be considered the end post and the point used for measuring the rail length shall be the midpoint between the 2 bolts attaching the rail element to the structure, barrier, wall or abutment.
- The measurement shall be made along the face of the rail elements without allowance for overlap at rail splices.
- The quantity of the various types of terminal systems end treatments for metal beam guard railing will be measured as units determined from actual count in place in the completed work.
- The quantities of end anchor assemblies (Type SFT or Type CA) and rail tensioning assemblies will be measured as units determined from actual count. An end anchor assembly (Type CA) with 2 cables attached to one concrete anchor will be counted as one terminal anchor assembly (Type CA) for measurement and payment.
- The quantities of return and end caps and the various types of terminal sections for metal beam guard railing will be determined as units from actual count.

83-1.04 PAYMENT

- The contract prices paid per linear foot for railings of the types shown in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the railings, complete in place, including, but not limited to, excavation, backfill and disposal of surplus material, concrete and reinforcing steel, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract unit price paid for the various types of terminal system end treatments for metal beam guard railing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in furnishing and installing terminal system end treatments, complete in place, including excavation, backfill and disposal of surplus material and connecting the terminal system to new or existing metal beam guard railing, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract unit prices paid for end anchor assembly (Type SFT), end anchor assembly (Type CA), and rail tensioning assembly shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in constructing the end anchor assemblies, complete in place, including drilling anchor plate bolt holes in rail

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elements, driving steel foundation tubes, excavating for concrete anchor holes and disposing of surplus material, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

- The contract unit prices paid for return caps, end caps, and the various types of terminal sections for metal beam guard railing shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in installing terminal sections, return and end caps, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Concrete in concrete railing will be paid for as provided in Section 51, "Concrete Structures." Bar reinforcing steel in concrete railing will be paid for as provided in Section 52, "Reinforcement."
- Full compensation for connecting metal beam guard railing to bridge sidewalks and curbs, bridge railing, barriers, retaining walls, abutments and other flat concrete surfaces, and constructing guard rail layout flares (including special size and spacing of posts) shall be considered as included in the prices paid for the various items of metal beam guard railing work and no additional compensation will be allowed therefor.
- Full compensation for furnishing connections on metal railing for steel picket railing, chain link railing and other classes of metal railing designated on the plans, drilling anchor bolt holes and anchoring bolts for railings shall be considered as included in the prices paid for the various items of railing work involved and no additional compensation will be allowed therefor.
- Full compensation for buried post anchors shall be considered as included in the contract price paid per linear foot for metal beam guard railing and no separate payment will be made therefor.

83-2 BARRIERS

83-2.01 DESCRIPTION

- This work shall consist of constructing single and double thrie beam barrier and concrete barrier at the locations and in conformance with the details shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The type of barrier to be constructed will be specified in the special provisions or shown on the plans.
- If there is an existing median barrier, the existing barrier shall not be removed more than 500 feet in advance of the new barrier being constructed.
- At the end of each day's operation, the existing median barrier removed shall be reinstalled without mesh or glare screen and anchored as approved by the Engineer, such that no gap will be left between the reinstalled barrier and the barrier being installed. At the option of the Contractor, temporary railing (Type K) conforming to the provisions in Section 12-3.08, "Temporary Railing (Type K)," may be placed instead of reinstalling the existing barrier.

83-2.02 MATERIALS AND CONSTRUCTION

- Materials and construction for the various types of barriers shall conform to the following requirements:

83-2.02A (Blank)

83-2.02B Thrie Beam Barrier

- Thrie beam barrier shall conform to the provisions for metal beam guard railing in Section 83-1.02B, "Metal Beam Guard Railing," except as otherwise provided in this Section 83-2.02B.
- Rail elements, backup plates, terminal connectors, terminal sections, and return caps shall conform to Class A, Type 1 thrie beam guard railing as shown in AASHTO Designation: M 180.
- Posts for thrie beam barrier on bridges shall be steel. Posts for approach barrier transitions to connect to concrete structures, and posts set in steel foundation tubes at trailing end anchors, shall be wood. At all other locations, posts for thrie beam barrier shall be wood or steel at the Contractor's option, however, only one kind of post shall be selected in any one continuous length of barrier.
 - Wood blocks shall be used with wood posts and with steel posts.
 - Toenailing of wood blocks to wood posts will not be required.
 - Unless otherwise specified, anchor bolts and threaded rods shall conform to the requirements in ASTM Designation: A 307.
 - Plates shall be structural steel conforming to the provisions in Section 55, "Steel Structures."
 - When the barrier is to be installed on existing structures, the posts shall be anchored to the deck as shown on the plans.
 - When cored or drilled holes for anchor bolts must be offset to avoid existing main reinforcing steel, the corresponding base plate anchor bolt holes may be slotted to adjust to the new anchor bolt locations. Slotting shall not reduce the edge distance of the hole to less than $\frac{7}{8}$ inch.
- Mortar under base plates shall conform to the provisions in Section 83-1.02, "Materials and Construction."
- Drilling of anchor bolt holes and grouting of the bolts shall conform to the provisions for grouting dowels in Section 51-1.13, "Bonding."
- Posts shall be placed at equal intervals, as shown on the plans, except that the end posts may be spaced closer to adjacent posts if directed by the Engineer.

