

MIDWEST POOLED FUND PROGRAM

Progress Report - Fourth Quarter 2010

October 1st to December 31th

Midwest Roadside Safety Facility
Nebraska Transportation Center
University of Nebraska-Lincoln

January 7, 2011

Pooled Fund Projects with Bogie or Full-Scale Crash Testing in Past Quarter

Universal Breakaway Steel Post for Thrie-Beam Bullnose - Program Year 21 [TPF-5(193) – Supp. #35]

This research project provided continuation funding for the development and testing of a universal breakaway steel post for the thrie beam bullnose barrier system. The initial development and crash testing was performed under a recent MnDOT research study using the NCHRP Report No. 350 safety performance guidelines.

Two full-scale vehicle crash tests were planned under this supplemental project. The first crash test (test designation no. 3-30) was performed on September 13, 2010 using an 820C small car vehicle impacting at the target conditions of 100 kph and 0 degrees on the nose of the barrier system and offset using the ¼-point aligned with the centerline of the device. During the test, the vehicle was safely contained within the bullnose median barrier system, and all of the occupant risk measures were met. Photographs for this test are shown below.

The second crash test (test designation no. 3-31) was conducted on October 6, 2010 using a 2000P pickup truck vehicle impacting at the target conditions of 100 kph and 0 degrees. This test was used to evaluate the penetration distance of the 2000P vehicle into the system. During the test, the vehicle was safely captured within the bullnose median barrier system, and all of the occupant risk measures were met. Photographs for this test are shown below.





Development of a TL-4, Four-Cable, High-Tension, Barrier System for 4:1 V-Ditch Applications – Program Years 12, 14, 18, 19, and 20

In the Fourth Quarter of 2010, MwRSF reconstructed the high-tension, four-cable median barrier system with modified cable bracket located in a 4:1 V ditch and 4 ft away from the ditch bottom and up the back slope. Subsequently, an 1100C small car re-test (test no. 4CMB-4) was performed on December 22, 2010 using the TL-3 safety performance guidelines found in MASH. During the test, the small car was successfully contained and redirected by the bottom cable positioned 13.5 in. above the soil surface.

Photographs for this test are shown below. The data analysis, test documentation, and reporting will be performed in the First and Second Quarters of 2011.

In the First Quarter of 2011, MwRSF will make preparations to conduct the TL-3 2270P pickup truck test on the cable barrier system with modified cable bracket and placed 12 ft laterally away from the slope break point adjacent to the roadway edge.



Standardizing Posts and Hardware for MGS Transition – Program Years 18 and 19

A final report was prepared for the simplified, steel-post, approach guardrail transition system attached to the MGS.

A BARRIER VII computer simulation effort was nearly completed to evaluate the dynamic barrier performance when using wood posts with both an upper and lower bound for post-soil behavior. Initially, an 8-in. x 10-in. wood post was being considered as a replacement for W6x15 steel posts used in approach guardrail transitions. However, dynamic bogie testing was re-initiated to explore the impact performance of 6-in. x 10-in. wood posts embedded in soil. During the testing of two 6-in. x 10-in. posts, inconclusive results were obtained as one post fractured and another provided desirable results. As such, a third bogie test was performed on October 1, 2010. Since fracture was again observed, the BARRIER VII simulation effort will commence with the use of 8-in. x 10-in. wood posts. A second report will contain the results of the wood-post transition system as well as the wood-post bogie testing program. The wood-post research program should be completed in the First Quarter of 2011.

Impact Evaluation of Free-Cutting Brass Breakaway Couplings – Program Year 20

In 2009, two low-speed pendulum tests were performed. The maximum allowable change in velocity was exceeded in both pendulum tests. The Illinois DOT modified the design of the brass couplers. In June 2010, two additional low-speed pendulum tests were performed on the modified brass couplers. The third pendulum test was unsuccessful with a 50-ft tall, heavy steel pole, while the fourth test was successful with a 30-ft tall, aluminum pole. A fifth test was performed on the currently-available coupler in combination with the tall, heavy steel pole. For the low-speed test on the currently-available coupler, the change in velocity was below the limit of 5 m/s. However, the high-speed extrapolation for the change in velocity exceeded the limit when considering the critical pole configuration.

Later in 2010, the ILDOT further modified the brass coupler and conducted static component testing to evaluate design changes. In the Fourth Quarter and on December 1st, two additional low-speed pendulum tests were performed on the third design variation of the brass couplers. The sixth pendulum test was successful with a 45-ft tall, heavy steel pole, while the seventh test was successful with a 55-ft tall, aluminum pole. Subsequently, the high-speed change in velocity was determined for the 45-ft steel and 55-ft aluminum poles using the conservative extrapolation procedures. Unfortunately, the change in velocity exceeded the maximum limit for the 45-ft steel pole, but the 55-ft aluminum pole produced acceptable results.

Subsequently, recommendations were made for acceptable pole sizes in both steel and aluminum configurations. A final report was prepared and published in the Fourth Quarter of 2010. MwRSF also submitted an application seeking FHWA acceptance of the breakaway brass couplers under the NCHRP Report No. 350 guidelines.

Pooled Fund Projects with Pending Bogie or Full-Scale Crash Testing

Phase I and II – Guidelines for Post-Socket Foundations for Four-Cable, High-Tension, Barrier Systems – Program Years 19 and 20

Previously, four dynamic component tests were performed on prototype post-socketed foundation systems placed in a weak soil condition (sand). Concrete fracture was observed in the two 5-ft long test specimens, while only concrete cracking of the shaft was observed in a 3-ft long specimen. Due to the rupture of several concrete shafts, the design criteria were re-evaluated and revised.

In the Third Quarter, the design criteria was modified to incorporate only the peak loading that could be imparted to the foundations from vehicles striking the S3x5.7 posts. Previously, a higher design loading was utilized based on the strongest post found in highway cable barrier systems. Subsequently, four new post-socket designs were configured. CAD details were completed in the Fourth Quarter. Construction and dynamic component testing of new post-socketed foundation systems will occur in the First or Second Quarter of 2011.

Testing of End Terminal for Four-Cable, High-Tension Barrier (1100C & 2270P) – Program Years 17 and 20

Previously, this project was delayed in order to complete the crash testing of the high-tension, four-cable barrier system placed in the V-ditch. However, work has begun to be ready for compliance testing in mid to late 2011. The research objective includes the adaptation of a prior low-tension, cable barrier end terminal for use with high-tension cable barrier systems. The end terminal system incorporates a cable release lever technology at each end anchor foundation as well as steel breakaway support posts in the terminal region.

In the Second and Third Quarters, MwRSF reviewed and examined prior crash testing programs of cable barrier end terminals, reviewed existing terminal post configurations, and evaluated the potential for modifying the terminal posts and/or eliminating the breakaway slipbases. From this review, it is MwRSF's opinion that: breakaway posts are beneficial for improving vehicle stability within the terminal region;

releasable versus non-releasable cable ends reduce concerns for a centerline end-on impact resulting in a vehicle vaulting into the air with the undercarriage landing onto top of the steel terminal and line posts; the entire terminal geometry should be examined when selecting the critical lateral impact point of the terminal system and conducting the ¼-point offset, end-on small car test; and the cable barrier and end terminal systems should have sufficient length to adequately evaluate the potential for vehicular instabilities during end-on crash tests.

LS-DYNA computer simulations will be performed in the First and Second Quarters to predict and validate the small car behavior and dynamic barrier performance observed in test no. CT-4 (test designation no. 3-30) on the low-tension, three-cable, end terminal system.

Wood Post MGS

Program Year 21 [TPF-5(193) – Supp. #31]

This research project provides funding for the crash testing and evaluation of the Midwest Guardrail System (MGS) installed with 6-in. by 8-in. Southern Yellow Pine (SYP) timber posts embedded in level terrain. Two full-scale vehicle crash tests are planned under this project using the Test Level 3 (TL-3) MASH safety performance guidelines – one with an 1100C small car and another with a 2270P pickup truck. CAD details were completed in the Fourth Quarter. Construction materials were acquired in the Fourth Quarter. Construction and/or crash testing will likely commence in the First Quarter of 2011.

MGS Without Blockouts

Program Year 21 [TPF-5(193) – Supp. #33]

This research project provides funding for the crash testing and evaluation of the non-blocked, Midwest Guardrail System (MGS) installed W6x9 or W6x8.5 steel posts embedded in level terrain. Two full-scale vehicle crash tests are planned under this project using the Test Level 3 (TL-3) MASH safety performance guidelines – one with an 1100C small car and another with a 2270P pickup truck. CAD details were completed in the Fourth Quarter. Construction materials were acquired, and the barrier system was installed for the first crash test. Crash testing will likely occur early in the First Quarter of 2011.

Midwest Guardrail System Placed at the Breakpoint of a 2:1 Slope – Bogie Testing Project Using Year 14 Contingency Funds

An MGS system utilizing 9-ft long, W6x9 steel posts spaced at 6-ft 3-in. centers was successfully crash tested utilizing a 2270P Dodge Quad Cab vehicle. A draft report was sent to the States in the Fourth Quarter of 2009. A final report was completed in the First Quarter of 2010.

Previously, several member states noted a desire for a wood-post alternative for the MGS placed on a 2:1 slope. As such, a dynamic bogie testing program was conducted in order to determine the appropriate length of a 6-in. x 8-in. wood post for placement at the slope breakpoint of a 2:1 fill slope. A second final report containing the results from the wood-post, component testing program as well as some additional steel post tests for comparison purposes was prepared and published in the Fourth Quarter of 2010.

Paper Studies

Cost-Effective Measures for Roadside Design on Low-Volume Roads – Program Year 16

The analysis, evaluation, and documentation of treatment options for culverts, trees, bridges, and slopes/ditches found along low-volume roadways has been completed. A draft report has been prepared and is undergoing internal review. The draft and final reports should be completed in the First Quarter of 2011.

Submission of Pooled Fund Guardrail Developments to AASHTO TF-13 Hardware Guide

To date, 15 components and 21 systems have been submitted to TF-13 for review and approval, and all have been approved for the Guide over the last 2 years. A small portion of supplemental funding was allocated in the Year 21 Pooled Fund Program. Late in the Third Quarter, 7 additional components and 7 additional systems were submitted to TF-13 for review and approval. Three of the systems were reviewed during the TF-13 September 2010 meeting.

Cost-Effective Upgrading of Existing Guardrail Systems – Program Year 17

In June 2009, an MwRSF field investigation team conducted a field survey of selected barrier installations throughout the State of Kansas. As part of this one week investigation, more than 60 specific sites were visited, measured, photographed, and documented. A review and compilation of the field survey information was completed in the Fourth Quarter of 2009. An analysis of the field data was initiated in the Fourth Quarter of 2009. Due to a shifting of staff priorities, work was greatly slowed in early 2010. However, analysis of field data was completed in the Third Quarter of 2010. In the First and Second Quarters, a sensitivity study using RSAP was initiated to decrease the size of the analysis matrix. This analysis was completed in the Third Quarter. A containment level analysis to determine the appropriate severity indices was completed during the Fourth Quarter. The analysis matrix was also completed during the Fourth Quarter. Evaluation and documentation of the analysis will be completed during the First and Second Quarters of 2011.

