

Chapter 21
RAILROADS

NDOT STRUCTURES MANUAL

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Chapter 21

RAILROADS

21.1 HIGHWAY BRIDGES OVER RAILROADS

21.1.1 Design Policies and Practices

Highway bridges constructed over railroads must be designed to be consistent with the requirements from a variety of sources. The following summarizes these sources:

1. FHWA. The Code of Federal Regulations (23 CFR 646 Subpart B “Railroad-Highway Projects”) prescribes the FHWA policies and procedures for advancing Federal-aid projects involving railroad facilities.
2. Nevada Administrative Code (NAC). Chapter 705 “Railroads” presents the State of Nevada requirements with respect to railroads operating in the State. NDOT must receive approval from the Nevada Public Utilities Commission (PUC), which enforces the NAC, on all NDOT projects that impact railroads.
3. AREMA. The American Railway Engineering and Maintenance-of-Way Association (AREMA) provides a forum for the development and study of recommended engineering practices for railroad design and construction throughout the United States. To document these practices, the organization has published the *AREMA Manual for Railway Engineering*. This *Manual* has approximately the same status to railroad engineers as the *LRFD Specifications* has to highway bridge engineers.
4. Railroad Companies. The following Railroads operate in the State of Nevada:
 - Union Pacific (UPRR),
 - Nevada State Railroad Museum Boulder City Branch Line,
 - Northern Nevada, and
 - Virginia and Truckee.

In addition, Burlington Northern Santa Fe (BNSF) has trackage rights over the UPRR lines, and AMTRAK (i.e., the *California Zephyr*) operates on the freight railroad lines across northern Nevada between Chicago and Oakland.

UPRR has promulgated its specific criteria for highway bridges over railroads in a BNSF/UPRR publication “Guidelines for Railroad Grade Separation Projects.” NDOT policy is that this publication will be used in the development of all projects for highway bridges over railroads.

5. LRFD Specifications. LRFD Article 3.6.5.2 presents criteria for the design of highway abutments and piers within 50 ft of the centerline of a railway track.

For each highway-bridge-over-railroad project, the bridge designer’s responsibility is to evaluate each of the above during project development. [Section 21.1](#) has been organized by project design element and, as applicable, references one or more of the above sources for the information.

21.1.2 Structure Type and Configuration

Chapter 11 of the *NDOT Structures Manual* presents NDOT criteria on the selection and configuration of a structure type for highway bridges. Specifically for highway bridges over railroads, the following applies:

1. Span Length/Configuration. Railroads usually require that their tracks and maintenance roads be clear spanned. Therefore, the typical span configuration over a railroad is a single-span or three-span bridge.
2. Structure Type. Railroads may prefer bridges that do not use falsework over their tracks. This usually limits the superstructure selection to structural steel girders or precast concrete girders. Continuous steel girder bridges can span up to 400 ft; precast, prestressed concrete I-girder bridges can span up to 150 ft.

See Chapter 11 for more information.

21.1.3 Geometrics

21.1.3.1 **Basic Configuration**

The basic geometric configuration of the railroad cross section passing beneath a highway bridge is based on the following:

- number and type of tracks,
- drainage treatments,
- access/maintenance roadway (if present),
- lateral clearances, and
- vertical clearances.