SECTION 83

RAILINGS AND BARRIERS

- When the spacing between the posts must be varied from standard spacing because of construction or other controls, the metal railing may be modified in the field, subject to approval by the Engineer. Damaged galvanizing shall be repaired as specified in Section 75-1.05, "Galvanizing."
- All metal work shall be fabricated in the shop, and no punching, cutting or welding will be permitted in the field. Rail elements shall be lapped so that the exposed ends will not face approaching traffic. Terminal sections and return caps shall be installed in conformance with the manufacturer's recommendation.

83-2.02C (Blank)

83-2.02D Concrete Barrier

- This work shall consist of constructing concrete barriers at the locations and in conformance with the details shown on the plans and in conformance with the provisions in Sections 51, "Concrete Structures," 52, "Reinforcement," and these specifications.

83-2.02D(1) General

- If it is necessary, during construction on highways open to public traffic, to leave a gap in concrete barriers due to the equipment chosen or due to special drainage features, the gaps shall be closed by temporary or permanent means at all times when work is not actively in progress at the location of the gap.
- Concrete barriers shall present a smooth, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the plans or ordered by the Engineer, and shall be free of lumps, sags or other irregularities. The top and exposed faces of the barrier shall conform to the following requirements when tested with a 10-foot straightedge laid on the surfaces:
 - a. For concrete barriers Type 50 and 60 series, the top shall not vary more than 0.02-foot from the edge of the straightedge and the faces shall not vary more than 0.04-foot from the edge of the straightedge.
 - b. For concrete barriers other than Type 50 and 60 series, both the top and faces shall not vary more than 0.02-foot from the edge of the straightedge.
- When concrete barriers are to be constructed on recently completed bridges, the height of the barriers shall be adjusted to compensate for the camber and dead load deflection of the superstructure. The amount of adjustment will be determined by the Engineer and will be ordered before the concrete is placed. The barriers shall be placed after falsework has been released and as long after superstructure construction as the progress of the work will permit, unless otherwise ordered by the Engineer.
- When concrete barriers are to be constructed on existing pavement or existing structures, the height of the barriers shall be adjusted to compensate for irregularities in the existing grade. The amount of the adjustment will be determined by the Engineer and will be ordered before the concrete is placed.
- *When concrete barriers are to be constructed on existing structures, the dowels shall be bonded in holes drilled in the existing concrete. Drilling of holes and bonding of dowels shall conform to the following:*

1. *The bonding materials shall be either magnesium phosphate concrete, modified high alumina based concrete or portland cement based concrete. Magnesium phosphate concrete shall be either single component (water activated) or dual component (with a prepackaged liquid activator). Modified high alumina based concrete and portland cement based concrete shall be water activated. Bonding materials shall conform to the following requirements:*

<i>Property</i>	<i>Test Method</i>	<i>Requirements</i>
<i>Compressive Strength</i>		
<i>at 3 hours, MPa</i>	<i>California Test 551</i>	<i>21 min.</i>
<i>at 24 hours, MPa</i>	<i>California Test 551</i>	<i>35 min.</i>
<i>Flexure Strength</i>		
<i>at 24 hours, MPa</i>	<i>California Test 551</i>	<i>3.5 min.</i>
<i>Bond Strength: at 24 hours</i>		
<i>SSD Concrete, MPa</i>	<i>California Test 551</i>	<i>2.1 min.</i>
<i>Dry Concrete, MPa</i>	<i>California Test 551</i>	<i>2.8 min.</i>
<i>Water Absorption, %</i>	<i>California Test 551</i>	<i>10 max.</i>
<i>Abrasion Resistance</i>		
<i>at 24 hours, grams</i>	<i>California Test 550</i>	<i>25 max.</i>
<i>Drying Shrinkage at 4 days, %</i>	<i>ASTM Designation: C 596</i>	<i>0.13 max.</i>
<i>Soluble Chlorides by weight, %</i>	<i>California Test 422</i>	<i>0.05 max.</i>
<i>Water Soluble Sulfates by weight, %</i>	<i>California Test 417</i>	<i>0.25 max.</i>