Safety Performance Evaluation of Vertical and Safety Shaped Concrete Barriers – Program Year 16

In the Second Quarter of 2010, the research team requested assistance with the identification of bridge railing type for specific bridge accident sites in order to increase the number of accident records to be used in the analysis. These accident sites were all located at county roads. In the same quarter, the research team waited for the counties to gather the information on bridge railing type. In August 2010, the counties started sending pictures from the bridge railing sites. By the end of August 2010, only one third of the counties sent the necessary information, and only 20 percent of those bridge railings were concrete barriers. In late August, the research team decided to proceed with the project analysis using only those bridges located on State maintained highways. In the Fourth Quarter of 2010, the available accident data was re-processed and evaluated, and conclusions were prepared using the preferred statistical procedures. Documentation of the research findings was begun. In the First Quarter of 2011, the draft and final reports should be completed along with a Ph.D. student's dissertation.

MGS Implementation – Program Year 18

In 2007, consulting funds were used to assist states with the MGS implementation effort. MwRSF began the effort with a review of CAD details from the Illinois and Washington DOTs. Project correspondence occurred via email with a pre-determined Technical Working group. To date, three subject areas were covered and are as follows: (1) Standard, Half, and Quarter Post Spacing; (2) MGS with Curbs and MGS on 2:1 Slopes; and (3) MGS with Culvert Applications. A fourth category, MGS Stiffness Transition, was delayed in order to await the completion of a simplified, steel-post and wood-post approach guardrail transition.

The final reporting of the simplified, steel-post, approach guardrail transition system attached to the MGS was completed in the Fourth Quarter of 2010. The wood post R&D effort is Barrier VII analysis. Once this analysis is completed, draft and final reports will be prepared in early 2011. The MGS implementation effort will likely commence in the First or Second Quarters of 2011 after the simplified, wood-post transition report has been finalized.

LS-DYNA Modeling Enhancement Funding – Program Year 18

No work was performed on this project during the reporting period.

Projects Funded by Individual State DOTs and Routed Through NDOR and/or Pooled Fund Program

Development of a New, TL-4 Precast Concrete Bridge Railing System (Nebraska Department of Roads)

For this project, a TL-4, aesthetic, open concrete bridge railing was developed for use on cast-in-place decks as well as precast deck panels. Due to many factors, existing project funds were insufficient to complete the construction and crash testing phases of this research study. MwRSF-UNL researchers have sought funds from alternative sources including the NCHRP IDEA program and the 2009 Midwest States Pooled Fund Program. In the future, MwRSF will seek funding from the FHWA Highways for Life Program. The draft report of the initial design work was initiated.

Awaiting Reporting

Maximum MGS Guardrail Height – Program Year 20

On June 29, 2010, MwRSF conducted one small car crash test (test no. MGSMRH-1) into a 34-in. tall Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 safety performance guidelines of MASH. The small car was successfully contained and redirected. Photographs for this test are shown below. On September 9, 2010, a second small car test (test no. MGSMRH-2) was conducted into a 36-in. tall Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 MASH safety performance guidelines. Again, the small car was successfully contained and redirected. The documentation and reporting of this testing program will be initiated in the First or Second Quarter of 2011. The LS-DYNA analysis effort will likely be performed in the summer of 2011.

Draft Reports - Pooled Fund

Not Applicable.

Final Reports - Pooled Fund

Putjenter, J., G., Rosenbaugh, S.K., Lechtenberg, K.A., Faller, R.K., Reid, J.D., and Sicking, D.L., ***Performance Evaluation of Brass Breakaway Couplings***, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-248-10, Project No.: TPF-5(193), Project Code: RPFP-10-POLE - Year 20, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 22, 2010.

Rosenbaugh, S.K., Lechtenberg, K.A., Faller, R.K., Sicking, D.L., Bielenberg, R.W., and Reid, J.D., ***Development of the MGS Approach Guardrail Transition Using Standardized Steel Posts***, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-210-10, Project Nos.: SPR-3(017) and TPF-5(193), Project Codes: RPFP-08-05 and RPFP-09-03 - Years 18 and 19, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 21, 2010.

Schmidt, J.D., Sicking, D.L., Faller, R.K., Reid, J.D., Bielenberg, R.W., and Lechtenberg, K.A., ***Investigating the Use of a New Universal Breakaway Steel Post - Phase III***, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-244-10, Project No.: TPF-5(193), Supplement No. 35, Project Code: RPFP-11-BNOSE - Year 21, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 16, 2010.

McGhee, M.D., Lechtenberg, K.A., Bielenberg, R.W., Faller, R.K., Sicking, D.L., and Reid, J.D., ***Dynamic Impact Testing of Wood Posts for the Midwest Guardrail System (MGS) Placed Adjacent to a 2H:1V Fill Slope***, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research

Report No. TRP-03-234-10, Project No.: SPR-3(017), Project Code: RPFP-05-09 - Year 15, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 16, 2010.

Thiele, J.C., Reid, J.D., Lechtenberg, K.A., Faller, R.K., Sicking, D.L., and Bielenberg, R.W., ***Performance Limits for 6-In. (152-mm) High Curbs Placed in Advance of the MGS Using MASH Vehicles - Part III: Full-Scale Crash Testing (TL-2)***, Final Report to the Midwest States Regional Pooled Fund Program, Transportation Research Report No. TRP-03-237-10, Project No.: SPR-3(017), Project Code: RPFP-07-03 - Year 17, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 24, 2010.

Draft Reports - Individual State DOT and Routed Through NDOR/Pooled Fund

Stolle, C.J., Lechtenberg, K.A., Faller, R.K., Rosenbaugh, S.K., Sicking, D.L., and Reid, J.D., ***Evaluation of the Midwest Guardrail System (MGS) with White Pine Wood Posts***, Draft Report to the Wisconsin Department of Transportation, MwRSF Research Report No. TRP-03-241-10, Project No.: TPF-5(193), Supplement #12, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 20, 2010.

Final Reports - Individual State DOT and Routed Through NDOR/Pooled Fund

Not Applicable.

Pooled Fund Consulting Summary

Midwest Roadside Safety Facility
October 2010 – January 2011

This is a brief summary of the consulting problems presented to the Midwest Roadside Safety Facility over the past quarter and the solutions we have proposed.

Problem # 1 – ADOT Long Span

State Question:

Ron - attached is our draft of the MGS Long Span Guardrail. We basically allow for one, two or three posts to be eliminated within the 25' maximum span. We call for the 3 CRT posts on each end when any posts are eliminated- would this still be prudent when only one or two posts are skipped? We also allow for 25' guardrail sections so the splice would be eliminated at midspan wherever it happens to fall in the guardrail run. We assume this also applies to the normal MGS guardrail runs when 25' rail elements are used. We would appreciate if you could take a look and provide any comments you feel appropriate.

Thanks very much. Terry

Terry H. Otterness, P.E.
Technical Support Engineer

MwRSF Response:

Terry:

When one, two, or three posts are removed in a row of MGS, MwRSF still recommends that three MGS CRT posts be utilized on the upstream and downstream sides of the 12.5 ft, 18.75 ft, and 25 ft unsupported lengths. The span could be accommodated with 25 ft long guardrail segments where the rail splice does not occur at the post locations. The CRT posts were modified for MGS Long-Span applications by raising the hole locations to account for higher rail heights. For metric-height guardrail, different CRT posts were used for long-span applications. As such, CRT posts for the MGS long-span uses different hole locations than those placed in the CRT posts for metric-height W-beam long-span applications. It may have been more clear if we had referred to the posts as MGS CRT posts or 31" guardrail CRT posts. As long as you provide dimensions, it should not be an issue. You might consider showing the two holes in the six posts adjacent to the long span in PLAN and ELEVATION views.

As a minor point, the guardrail posts appear to be square in the PLAN view. Also, there are some extra dashed lines in PLAN view across vertical surface between post and blockout – not sure if those are nails or something else. May also want to add barrier height to ELEVATION view.

Let us know if you have any further questions or comments. Thanks!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

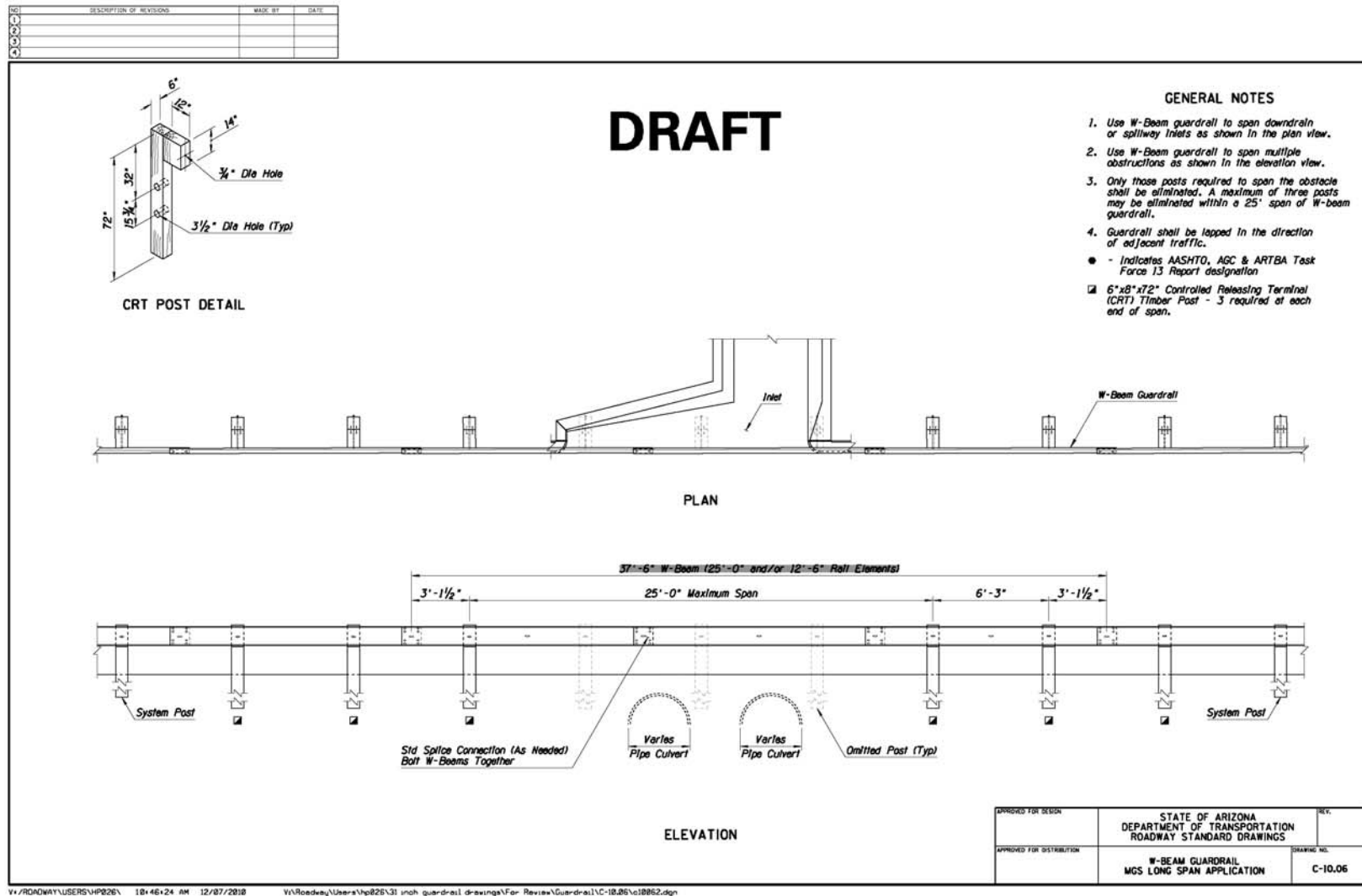


Figure 1. ADOT Long Span Details

Problem # 2 – Additional Blockout Depth

State Question:

Dear MwRSF,

FHWA's NHI Roadside Design Class allows for extra block outs to be installed within a given run of beam guard. WisDOT has adopted this within its current standard detail sheet for regular beam guard.