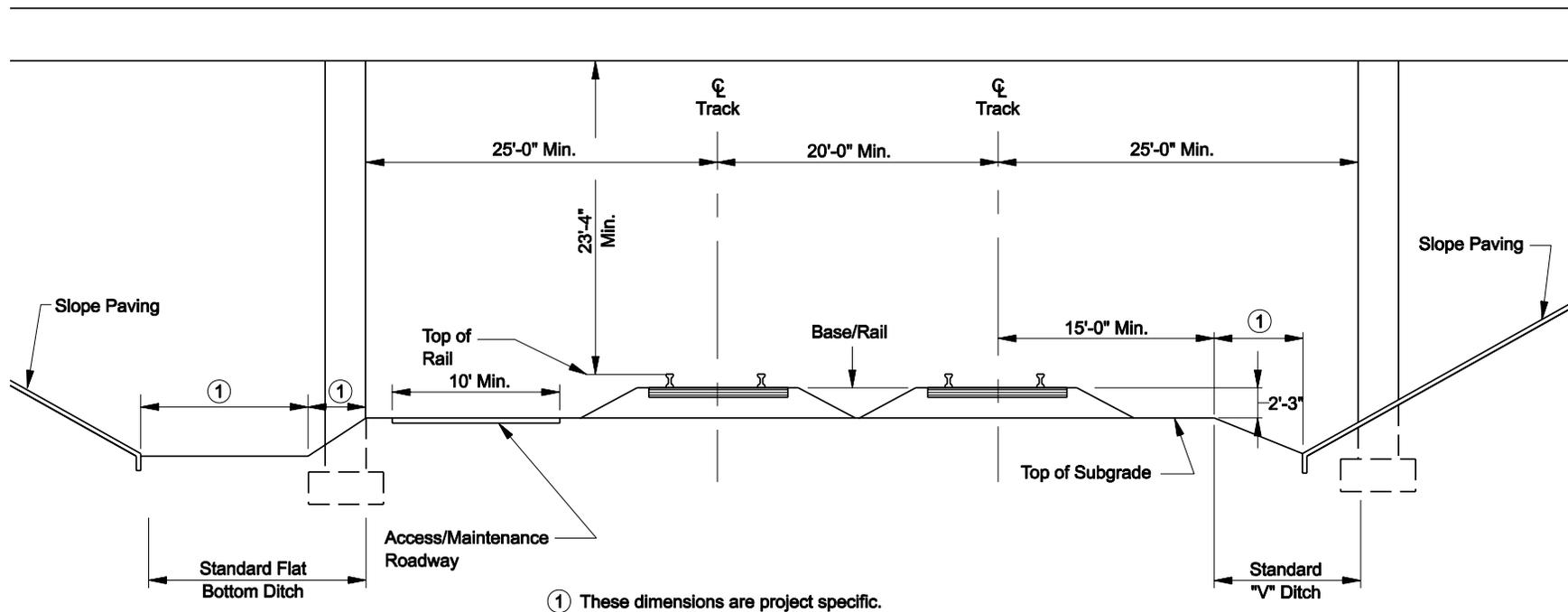
Figure 21.1-A presents the basic railroad cross section based on these variables. This Figure can be used for preliminary design and the preparation of the Bridge Front Sheet. The following Sections present additional information that must be considered.

21.1.3.2 **Lateral Clearances**

21.1.3.2.1 *FHWA*

The Appendix to Subpart B of 23 CFR 646 presents FHWA Federal-aid participation limits for lateral clearances. The following summarizes these criteria:

1. Basic Clearance. FHWA will fully participate in the costs of a 20'-0" horizontal distance measured at right angles from the centerline of track at the top of rails to the face of the embankment slope at a height equal to the elevation of the top of the outside rail.



Notes:

1. Horizontal dimensions shown are perpendicular to centerline of track.
2. Horizontal dimensions shown are the minimum distances to construct a standard railroad roadbed section. Actual required horizontal clearances may need to be increased due to the existing roadbed section and alignment, location of parallel ditches, and/or hydrologic conditions.

RAILROAD CLEARANCES

Figure 21.1-A

2. Additional Clearance. FHWA will participate in lateral clearances greater than 20'-0":
 - to provide for drainage, if justified by a hydraulic analysis; or
 - to allow adequate room to accommodate special conditions, if the railroad demonstrates that this is its normal practice.
3. Maintenance Equipment. FHWA will participate in an additional 8'-3" of lateral clearance (an increase in the clearance from either No. 1 or No. 2) for off-track maintenance equipment, provided that adequate horizontal clearance is not available in adjacent spans of an existing access road or by evidence of the future need for such equipment.
4. Piers. All piers should be placed at least 9'-3" horizontally from the centerline of the track and preferably beyond the drainage ditch. However, based on UPRR requirements, NDOT policy is to place piers beyond the drainage ditch or at a 25'-0" horizontal clearance, whichever is more and if practical.
5. Multiple Tracks. For multiple track facilities, all dimensions apply to the centerline of the outside track.

