Problem # 8 – MnDOT Questions Regarding Bridge Barriers

State Question and MwRSF Response:

MnDOT had a conference call with MwRSF to discuss various questions regarding barriers on superelevations and cross slopes. A summary of the discussion is located below.

TO: Bridge R&D Committee Members
Meeting Attendees, Dave Dahlberg

FROM: Paul Rowekamp, Bridge Standards Engineer

DATE: April 14th, 2011

SUBJECT: Discussion Regarding Barriers & Barrier Transitions with Staff from the Midwest Roadside Safety Facility (Univ of Nebraska, Lincoln)

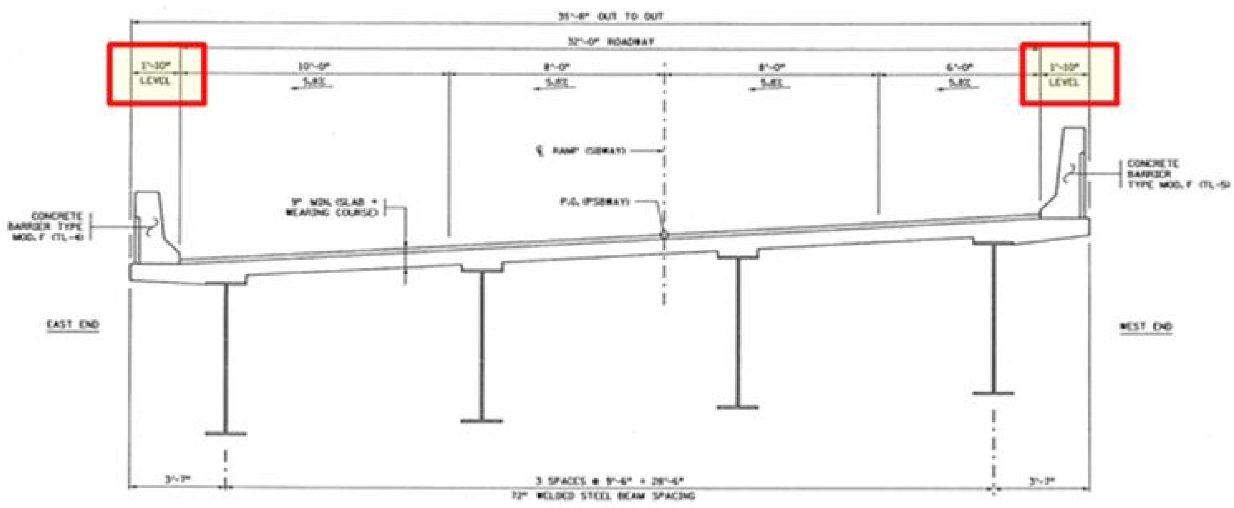
This is a summary of discussions from a teleconference held on March 31st, 2011 regarding various bridge barrier and barrier transition issues.

Attendees: From the Midwest Roadside Safety Facility (MwRSF) in Lincoln, NE (on the phone): Dean Sicking, Ron Faller, Bob Bielenberg; From the FHWA: Romeo Garcia, Will Stein; From the Mn/DOT Office of Technical Support: Mike Elle, Jim Rosenow; From the Mn/DOT Bridge Office: Keith Molnau, Kevin Western, Dan Prather, Arielle Ehrlich, Paul Rowekamp

The group met to discuss various issues regarding barriers including the following;

#1). Mn/DOT's current policy regarding placement of traffic barriers on bridges is to place them "plumb" or "level" as indicated in the drawing below.