With MGS using larger blockouts, would the same guidance that is in the NHI class still apply?

Sincerely,

Erik Emerson P.E.
Standards Development Engineer-Roadside Design
Wisconsin Department of Transportation

MwRSF Response:

Erik:

Historically, MwRSF may have allowed the use of up to triple 8-in. deep blocks at a few locations within a run of metric-height W-beam guardrail, thus resulting in an offset of 24 in. However, it is uncertain as to whether the use of three 8-in. deep blocks may be too excessive when used continuously with metric-height W-beam guardrail. In the metric-height W-beam long span guardrail, MwRSF incorporated the use of double, 8-in. deep wood blockouts with the three CRT posts adjacent to the long span.

The MGS utilizes 12-in. deep blocks for standard applications as well as for special applications. For example, the MGS long span design utilizes one 12-in. wood block with three CRT posts instead of two stacked 12-in. deep blocks. For the MGS, it would seem reasonable that the use of two 12-in. deep stacked blocks could be accommodated at a few locations as well, thus also resulting in a rail offset of 24 in. However, it is uncertain as to whether the use of two 12-in. deep blocks may be too excessive when used continuously with the MGS.

Thus, based on previous testing of systems with deep or extended blockouts and an analysis of the contact lengths of typical MGS testing, MwRSF would recommend the following:

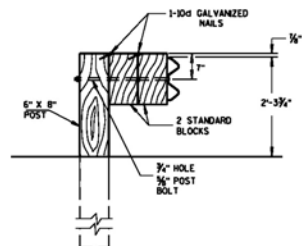
1. Double standard blockouts or combinations of blockouts up to 16-in. deep may be used continuously in a guardrail system.
2. Triple standard blockouts or combinations of blockouts up to 24-in. deep should be limited to one in any 75 ft of guardrail.

Respectfully,

Ron

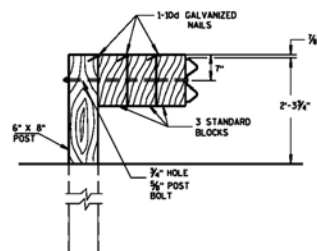
Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

6



DETAIL FOR DOUBLE BLOCKS

THE NUMBER OF DOUBLE BLOCK POSTS WITHIN A BARRIER RUN IS UNLIMITED

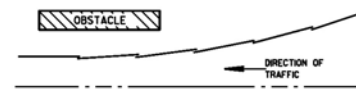


DETAIL FOR TRIPLE BLOCKS

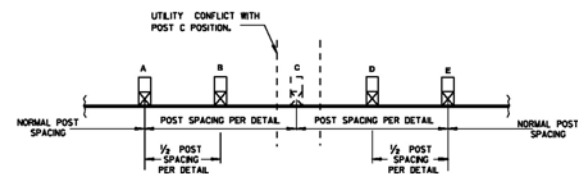
TRIPLE BLOCK DETAIL IS LIMITED TO ONE LOCATION WITHIN A BEAM GUARD RUN.

NOTES: USE DOUBLE OR TRIPLE BLOCKS WHEN UNDERGROUND OBSTACLES PREVENT THE POST FROM BEING INSTALLED.

DO NOT USE EXTRA BLOCKOUTS IF IT CAUSES THE POST TO BE DRIVEN BEYOND SHOULDER HINGE POINT OR CAUSES A FIXED OBJECT TO BE WITHIN THE DEFLECTION DISTANCE OF THE BARRIER.



PLAN VIEW BEAM LAPPING DETAIL



POST DRIVING FOR CONTINUOUS UNDERGROUND OBSTRUCTION

STEEL PLATE BEAM GUARD,
CLASS "A",
INSTALLATION & ELEMENTS

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

S.D.D. 14 B 15-6c

Figure 2. Wisconsin Triple Blockout Details

Problem # 3 – FHWA Application and Installation of Roadside Hardware Memo 10-1-10

State Question:

Dear MwRSF,

FHWA has sent out a memo titled: “Application and installation of Roadside Hardware”.

My first scan of the document found some things that I have concerns on . For an example:

Q: OUR GUARDRAIL CROSSES A CULVERT AND WE CAN'T DRIVE A POST. CAN WE OMIT THE POST?

A: The Midwest Guardrail System (31-inch rail height) has been successfully tested with three posts omitted, leaving a span of 25 feet. Special posts are used at either end of the gap but the rail does not have to be doubled up, or “nested” over the gap. Standard strong-post w-beam rail (minimum 27-3/4 inch rail height) can be installed with one or two posts omitted but the rail needs to be nested across the gap as well as up- and down-stream from the gap.

What the FHWA memo leaves out is that special post and grading is also needed on the standard beam guard installation when a long-span system is in use.

There are some other things also listed in this memo that I have questions on.

If MwRSF could review the document and provide comments it would be greatly appreciated.

Sincerely,

Erik Emerson P.E.
Standards Development Engineer-Roadside Design
Wisconsin Department of Transportation

MwRSF Response:

Hi Erik,

I have reviewed the email memo that you attached from FHWA regarding commonly asked safety hardware questions and FHWA's response. I would agree that some of the information in the memo is incomplete or misleading. I have copied items that were needed addressing below along with comments in red.

I will forward this response on to FHWA as well.

Thanks

Bob Bielenberg, MSME, EIT

Research Associate Engineer
Midwest Roadside Safety Facility
130 Whittier Building
Lincoln NE, 68583-0853
402-472-9064
rbielenberg2@unl.edu

Q: WHEN CAN I USE A NON-REDIRECTIVE CRASH CUSHION?

A: Care must be used in applying a non-redirecting, gating crash cushion. They are designed to decelerate a vehicle impacting head-on on the nose. Vehicle penetration is likely to occur for angle hits from the nose to near the mid-point of the array. Vehicle penetration / override of the system is possible for high speed, high angle impacts near the rear of the device.

All gating, non-redirective crash cushions should be applied to hazards that are not likely to be impacted at an angle on the side at any significant velocity. They are appropriate on low speed facilities, and in work zones with higher speeds where lane widths are constrained and the potential for high angle hits is limited. Potential problems with these non-redirecting attenuators include vaulting over the nose of the attenuator into the work area, and inadequate clear run out areas behind the devices. All users of these devices should be made aware of the factors that contribute to proper performance as outlined in the crash test report. Examples of non-redirecting, gating crash cushions include all sand barrel arrays, the Triton CET (Concrete End Treatment) and the ABSORB 350 (which was specifically designed for use with the Quickchange Moveable Barrier.)

It should also be noted that non-redirective crash cushions such as sand barrel arrays can pose a hazard if impacted in the reverse direction on the heavy barrels adjacent to the rigid hazard. Impact in the reverse direction at this point in the array is untested and the large mass of the final barrels could cause rapid and violent deceleration of the impacting vehicle that would exceed our occupant risk limits.

Q: WHY IS THE W-BEAM CONSTRUCTION TOLERANCE NOW ONLY ONE INCH?

A: Crash testing has shown that the standard strong post w-beam guardrail without rub rail is acceptable in the range from 27-3/4 inches to 30 inches above the ground. When the rail was tested at a lower height the pickup truck vaulted over the rail. A taller rail without rub rail can cause significant wheel snagging on small cars. This leaves a very narrow range of installation heights, and FHWA recommended 29 inches +/- one inch.

The Midwest Guardrail System (MGS) tolerance is greater at +/- 3 inches. The MGS was initially tested at its design height of 31 inches with 12-inch blockout with no rub rail. It was known that the performance would be acceptable down to 27-3/4 inch just like the G4(1S) but we wanted to encourage the taller initial height so we recommended a construction tolerance of just one inch. A subsequent crash test (in July 2010) of the MGS at a height of 34 inches using the small passenger car was successful, and now validates the MGS tolerance is plus or minus 3 inches.

The height tolerance for the MGS cannot be listed as + 3" at this time. As you noted we have conducted testing at 34" that worked with the small car. In addition, we have recently conducted an acceptable small car test at 36" top of rail height. While this would suggest that there is potential for safe application of the MGS at higher rail heights, there are still some issues to resolve before we would recommend the upper tolerance higher than 1". First, we have not tested this system with the 2270P vehicle. While we believe that the higher guardrail heights can contain the 2270P vehicle, we do not have full-scale testing to verify this, nor do we know what effect the higher rail heights would have on the working width and deflections of the system. Second, by raising the rail height, we significantly change the loading of the end anchorages in the system. The increased height changes the angle of the cable anchorage and can affect system performance. This effect was noted in the development of the MGS system when we first tested with a 2000P at the 31" height. Thus, in order to allow the MGS system to be used at higher heights would require analysis of the effects on the anchorage system, potential redesign of the end anchors, and full-scale testing.

Based on these concerns, we would not recommend a top end tolerance of more than 1" until such time as we can more fully research the 2270P impact and conduct full-scale testing.

Q: HOW DO WE HANDLE THE HEIGHT TRANSITION BETWEEN G4(1S) AND MGS AND THEIR TERMINALS?

A: You should transition from a 27-3/4 inch tall barrier or terminal to a 31-inch tall barrier over the span of two 12-foot, 6-inch pieces of w-beam rail. When replacing or repairing long portions of a damaged rail the new rail should be installed at the proper design height, transitioning down to the existing rail over the length of two 12 foot, six inch, pieces of rail at either end. W-Beam to Thrie-Beam bridge transitions may need to use the non-symmetric W-to-Thrie connector that keeps the top height of the entire rail at approximately 31 inches.

It should be noted that there is no need to transition in height to a 27 3/4" high terminal design. The SKT, FLEAT, and ET end terminals have all been tested and approved at the 31" rail height and provide the benefits of 31" guardrail without transitioning in height down to a lower system.

Q: OUR GUARDRAIL CROSSES A CULVERT AND WE CAN'T DRIVE A POST. CAN WE OMIT THE POST?

A: The Midwest Guardrail System (31-inch rail height) has been successfully tested with three posts omitted, leaving a span of 25 feet. Special posts are used at either end of the gap but the rail does not have to be doubled up, or "nested" over the gap. Standard strong-post w-beam rail (minimum 27-3/4 inch rail height) can be installed with one or two posts omitted but the rail needs to be nested across the gap as well as up- and down-stream from the gap.