2. *Magnesium phosphate concrete shall be formulated for minimum initial set time of 15 minutes and minimum final set time of 25 minutes at 70° F. The materials, prior to use, shall be stored in a cool, dry environment.*

3. *Mix water used with water activated material shall conform to the provisions in Section 90-2.03, "Water."*
 4. *The quantity of water for single component type or liquid activator (for dual component type) to be blended with the dry component, shall be within the limits recommended by the manufacturer and shall be the least amount required to produce a pourable batter.*
 5. *Addition of retarders, when required and approved by the Engineer, shall be in conformance with the manufacturer's recommendations.*
 6. *Before using concrete material that has not been previously approved, a minimum of 45 pounds shall be submitted to the Engineer for testing. The Contractor shall allow 45 days for the testing. Each shipment of concrete material that has been previously approved shall be accompanied by a Certificate of Compliance as provided in Section 6-1.07, "Certificates of Compliance."*
 7. *Magnesium phosphate concrete shall not be mixed in containers or worked with tools containing zinc, cadmium, aluminum or copper metals. Modified high alumina based concrete shall not be mixed in containers or worked with tools containing aluminum.*
 8. *The surface of any dowel coated with zinc or cadmium shall be coated with a colored lacquer before installation of the dowel. The lacquer shall be allowed to dry thoroughly before embedment of the dowels.*
 9. *The holes shall be drilled by methods that will not shatter or damage the concrete adjacent to the hole. The diameter of the drilled hole shall be $\frac{1}{2}$ inch larger than the nominal diameter of the dowels.*
 10. *The drilled holes shall be clean and dry at the time of placing the bonding material and the steel dowels. Bonding material and dowel shall completely fill the drilled hole. The surface temperature shall be 40° F or above when the bonding material is placed.*
 11. *After bonding, dowels shall remain undisturbed for a minimum of 3 hours or until the bonding material has reached a strength sufficient to support the dowels. Dowels that are improperly bonded, as determined by the Engineer, shall be removed. The holes shall be cleaned or new holes shall be drilled and the dowels replaced and securely bonded to the concrete. Removing, redrilling and replacing improperly bonded dowels shall be performed at the Contractor's expense. Modified high alumina based concrete and portland cement based concrete shall be cured in conformance with the provisions in Section 90-7.01B, "Curing Compound Method," of the Standard Specifications. Magnesium phosphate concrete shall not be cured.*
- Excavation and backfill shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill," and as provided herein.
 - The portion of barrier below finished grade may be placed to the neat lines of the excavation.
 - *Granular material for backfill between the 2 walls of concrete barrier (Types 50E, 60F, 60GE and 60SF), as shown on the plans, shall be placed without compaction.*
 - At connections to structures, a uniform film of grease shall be applied to the upper surface of the neoprene strip prior to placing the sheet metal.
- 83-2.02D(2) Materials**
- Type 50 and 60 series concrete barriers shall be constructed of minor concrete conforming to the provisions in Section 90-10, "Minor Concrete," except as follows:
 - a. The maximum size of aggregate used for extruded or slip-formed concrete barriers shall be at the option of the Contractor, but in no case shall the maximum size be larger than 1 $\frac{1}{2}$ inch or smaller than $\frac{3}{8}$ inch.
 - b. *If the 3/8-inch maximum size aggregate grading is used to construct extruded or slip-formed concrete barriers, the cementitious material content of the minor concrete shall be not less than 675 pounds per cubic yard.*
 - Concrete barriers other than Type 50 and 60 series shall be constructed of Class 2 concrete conforming to the provisions in Section 90, "Portland Cement Concrete."
 - *The concrete paving between the tops of the 2 walls of concrete barrier (Types 50E, 60F, 60GE, and 60SF) and the optional concrete slab at the base between the 2 walls of concrete barrier (Types 50E, 60F, 60GE, and 60SF) shall be constructed of minor concrete conforming to the provisions of Section 90-10, "Minor Concrete," except that the minor concrete shall contain not less than 505 pounds of cementitious material per cubic yard.*
 - Reinforcing bars shall conform to the provisions in Section 52-1.02A, "Bar Reinforcement."
 - Structural steel plates and hardware required to join concrete barrier at gaps caused by foundations of overhead signs, electroliers, drainage structures and at other locations shown on the plans shall conform to the details shown on the plans and to the provisions for materials, fabrication and galvanizing in Sections 75-1.03, "Miscellaneous Bridge Metal," and 75-1.05, "Galvanizing."
 - Polystyrene shown on the plans at connections to structures and at transitions to bridge columns shall conform to the provisions in Section 51-1.12D, "Sheet Packing, Preformed Pads and Board Fillers."
 - The sheet metal, neoprene strip and grease required at connections to structures shall conform to the following:

- a. Sheet metal shall be commercial quality galvanized sheet steel, smooth and free of kinks, bends or burrs. Joints in the sheet metal shall be butt joints sealed with plastic duct sealing tape.
- b. Neoprene strip shall conform to the provisions in Section 51-1.14, "Waterstops."
- c. Grease shall conform to the requirements in Military Specification MIL-S-8660.

Granular material for backfill between the 2 walls of concrete barrier (Types 50E, 60F, 60GE and 60SF) shall be earthy material suitable for the purpose intended, having no rocks, lumps or clods exceeding 1-1/2 inches in greatest dimension.

83-2.02D(3) Construction Methods

- Type 50 and Type 60 series concrete barriers shall be constructed by either the "cast-in-place with fixed forms" method or the "extrusion or slip form" method or a combination thereof, at the Contractor's option.
- Concrete barriers other than Type 50 and Type 60 series shall be constructed by the "cast-in-place with fixed forms" method.

83-2.02D(3a) Cast-In-Place with Fixed Forms

- Concrete barriers constructed by casting-in-place with fixed forms shall conform to the provisions in Section 51, "Concrete Structures," and the details shown on the plans.
- Precast mortar blocks shall not be used to support the reinforcing steel on the traffic side of barriers.

83-2.02D(3b) Extrusion or Slip Form

- Concrete barriers constructed by using an extrusion or slip form machine or other similar type equipment shall be of well compacted, dense concrete, and the exposed surfaces shall conform to the provisions in Section 51, "Concrete Structures," and this Section 83-2.02D(3b). The Contractor may be required to furnish evidence of successful operation of the extrusion or slip form machine or other equipment.
- The combined aggregate grading for the minor concrete shall be as necessary to produce concrete of the shape and surface texture conforming to the provisions in this Section 83-2.02D(3b).
- At the option of the Contractor, concrete may be made with the materials continuously batched by volume and mixed in a continuous mixer in conformance with the batching and mixing requirements in ASTM Designation: C 685.
- Concrete shall be fed to the extrusion or slip form machine at a uniform rate. The machine shall be operated under sufficient uniform restraint to forward motion to produce a well compacted mass of concrete free from surface pits larger than one inch in diameter and requiring no further finishing, other than that conforming to the provisions in Section 83-2.02D(4), "Finishing."
- The concrete shall be of such consistency that, after extrusion or slip forming, it will maintain the shape of the barrier without support.
- The grade for the top of the concrete barrier shall be indicated by an offset guide line set by the Contractor from survey marks established by the Engineer. The forming portion of the extrusion or slip form machine shall be readily adjustable vertically during the forward motion of the machine to conform to the predetermined grade line. A grade line gage or pointer shall be attached to the machine in such a manner that a continual comparison can be made between the barrier being placed and the established grade line as indicated by the offset guide line.
- Instead of the above method for maintaining the barrier grade, the extrusion or slip form machine may be operated on rails or forms set at uniform depth below the predetermined finished top of the barrier grade, or on existing pavement or bridge decks.
- Expansion joints of the width shown on the plans may be constructed by sawing through the barrier section to its full depth. Insertion of joint filler will not be required.
- When expansion joints are not constructed by sawing, the expansion joints shall be constructed in conformance with the provisions in Section 51, "Concrete Structures."
- If sawing or forming joints is performed before the concrete has hardened, the adjacent portions of the barrier shall be supported firmly with close fitting shields.
- When sawing or forming joints is performed after the application of curing compound, the exposed faces of the barrier in the vicinity of the joint shall be treated with curing compound after sawing or forming the joints.
- If extrusion or slip forming methods of placement are used, the horizontal reinforcing bars shall be placed continuously.

