

Bridge Railings

The FHWA has begun enforcing the use of crash tested railings on bridges. There is a lot of confusion as to what can and can't be used. The following is a link to their web site:

<http://www.fhwa.dot.gov/safety/fourthlevel/hardware/bridgerailings.htm>

MnDOT's office of Bridges and Structures is in the process of updating the Bridge Design Manual. As part of this manual, a revised Bridge Railing chapter is being developed that will contain the new standards. We are including a copy of the interim revised chapter for your convenience. Please be advised that this is a work in progress and further updates may be coming.

5-392.204 BRIDGE RAILINGS

A. Introduction

The design requirements for railings utilized on Mn/DOT bridges have undergone changes in recent years. Crash testing requirements have been established by the Federal Highway Administration (FHWA) and AASHTO Specifications have been revised. Additionally, the desire for more attractive railings has influenced the style of railings on projects where aesthetics has been a major consideration. Accidents involving objects thrown from overpasses onto traffic below has led to the adoption of protective screening requirements. The rapid increase in bicycle trails and traffic has increased attention on bicycle railings. This section of the Bridge Design Manual details our policies regarding the design of bridge railings for Mn/DOT projects.

B. General

The design of newly constructed bridge railings must conform to the requirements of the latest edition of the “AASHTO LRFD Bridge Design Specifications” as given in chapter 13. This specification gives geometric and strength requirements and also requires crash testing. FHWA requires all bridges carrying traffic on the National Highway System (NHS) to be crash tested regardless of speed, in accordance with NCHRP Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features. There are 6 levels of service and testing depending on vehicle size and speed. A list of crash tested railings is found on the FHWA Web sites:

<http://safety.fhwa.dot.gov/fourthlevel/hardware/bridgerailing.htm>

<http://safety.fhwa.dot.gov/fourthlevel/hardware/longbarriers.htm>

Crash testing requirements may be waived if an analytical evaluation shows the railing to be crash worthy. This allows minor changes to crash tested railings without having to go through the time and expense of crash testing. For bridges on the NHS any such evaluation must be approved by the FHWA.

Crash testing has shown that during impact vehicles slide along the top of the railing and parts of the vehicle, especially the boxes on trucks, extend beyond the face of the railing a considerable distance. Attachments to bridge railings such as architectural metal railings or objects just behind the railing such as light poles must address safety concerns presented by this encroachment including:

1) Snagging on posts which can result in the attachment (post for example) penetrating the occupant compartment or causing the vehicle (hood for example) to penetrate the cab.

2) Spearing – objects such as a horizontal railing member penetrating windshields and injuring occupants.

3. Debris falling onto traffic below.

Attachments within the area of encroachment shall be designed to break away before severely damaging the vehicle, contain any debris from damaging traffic below and have no members, such as rail ends, which might spear the occupant compartment. Ends of rails shall be sloped at 45 degrees or flatter to reduce the chances of spearing. Posts should be set back from the face of railing to minimize snagging.

Small sections of curb or sidewalk placed in front of railings cause vehicles to vault up onto the railing. For this reason sidewalks with a projection between 9 inches and 3.5 ft.

from the face of railing are not allowed and curb heights are limited to a maximum of 8 inches.

Railing designs should include consideration of safety, cost, aesthetics and maintenance. The safety shapes (Type J & F) were developed to minimize damage to vehicles as well as containing and redirecting vehicles back onto the roadway and have low initial and maintenance costs. Maintenance costs can be minimized by using designs that allow for easy replacement of damaged sections and use of standard railings so replacement components can be stockpiled. Coatings on metal railings should be as durable as possible to withstand the harsh environment of snow and salt.

The three general classes of bridge railings are Traffic Railings, Pedestrian or Bicycle Railings and Combination Railings. Bridge cross sections showing these three classes are shown in

Fig. A 5-392.204. These classes of railings are further defined in the following sections.

C. Traffic Railings

Traffic railings are designed to contain and safely redirect vehicles. Requirements based on speed are as follows.

