

NORFOLK SOUTHERN CORPORATION

UNDERPASS GRADE SEPARATION DESIGN CRITERIA

PURPOSE AND SCOPE

These criteria modify and supplement the applicable sections of the AREMA Manual of Recommended Practice in connection with the design of ballasted deck railway bridges, in order to produce a structure which will minimize interference with mechanized track maintenance, as well as reduce the effects expected from derailments.

I. SPECIFICATIONS

A. Design Specifications:

American Railway Engineering and Maintenance-of-Way Association Manual of Recommended Practice, Current Edition.

B. Construction Specifications:

1. Fabrication and Erection of Structural Steel (AREMA Chapter 15).
2. Concrete Structures and Foundations (AREMA Chapter 8).
3. Damproofing and Waterproofing (AREMA Chapter 29).
4. The Standard Specifications of the State Highway Department where the bridge is to be constructed shall be used for the remainder of the construction.

II. BRIDGE LAYOUT

The following items shall be considered when the initial bridge layout is prepared:

1. The distance from the centerline of bridge to the nearest milepost shall be shown on the plan, and the Railroad Valuation Stations shall be shown at the fill face of backwalls
2. For bridges located within a curve, the girders, abutments and piers shall be located with reference to chords.
3. All spans are to be simply supported. If the bridge is to be maintained by the Railroad, thru-girder and thru-truss designs will be allowed only after approval by Railroad's Chief Engineer-Bridges and Structures, and if approved, foundations must be at a 90 degree angle to track (main chord if track is curved).
4. The preferred angle of the roadway crossing relative to the centerline of track is 90°. However, in cases where a 90° crossing cannot be obtained, the angle of the roadway crossing relative to the centerline of track shall not deviate more than 30° from the preferred 90° crossing.
5. Vandal fencing shall be provided on all underpass structures in urban areas and on underpass structures in rural areas where pedestrian traffic patterns, past history of vandalism, or other conditions near the project site (such as nearby schools), may warrant the use of vandal fencing.

III. DESIGN LOADS

1. Railroad bridges shall be designed for all loads specified in Chapter 8 and 15 of the AREMA Manual of Recommended Practice.
2. Live Load: Cooper E-80, diesel impact.
Alternative Live Load.

3. In computing dead load, include the weight of an additional 6" of ballast for future track surfacing.
4. Under normal working loads, some composite action may be expected between a concrete deck and its supporting steel members, whether or not special devices are furnished for shear transference. The bottom of the deck slab shall be placed at least one inch (1") below top of supporting steel members. For design purposes, however, the supporting steel members shall be proportioned to carry the entire load without taking into account any stresses which may be induced in the concrete slab by composite action. Composite action may be taken into account when satisfying the deflection-length ratio requirement of Chapter 15, Article 1.2.5 of the AREMA Manual of Recommended Practice provided shear transfer devices are installed.

IV. MATERIAL REQUIREMENTS

1. The minimum thickness of any steel member is 1/2"
 2. The minimum bolt diameter is 7/8"
 3. The minimum thickness of any preformed bearing pad is 1/2"
- A. Structural Steel:
1. The engineer shall call out all fracture critical members on the plans.
 2. Structural Steel Shall be in accordance with Norfolk Southern's "Structural Steel" Specifications.
- B. Concrete:
1. The allowable bearing pressures as contained in AREMA Chapter 8 are to be used for concrete superstructure bearing on concrete substructure.

2. The allowable bearing pressures as contained in AREMA Chapter 15 are to be used for steel superstructure bearing on concrete substructure.
3. Concrete shall be in accordance with the current "Norfolk Southern Corporation Specifications for Cast-In-Place Concrete."

C. Reinforcing Steel: Shall be in accordance with the reinforcing steel section of the current "Norfolk Southern Corporation Specifications for Cast-In-Place Concrete."

V. SUPERSTRUCTURE FOR BALLAST DECK RAILWAY BRIDGES

For typical layout of superstructure, see Sheets 5 and 6.

A. Bridge Deck

1. Width of Trough: On a single track, the trough shall not be less than 20' wide, measured from inside face of curb to inside face of curb. The clear distance from centerline of track to inside face of curb shall not be less than 9'-6".

For multiple main tracks, the clear distance from center line of each track to the inside face of curb shall not be less than 9'-6".

All trough design shall provide fastening arrangements for a handrail such that the handrail will be 10' horizontal clear distance from the centerline of track on both sides.

2. Curb Height: The top of curb shall be approximately the same elevation as top of low rail.
3. Handrail: Adequate handrails shall be provided on both sides of the structure, located so that the horizontal clearances to centerline of nearest track is not less than 10'-0". See "Handrail Details" - Sheet 7.