The FHWA memo is unclear as to the required details for the MGS long-span and standard W-beam long-span systems. For MGS, three CRT wood posts are required adjacent to the unsupported length. For the standard W-beam system with long-span, three CRT wood posts are also required along with 100 ft of nested W-beam. Both systems work with three posts omitted over the culvert length! No comment was provided as per the lateral placement of the posts/rail

relative to the face of the culvert headwall. The MGS system is allowed to be placed closer to the headwall than the nested W-beam long span system.

Q: CAN WE PAVE A MOW STRIP UNDER OUR GUARDRAIL?

Q: CAN WE PLACE GUARDRAIL POSTS IN A CONCRETE SIDEWALK OR MEDIAN?

A: A two-inch thick asphalt pavement should not adversely affect the crash performance of w-beam guardrails as it will break up when the post moves backwards in the soil. Concrete under the guardrail would have to be constructed with a gap behind the post and backfilled with a loose material to allow the post to move when the rail is struck. There are also various commercial products that can be placed under the w-beam to block weeds. Check with the manufacturer to see that they have designed the product with post deflection in mind.

TTI has conducted a considerable amount of research into the development of safe and effective mow strip designs. There reports (FHWA/TX-04/0-4162-2 and 405160-14-1) contain the best current guidance for installation of posts in mow strips and concrete surfaces.

Previous research by MwRSF and TTI has suggested that installation of posts in concrete is not safe. Further, installation of posts in asphalt, as recommended above, is not recommended due to the expected increase in the forces required to rotate the post in the soil and develop the proper energy absorption by the post. This is especially critical for wood post systems because the wood posts would have a tendency to fracture and absorb very little energy. TTI conducted limited testing of posts in asphalt and found that it was not a suitable material for placing post in.

Q: MANY OF OUR GUARDRAIL TERMINALS HAVE A STEEL BEARING PLATE ON THE FIRST POST THAT SOMETIMES ROTATES UNTIL IT IS UPSIDE-DOWN. IS THIS OK?

A: No. This bearing plate (8 x 8-inch square with an off-center hole) must be installed with the longer dimension upright (5" dimension up and the 3" dimension down). If the cable slackens over time traffic vibrations may allow this plate to rotate downward due to gravity. If this happens the ability of post #1 to fracture in a head-on impact (thus preventing a snag point) is severely compromised. On wood posts, a nail can be driven to prevent this rotation. A solution that works on both wood and steel breakaway posts is to specify that this steel plate be fabricated with tabs on either side that will wrap around the side of the post an inch or so to prevent rotation. This is an acceptable modification to all crashworthy terminals that use this 8 x 8-inch bearing plate. Of course, it is still critical to install the bearing plate with the 5" dimension up and the 3" dimension down.

The statement above suggests that the bearing plate in question serves to facilitate the fracture of the first post in the anchorage. This is NOT the function of the bearing plate. The bearing plate functions to transfer longitudinal loads from the rail to the end anchorage to develop tension in the guardrail for redirective impacts near the terminal end. It serves no purpose in the fracture of the first post.

Q: WHAT KIND OF FOUNDATION DO WE NEED FOR OUR CONCRETE MEDIAN BARRIER?

Many variations exist between highway agencies regarding reinforcing and footing details for concrete median barriers; however there have been few reported problems with any particular design and a need for a standard detail is not apparent. Research by the California Department of Transportation has shown that a concrete footing is not necessary; the concrete can be cast directly on asphaltic concrete, Portland cement concrete, or a well-compacted aggregate base.

The statement above is misleading in that it considers only foundation design (or lack of it) with no regard to the barrier design. Concrete median barriers develop loads as a function of the barrier capacity and the foundation capacity. While it is true that some median barrier designs have been shown to work with minimal foundation design, this does not suggest that any median barrier design can be installed in this manner. Thus, it falls on the designer to consider the combination of barrier and foundation that meets the design impact loading safely.

Q: SHOULD WE USE BREAKAWAY BASES FOR SIGN AND LIGHT POLES MOUNTED ON CONCRETE MEDIAN BARRIERS?

A: No, breakaway bases should not be used. Mounting any pole on top of a median barrier should be avoided because trucks will lean over the barrier upon impact and hit whatever is on top. A rigid pole may or may not break off, but there is no safety advantage in making it easier for the pole to break away and fly into the opposing travel lanes.

The potential for a pole being struck by the box of the truck can be minimized by making the barrier wider. If you transition to a vertical face and/or taper the width of the barrier you can provide additional offset to the pole. The point is to minimize the potential for broken poles to fly into the opposite roadway. Work zone signs may be mounted on barriers if you use roll up signs on fiberglass supports as they have less potential for causing serious damage.

In addition to the concerns for the impact of large truck boxes on sign and light poles mounted on median barriers, there are further concerns regarding the Zone Of Intrusion (ZOI) for small cars and pickup trucks as well as concerns regarding occupant head ejection from the vehicle that may impact such devices. Thus, these devices mounted on median barriers may pose a significant risk to passenger vehicles as well.

Q: WE WANT TO ADD LIGHTS, A BATTERY, AND A SOLAR PANEL TO OUR SCHOOL ZONE SIGN. DOES THE COMBINATION HAVE TO BE CRASH TESTED?

A: There are four factors that determine the acceptability of breakaway supports:

- 1) Stub height (Must be 4 inches or less. As this will not change with the addition of ITS hardware it will not be discussed further.)
 - 2) Vehicle velocity change / occupant impact forces
 - 3) Windshield penetration
 - 4) Roof crush
- 2) The addition of flashing lights and solar panels or other ITS equipment will not likely affect the change in velocity experienced by the vehicle or its occupants unless it becomes substantial compared to the mass of the pole. Additional hardware attached at or above the sign will raise the center of gravity of the system slightly but since it is away from the base the breakaway features will still perform as intended. The overall mass of the pole, sign, and auxiliary equipment should not exceed 600 pounds.

3) Windshield damage was not a formal pass/fail criterion under the 1985 AASHTO Sign and Luminaire spec and we did not change this when we adopted Report 350 in 1994. However, windshield damage will be pass/fail evaluation criteria under the AASHTO MASH. If the auxiliary hardware is at or above the sign, the effect should be minimal.

NCHRP 350 does include windshield damage in the evaluation of signs. The guidance in NCHRP 350 is somewhat subject and not rigorously defined, but it is an evaluation criteria and should be considered when evaluating sign performance under NCHRP 350.

Safe placement of these types of devices on the sign depend on more than placing the hardware at or above the sign. It would also depend on the structure of the sign, the sign height, the type of vehicle impacting the sign, and the deformation or breakaway of the sign support when it is impacted. Thus, effective placement of the auxiliary hardware on the sign would require further analysis than simply placing the hardware at or above the sign.

4) Roof crush up to 5 inches was permitted under NCHRP Report 350, but very few sign installations even approached that amount. (Luminaire poles weighing 1000# or more could easily fail this test.) The addition of more hardware could increase the risk under low speed impacts, but roof crush can be controlled by following the 600 pound weight limit mentioned above. Under MASH, roof crush will be limited to 3 inches maximum.

Problem # 4 – Wood Blockout Splitting

State Question:

All,

On a recent contract we received a concern from the field because brand new 12" wood blockouts have significant splitting. Some of the blocks have splits on each side of the block that almost meet in the middle.

The question is whether or not this will affect the performance of the block or is it essentially the same as using 2 blocks to achieve the 12" dimension? It would seem that once the blocks are in place and clamped between the rail and post they cannot go anywhere.

Should these blocks be rejected?

Is there any concern that they will not perform as expected?

has this come up as an issue in the past?

Is there an acceptable amount of splitting that can be allowed?

Thanks,
Tracy Borchardt
IL Tollway GEC



Figure 3. Wood Blockout Splitting

MwRSF Response:

Tracy:

I do not believe that the noted checking/splitting within the timber blockouts is a major concern in terms of guardrail performance. The primary load direction is compression from the rail being pushed back toward the blocks, then posts. The cracking should not significantly affect this behavior. However, for timber blocks located upstream and downstream from the impacted region, the tensile action will pull the rail in front of the blocks, thus causing a twisting action for the posts and blocks. This tensile load in rail will accentuate blockout fracture away from the impact region in blocks with significant cracking on their side faces. Thus, more blockout damage may occur during vehicular impacts, but this compounded damage is not believed to degrade barrier performance within the impacted region.

I have also sent copies of the supplied photos to my contact at the Forest Products Laboratory. I have yet to hear back from him regarding this request.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 5 – Guardrail Placement in a Cut Area**State Question:**

Here is a question that has been posed to me by a designer in one of our Districts. They want to minimize cut of the existing back slope (virtually not touch it), while squeezing in a curb and guardrail along the roadway. This results in the earth slope rising steeply behind the curb and within the deflection space of the guardrail system.

I am suggesting to them to use a concrete barrier, if a barrier is needed here.

However, can you see any way the guardrail might work? I think this probably is not possible because the increased embedment of the posts would lead us to a shorter post in order to compensate for the increased fill. However, there is not room for deflection before encountering the back slope and the deflecting system will be interfered with by that slope. Also, the vehicle itself will encroach into the back slope area, contributing lifting and/or snagging potential.

David L. Piper, P.E.
Safety Implementation Engineer
Bureau of Safety Engineering



Figure 4. Guardrail Placement in an Cut Area

MwRSF Response:

Dave:

Both the 1:1 and 1.5:1 cut or back-slopes on the upper side of the road would be potentially hazardous and provide an increased propensity for impacting vehicles to climb the unprotected slope and result in vehicle rollover. As such, your group has accurately identified the need to shield the hazard if it cannot be removed, flattened, etc. assuming traffic volumes, speeds, other factors, etc. warrant shielding it.

Placing a standard MGS directly in front of the steep slope would result in the impacted vehicles contacting the slope under the rail as the barrier deformed backward. The guardrail system would likely be more stiff as the built-up soil would provide increased soil resistance for the steel posts in addition to that already provided by the increased fill height located behind the curb section. The back side of the guardrail system would also likely make contact with the back-slope as it deformed during the high-energy impact event.

Although there would exist the possibility for this system to perform in an acceptable manner, full-scale testing would likely be needed to demonstrate satisfactory performance for the MGS with a back-slope starting under the rail and at the post locations. If 12 in. of clear and level terrain (33 in. from rail face) were provided behind the posts, I think the system would likely perform in an acceptable manner with the adjacent 1:1 back-slope shown in the plans.

Unfortunately, it does not appear as though the clear and level terrain can be provided behind the guardrail system. For such situations, it may be necessary to utilize a more rigid barrier system at the base of the back-slope.

Please let me know if you have any questions or comments regarding the information contained above. Thanks!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 6 – INDOT F-shape PCB – Part I**State Question:**

Great talking with you today about the INDOT barrier wall.

As discussed, we need to get an anchored temporary barrier wall 350 approved for INDOT. Because time is of the essence, our concept is to take a 350 approved anchored system such as the Drop Pin or Kansas anchored system and modify the design to fit within the 350 approved Indiana 'F' shape. That is we would use the reinforcing and anchoring system from the approved wall and modify it to fit within the INDOT barrier wall.

I have attached the approval letter and INDOT standard for your review. I will also try to retrieve the report completed for the INDOT wall.

In the meantime, please review and provide any comments you have concerning our approach.

Thanks. ...ken

Ken Leuderalbert, PE
FHWA, Indiana Division

MwRSF Response:

Hello Yadu,

We have reviewed your TCB details. I have attached details for the F-shape barrier used by Kansas developed at MwRSF.

