C5.8.1 Railings

C5.8.1.1.1 Policy overview

Before 01 August 2023 ~ F-shape barrier rails and NCHRP 350

MASH 2nd edition (2016) compliant single slope rails were incorporated into the BDM in August 1, 2023 and were incorporated into projects starting with the October 2024 letting. Previous to these dates most new Iowa highway bridges made use of F-shape barrier rails based on National Cooperative Highway Research Program (NCHRP) Report 350 (1993). The F-shape rail is a safety shape similar to the older New Jersey shape except for some geometry modifications which reduced vehicular climbing. The 34-inch tall and 44-inch tall Iowa standard F-shape barrier rails met NCHRP 350 Test Level 4 (TL-4) and Test Level 5 (TL-5) criteria, respectively. Note that the Iowa standard F-shape barrier rails were 2 inches taller than the minimum heights required for TL-4 and TL-5 barrier rails under NCHRP 350 to account for the possibility of a 2 inch thick future overlay. Table C5.8.1.1.1 list the CADD standard sheets containing the F-shape barrier rail details that were in use prior to August 1, 2023. Figure C5.8.1.1.1 has representative cross-sections of the TL-4 and TL-5 F-shape barrier rails.

Table C5.8.1.1.1 Standard F-shape barrier rails for PPCB and CWPG bridges (1)

Test Level	Abutment Type	Skew	Additional Information	End or Standard Rail Section	Standard Sheet Number (2)
TL-4	---	---	7'-0 wing	End	1017, 1017S
TL-4	Integral	---	---	Standard	1020A, 1020SA
TL-4	Integral	---	Wing extension	Standard	1020C, 1020SC
TL-4	Integral	---	Urban approach slab with curb	End, standard	1019A, 1019SA
TL-4	Stub	No skew	Wing extension	Standard	1020B, 1020SB
TL-4	Stub	Skew	Wing extension	Standard	1018, 1018A, 1018S, 1018SA
TL-4	Stub	No skew	Urban approach slab with curb	End, standard	1019B, 1019SB1, 1019SB2
TL-5	Integral	---	---	Standard	1020D, 1020SD
TL-5	Integral	---	Wing extension	Standard	1020F, 1020SF
TL-5	Stub	No skew	Wing extension	Standard	1020E, 1020SE
TL-5	Stub	Skew	Wing extension	Standard	1018C, 1018D, 1018SC1, 1018SC2, 1018SD1, 1018SD2

Table notes:

(1) This Table was previously designated as Table 5.8.1.2.1.1 when it was present in the main body of the BDM prior to August 1, 2023. Signed standard bridge plans for CCS, PPCB and RSB bridges also include details for standard F-shape barrier rails. [Some of the table notes from the original table were modified or deleted since the context of those notes no longer fits.]

(2) A designation of “S” in the standard sheet number indicates the use of stainless steel for the barrier rail to bridge deck/wing reinforcement.