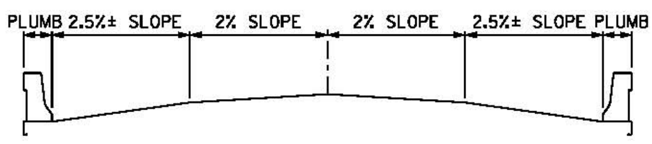
Typical Mn/DOT Bridge Barrier Placement

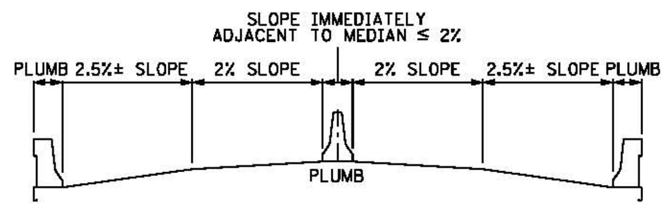


TRANSVERSE SECTION

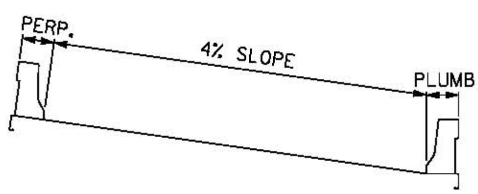
Based on simulation and testing of 3 barrier types, the MwRSF suggested consideration of different guidance depending on the cross slope of the roadway/bridge;

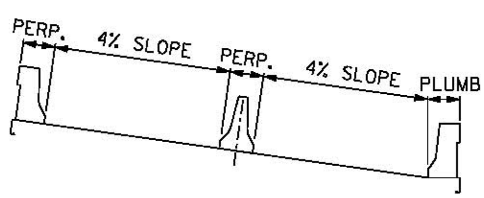
a) for driving surfaces with a normal crown section the barriers may be constructed plumb or "level", as shown in the sketch below:



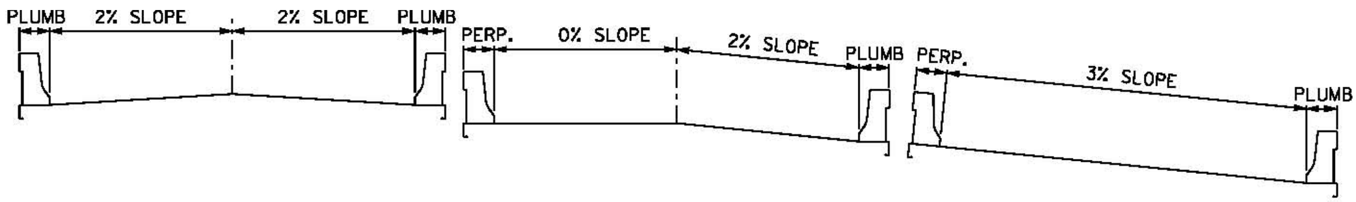


b) for driving surfaces with a constant cross slope or superelevation exceeding 2%, the angle between the bridge deck or roadway and the vertical axis of the barrier should not exceed 90 degrees as shown below:



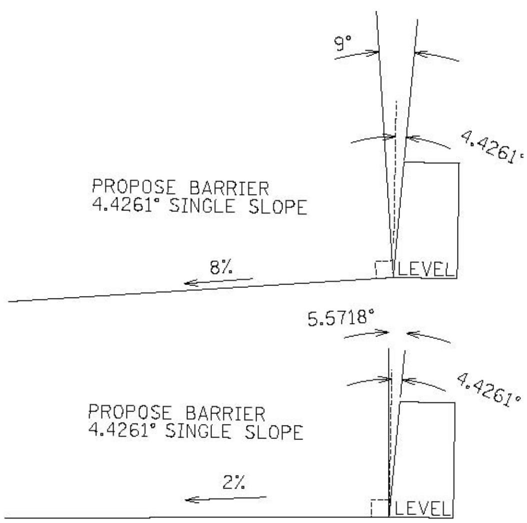


c) for bridge decks with a variable or changing cross slope or superelevation, the angle between the bridge deck or roadway and the vertical axis of the barrier should transition from plumb to perpendicular (or vice versa) starting at 0% as shown below (in this example the cross section changes from a "normal" cross slope to a 3% superelevation, the barrier changes from "level" to "Perpendicular" at 0% slope):



As indicated by the examples above, the vertical position of the barrier axis varies depending on the adjacent bridge/roadway slope, hence, it's imperative that the bridge and roadway designers work together to make sure that design plans are well coordinated and that the detailing on the bridge plan matches the roadway plan and vice versa.