We would recommend the following with respect to modifying your barrier section.

1. The Indiana barrier would need to be modified to accommodate the anchor holes and additional reinforcement for the anchors holes present in the MwRSF design.
 - a. It should be noted that the toe of the Indiana barrier is 1" shorter than the toe of the MwRSF barrier, thus it may be difficult to fit the reinforcing steel and anchor holes in the barrier with appropriate concrete cover.
2. The Indiana barrier is 2' shorter than the MwRSF barrier. This should not be an issue, but we would still require the same number of anchor points as the MwRSF design.
3. The Indiana barrier would need to be modified to have equal or greater barrier reinforcement throughout the barrier as the MwRSF design. Our testing of these barrier in their anchored configuration has shown that we are very close to the capacity of the barrier section we have. We would also like to see the shear steel extended into the toe of the barrier in a manner similar to the MwRSF design.
4. We would recommend that the Indiana barrier switch to a 6 loop end connection configuration similar to the MwRSF design. The 6 loops design tends to be stiffer than traditional 4 loop designs, reduces loads on the connection pin, and help prevent barrier rotation when the system is used with anchors.
5. The connection pin used in the Indiana barrier is listed as a 1 3/16" bolt. No grade is listed for this bolt. The MwRSF design used a 1 .25" diameter A36 steel pin. The connection pin would need to have equal or greater strength and ductility to the pin used in the MwRSF barrier.

Let me know if you have any comment or questions regarding these recommendations. We would be happy to review your modifications and provide more feedback prior to your producing the barrier.

Bob Bielenberg

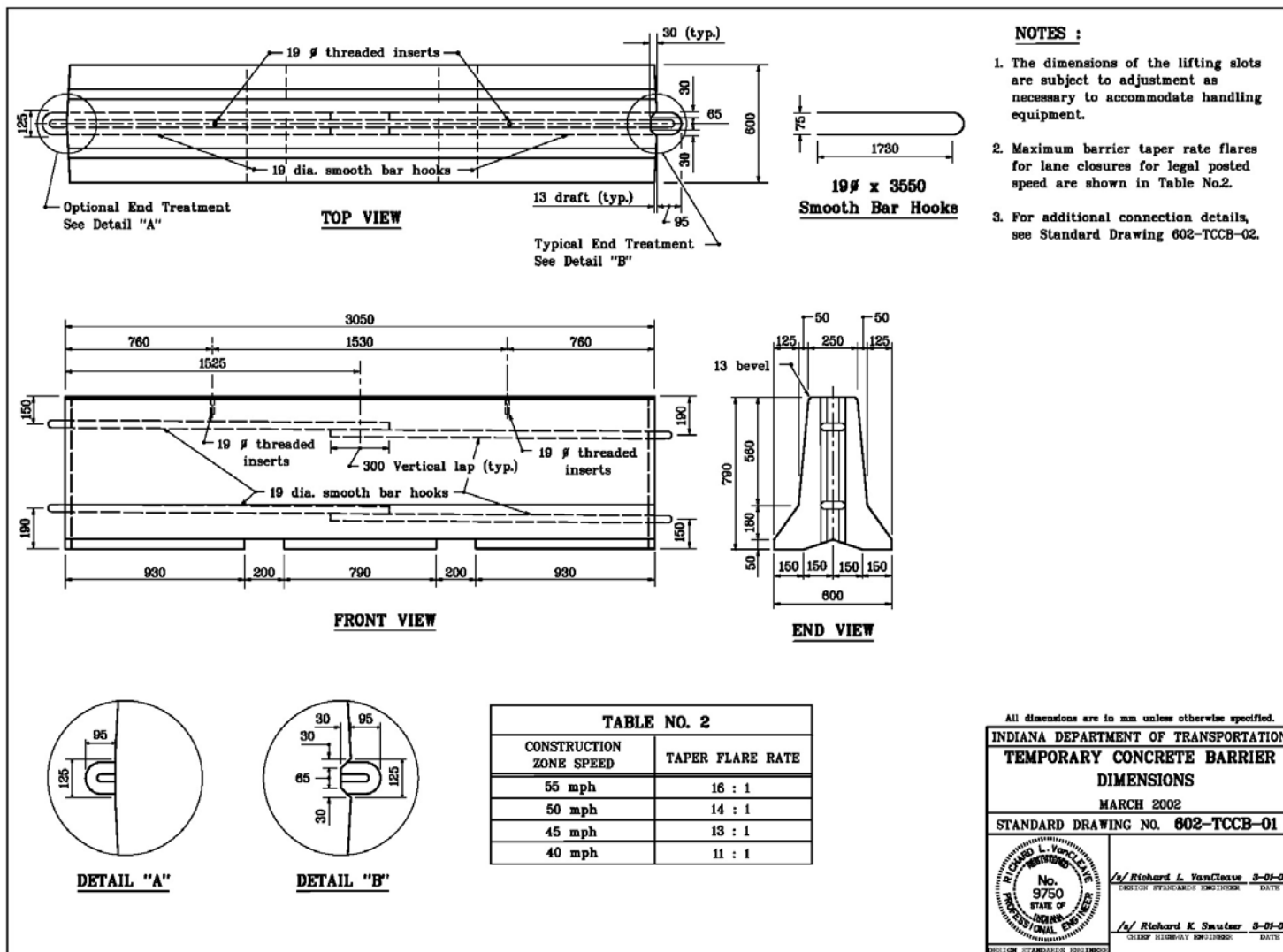


Figure 5. INDOT PCB Details

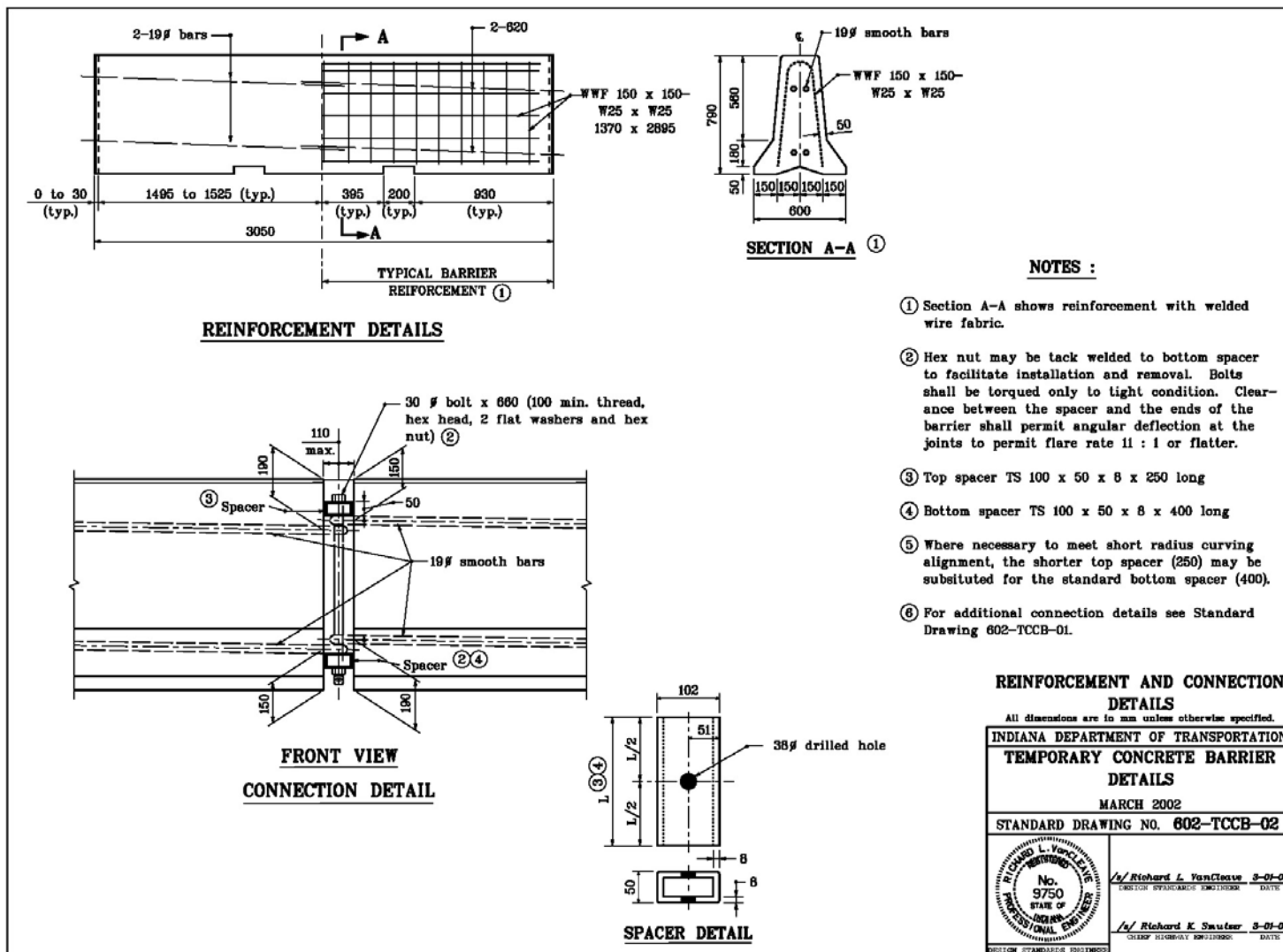


Figure 6. INDOT PCB Details

Problem # 7 – INDOT F-shape PCB – Part II

State Question:

Bob,

Attached preliminary drawings show modified INDOT F-shape TCB with Kansas F-shape TCB reinforcing bars and anchor bolt details.

1. The drawing sheet I of 2 shows modified shape of the INDOT TCB to accommodate the anchor holes and additional reinforcement for the anchor holes same as Kansas barrier. The drawing also shows the comparisons between the two barrier shapes and the barrier steel and concrete strength details which are same as Kansas barrier. Note that INDOT barrier toe is 2" but has same concrete cover and clearances as Kansas barrier.
2. The Indiana barrier is 2'-6" shorter than Kansas barrier but will have same number of anchor points (anchor bolts on traffic side only).
3. Indiana Barrier will have equal barrier reinforcement similar to the Kansas barrier but closely spaced due to the shorter length of the Indiana barrier as shown on sheet 2 of 2 of the attached drawing.
4. The sheet 2 of 2 of the drawing shows six loops design as you have recommended.
5. The connection pin between barriers will be 1 1/4" diameter, A36 steel minimum.

Please review these modifications to the Indiana F-shape anchored barrier and provide your feedback and let us know if this anchored barrier can be qualified and approved to NCHRP 350, TL3 without test. We are planning to prepare final drawings of the Indiana modified barrier after we hear from you. We will send you the final drawings again for your review.

Thank you,

Yadu Shah, MS,P.E.
Highway Engineer II, Roadway Standards
Indiana Department of Transportation

MwRSF Response:

Hello Yadu,

I have reviewed the details you sent and have the following comments.