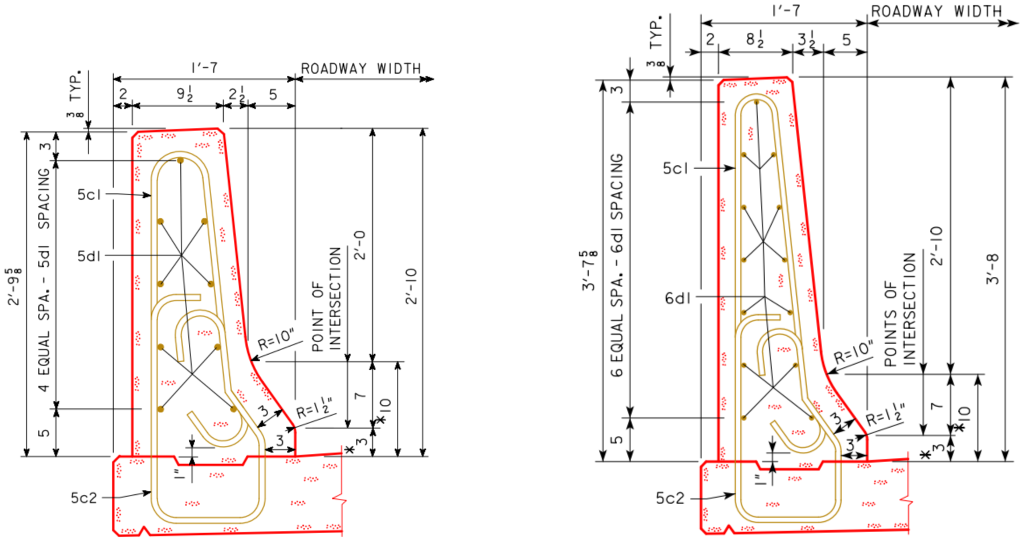


Figure C5.8.1.1.1 Typical TL-4 and TL-5 F-shape barrier rails

01 January 2015 ~ Guidelines for stainless steel

BSB adopted the use of stainless steel rebar between the barrier rail to bridge deck/wing connections for interstate and primary bridges starting with the January 2015 letting.

Before 01 October 2007 ~ Guidelines for conduit and lighting on bridges

The policy for lighting on bridges up until October 1, 2007 has been for the design engineer to evaluate whether the bridge is located near an urban area. For projects determined to be in an urban area, the Engineer had to make a request (send a copy of the TS&L) to the Traffic and Safety Bureau to determine the lighting and conduit requirements. Traffic and Safety would determine the conduit size and locate the conduit and light pole bases (if needed) on a TS&L sheet for the bridges submitted and return the information back to our Bureau. This policy was revised on October 1, 2007.

After 01 October 2007 ~ Guidelines for conduit and lighting on bridges

Conduit will be provided in accordance with the Traffic and Safety Manual, Chapter 6E-1, "Bridge Lighting" (http://www.iowadot.gov/traffic/manuals/pdf/06e-01.pdf). If the bridge is near an urban area or interchange, then the bridge may require light pole blisters. In this case the TS&L should be submitted to the Traffic Engineering Unit of the Traffic and Safety Bureau for review. Traffic and Safety will review the site to determine if existing lighting is present or if a lighting project is planned in the near future. If it is determined that continuous lighting will be present at this location, light pole blisters and possibly underdeck lighting will be located and noted on a TS&L sheet and returned to the Engineer.

Where possible, light pole blisters should be centered above substructure elements. Consult the Traffic and Safety Bureau regarding adjustments of light locations to coincide with pier centerlines. Junction boxes will be placed at both ends of a bridge as a minimum. Additional junction boxes may be required to keep the maximum distance between them less than 500 feet. The maximum junction box spacing depends on the equipment used by the contractor. Most contractors can handle pulls under 500 feet and some contractors can handle pulls of 1000 feet and more. Conduits should be placed to line up with the junction boxes provided when possible, to limit the number of bends required in the conduit. The sum of the conduit bends between junction boxes shall not be more than 360 degrees as specified in the "National Electric Code".

In discussions with our lighting crews, it was found that conduit could be cleaned out and used even if the bridges have been in service for a number of years. CADD standard 1030A, 1and 2 of 2, "Lighting Details" are available.

01 July 2015 ~ Statement concerning PVC conduit

Conduit used in concrete barrier rails shall be galvanized rigid steel conduit. PVC conduit shall not be substituted. PVC pipe can experience damage during concrete placement particularly when barrier rails are slip formed. Additionally, the difference in the coefficient of linear expansion between PVC and concrete requires a significant number of expansion fittings which are prone to durability issues.

01 January 2016 ~ Additional conduit guidelines for ITS communication wires

Separate conduit and junction boxes should be used in the rail when both conductor and communication wires are required. ITS communication wires require a 2" minimum conduit and no more than six 45-degree elbow bends between conduit junction boxes with a minimum inside bend radius of 18 inches. CADD Note E1085 should be included in the plans when I.T.S. conduit is required.

C5.8.1.2.1 Traffic railings

01 August 2023 ~ Bridge Railing Selection on Interstate and Primary Highways

The policy w.r.t. the selection of TL-4 and TL-5 rail has remained the same, but the rail types have changed from NCHRP 350 F-shape rails to MASH single slope rails. Figure 1 below was updated in BDM 5.8.1.2.1 for the new rails and rail heights. No other changes were made to the policy.