21.1.3.2.2 UPRR

See Sections 4 and 5 of the "UPRR Guidelines for Railroad Grade Separation Projects" for the Railroad Company's criteria for permanent lateral clearances. Section 4.1.2 of the Guidelines requires a minimum spacing of 20 ft between two freight tracks and 25 ft between freight and commuter tracks.

For minimum temporary horizontal construction clearances, the railroad underpass shall provide 12 ft, as measured perpendicular from the centerline of the nearest track to all physical obstructions including but not limited to formwork, stockpiled materials, parked equipment, bracing or other construction supports. The temporary horizontal construction clearance shall provide sufficient space for drainage ditches parallel to the standard roadbed section or provide an alternative system that maintains positive drainage.

21.1.3.2.3 Nevada Administrative Code

§705 of the *Nevada Administrative Code* presents the lateral clearance requirements for railroads in Nevada. These requirements are typically less than those required for Federal-aid projects. The minimum centerline of main track to centerline of main track is 14'-0". The minimum centerline of main track to non-main track is 15'-0".

21.1.3.2.4 AREMA

AREMA stipulates the following:

1. Horizontal Clearances (Tangent Track). Abutments and/or piers for overhead bridge structures shall be located to clear the ditches of a typical track roadbed section and, where possible, be set with a minimum of 25 ft from the face of pier to the centerline of the track.

2. Horizontal Clearances (Curved Tracks). On curved track, the lateral clearances on each side of the track centerline shall be 1½ in per degree of curve on the railroad alignment. When the fixed obstruction is adjacent to the tangent track but the track is curved within 80 ft of the obstruction, the lateral clearances on each side of the track centerline shall be increased as shown in [Figure 21.1-B](#).

On superelevated track, the track centerline remains perpendicular to a plane across the top of rails. Where the track is superelevated, clearances on the inside of the curve shall be increased by 3½ in for each inch of elevation differential between the inside and outside edges of the superelevated section.

Distance from Obstruction to Curved Track (ft)	Increase Per Degree of Curvature (in)
20	1½
40	1⅛
60	¾
80	⅝

Note: To convert radius of curve (R, in ft) to degree of curvature (D, based on the chord definition), $D = 2(\sin^{-1} (50/R))$.

**LATERAL CLEARANCE INCREASE
(For Tracks on Horizontal Curves)**

Figure 21.1-B

21.1.3.3 Vertical Clearances

21.1.3.3.1 FHWA

The Appendix to Subpart B of 23 CFR 646 presents FHWA Federal-aid participation limits for vertical clearances. The following summarizes these criteria:

1. Basic Clearance. FHWA will fully participate in the costs of a vertical clearance of 23'-4" above the top of rails, which includes an allowance for future ballasting of the railroad tracks.
2. Additional Clearance. Vertical clearances greater than 23'-4" may be approved when the Public Utilities Commission requires a vertical clearance in excess of 23'-4" or on a site-by-site basis where justified by the Railroad to the satisfaction of NDOT and FHWA. A Railroad's justification for increased vertical clearance should be based on an analysis of engineering, operational and/or economic conditions at a specific structure location.
3. Electrification. Federal-aid highway funds are eligible to participate in the cost of providing vertical clearances greater than 23'-4" where a Railroad establishes to the satisfaction of NDOT and FHWA that it has a definite, formal plan for electrification of its rail systems where the proposed grade separation project is located. The plan must cover a logical, independent segment of the rail system and be approved by the Railroad's corporate headquarters. For a 25-kv line, a vertical clearance of 24'-3" may be approved. For a 50-kv line, a vertical clearance of 26'-3" may be approved.

A Railroad's justification to support its plans for electrification shall include:

- maps and plans or drawings showing those lines to be electrified;
- actions taken by its corporate headquarters committing it to electrification including a proposed schedule; and
- actions initiated or completed to date implementing its electrification plans such as documenting the funding amounts and the identification of structures, if any, where the Railroad has expended its own funds to provide added clearance for the proposed electrification.