4. Depth of Ballast: On superelevated track, the depth of ballast underneath the low end of crossties shall be 8" minimum. On track not superelevated, the depth of ballast underneath the crossties shall be 9" minimum.
5. Thickness of Trough: Minimum thickness of concrete trough shall be 8".
6. Drainage: the top of concrete ballast trough shall be sloped transversely not less than one percent in order to drain. Low points in the top of trough shall be located not less than 6'-0" from a centerline of any track and shall be within the outside beams or girders of bridge. A longitudinal collection system shall be provided to dispose of drainage without permitting it to enter the ballast section of backfill beyond the bridge. This system shall be sloped not less than one percent in order to drain. If an approach grade descends toward the bridge, drainage from the approach ballast and top of roadbed section shall be intercepted by appropriate means so that it will not come onto the bridge.
7. Waterproofing and Asphalt Panels: Waterproofing membranes and asphalt protection panels shall be used on all bridge decks, and all material used shall comply with AREMA Manual of Recommended Practice, Chapter 29.
8. Reinforcing Steel: All reinforcing steel in the concrete deck and curbs shall be epoxy-coated. See the reinforcing steel section of the current "Norfolk Southern Corporation Specifications for Cast-In-Place Concrete."

B. Steel Supporting Members:

1. Layout and Design: Steel supporting members shall be equally spaced across the width of the structure. Not less than two support members per rail shall be provided.

The exterior overhang of the deck slab, measured from centerline of the outside supporting member to outside face of curb shall be not more than 4'-0", and any steel supporting member added on account of this requirement shall be of the same section as those used under the track. Any such exterior beam added will be assumed to carry an appropriate portion of the dead load.

2. Crossframes and Diaphragms: The supporting steel members having depth greater than 3'-6" and spaced more than 4'-0" on centers, shall be braced with cross frames.

The angle of cross frame diagonals with the vertical shall not exceed 60 degrees, or be less than 30 degrees.

Supporting steel members not requiring cross frames shall be braced with approved diaphragms which are as deep as the depth of the member will permit. Such diaphragms shall be connected to the members' web by means of suitable angles, bolted, or their equivalent, if welded.

Cross frame and diaphragm spacing shall not exceed 12 feet.

Jacking stiffeners are required in all end diaphragms, jacking stiffeners may be eliminated if an alternate jacking method is approved.

Access holes, minimum 12" diameter, are required in all end diaphragms. Access holes are not required for intermediate diaphragms.

3. Painting: Shall be in accordance with current "Norfolk Southern Paint Specifications for Shop Fabricated Bridge Steel."

C. Design of Superstructure for Derailment:

1. The deck slab beyond the outermost steel support shall be adequate to resist a derailment condition involving an axle load, plus an impact load equal to $LL \times LL / (DL + LL)$ distributed uniformly over 5'-0" in a direction parallel to the track and 7'-6" in a direction at right angles to the track, with 7'-6" distance measured from the inside face of curb. Allowable unit stresses in concrete and reinforcing steel shall be not more than 25 percent greater than the normal allowable unit stresses.
2. The supporting steel members, whose centerlines measure not more than 11'-0" from the outside face of curb shall be considered as carrying the derailed load. An impact load, equal to 0.8x live load, shall be provided. Allowable unit stresses in steel shall be not more than 70 percent greater than the normal allowable unit stresses.

VI. SUBSTRUCTURE

The concrete substructure units shall be designed in accordance with Chapter 8 of the AREMA Manual of Recommended Practice.

A. Abutments:

The abutment shall be designed in accordance with the requirements of Chapter 8, Part 5 of the AREMA Manual of Recommended Practice.

The abutment shall be wide enough to provide for a 14'-0" shoulder, measured from the centerline at the nearest track on each side. In case of multiple track bridges, the abutment width shall be sufficient to provide for standard 14'-0" shoulder on both sides and 14'-0" center to center between tracks. Wingwalls shall be designed to support 2 horizontal: 1 vertical embankment slopes.

There shall be a minimum of 3" between end of structural steel and face of backwall.

Use fill face of backwall and centerline of track as reference for abutment layout.

Provide a minimum edge distance of six inches from edge of the masonry plate or shoe to edge of concrete.

B. Piers:

Provide a minimum edge distance of six inches from edge of masonry plate or shoe to edge of concrete.

Provide a minimum of 18 inches beyond the outside edge of the outermost masonry plate or shoe to the end of the pier.

Provide four inches minimum clearance between ends of structural steel.