29 June 2007/Revised 11 June 2009 ~ Bridge Railing Selection on Interstate and Primary Highways

Generally, TL-4 (minimum height of 34": 32" plus 2" for future overlay) is considered acceptable for most interstate and primary roads with a mixture of trucks and heavy vehicles. But in some cases, other factors may require the use of TL-5 (minimum height of 44": 42" plus 2" for future overlay). These factors may include:

- Traffic volume and mix: The presence of high number of a van-type tractor-trailer as determined from predicted traffic data for the design year.
- Unfavorable site conditions where a rollover or penetration beyond the railing could result in severe consequences. This applies to bridges with fracture critical elements within the zone of intrusion or flyover bridges. Unfavorable site conditions include:
    - Reduced radius of curvature
    - Steep downgrades on curvature
    - Variable cross slopes

  Examples of fracture critical elements may include cables on cable stayed bridges, hangers on arch bridges, and truss members on truss bridges or supports for sign structures.
- Approach roadway rail height
- Headlight glare
- Snow pile up during snow removal spilling over roadways below
- Snow pile up causing ramping up the barrier rail

The need for TL-6 (minimum height of 92") railing which is suitable for higher level of protection is not anticipated for the vast majority of bridges in Iowa.

A flow chart (**Figure 1 was revised on 5 May 2009 to include bridges over BNSF and UP Railroads.**) has been developed to aid in the determination of the appropriate test level. The appropriate test level/rail height will need to be determined by the Pre-Design Unit (Design Bureau) in the early phase of project conception with input from the Districts during concept field exam. On projects that are not initiated in the Pre-Design Unit, the determination of the test level will be the responsibility of the Preliminary Bridge Design Unit (Bridges and Structures Bureau). This effort will require some coordination among the various Engineering Bureau offices and the Districts.

Based on examining the factors discussed above and the predicted truck traffic for 2035 (see Figure 2), all mainline interstate bridges except as noted below would qualify for TL-5 railing with a height of 44”. Rail height on mainline bridges near on-ramps need to be investigated for potential conflict with sight distance. Bridges on other highways in Iowa, overhead bridges and ramp bridges would require a similar evaluation using the attached flow chart. Overhead bridges near interchanges, especially in urban areas near side roads/streets, will require close evaluation of the available sight distance to avoid potential conflict.

The evaluation criteria discussed in this memo applies to both the median and outside railings and in some cases may results in different railing heights on the same bridge. Other considerations such as aesthetics may influence the decision on whether same railing height would be used for both the median and outside railings. Cost is a minor contributor based on comparing concrete volumes between the 34” and 44” rails. The 44” rail requires an additional 0.023 cu. yd. of concrete per lineal foot.

This policy is applicable to new bridges, bridge replacements, deck replacements and bridge widening. Bridge repair or rehabilitation projects where the existing railing is not affected by such work will not be required to comply with this policy and no retrofit is needed.

FIGURE 1

Flow Chart for determining Bridge Barrier Rail Height for New Bridges on Interstate and Primary Highways