If available, the Railroad's justification should also include information on its contemplated treatment of existing grade separations along the section of its rail system proposed for electrification.

The cost of reconstructing or modifying any existing railroad-highway grade separation structures solely to accommodate electrification will not be eligible for Federal-aid highway fund participation.

4. Temporary Clearances. For temporary applications, the minimum vertical clearance for a highway over railroad may be reduced to 21'-0" upon approval of the Railroad.
5. Summary. See [Figure 11.9-A](#) for a summary of vertical clearance information for highway bridges over railroads.

21.1.3.3.2 UPRR

See Sections 4 and 5 of the "UPRR Guidelines for Railroad Grade Separation Projects" for the Railroad Company's criteria for permanent vertical clearances. In general, UPRR stipulates the FHWA maximum vertical clearance of 23'-4" (for Federal-aid participation) as its minimum vertical clearance. In addition, UPRR requires additional vertical clearance for items such as:

- correction of sag in the track,
- construction requirements, and
- future track raises.

UPRR will consider the potential need for track re-profiling when evaluating plans for new or widened overhead structures. Preliminary plan submittals from NDOT must include track survey information at 100-ft maximum centers for a minimum of 1000 ft on both sides of the structure centerline.

The railroad underpass shall provide a minimum temporary vertical construction clearance of 21 ft as measured above the top of high rail for all tracks. The 21-ft temporary vertical clearance shall not be violated due to deflection of formwork. Greater temporary vertical clearances may be required. The temporary vertical clearances are subject to Railroad local operating unit requirements.

21.1.3.3.3 Nevada Administrative Code

§705 of the *Nevada Administrative Code* requires a minimum vertical clearance of 23'-0". Use this clearance for all non Federal-aid projects.

21.1.3.4 Pier Protection

To limit damage by the redirection and deflection of railroad equipment, piers supporting highway bridges over railways and with a clear distance of less than 25 ft from the centerline of a railroad track shall be of heavy construction (defined below) or shall be protected by a reinforced concrete crash wall. The following will apply:

1. Single-Column Piers. Crashwalls for single-column piers shall be a minimum of 2'-6" thick and shall extend a minimum of 10 ft above the top of high rail. The wall shall extend a minimum of 6 ft beyond the column on each side in the direction parallel to the track.
2. Multiple-Column Piers. The columns shall be connected with a wall of the same thickness as the columns or 2'-6", whichever is greater. The wall shall extend a minimum of 2'-6" beyond the end of outside columns in a direction parallel to the track and shall extend at least 4 ft below the lowest surrounding grade.
3. Reinforcing Steel. Reinforcing steel to adequately anchor the crashwalls to the column and footing shall be provided.
4. Heavy Construction. For piers of heavy construction, crashwalls may be omitted. Heavy construction is considered as solid piers with a minimum thickness of 2'-6" and a length of 20 ft; single-column piers of a minimum of 4 ft by 12'-6" dimensions; or any other solid bent sections with equivalent cross sections and a minimum of 2'-6" thickness. In addition, LRFD Article 3.6.5.2 applies to piers not protected by crashwalls.