1. High speed roadways with a design speed of 45 mph or more:

Mn/DOT requires crash testing to Test Level 4 as the minimum standard for these roadways. Test level 4 is run with a small car at 60 mph, a pickup truck traveling 60 mph and a single unit van truck impacting at 50 mph. This railing will normally be the 32" high Type F concrete barrier (Std. Fig. 5-397.114-117). Where aesthetics is a concern the tubular traffic railing which has a 1'-9" high concrete base with a structural tube railing and posts mounted to the top of the concrete base (Std. Fig. 5-397.157) is an acceptable alternative and provides a more open view to drivers crossing the bridge. The Preliminary Bridge Unit should be consulted for additional acceptable railings.

A bicycle railing attachment to the F barrier has been developed by Mn/DOT for use where the bridge shoulders carry a bicycle route as defined in the Mn/DOT State Bicycle Transportation System Plan or another recognized authority. This attachment (Std. Fig. 5-397.158) has been crash tested to Level 4. The bicycle railing addition adds height to the railing to protect bicycle riders and has a cable system in the rails to contain pieces of the railing in the event of an accident and a weakened post designed to lessen the impact to vehicles in the event of a hit. This railing may be applied to other traffic railings provided that the same or greater offset distance to the face of metal rail is provided and the post attachment has the same or greater strength. The cable system must be maintained even if there is no traffic below as the cables act to keep the entire rail system intact during a crash.

Attachments other than for traffic safety features (signs and lighting) are discouraged and are allowed only if crash tested or an analytical evaluation has shown them to be crash worthy. Light poles should be located behind the back of the barrier.

A more stringent rail design may be considered on a case-by-case basis for bridges with high design speeds, high truck volume, and curvature or other site-specific safety considerations. Generally a Test Level 5 railing should be considered for these sites. Test Level 5 includes a small car and a pickup truck, all traveling at 60 mph plus a van-type tractor trailer impacting at 50 mph. As a guide a 42 inch high Type F railing is recommended for bridges having a horizontal curvature of 5 degrees and sharper on a roadway where the design speed is 45 mph or higher. The Preliminary Bridge Plans engineer will designate the rail design on the Preliminary Bridge Plan.

2. **Low speed Roadways having a design speed of 40 mph or under:** Mn/DOT requires crash testing to Test Level 2 as the minimum standard for these roadways. Test Level 2 is run with an automobile and pickup truck, both impacting at a speed of 45 mph.

Normally these railings will be the same as used for higher speeds, usually the Type F concrete railing, but with the reduced level required for crash testing more options are available. The Preliminary Bridge Unit should be consulted for additional acceptable railings.

If the addition of an ornamental metal railing to the top of the traffic railing is desired a 32" high vertical faced traffic railing shall be used rather than the Type F. The vertical face will cause more damage to a vehicle for minor hits but reduces the tendency for the vehicle to climb the face or roll over and will keep the vehicle back from the metal rail. A small, 2" wide by 6" high curb should be provided at the base of the rail to minimize snowplow damage to the railing. For design speeds of 35 mph and below a metal railing may be used on the top of the concrete railing, as it is unlikely that vehicles will contact the metal portion.¹ For a design speed of 40 mph the front face of the metal railing shall be offset a minimum of 9 inches from the face of railing at the top of concrete.²

D. Pedestrian or Bicycle Railings

Pedestrian or bicycle railings are generally located at the outside edge of a bridge sidewalk and are designed to safely contain pedestrian or bicyclists. AASHTO specifications require pedestrian railings to be at least 3'-6" in height and bicycle railings to be at least 4'-6" in height. The height is measured from the top of the walkway to top of rail.

The openings between members of a pedestrian railing should not allow a 4 inch sphere to pass through the lower 27 inches of the railing and a 6 inch sphere should not pass through any openings above 27 inches. This is more restrictive than AASHTO and is intended to prevent small children from slipping through the railing. The Uniform Building Code requires a 4 inch maximum opening.