Revised 5 May 2009

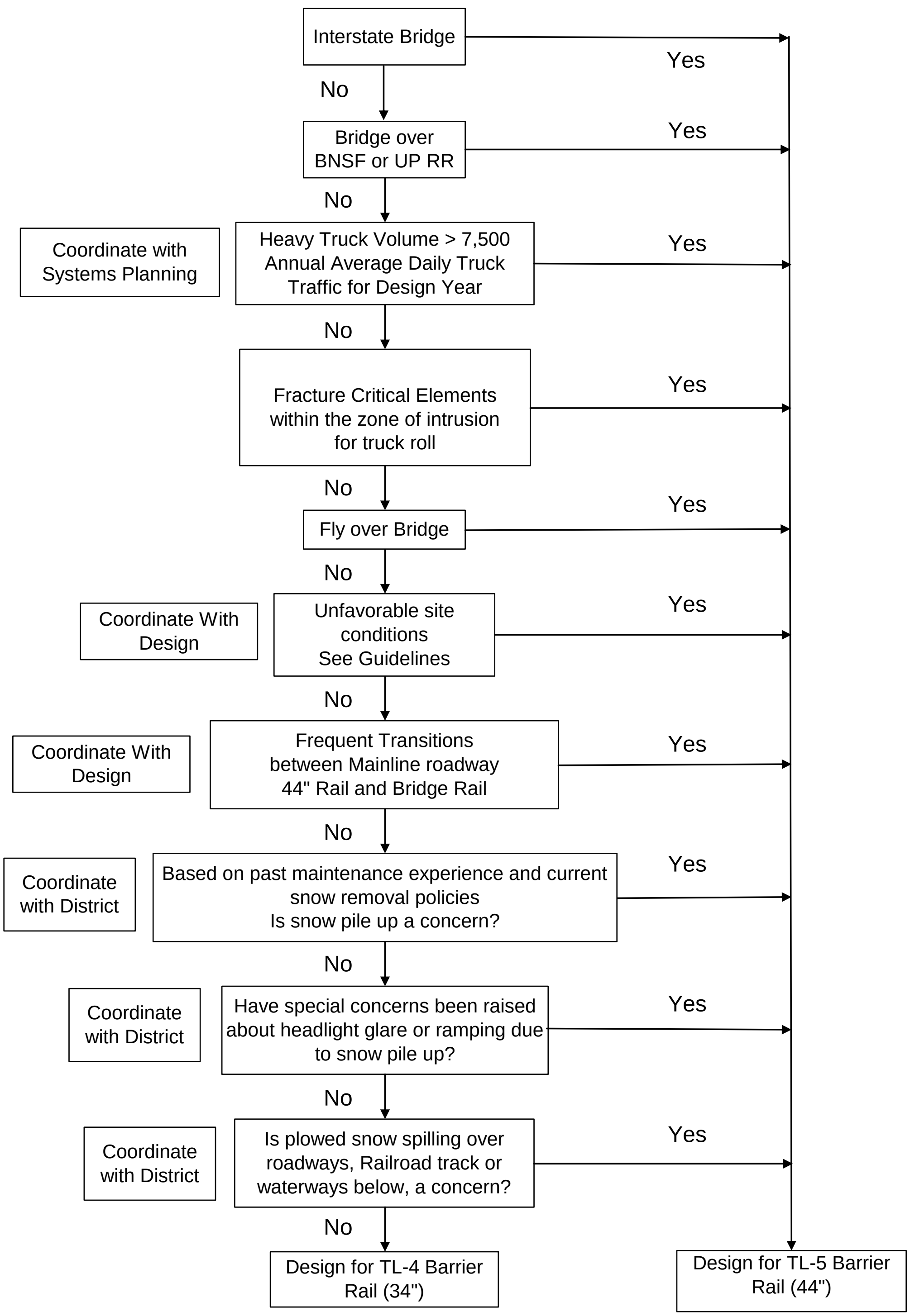
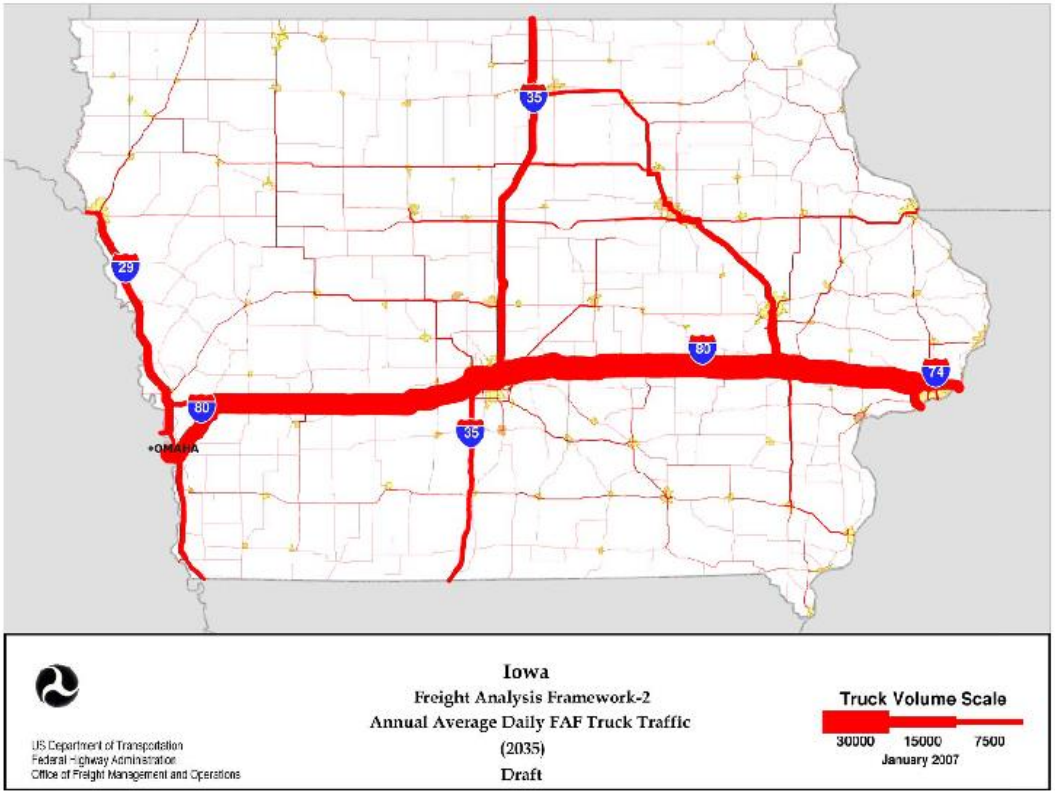