1. You list loop bars as 3/4" diameter smooth bars with $F_y = 60$ ksi. This is not the correct spec. The proper spec for the loop bar steel is, "The loop bars (6d1, 6d2, and 6d3) shall be A706 Grade 60 or A709 Grade 70 0.75" [19] smooth or deformed steel bars. Alternative steel chemistry may be used as long as the alternative material provides a minimum yield of 60 ksi [420 MPa], a tensile strength of not less than 1.25 times the yield strength but a minimum of 78 ksi [550 MPa], a minimum 14% elongation in 8" [203], and passing a 180 degree bend test using a 3.5D pin bend diameter. The loops shall be installed within 0.12" [3] of the plan dimensions."

2. We are concerned that the height of the barrier is only 31". All previous testing of the MwRSF F-shape barrier was conducted with a 32" high barrier. In F-shape barrier impacts we have observed a tendency for the vehicle to climb the barrier face. Thus, the height of the barrier is critical in achieving proper redirection. As such, we would recommend that the barrier be 32" high.

3. With the shorter toe on your proposed barrier, there is slightly less cover for the loops used to retain the anchor bolts. This may adversely affect the longevity of the barrier segment and potentially its capacity.

4. On one of your details, you show the three loop connection attached to your current F-shape barrier with two loops. While we believe that this type of connection can work, we would only recommend mixing barrier segments in free-standing barrier installations. Also, when connecting barriers with dissimilar loop connections, we would recommend that a 1/2" dia. x 10" Grade 5 Hex bolt and 2.5"x4"x1/2" keeper plate be used at the bottom of the connection pin to insure the pin does not pull out of the loops under load. This bolt and keeper plate were part of the original barrier connection, but were eliminated after switching to the 3 loop connection. However, if you connect the three loop connection to your current F-shape barrier with two loops, we would recommend that the bolt and keeper plate be used.

Other than the four issues above, we see no other problems with the barrier as shown. I should also note that we cannot determine if this barrier can be qualified and approved to NCHRP 350, TL3 without test. The acceptance of the design must be done by FHWA through their approval process. We can help you get in contact with Nick Artimovich if need be. I am not certain at this time that the barrier could be approved to NCHRP 350 as the deadline for all NCHRP 350 approvals was 12/31/10. As such, you may need to seek approval under MASH. This may be possible as the MwRSF F-shape has undergone several full-scale tests using the MASH criteria.

Please contact me with further comments or concerns.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer
Midwest Roadside Safety Facility

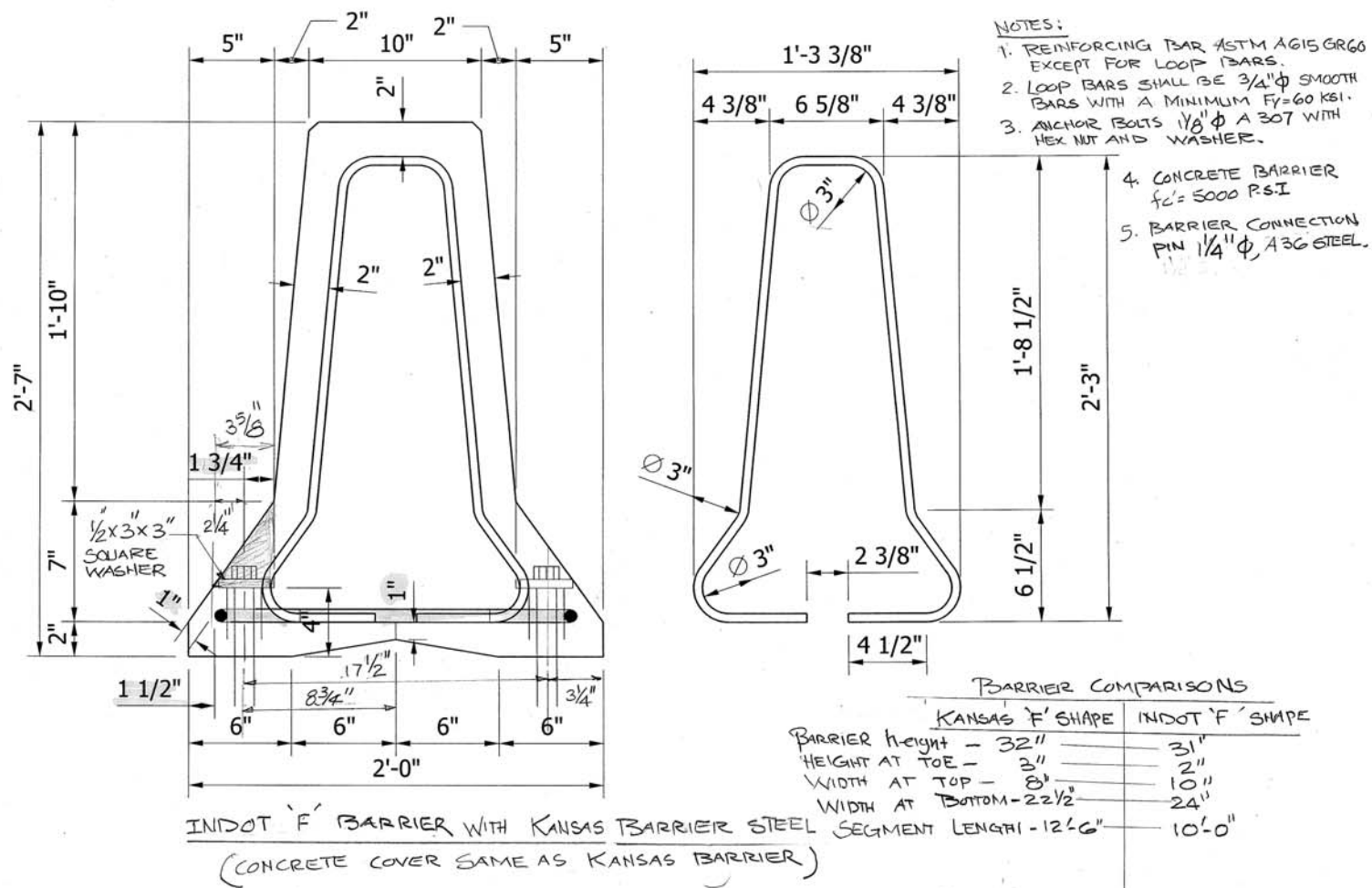


Figure 7. Modified INDOT PCB Details

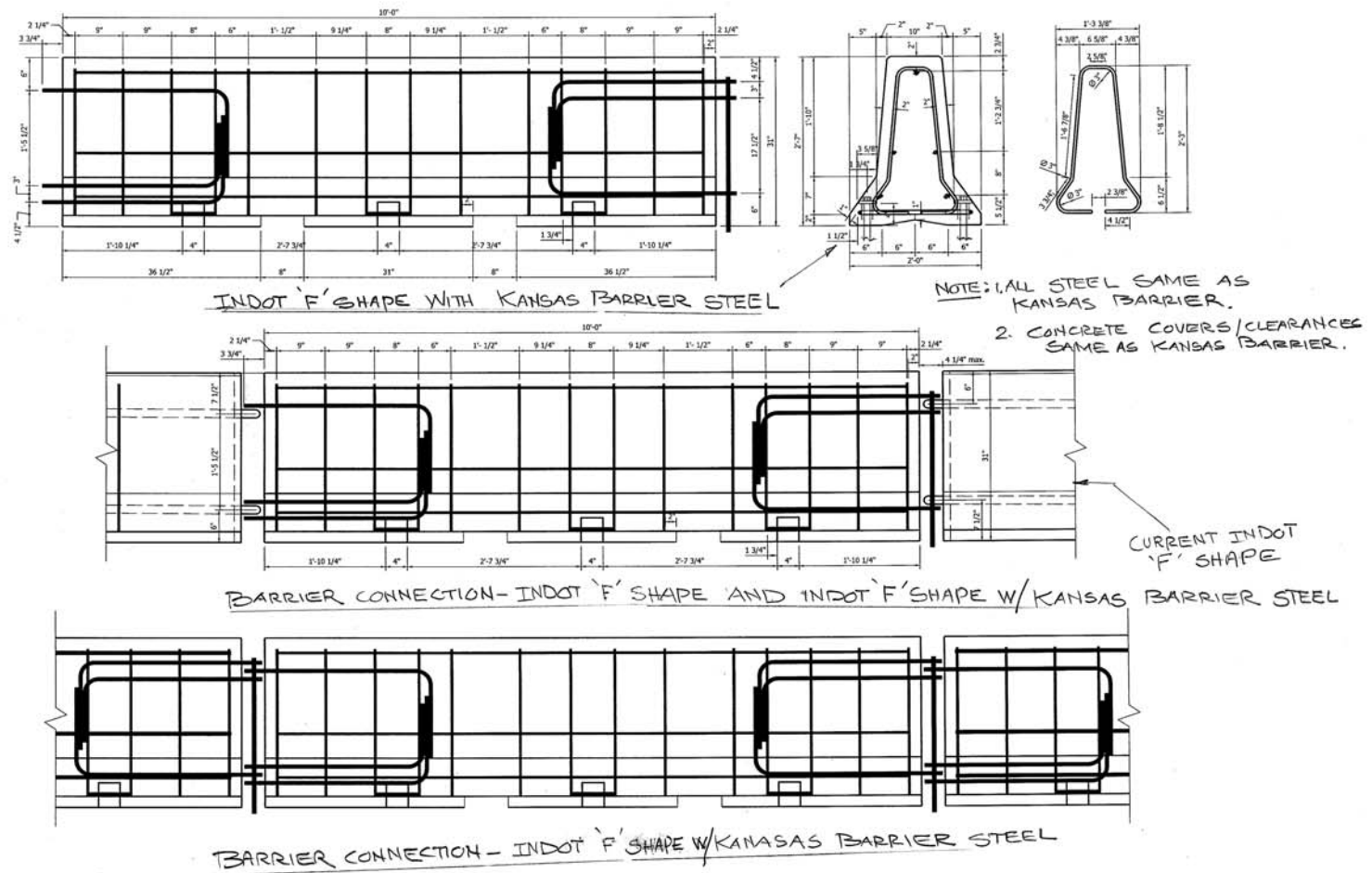


Figure 8. Modified INDOT PCB Details

Problem # 8 – Inserts for Bridge Approach Section

State Question:

Ron,

Is there design for Inserts for attaching bridge approach sections rather than having to drill all the way through the bridge rail?

This is an existing bridge rail where we did not get a precast insert into the off-end of the rail. Now we are switching to head to head traffic where it now will have a chance of getting hit from the other direction.

What size/ length of insert is required here?

Phil TenHulzen PE
Design Standards Engineer
Nebraska Dept. of Roads

MwRSF Response:

Phil:

I am enclosing a copy of an excel table that I have used over the years to obtain capacities for threaded bolts and anchor rods. Please note that the contents of the table do not reflect reduction factors of any kind. Based on your proposed rod size, it would appear that five ¾-in. diameter, 36 ksi steel threaded anchor rods would not meet your shear load requirement. However, five ¾-in. diameter, 92 ksi steel threaded anchor rods would meet the requirement if no reduction factor is utilized, but it would not meet the 80-kip requirement if the 0.75 reduction factor is used.

If we considered 7/8-in. or 1-in. diameter anchor rods of 92 ksi (Grade 5, 325, 193-B7, etc.) steel material, then both anchor rod sizes would provide adequate shear capacity, even with using the shear reduction factor.

Can you provide details for the swedge fittings?