83-2.02D(4) Finishing

- The surface finish of concrete barriers Type 50 and Type 60 series, prior to the application of the curing compound, shall be free from surface pits larger than one inch in diameter and shall be given a final soft brush finish with strokes parallel to the line of the barriers. Finishing with a brush application of grout will not be permitted.
- To facilitate finishing, fixed forms for cast-in-place concrete barriers Type 50 and Type 60 series, shall be removed as soon as possible after the concrete has set enough to maintain the shape of the barrier without support.
- Not less than 7 days after placing, exposed surfaces of concrete barriers, Type 50 and Type 60 series, shall receive a light abrasive blast finish so that a uniform appearance is achieved.
- The final surface finish of concrete barriers other than Type 50 and Type 60 series shall be Class 1 Surface Finish conforming to the provisions in Section 51-1.18B, "Class 1 Surface Finish." Alternative final surface finish methods proposed by the Contractor shall be submitted in writing and shall not be used unless approved by the Engineer.

83-2.02D(5) Curing

• Exposed surfaces of concrete barriers shall be cured with the non-pigmented curing compound (6) conforming to the provisions in Section 90-7.01B, "Curing Compound Method." At the Contractor's option, the formed surfaces of concrete barriers, which are on bridges or walls but which do not support soundwalls, may be cured as provided in Section 90-7.01D, "Forms-In-Place Method," except the forms shall be retained in place for a minimum period of 12 hours after the concrete has been placed. When curing Type 50 and Type 60 series concrete barrier, curing compound shall be applied by a mechanical sprayer capable of applying the curing compound to at least one entire side and the top of the concrete barrier in one application at a uniform rate of coverage. The spray shall be adequately protected against wind.

83-2.03 MEASUREMENT

- Except for single thrie beam barrier within the pay limits of transition railing (Type STB), single thrie beam barrier will be measured by the linear foot from end post to end post along the face of the rail element of the installed barrier. Single thrie beam barriers constructed on each side of piers under structures or other obstructions will be measured for payment along each line of the installed barrier.
- Except for double thrie beam barrier within the pay limits of transition railing (Type DTB), double thrie beam barrier will be measured by the linear foot from end post to end post along the center line of the installed barrier.
- The point of measurement at end posts of single and double thrie beam barriers will be the center of the bolt or rod attaching the rail element or elements to the end post. At locations where single barriers are constructed on each side of median obstructions and the single barriers merge into double barrier, the post with 2 blocks attached thereto shall be considered an end post for measuring the length of single and double barrier.
- Transition sections will be measured and paid for by the linear foot as single thrie beam barrier.
- The quantity of return caps, terminal connectors and the various types of terminal sections for single and double thrie beam barriers will be determined as units from actual count.
- The quantity of end anchor assemblies will be paid for as units determined from actual count.
- Concrete barriers will be measured by the linear foot.
- *Concrete barriers, except Type 50E, Type 60F, Type 60GE, and Type 60SF will be measured along the top of the barrier.*
- *Concrete barriers Type 50E, Type 60F, Type 60GE, and Type 60SF will be measured once along the centerline between the 2 walls of the barrier.*

83-2.04 PAYMENT

- The various types of thrie beam barrier, measured as specified in Section 83-2.03, "Measurement," will be paid for at the contract price per linear foot for single or double thrie beam barrier, whichever applies, and the contract unit price or prices for end anchor assemblies, return caps, terminal connectors and the various types of terminal sections.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the barrier, complete in place, including drilling holes for wood posts, driving posts, backfilling the space around posts, excavating and backfilling end anchor assembly holes, connecting thrie beam barrier to concrete surfaces and disposing of surplus excavated material, and for furnishing, placing, removing and disposing of the temporary railing for closing the gap between existing barrier and the barrier being constructed as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- *The contract prices paid per linear foot for concrete barrier of the type or types listed in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the concrete barriers, complete in place, including bar reinforcing steel, steel dowels and drilling and bonding dowels in structures, hardware for steel plate barrier, miscellaneous metal, excavation, backfill (including concrete paving for, and granular material or concrete slab used as backfill in Type 50E, Type 60F, Type 60GE, and Type 60SF concrete barrier), and disposing of surplus material and for furnishing, placing, removing and disposing of the temporary railing for closing the gap between existing barrier and the concrete barrier being constructed, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.*
- Steel plate barrier attached to concrete barrier at overhead sign foundations, electroliers, drainage structures, and other locations shown on the plans will be measured and paid for as the type of concrete barrier attached thereto.