If Mn/DOT eventually adopts a single slope barrier the relative change in slope between barrier face and roadway surface should be limited to about 9 degrees. And, since barriers tested with either a vertical face or a single slope with a 9 degree slope both performed well, it was suggested that, logically, any slope between vertical and 9 degrees should perform well. Therefore a slope that, when mounted 'plumb' on a deck from 2% - 8% slope would result in a single slope not to exceed the acceptable 9 degrees (measured normal to the deck). Hence, a single slope barrier with a 4-5 degree slope may ultimately become a preferred shape (see sketch below).



MwRSF believes that there is a strong potential that this may be feasible. However, the previous safety shape and single slope testing that these geometric recommendations are made on were not evaluated using the MASH vehicles and impact conditions. Thus, further study may be required to verify this recommendation.

The Florida DOT has also recently discussed this issue and the same changes were recommended to them by the Texas Transportation Institute. In 2002, TTI investigated parapet orientation on super elevated structures for Florida DOT through computer simulation. Florida DOT has historically used Jersey shaped concrete barriers on their elevated structures. Barriers have been installed both vertical and perpendicular to the road surface. The study was limited to known

NCHRP 350 impact conditions for the pickup with up to 10% cross slope. Vertically oriented parapets on the upper portion of the super elevation introduced more instability with increased cross slope. Thus, it was recommended that the barrier at the top of the cross slope be installed perpendicular to the deck to improve vehicle stability.

The same recommendations would apply to median barrier.

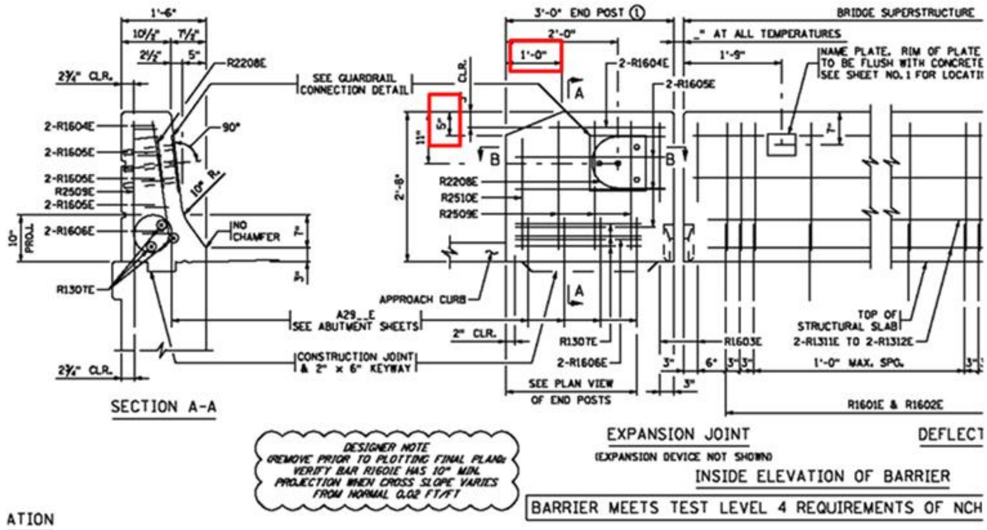
#2). Mn/DOT's current policy on when to use TL-5 barrier (42" high) on a bridge (in lieu of 32" high TL-4) includes the following criteria; Degree of curvature > 5 degrees (radius of 1145 ft) and speed > 40 mph. Other states in our region have been considering guidance that would implement TL-5 barriers more frequently.

A 3 yr study of bridge barriers in California, Texas, and Wyoming with designs based on the 1964 AASHTO Bridge Specifications predicted that there would be limited penetration of the barriers over the life of the bridge. Additional studies on barriers from Kansas came to basically the same conclusion based on a 32" barrier height. Studies and tests have also shown it is possible for a vehicle to climb over most "tall" barrier shapes. It's also understood that while taller barriers may provide more protection for large semi-tractor trucks & trailers such barriers generally cause more damage and injuries to passenger vehicles and their occupants. Given the percentage of cars and small trucks vs. large trucks on most highways it seems logical to optimize the barrier height/shape for passenger vehicles, not large trucks.