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Nominal			Gross	Calculated	Net				Maximum	Net	Net	Net	Net
Threaded Rod	Gross	Tensile	Elastic Section	Rod	Elastic Section	Steel	Yield	Ultimate	Shear	Yield	Ultimate	Elastic Bending	Shear
Diameter	Area	Area	Modulus	Diameter	Modulus	Grade or	Strength	Strength	Strength	Force	Force	Capacity	Force
(in.)	(in.2)	(in.2)	(in.3)	(in.)	(in.3)	Specification	(ksi)	(ksi)	(ksi)	(kips)	(kips)	(kip-in.)	(kips)
0.75	0.4418	0.334	0.0414	0.6521	0.0272	A307	36	60	20.7846	12.0240	20.0400	0.9801	6.9421
0.75	0.4418	0.334	0.0414	0.6521	0.0272	A325	92	120	53.1162	30.7280	40.0800	2.5048	17.7408
0.875	0.6013	0.462	0.0658	0.7670	0.0443	A307	36	60	20.7846	16.6320	27.7200	1.5945	9.6025
0.875	0.6013	0.462	0.0658	0.7670	0.0443	A325	92	120	53.1162	42.5040	55.4400	4.0749	24.5397
1.000	0.7854	0.606	0.0982	0.8784	0.0665	A307	36	60	20.7846	21.8160	36.3600	2.3954	12.5955
1.000	0.7854	0.606	0.0982	0.8784	0.0665	A325	92	120	53.1162	55.7520	72.7200	6.1216	32.1884
1.125	0.9940	0.763	0.1398	0.9856	0.0940	A307	36	60	20.7846	27.4680	45.7800	3.3842	15.8587
1.125	0.9940	0.763	0.1398	0.9856	0.0940	A325	81	105	46.7654	61.8030	80.1150	7.6144	35.6820
1.250	1.2272	0.969	0.1917	1.1108	0.1345	A307	36	60	20.7846	34.8840	58.1400	4.8434	20.1403
1.250	1.2272	0.969	0.1917	1.1108	0.1345	A325	81	105	46.7654	78.4890	101.7450	10.8977	45.3156

Figure 9. Anchor Rod Capacity Table

Problem # 9 – Minnesota TL-4 Combination Bridge Rail

State Question:

Karla,

The conclusions/recommendations of the researchers in this report (..Minnesota TL-4 Combination Bridge Rail...) are as following:

Finally, the authors believe that this combination traffic/bicycle bridge railing can be adapted to other safety shape bridge railings (i.e., F-shape and single slope) or vertical parapets of similar height and top width with only minor modifications. Additionally, it is believed that no further testing will be required since the F-shape and single-slope barriers are considered to behave slightly better than the New Jersey shape in crash testing (6.8.23).

--

As far as you know, is this railing can be successfully installed at the top of a 1070 mm (42 in.) F-Shape barrier?

Thank you and best regards.

Pierre Desmarchais, ing.
Direction du soutien aux opérations
Transports-Québec

MwRSF Response:

Pierre,

We believe that this railing with vertical spindles would perform better when placed on a 42” parapet versus a 32” parapet. The increased height should reduce vehicle engagement with the bike-pedestrian rail. Of course, the only certain way to evaluate its safety performance is through full-scale vehicle crash testing.

Regards,
Karla Lechtenberg
Research Associate Engineer

Problem # 10 – Guardrail for Fill Slope Applications

State Question:

Here is a question regarding options for a roadside barrier in a location where there has been an embankment failure and subsequent repair using a soil nail repair procedure. Also, the roadway top width is narrow, such that we would not have 2’ of embankment behind the back of guardrail

posts. Records show that the soil nails are present at 4.26 to 5.16 feet below ground surface. If we were to use the 9' posts recommended for guardrail (MGS) in this location, the posts would extend about 6 feet below ground surface, and interference with soil nails would be a concern.

As noted in the string below, we have brainstormed about what systems might work.

We are wondering if you are aware of any other alternatives or variations of roadside barrier systems that might be considered?

Also, would use of standard length 6' posts, on 3' 1 1/2" spacing be considered under all these constraints? I understand that MwRSF prefers the longer posts for more uniform, reliable results, but we would be open to ideas for mitigating this (soil plates?). Terminals for the guardrail could be placed outside the slope repair.

David L. Piper, P.E.
Safety Implementation Engineer
Bureau of Safety Engineering

MwRSF Response:

Dave:

Recall, MwRSF has developed two barrier options for use on 2:1 fill slopes. Below, you noted the MGS option which utilizes 9-ft long steel posts spaced on 6 ft – 3 in. centers. The 31-in. tall, MGS option was developed under the MASH safety performance criteria. The maximum dynamic deflection was found to be approximately 58 in.

Several years ago, MwRSF also developed a metric-height, W-beam guardrail system for 2:1 fill slopes using 7-ft long steel posts spaced on 3 ft – 1 1/2 in. centers. This 27 3/4-in. tall, W-beam guardrail option was developed under the NCHRP Report No. 350 safety performance criteria. The maximum dynamic deflection was found to be approximately 32 in.

Based on the successful performance of the MGS system with 9-ft long posts in conjunction with 58 in. of dynamic deflection, it would seem reasonable that the metric-height system could be raised to a 31-in. height and converted to a MGS system. With this modification, the post embedment depth would be reduced by only 3 1/4 in. from that used for the noted development and crash testing program. In addition, the maximum dynamic barrier deflection would likely fall between 32 and 58 in. With 7-ft long posts, the embedment depth would be 52 in. or 4.33 ft.

Based on the information noted above, it is my opinion that MGS should perform in an acceptable manner when installed at the SBP of 2:1 fill slopes if configured with 7-ft long steel posts spaced on 3 ft – 1 1/2 in. centers. If necessary, it would seem reasonable to also construct the MGS at the 32-in. upper height tolerance using 7-ft long posts. With this variation, the post embedment depth would be 4.25 ft.

Please let me know if this option can be made to work for your special situation! Thanks again.

Respectfully,

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 11 – MGS Installed on 2:1 Slopes

State Question:

Dear MwRSF,

I've been working on developing WisDOT's standard detail drawings for the MGS system and I have a question. I was reviewing MwRSF's crash test report, "Development and Evaluation of the Midwest Guardrail Systems (MGS) Placed Adjacent to a 2:1 fill Slope" (TRP-03-185-10).

In this report, MGS with standard post spacing, 6' 4" post embedment was tested at two rail heights (27 ¾" and 31"). The 31" height passed MASH, but the 27 ¾" rail height failed MASH.

What would be the lower height limit for MGS on a 2:1 slope? What modifications should a designer do a MGS system with standard post spacing and 6' 4" of embedment that has had the 31" rail mounting height lessened by overlays (e.g. install a normal length post at the midspan)?

Your help as always is appreciated.

Erik Emerson P.E.
Standards Development Engineer-Roadside Design
Wisconsin Department of Transportation

MwRSF Response:

Erik:

Initially, the development and crash testing program began with the plan to demonstrate satisfactory safety performance for the MGS installed on 2:1 fill slopes using the same lower height tolerance obtained for standard MGS. After the first test failed MASH test designation 3-11, we chose to then re-test the modified barrier system at the same nominal height used for the standard MGS. Although we believe that the MGS installed on 2:1 fill slopes would perform in an acceptable manner at heights below 31 in. (such as for 29 or 30 in.), we are unable to recommend these lower height tolerances without first demonstrating acceptable safety performance through the use of full-scale vehicle crash testing.

For situations where pavement overlays are placed adjacent to the MGS installed on 2:1 fill slopes, one possible option would include raising the guardrail post and rail height by an amount approximately equal to the thickness of the adjacent pavement overlay.

We have discussed options for your prior question regarding overlays next to MGS for 2:1 fill slopes. Our options are listed below.

- (1) Utilize two bolt holes in the 9-ft long steel posts placed at full-post spacing. If an overlay causing the rail height to drop 2 to 3 in., the W-beam rail and blockout can be mounted to each post using the upper bolt hole in order to retain 31-in. top rail height.
- (2) Implement Option 1 plus also install 7-ft long posts at half-post spacings. This conservative option may provide most safety.
- (3) Install MGS at 33 in. near 2:1 fill slopes and taper barrier ends to 31 in. after extending beyond 2:1 sloped region. After overlay is placed, the rail height would be about 31 in.

A distant 4th option is noted below but it carries more risk of vehicle override with lower rail height.

- (4) Install 7-ft long posts at half-post spacings and between existing 9-ft long posts. Leave rail height at 28 to 29 in. after overlay placed.

Please let me know if you have any questions regarding this information. Thanks!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 11 – NDOR Temporary Concrete Barrier – Part I

State Question:

Ron,

We are trying to implement the KsDOT Barrier in the next week.

I question how to raise the bottom of the barrier 2” (preferred).

Bar 4a1 is a stirrup which usually comes within 2” of the bottom of the barrier/ ground.

The rise on the left half of the barrier is preferred, the right is an odd option I think will lose the 3” base piece.

Can the stirrups labeled 4a1 be cut to keep the steel from being closer than 2” to the bottom when we raise it like the right half?

Or can 4a1 be bent slightly different to meet our 2" distance to the outside of the barrier?

I will try to put together a few questions for your official review of this plan for documenting by Friday.

Thanks
Phil

MwRSF Response:

Phil:

I have reviewed your email questions below and have a few comments. See below!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

We are trying to implement the KsDOT Barrier in the next week.

I question how to raise the bottom of the barrier 2" (preferred).

****I am not sure that I understand the concept of raising the bottom of the barrier by 2 in. However, I assume that you are referring to the need to add increased hydraulic drainage flow to specific locations on the bottom of the barrier.**

Bar 4a1 is a stirrup which usually comes within 2" of the bottom of the barrier/ ground.

****In the original TCBs, the vertical stirrups and lower longitudinal rebars were placed close to the barrier's base with an acceptable concrete cover for the steel bars. Later, the Pooled Fund member states met in St. Joseph, MO to discuss the standardization of the TCB as well as the modifications/addition of some other features, including fork lifting slots. When the fork lifting slots were incorporated, the shape and placement of the vertical stirrups remained the same but the lower longitudinal rebars had slightly moved upward to provide cover above the fork lifting holes. The affect of these changes can be garnered by viewing the original details and comparing them to those details listed for the KS/FL (Midwest) TCB free-standing and tied-down systems.**

The rise on the left half of the barrier is preferred, the right is an odd option I think will lose the 3" base piece.

****The modifications on the left side of the barrier depict a distinct fork lifting slot and a separate drain slot. However, on the right side, there exists a fork lifting slot that it integrated into the drain slot, thus requiring a modification to the vertical stirrup and reduced barrier contact with the ground. Personally, I like the detail on the left side more than that on the right side. If provision for drainage is really needed, I would almost rather see four fork lifting slots centered between the vertical stirrups such that the vertical stirrups do not require modification and barrier support is better distributed. With this change, there would not be narrow, 3-in. wide segments.**

On another note, are you counting on the 3-in. wide drainage slots between the barrier ends? If not, would the two fork lifting slots be sufficient?

Can the stirrups labeled 4a1 be cut to keep the steel from being closer than 2" to the bottom when we raise it like the right half?