¹ See Guidelines for Attachments to Bridge Rails and Median Barriers by Keller, Sicking, Faller, Polivka & Rhode, Draft Report April 13,2001 p 6&19

² See Guidelines for Attachments to Bridge Rails and Median Barriers by Keller, Sicking, Faller, Polivka & Rhode, Draft Report April 13,2001 p 28. 9" offset at 40 mph judged acceptable based on 12" offset at 45 mph.

E. **Combination Railings**

Combination Railings are dual purpose railings designed to contain both vehicles and pedestrians or bicycles. These railings are generally located at the outside edge of a bridge sidewalk. A raised sidewalk is used to clearly define the walkway area and keep roadway drainage off the walkway and the sidewalk curb offers some protection to pedestrians from errant vehicles entering the walkway. There is no other barrier between the roadway and the sidewalk. Combination railings are applicable for design speeds of 40 mph and under - above that speed a barrier is required between the roadway and sidewalk. Mn/DOT requires crash testing to Test Level 2 for these railings and the strength and geometrics requirements for bicycle or pedestrian railings also apply.

Combination railings will normally consist of a 2'-4" high concrete parapet with a fence or ornamental metal railing mounted on the top. The concrete parapet serves to contain traffic and has been judged to meet crash test Level 2. The metal railing must comply with the strength and geometric requirements for bicycle or pedestrian railings. A non-crash tested metal railing may be used on the top of the concrete barrier, as it is unlikely that vehicles will contact the metal portion.

The highway face of the concrete parapet shall be relatively smooth with beveled recesses up to 2 inches deep allowed for inset panels and beveled form liner textures. Concrete posts above the parapet are acceptable but they may not project in front of the parapet.

When there is a bikeway or sidewalk separated from traffic by a railing, the railing should be the 32" Type F concrete railing when the shoulder is 6'-0" or greater in width. If the roadway shoulder is less than 6'-0", a 42" Type F concrete railing should be utilized for added protection. Metal railings should not be placed on top of the traffic railing between a sidewalk and a roadway. Although they might increase protection somewhat for bicyclists, they can be a definite hazard to vehicles.

F. **Protective Screening for Bridge Overpasses**

The addition of protective screening to bridge railings is a further Mn/DOT policy requirement. The practice of adding protective screening is common nationwide in response to accidents and fatalities that have occurred due to pedestrians throwing objects from overpasses onto vehicles below.

Protective screening will be included in the design of bridges crossing another roadway, or railroad, for new bridges and when railings are replaced on existing bridges as follows.

1. On all bridges where there is a sidewalk included in the design. A protective screening system will be incorporated in the design of the railing adjacent to the sidewalk.
2. On all pedestrian bridges. The protective screening will be placed on both sides of the bridge.

The protective screening system will preferably be a chain link fence system or a railing system. The height of the fence or railing will be 8'-0" above the top of the sidewalk. For sites with special aesthetic treatments involving ornamental railings, a minimum

height of 6'-0" will be allowed. However, it should be recognized the lower railing height provides a reduced level of protection. The protective screening system will not allow objects 6" in diameter or greater to pass through the fence or railing.

G. Architectural/Ornamental Railings

In response to local requests, special railing designs have been incorporated in some projects to address aesthetic concerns. These ornamental architectural bridge railings have been utilized in lieu of standard combination railings for placement on the outboard side of bridge sidewalks. The Office of Bridges and Structures will consider railing designs in addition to our standard railings for such locations and corridors. It is recommended that special railings incorporate features from the standard railings, such as connection details, as much effort in design, fabrication and construction has gone into developing these details.

Mn/DOT participation in the cost of aesthetic railings is governed by the Mn/DOT Policy Manual of June 2001. See Web sites:

<http://www2.dot.state.mn.us/engserv/techsup/prelet/municipal/files/ds11.pdf>

<http://www2.dot.state.mn.us/engserv/techsup/prelet/municipal/files/ds12.pdf> .

Railings are included with other aesthetic costs of the bridge and Mn/DOT participation is limited to 5%, 7% or 15% of the cost of a basic bridge, depending on the aesthetic level of the bridge.