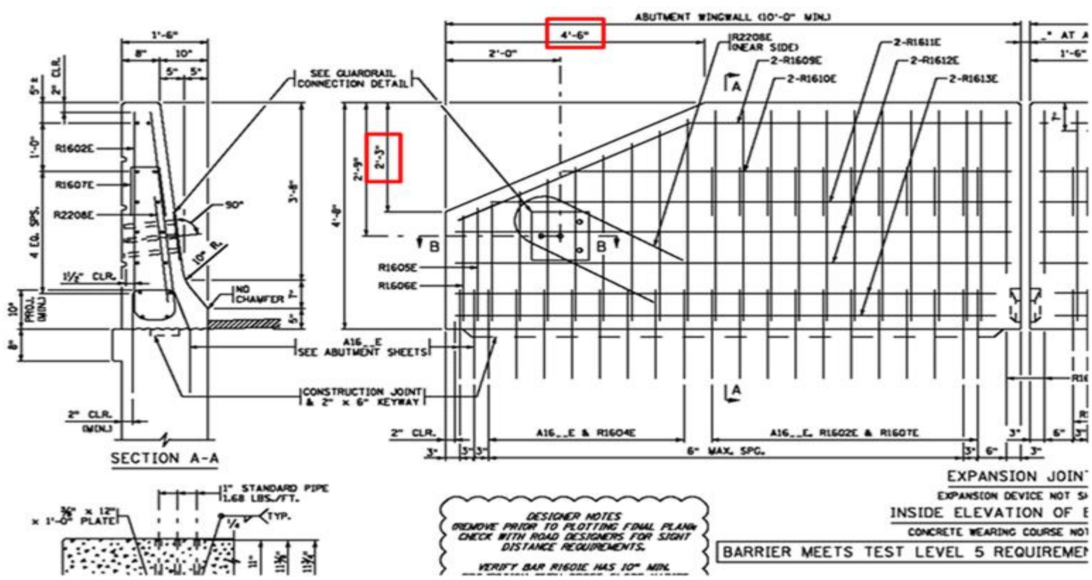
NCHRP study 22-13(3) started in the fall of 2010 and will last 24 months. This study will produce recommended guidelines for the selection of test levels TL-2 through TL-5 for bridge railings/barriers. Early results of the research imply that a TL-3 barrier may be adequate for most circumstances. In addition, recent research studies by MwRSF and TTI suggest that TL-4 barrier will likely need a minimum height of 34 or even 36 inches. In MwRSF's judgment, the expense of a TL-5 rail is difficult to justify for safety reasons under almost any circumstances.

It was decided that Mn/DOT will maintain its existing policy regarding use of TL-5 barriers until completion of the 22-13(3) research.

#3). At the end of a 32" or 34" tall concrete barrier, where it transitions to a guardrail connection, Mn/DOT details a slight slope (5V:12H) to the top of the barrier (see top sketch below). What is the appropriate slope or taper length that should be used when transitioning from a 42" (or taller, glare screen barrier that is 4'6" tall, 6V:12H taper) barrier to a guardrail connection?