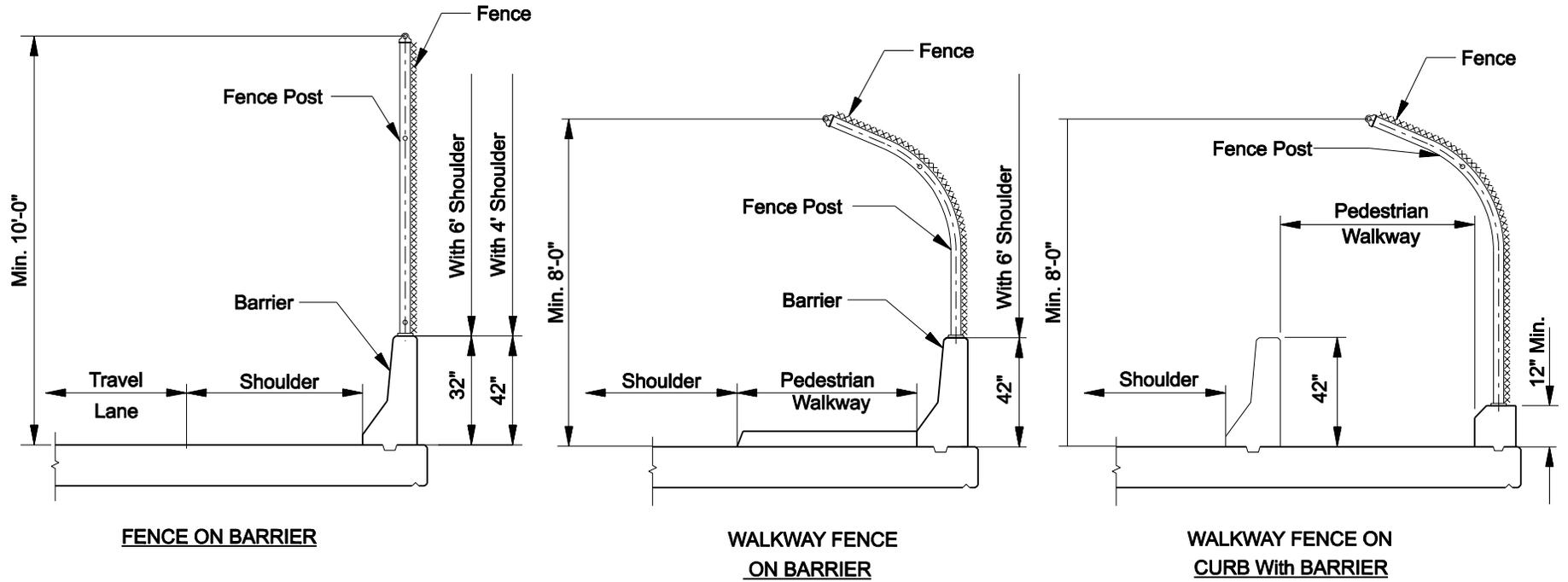
See Section 5.5.2 of the "UPRR Guidelines" for additional information.

21.1.3.5 Side Slopes

To prevent embankment material from sloughing and drainage waters from undermining the track subgrade, embankment slopes adjacent to tracks should be paved with concrete around the curved face to a line opposite the abutment or other appropriate slope protection. Provide self-cleaning paved ditches to carry water through the highway overpass area and disperse the water away from the track. Side slopes shall be no steeper than 2H:1V. See Section 5.5.3 of the "UPRR Guidelines" for additional information.

21.1.4 Fencing

A protective fence across the highway bridge shall be provided on both sides of highway bridges over railroads. The limits of the fence with barrier rail shall extend to the limits of the Railroad right-of-way or a minimum of 25 ft beyond the centerline of the outermost existing track, future track or access road, whichever is greater. All parallel overhead structures that have a gap of 2 ft or more shall be protected with fencing. Structures with a gap of 2 ft or less shall either have the gap covered or be fenced on both sides. [Figure 21.1-C](#) illustrates acceptable fencing applications for bridges over UPRR track. See Sections 4.6 and 5.4.2 of the "UPRR Guidelines" for more information.



Note: Barrier heights shown differ from UPRR guidelines in order to satisfy AASHTO height requirements.

FENCING APPLICATIONS
(UPRR)

Figure 21.1-C

21.1.5 Control of Drainage from Highway Bridge Deck

Deck drains shall not be allowed to discharge onto railroad right-of-way. [Section 16.4](#) of the *NDOT Structures Manual* discusses bridge deck drainage. Where drains are required within the Railroad right-of-way, a closed drainage system shall be used, and the drainage shall be directed away from the Railroad right-of-way. See Section 5.7 of the "UPRR Guidelines" for more information.

21.1.6 Construction Requirements

For information on shoring for construction excavations, see the "UPRR Guidelines for Temporary Shoring" and the *AREMA Manual for Railway Engineering*. In addition, see Plan No. 710000 "General Shoring Requirements" in the "UPRR Guidelines for Railroad Grade Separation Projects." [Figure 21.1-D](#) duplicates a portion of UPRR Plan No. 710000.