FIGURE 2



C5.8.1.2.4 Separation railings

01 August 2023 ~ Additional discussion of separation railings

The Iowa DOT BSB's standard TL-4 and TL-5 single slope (SS) concrete barriers are currently not anticipated to be used as separation barriers on bridges for several reasons. First, it is standard Iowa DOT practice to use combination traffic and pedestrian railings that are also bicycle compliant, and an all-concrete barrier does not meet the full intent of a bicycle separator because it lacks a steel tube railing that can be easily grasped by a falling cyclist (AASHTO *Guide Specifications for Bridge Railings, C G2.7.1.2.2*). If used without a bicycle railing along a trail, a Design Exception would be required. The addition of a steel tube railing to the Iowa DOT standard TL-4 SS barrier at the proper height for a cyclist would place the attachment within the barrier's ZOI, which is not allowed. Such a bicycle railing attachment could be placed on the back side of the standard TL-5 SS barrier and remain outside the ZOI, but only if the sidewalk/trail surface was not raised. Either the TL-4 or TL-5 SS barrier could potentially be used as a separator without attaching a bicycle railing and meet AASHTO requirements for a pedestrian-only separator (i.e. min. 24 inches tall on the sidewalk side), but again this would go against Iowa DOT standard practice of accommodating occasional bike traffic on all side paths on bridges. Additionally, at least one incident has been reported involving pedestrian injury associated with a short separation barrier with no bicycle railing.

In some cases, it may be desirable to omit the steel bicycle railing from a sidewalk separator, especially on narrow sidewalks where bicycle traffic is discouraged, where no significant bicycle traffic is expected, or where bike lanes are located within the roadway. Sight distance issues can also be made more complicated by barrier attachments when bridges are located in urban conditions. In these cases, the separation barrier must be a minimum of 24 inches high on the pedestrian side (AASHTO 1989 *Guide Specifications for Bridge Railings* G2.7.1.2.2). Omission of the bicycle railing or violation of the 42 inch minimum separator height is strongly discouraged at locations near schools, playgrounds, parks, or other facilities that attract children. It may also not be desirable to omit the bicycle railing when replacing a bridge that included a precedent separator with bicycle railing, regardless of other conditions. In cases where a bicycle railing is required but is considered for omission, an approved Design Exception is required before proceeding. Consult the Methods Engineer when special cases arise.

In congested urban conditions and other cases where sideroad tie-ins may be very close to bridge ends, sight distance can be difficult or impossible to achieve if the separation barrier on the bridge is as tall as the standard or typical applications. It has been necessary on some projects to eliminate the bicycle railing attachment, reduce the height of the concrete barrier, or both. Any such reductions in required minimum height(s) will typically require a Design Exception to be submitted to FHWA for review and approval prior to commencing design.