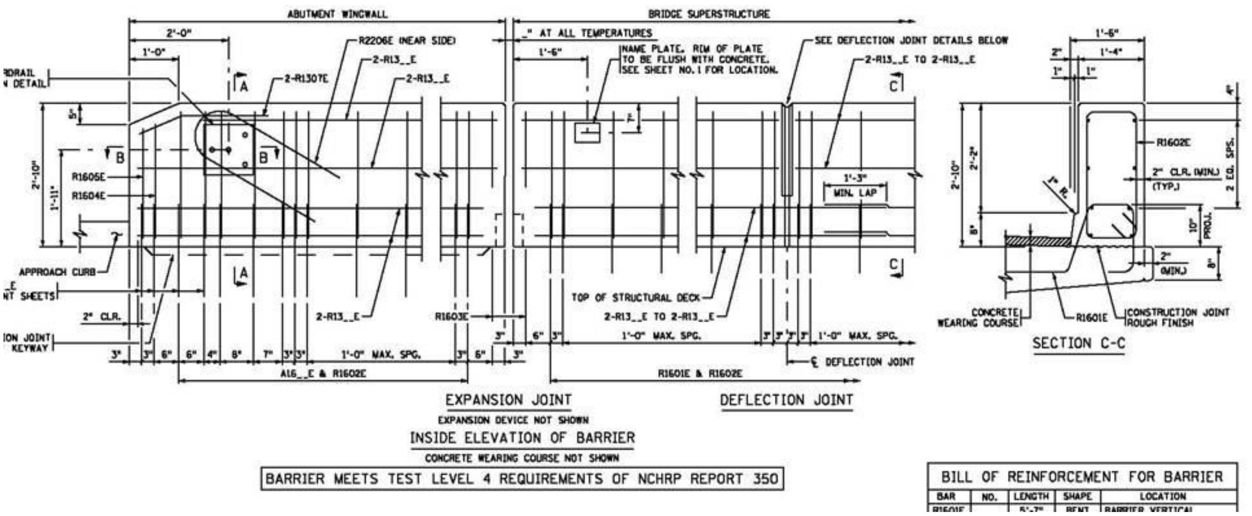
TL-4 (32" Tall) Barrier



TL-5 (Glare Screen) Barrier

The 5V:12H taper shown on the end of the 32" and 34" tall Mn/DOT TL-4 barrier has been crash tested and is okay to remain as is. End tapers for barriers taller than 34" should be modified to 1V:8H. The Bridge Standards Unit will put a "temporary hold" on tall bridge barrier standards (>34") showing the 5V:12H taper and begin the process of revising the standards to 1V:8H.

#4). Mn/DOT has developed a vertical face bridge barrier as shown below. Other states have developed single slope barrier faces. What are the advantages, disadvantages and design considerations for the various shapes?



TL-4 (Vertical Face) Barrier

Texas has developed a single slope shape with a 10.3 degree slope. California has developed a shape with a 9.1 degree single slope. Some observations based on studies of bridge rails in Iowa and elsewhere;

The safety shape generally causes more rollovers and injuries than the vertical shape.

The single slope generally leads to more "climbing" and rollovers than the vertical shape.

The vertical shape is more prone to "head slap" injuries than either the safety or single-slope shapes.

The rate of serious injuries and fatalities are fairly similar for all 3 shapes.

There is no clear very best shape.

If vertical shapes taller than 32" are implemented, they should consider a blockout above 32" to reduce head slap injuries.

Similar to the conclusion from item #1 above, a single slope barrier with a 4-5 degree slope may ultimately become a preferred shape, but further research and study is necessary.

#5). General discussion

The MwRSF has previously developed standards for a Midwest Guardrail System (MGS) that is capable of spanning up to 25' over culverts without intermediate posts. No further testing or studies are planned regarding increasing the current 25 foot maximum span. Mn/DOT eventually plans to implement the MGS system but has higher priority standards development issues to deal with first.

The Mn/DOT Standards Unit recently revised and updated the standards for temporary concrete barrier. Next steps will include revising the anchors used to hold the barriers in place. The Bridge Office will likely eliminate any bridge related standards involving anchoring temporary barriers to pavement or ground surfaces and will reference the forthcoming roadway standards.

The MwRSF will provide Mike Elle/Jim Rosenow with guidance regarding “free” distance requirements behind unanchored temporary barriers on bridges.

It seems likely that new TL-4 barrier requirements will necessitate increasing the height from 32” to 34 or 36” for new installations. It’s likely that existing 32” installations will be allowed to remain inplace without need for retrofit as long as the shape and capacity has previously passed NCHRP 350. The costs of retrofitting existing 32” tall TL-4 barrier to 34 or 36” cannot be justified by the slight increase in safety and performance.