Section 4.4 of the "UPRR Guidelines for Railroad Grade Separation Projects" discusses many other elements of construction that apply. In addition, UPRR has published a separate document "Guidelines for Preparation of a Bridge Demolition and Removal Plan for Structures over Railroad" that should be consulted as needed.

Temporary steel casings must be used in the construction of drilled shafts that are in load influence zones of railroad tracks. Casings shall be used for the entire length of drilled shafts. The required thickness of casings shall be decided on a case-by-case basis. The Geotechnical Section is responsible for ensuring that the following are shown in the contract documents:

- temporary casing for the entire length of the drilled shaft, and
- the minimum thickness of the temporary casing.

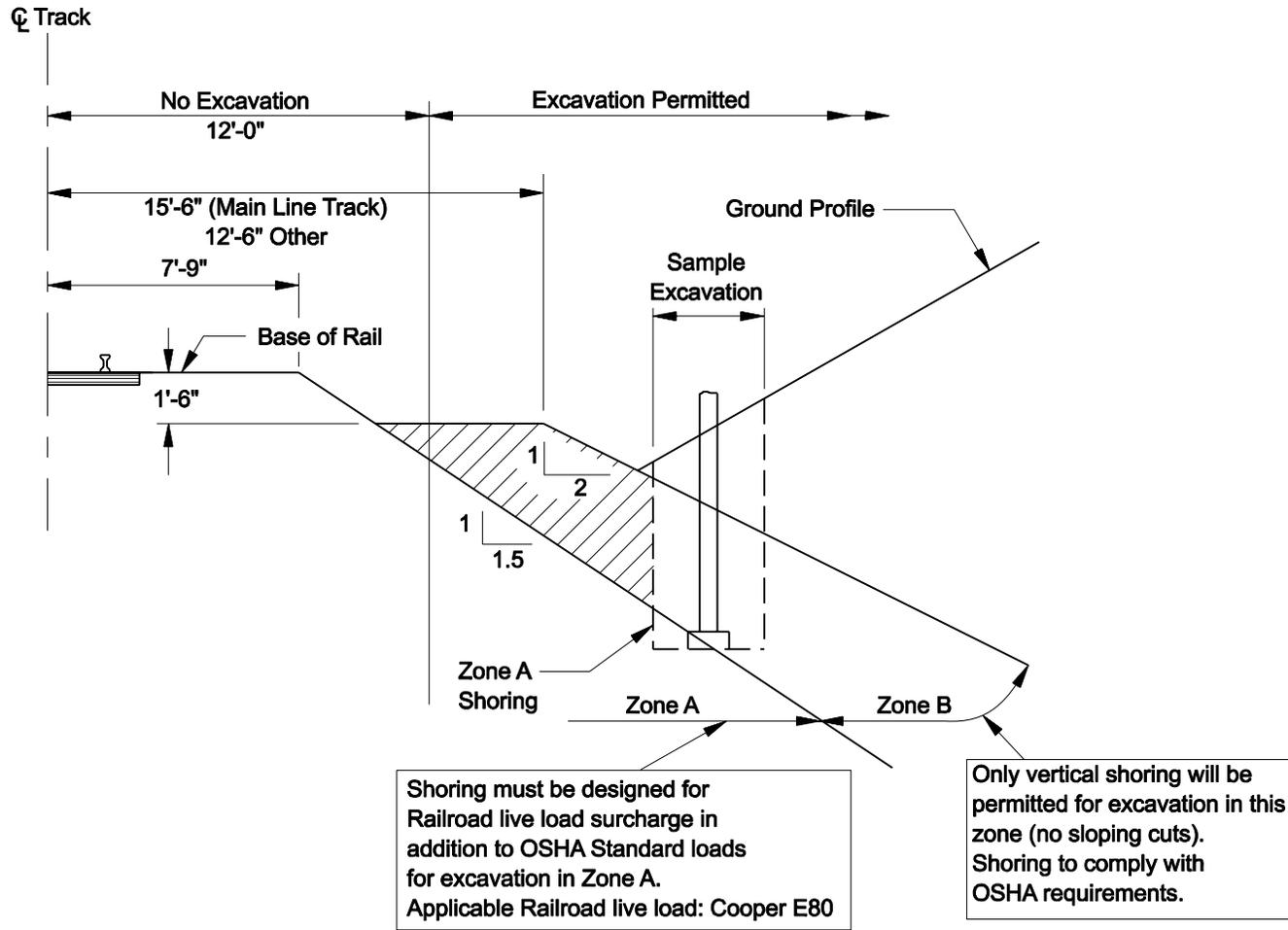
21.1.7 Utilities

See Section 4.9 of the "UPRR Guidelines" for the Railroad requirements for utilities. See [Section 16.5.4](#) of the *NDOT Structures Manual* for NDOT requirements.

21.1.8 NDOT Procedures

21.1.8.1 Right-of-Way Division, Utilities Section

The Right-of-Way Division, Utilities Section is responsible for coordinating with the Railroad Companies where NDOT projects impact railroads. The Utilities Section's responsibilities include obtaining cost estimates for securing agreements with Railroads for the relocation and adjustment of their facilities, as required for highway construction, and conducting direct negotiations with Railroads, when necessary.



**TEMPORARY SHORING
(UPRR)**

Figure 21.1-D

21.1.8.2 Project Development

Because of the unique nature of highway-railroad grade separations, special coordination is necessary where a railroad alignment and a highway alignment intersect or where these alignments are in close proximity to each other. The bridge designer must prepare a preliminary design and Bridge Front Sheet considering the minimum required horizontal and vertical clearances, which is submitted to the Utilities Section. The Utilities Section will coordinate with representatives from the impacted Railroad.

The Utilities Section will advise the bridge designer if the preliminary design is acceptable or if revisions are needed. Final bridge and roadway plans will be developed and then forwarded to the Utilities Section. The Utilities Section will forward the final plans to the Railroad for review and final approval for construction. The final plan submittal to the Railroad must be stamped by a Nevada registered professional civil/structural engineer.