For some specific conditions in urban low speed zones, crash-tested low profile TL-2 concrete separation barriers or barrier curbs may be desired to eliminate sight distance issues. However, this type of barrier may be deemed insufficient for containment of vehicles on the bridge, thus an acceptable barrier may also have to be located at the edge of deck along the sidewalk or trail. Complications can result when these combination barriers also have to provide fall protection for pedestrians. Options should be discussed with the Methods Engineer before proceeding to incorporate such special separation barrier configurations into projects.

C5.8.1.2.5 Aesthetic and special railings

01 August 2023 ~ Additional discussion of aesthetic and special railings

There are some aesthetic and special traffic barrier types that have been used on past projects in Iowa but are no longer considered viable for use under the current MASH specifications. Those barriers are listed here along with reasons they are no longer used on Iowa DOT projects. Projects may occasionally arise where there is a compelling reason to match an existing barrier configuration that may appear below. Assessments for re-use will be made on a case-by-case basis.

- **F-shape Barrier with Back Face Projection** - The F-shape is not being carried forward under MASH and has not been approved for continued use. The back face projection was not effective enough at increasing aesthetic appeal compared to the amount of material and effort required to construct it. Barrier back face rustication has been determined to be as effective.
- **Texas T80HT F-Shape with Steel Traffic Railing** - Also known as the PennDOT PA HT, this TL-5 barrier has not been re-tested under MASH and is not currently approved for use in Iowa. The elliptical top tube is manufactured by only one fabricator in the US, making it effectively proprietary which is not desirable under Iowa code. Steel railing installation quality has been poor on some projects using this barrier and detailing of expansion joints in the tube has raised questions about its long-term performance. The barrier also has high cost.
- **MnDOT Steel-on-Concrete Combination Railing** - This rail was used extensively on I-235 but has not been re-tested to MASH specifications and is not currently approved for use in Iowa. Height does not meet MASH TL-4 minimum requirements when 2-inch future grade raise is considered. Steel railing has suffered damage during service from vehicle contact and snowplow blades, compromising both the outer paint coating and the galvanizing in some instances. The barrier also has high cost.
- **Low-Profile TL-2 Barrier** - This barrier has been used on just one bridge in Iowa (E. 9th St. over I-235) to solve a severe sight distance problem. The barrier has not been re-tested under MASH and is not currently approved for use in Iowa. Use of this barrier requires a Design Exception process because it does not meet height minimums established by AASHTO specifications.

- **34-inch and 44-inch Vertical Face Barriers** - Originally based on designs from South Dakota and used extensively on past Iowa projects, these are not currently approved for use in Iowa. The 34-inch version no longer meets TL-4 minimum height requirements. The standard single slope 38-inch and 44-inch barriers are effectively similar in appearance and allow for similar aesthetic enhancement, so there is no aesthetic reason to continue using the vertical face barriers. The BMBR separator [BDM 5.8.1.2.4] can be used for TL-2 conditions or less and is similar in configuration to the 34-inch vertical barrier.
- **Michigan BR27C** - This barrier has been replaced by the updated Modified B-25 Series barrier [BDM 5.8.1.2.4] which is approved for use on Iowa DOT projects.

Some bridge barriers and hardware attachments that have been previously used in Iowa are under review at this time and are not approved under the Iowa DOT's MASH implementation policy. Some of these may not be approved for use in the future. These are as follows:

- **54-inch Single Slope (for structure shielding)**
- **44-inch Single Slope with Setback Top (for median conditions only)**
- **Texas C412 MASH TL-5 concrete barrier**
- **Barrier-mounted chain link fence (for debris retention, other)**
- **Acrylite Soundstop TL-4 Noise Wall System (barrier-mounted)**

The **PennDOT PA MASH TL-5 combination steel-on-concrete traffic barrier** has been approved for use on the Iowa 9 bridge over the Mississippi River in Lansing, IA. This barrier was chosen for its tall overall height to maximize protection from vehicle strikes for the above-deck truss superstructure. This barrier is not intended for general purpose use on other Iowa projects but may be considered if a similar situation arises where structure shielding is of special concern. This railing is expected to have high cost due to the steel railing and its embedded anchorage which requires cast-in-place parapet construction. There is currently no approved drilled-in anchorage to replace the preset condition. Consult the Methods Engineer before considering use of this barrier.