A solid pier with a minimum thickness of 4'-0" is preferred.

VII. CONSTRUCTION EXCAVATION

1. Footings for all piers, columns, walls or other facilities shall be located and designed so that any temporary sheeting and shoring for support of adjacent track or tracks during construction will not be closer than 10'-0" from centerline of track. Edges of footings located no closer than 11'-0" from centerline of track should satisfy the minimum of 10'-0".
2. All plans and calculations for shoring shall be prepared and signed by a Registered Professional Engineer. The Engineer will be responsible for the accuracy for all controlling dimensions as well as the selection of soil design values which will accurately reflect the actual field conditions.

3. The plans shall contain details of the shoring system showing sizes of all structural members, details of connection, and embedment depth. The plans shall include a plan view showing all the proposed excavations and distances from centerline of track to face of excavation. Plans shall show a section normal to the track showing the shoring location relative to centerline of track and showing the height of sheeting and track elevation in relation to the bottom of excavation. The plans must be complete and accurately describe the nature of the work.
4. Plans and calculations covering all falsework, shoring, excavation supports, etc., adjacent to railroad tracks should be certified to be complete and satisfactory by the submitting public agency prior to being submitted to the Chief Engineer Bridges & Structures for review. Four (4) copies of plans and calculations should be submitted. A minimum of 30 days should be allowed for the Railroad's review of such plans. No excavation will be allowed until the plans and calculations are reviewed and approved by the Chief Engineer Bridges & Structures.
5. Shoring located between 8'-6" and 14'-0" from the centerline of track should preferably be designed using interlocking sheeting. Soldier piles and lagging will be considered only when its use is specifically approved by the Chief Engineer Bridges & Structures. Consideration for the use of soldier piles and lagging will be made if the required penetration of steel sheet piling cannot be obtained and when dry, non-running, stable material will be encountered.
6. Excavations will not be allowed closer than 8'-6" from centerline of track unless specifically approved by the Chief Engineer Bridges & Structures.
7. All excavations on or adjacent to the Railroad right-of-way shall be reviewed by the Railroad before excavation.

8. All excavations within the limit shown on Sheet 4, copy attached, shall be designed for Railroad live load surcharge.
9. All shoring designed for Railroad live load surcharge shall be based on Cooper's E-80 live load. AREMA Chapter 8, Part 20, Section C, Paragraph 2(b), refers to the Boussinesq equation as a method to determine lateral pressure values for Railroad surcharge loading. Attached is a chart and graph indicating the lateral pressures associated with various depths of excavation and distances from the centerline of track as determined by the Boussinesq equation that may be used as a guide. The use of the AREMA Boussinesq equation is not the only method available to obtain lateral pressures for surcharge loading; however, pressure values significantly less than those determined by the Boussinesq equation do not adequately consider Railroad live load surcharge.
10. Railings are necessary around all excavations on Railroad's property, and shall be designed in accordance with AREMA Section 15, and plans approved by the Chief Engineer Bridges & Structures. Walkways with railings shall be constructed (in accordance with plans approved by the Chief Engineer Bridges & Structures) over open excavations adjacent to the tracks located within the normal walkway. Railings shall not be closer than 10'-0" horizontally from centerline of track.
11. Approval of the excavation plan does not relieve the submitting agency and/or designer and/or contractor of ultimate responsibility and liability for the excavation plan.

VIII. EROSION CONTROL

1. The general plans for the bridge shall indicate the proposed methods of erosion control and must specifically address means to prevent silt accumulation in the ditches and culverts and to prevent fouling the track ballast and sub-ballast. If the plans do not show erosion control, the contractor must submit a proposed method of erosion control and must have the method approved

by the Chief Engineer Bridges & Structures prior to beginning any grading on the project site.

2. Existing track ditches shall be maintained at all times throughout the construction period. After the construction has been completed, all erosion control devices must be removed, all deposits of silt removed, and the ditches must be restored.
3. Approval of the erosion control plan does not relieve the submitting agency and/or designer of ultimate responsibility and liability for a satisfactory erosion control plan.

IX. DRAINAGE

1. Maintaining the existing drainage and providing for future drainage improvements is of the utmost importance. Existing track ditches must be maintained at all times.
2. Drainage plans must be included with the general plans submitted to the Chief Engineer Bridges & Structures for approval. These plans must include hydrologic computations, indicating the rainfall intensity and duration of the design storm used, as well as the method of analysis. A 100-year recurrence interval is the minimum design storm.
3. Where project design calls for an increase in the flow through the railroad embankment, the flow may be required to be handled by means of a "separate drainage structure. See Guidelines for Under Track Culverts.
4. Horizontal clearances must provide sufficient space for construction of the required track ditch parallel to the standard roadbed section. If an adequate ditch cannot be provided, then a culvert of sufficient size (a minimum of 36" diameter CMP) must be provided.
5. When the proposed construction will change the quantity and/or character of flow in the track ditches, the ditches shall be modified as required to handle the drainage. Ditches shall be designed

in accordance with good drainage engineering practices.