Temporary structures, falsework, shoring, erection plans, demolition, etc., produced by the contractor will also require a Registered Professional Engineer stamp. The contractor will be responsible for producing the drawings for these items and ensuring that the drawings are stamped by a Nevada registered professional civil or structural engineer. The Special Provisions for a project must include these requirements plus appropriate review times. NDOT must review and approve the submittal drawings prior to submitting to the Railroad for its approval.

21.2 RAILROAD BRIDGES OVER HIGHWAYS

21.2.1 Preliminary Design

In the past, concrete railroad bridges were typically discouraged, most likely because of the tradition of wooden and steel railroad bridges. However, currently, the US railroad industry spends approximately 50% of its bridge capital improvements on concrete bridge construction. Concrete bridges represent approximately 20% of the total railroad bridge inventory based upon bridge length.

Many Railroads prefer simple-span bridges to continuous-span bridges, believing that they are easier to maintain and construct with less interruption to traffic. Specifically, Railroads find that:

- Simple-span railroad bridges have a long history of good performance.
- Repair or replacement of simple-span superstructure elements can be accomplished with less interruption of railroad traffic than for continuous-span superstructures.
- Construction of simple-span bridges can be completed more quickly than the construction of continuous-span bridges.
- Substructure settlement can be accommodated more easily with simple spans thereby reducing potential traffic interruption.

21.2.2 AREMA Requirements

The American Railway Engineering and Maintenance-of-Way Association (AREMA) *Manual for Railway Engineering* provides recommended practices for railroad bridge design. A major difference between the AASHTO *LRFD Specifications* and the AREMA *Manual* is the live-load model. AREMA specifies the Cooper E 80 load, which is 18 concentrated axle loads followed by a trailing uniform load, or a fraction thereof for each track. Further, the *Manual for Railway Engineering* is based upon the allowable stress design (ASD) methodology.