Some projects at the Local Systems (county, city) level have employed bridge barrier types not listed here. Some are barriers approved by other states such as the **Wyoming 2-Tube railing** and the **MnDOT combination traffic and bicycle railing**. Since barriers on Local Systems projects that are not on the NHS are not required to meet MASH specifications, these barriers are not addressed in this section. However, when these projects come under State review the Iowa DOT and the Bridges and Structures Bureau reserve the right to issue comments and recommendations relative to barrier hardware on these projects wherever barrier choices and detailing are related to safety and performance concerns. The Iowa DOT will not evaluate the potential performance of unapproved barrier systems and Local Systems plan information will not be thoroughly checked for accuracy.

The following comments are observations regarding various unusual or unique pedestrian fence and railing materials used on past Iowa DOT projects, and should be kept in mind when designing features that include these materials:

- **Welded Wire Mesh** - When welding is the attachment method for mesh to framing, material requires significant detailing and notation to ensure that best welding practices are employed. The mesh typically requires mechanical manipulation to properly engage with framing elements when welding. Welds should not occur on both ends of the same wire, since subsequent galvanizing operations can distort the mesh to a degree that results in tensile breakage of wire or failure of one or both welds. Some mesh distortion in the finished result is inevitable and must be considered tolerable in the design. Care must be taken in selection of wire thickness to avoid the possibility of permanent deformation from pedestrian contact or vandalism. When mesh is placed directly adjacent to bike facilities, it is preferable to orient mesh so that the horizontal wires are on the bikeway side to limit handlebar snagging potential on the vertical wires.
- **Perforated Metal** - This material can be particularly expensive, especially in aluminum. All suppliers who carry the material sought for use on a project shall be listed in the plans. Care must be taken in selection of sheet thickness to avoid the possibility of permanent deformation from pedestrian contact or vandalism. Since the punch-out side of the perforations is typically left

sharp from the manufacturing process, it is preferable to locate that side of the sheet way from pedestrians, and not to select punched openings that could trap or cut fingers. Painting is not advised, also due to the sharpness of corners and thinness of the sheet product. Weld attachment of this material to framing must carefully consider distortion effects, as should any specification that calls for galvanizing a perforated metal assembly. Bolted assembly may be preferable due to these factors, but distortion can also occur due to thermal factors after installation if panels are not properly allowed to expand and contract independently from the framing.

- **Weathering Steel** - Availability of the proposed steel sections must be checked before committing to this material. Is typically more expensive than other typical steel products, even those with finishes included (galvanizing, paint or powder coating). It is best to require application of 5 water mist treatments at the fabrication facility prior to delivery to the jobsite to thoroughly begin the weathering process. Staining of surrounding surfaces by leachates will occur throughout the life of the material, so detailing should attempt to address this, or staining must be considered tolerable in the design. Side-mounting of weathering steel railings has been done and is effective at controlling - but not eliminating - staining on the adjacent walkway surface. It is not advisable to use weathering steel railings adjacent to high volumes of high-speed traffic due to salt-laden spray or fog settling onto the material and causing excess corrosion.
- **Aluminum** - This material is very expensive, and the pool of Iowa DOT-approved fabricators is limited. Specifications must be thoroughly checked for the application and material availability established before committing to this material. Colors are limited to the available standard anodize finishes. It is currently unknown how well the darker colors of anodized aluminum railing perform near roadways, or if they are negatively and permanently impacted by salt spray. Painting of aluminum railings is not advised.

Acrylite (formerly Paraglas) Panels - This material is currently proprietary which requires a Public Interest Finding for use on Iowa DOT projects. Some custom shaping (single-direction curvature) is possible with this material. Machining requirements should be investigated and understood before providing plan guidance to the fabricator. It may be best to specify that the supplier/manufacturer’s recommendations be strictly followed for most preparatory work. Framing elements are typically custom and may require proprietary components, in whole or in part (e.g. gaskets). This material reportedly has good graffiti remediation potential, since the panels can be flamed with a torch in a controlled manner to burn off some common petroleum-based spray paints without permanently damaging or distorting the panel.