6. No roadway drainage, catch basins, inlets or outlets are permitted to drain onto Railway property. Any variance of this policy must have the approval of the Chief Engineer Bridges & Structures. If an exception is granted, maintenance of the drainage structures will be the responsibility of others and not the Railway. If the drainage muse conveyed into a railroad ditch, calculations must be provided to the Chief Engineer Bridges & Structures for approval that indicate the ability of the ditch to carry the additional runoff.
7. In order to evaluate the impact of the proposed project relative to existing site drainage, cross sections perpendicular to the centerline of track should be submitted along with the drainage plans.
8. Approval of the drainage plan does not relieve the submitting agency and/or designer of ultimate responsibility and liability for a satisfactory drainage design.

X. DEMOLITION, ERECTION, HOISTING

1. Railroad tracks and other railroad property must be protected from damage during the procedure.
2. The Contractor is required to submit a plan showing the location of cranes, horizontally and vertically, operating radii, with delivery or disposal locations shown. The location of all tracks and other railroad facilities as well as all obstructions such as wire lines, poles, adjacent structures, etc. must also be shown.
3. Crane rating sheets showing cranes to be adequate for 150% of the actual weight of the pick. A complete set of crane charts, including crane, counterweight, and boom nomenclature is to be submitted.

4. Plans and computations showing the weight of the pick must be submitted. Calculations shall be made from plans of the existing and/or proposed structure showing complete and sufficient details with supporting data for the demolition or erection of the structure. If plans do not exist, lifting weights must be calculated from field measurements. The field measurements are to be made under the supervision of the Registered Professional Engineer submitting the procedure and calculations.
5. A data sheet must be submitted listing the types, size, and arrangements of all rigging and connection equipment.
6. A complete procedure is to be submitted, including the order of lifts, time required for each lift, and any repositioning or re-hitching of the crane or cranes.
7. All erection or demolition plans, procedures, data sheets, etc. submitted must be prepared, signed and sealed by a Registered Professional Engineer.
8. The Railroad's representative must be present at the site during the entire demolition and erection procedure period.
9. All procedures, plans and calculations shall first be approved by the Engineer and the Railroad Engineer before procedure begins; however, such approval does not relieve the Contractor from liability.

XI.

MISCELLANEOUS

A. Maintenance of Railroad Traffic

1. It is essential that the construction be performed with a minimum interference with rail traffic. Continuity of safe rail operations will be required for the duration of the project.

2. The most effective method of maintaining traffic is to temporarily re-route rail traffic around the construction site using detour tracks. See "Guidelines for Design of Detour Track." All design requirements will be furnished by the Chief Engineer Bridges & Structures.
3. A detailed sequence of construction shall be shown on the plans. When construction requires total interruption of rail traffic, an estimate of the time required will be shown in the procedure. This interval must be within the approved time frame furnished by the Railway.
4. Prior to start of any construction on Railroad's right-of-way, written approval from the Railroad for the procedure of construction must be secured.
5. Railroad will cooperate fully with the responsible agency to provide as much track time as possible. The agency should contact the Railroad's chief Engineer Bridges & Structures in the preliminary design state to determine the Railroad's operational requirements, such as design speed, maximum curvature and superelevation, etc.

B. Plan Preparation and Submittal

1. Preliminary plans should be submitted to the Chief Engineer Bridges & Structures for review at least 78 weeks prior to the proposed letting date. See "Schedule for Review of Grade Separation Projects."
2. See "Design Criteria and Guidelines for Main Tracks and Detours" for information to be shown on the track plans.
3. The plans shall show dimensioned locations of all existing utilities, as well as the location of all proposed utilities, within the Railroad's right-of-way. The plans shall define the responsibility for locating,

marking or installing and protecting such utilities.

4. If fiber-optic cables are presently buried on the Railroad right-of-way, or if such installations are scheduled, the presence of such facilities shall be considered in the project design and appropriate measures for the installation and protection of the fiber-optic cables shall be addressed on the plans in the contract documents.
5. Provide one (1) set of original plans of Mylar reproducible tracings of the as-built design plans for the Railroad's file, after job completion.

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