****If the bottom side is raised under vertical stirrups, the bottom of the bars would be bent inward at a higher elevation to fit under the lower longitudinal bars. However, it is not recommended to have this change occur near the tie-down locations. Thus, the proximity of the drainage slots near the outer tie-down locations could result in increased concrete fracture when the barriers are anchored to a paved surface or bridge deck.**

Or can 4a1 be bent slightly different to meet our 2" distance to the outside of the barrier?

****As noted above, it would be possible to bend the lower stirrups ends inward at a slightly higher elevation to meet concrete cover. However, the drain slots should be integrated such that they do not pose concerns for increased concrete fracture at the tie-down locations.**

Problem # 12 – NDOR Temporary Concrete Barrier – Part II

State Question:

The Nebraska Department of Roads (NDOR) has recently contracted with a contractor to provide 25,000 Lin. Ft. of new concrete barrier and FHWA-NE is requesting the NDOR to update its design to something similar to the Kansas Portable Concrete Barrier (PCB) which has incorporated a pin and six connection loop system and some of these low-cost improvements to which Mr. Horne alluded. The Kansas PCB has been crash tested and is accepted by FHWA in letter HSA-10/B-122. As we have previously discussed, NDOR has determined that instead of directly adopting the Kansas design, we prefer to adopt a modified design that incorporates features that Nebraska has found to be beneficial.

NDOR is requesting that MwRSF review the following changes to the Kansas design and advise if the barrier will continue to perform satisfactorily with the desired changes.

Modifications to:

Loop Steel:

The Kansas plan calls for "1.25 times the yield strength but a minimum of 80 KSI" The ASTM standards for A706 steel include this. Both plans call for yield strength of 60 KSI. The minimum bending diameter for ASTM A706 steel is $4 \times (3/4" \text{ dia.}) = 3"$ our plan shows this in the bending diagrams.

Six Loop System – Connection Pin/ Retaining Bolt:

The six loop system does not require a retaining bolt at the bottom of the connection pin used to connect adjacent barriers; NDOR's barrier has this detail and we have elected to keep the detail only requiring it to be used when using the strap near a drop-off.

Anchor Bolt Block Out:

The Kansas plan shows a standard detail for an anchor bolt block out to allow the barrier to be bolted to the substrate; NDOR elected to make the anchor bolt block out optional and to be built at the discretion of NDOR since it is not required for all projects. The U-

shaped steel bars labeled 6A2 required for the anchor bolts to transfer load are also omitted when the anchor bolt breakout is absent.

Tie-Down Strap:

The Kansas barrier plan does not have an alternate of using a tie-down strap to mount the barriers to the substrate. The tie-down strap was tested with the NCHRP 350 testing procedures and is an accepted detail for the 12.5' barrier. NDOR desires to retain the option of using the tie-down strap.

Foot Print - bottom of barrier in contact with the ground:

The Kansas plan has a foot print of 12.9 square feet the proposed Nebraska design has 14.4 square feet. NDOR prefers that there be additional lifting slots for drainage conveyance under the barriers to reduce ponding on the roadway and allow movement by larger forklifts.

The modification is shown on the elevation view as being an additional 1' of barrier on each half elevated 3" from the ground for the width of the barrier and results in a reduction of 3.75 square feet of foot print. To mitigate this decrease in the area of the barrier in contact with the ground the NDOR plan removed the 7" wide x 1" high inverted V-shape on the bottom of the Kansas plan, shown on Section B-B of the Kansas plan, this had held 6.12 square feet from contact with the ground.

NDOR requests that MwRSF review this information along with the attached plans and advise if the Kansas barrier, modified as proposed will continue to function as tested and accepted or include further suggested modifications to perform satisfactorily.

NDOR further requests an opinion on whether the Nebraska PCB designs (both 4-loop & 6-loop) and the modified Kansas PCB can be pin connected together and be considered to perform satisfactorily to NCHRP Report 350 or MASH Test Level 3 evaluation criteria.

Sincerely

Phil TenHulzen PE
Nebraska Department of Roads

MwRSF Response:

Phil:

I have reviewed the enclosed NDOR materials and have the following comments.

(1) The reinforcing steel for loop bars are shown to conform to ASTM A706 Grade 60, which infers a minimum yield strength of 60 ksi, a minimum tensile strength of 80 ksi, and a minimum % elongation in 8 in. equal to 14% for no. 6 or ¾-in. diameter bars. A footnote also reads that the tensile strength shall not be less than 1.25 times the actual yield strength. It is acceptable for NDOR to denote that the loop bars conform to ASTM A706 Grade 60.

(2) Historically, the loop bars and reinforced concrete barriers have been fabricated and crash tested using a 2¾-in. pin diameter to achieve the specified loop geometry. Florida, Iowa, Missouri, and Kansas all utilize a 2¾-in. pin diameter. NDOR has depicted a 3-in. pin diameter. In order to maintain the same drop pin and rebar loop clearances, it would be recommended that NDOR utilize the 2¾-in. pin diameter.

On another issue, Iowa and Kansas specify that the steel rebar for loop bars pass the 180-degree bend test using a 3½-in. pin diameter, while Florida specifies that a 2¾-in. diameter pin be used for the 180-degree bend test. Missouri does not identify a bend-test requirement. NDOR does not currently identify a 180-degree bend test requirement. ASTM A706 denotes the bend test to demonstrate that the bar can be bent around the pin without cracking on the outside radius of the bent portion. Thus, if a bend test were to be performed, it would seem appropriate to run the 180-degree bend test using the same diameter that would be used in the final loop configuration.

(3) A six-loop rebar connection system with drop pin is shown in the NDOR CAD details. At the base of the drop pin, a horizontal retainer bolt was originally configured for use with the four-loop rebar connection system as well as for the tie-down strap anchor system. However, the retainer bolt is not required in free-standing TCB configurations that utilize the six-loop rebar connection.

(4) An alternative tie-down system was originally developed for the Midwest F-shape temporary concrete barrier which consisted of vertical bolts or rods penetrating the barrier's toe. At these anchor locations, horizontal rebar loops were incorporated to strengthen the TCB at the attachment locations. The NDOR temporary concrete barrier does not include these additional rebar loops in all sections, unless the barrier section will later be used in tied-down applications. It is acceptable to leave out these 6A2 bars if the TCB will only be used in free-standing applications or anchored using the tie-down strap.

(5) NDOR noted that Kansas does not utilize the alternate tie-down strap with the F-shape TCBs. However, I reviewed the Kansas standard plans and found detail RD622B which depicts the tie-down strap anchor method.

(6) NDOR has proposed to increase the length of the lateral openings on the underside of the TCB to allow for improved water drainage flow from the roadway to travel under the barrier, thus reducing concerns for water ponding near the travel lanes. The detail with four separate drainage slots is acceptable. After considering alternatives, it would also be acceptable to combine the two slots on each half of the barrier into one slot measuring 2 ft - 3 in. long and shifting the outer edge inward slightly to provide additional concrete cover near the outer tie-down holes. For this second alternative, the 4A1 bars above the slot would need to be modified slightly. The 2-ft long middle support section would be maintained.

Based on the features identified in Item Nos. (1) through (6), it is our opinion the modified NDOR F-shape TCB will provide an acceptable safety performance when used in similar applications to those approved for the Iowa, Kansas, Florida, and "Midwest" TCBs. The aforementioned barrier versions have been previously crash tested in free-standing and tied-

down applications according to either the NCHRP Report No. 350 or MASH impact safety standards.

Lastly, NDOR requested that MwRSF provide comment regarding the safety performance of a free-standing, TCB system which utilizes one end of a four-loop connection to attach to another end of a six-loop connection. As noted previously, the four-loop, Iowa TCB system was successfully crash tested under the NCHRP Report No. 350 impact safety standards. Later, the six-loop, Midwest/Kansas/Florida TCB system was successfully crash tested under the MASH impact safety standards. When the six-loop connection was integrated into the F-shape TCB section, the geometry of both loop connections was considered to ensure that the two designs could be attached to one another. Therefore, it is our opinion that a TCB barrier system which contains joints where both loop connections attach to one another would be considered crashworthy and capable of meeting the Test Level 3 impact conditions.

If you have any questions regarding the information contained herein, please feel free to contact me at your earliest convenience.

For informational purposes, I have attached PDF copies for the TCB CAD details for Kansas, Iowa, Florida, and Missouri.

Respectfully,

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 13 –Concrete Barrier Profile

State Question:

Linda,

I don't believe this is a problem since the more vertical a face is, the safer it usually is. I am concerned about the fact that this is not how this particular barrier was tested.

I am copying this reply to Dr. Ron Faller of the Midwest Roadside Safety Facility at the University of Nebraska-Lincoln, to on this reply to gage his concurrence.

Joe

From: Linda W Bokel/D8/MODOT
To: Joseph G Jones/SC/MODOT@MODOT, Travis D Koestner/SC/MODOT@MODOT
Cc: Gayle D Davis/D8/MODOT@MODOT, Brian A Todd/D8/MODOT@MODOT
Date: 11/29/2010 07:44 AM
Subject: concrete traffic barrier profile

Hi -- We are still needing to know if we can have the barrier face sloped 2 inches less than the standard shows

Thanks

Hi Joe and Travis

On the six laning of Route 65 -- there is concrete barrier being installed in the median to divide NB from SB

There is a curve on that job where the median is wide and the top of barrier on the high side of super was up to 3 ft more than the top on low side

We asked bridge office about this and they had a retaining wall/stepped barrier designed by the consultant

The contractor has poured the high side retaining wall portion of this median barrier and they are now trying to slip form in the half on the low side --(there is a base that was poured with the high part already for it to set on)

The contractor is having trouble with the slip form machine kicking out at the top portion as they pour this front face . They are ending up with an approx 2 inch gap behind the barrier at the top-- looks flush at the bottom

the contractor wants to fill this gap with expansion grout -- which construction thinks would be ok .

The question is : if the face of the barrier ends up more vertical -- by approx 2 inches, than standard , is that a problem from the crash/safety standpoint?

Thanks!

MwRSF Response:

Joe:

I am not concerned with a barrier shape with a front face that ranges between the single slope and vertical cross sections. I also agree that it would likely be beneficial to fill the back-side gap to prevent water from penetrating into this region and causing damage during freeze-thaw cycles.

Ron

Problem # 14 – MGS Working Width and Dynamic Deflection

State Question:

Dear MwRSF,

I was reading the consulting summaries and had a few questions.

My first question is on the discussion that Scott, Dr. Faller and I had about the bridge rail retro fit. During one of our phone conversations it was mention that MwRSF would talk to FHWA about this retro fit option. Has there been any progress with FHWA?

My second question is on the table of MGS guard rail. On the standard post spacing, W6x9 mash tests, there is a test where the working width and the dynamic deflection distance is differ only by 0.3 inches.

If working width is barrier system width plus maximum deflection or maximum vehicle lean and dynamic deflection is measured from back of system, shouldn't the difference between the two measurements be greater than 0.3? Most of the other deflections and working widths are greater than 0.3" except for the round DF test.

If this result is correct, you may wish to provide a note to discuss why it is correct.

Erik Emerson P.E.
Standards Development Engineer-Roadside Design
Wisconsin Department of Transportation

MwRSF Response:

Erik:

The working width and dynamic deflection for test 2214-MG1 was 57.3 in. and 57.0 in., respectively. The working width is the maximum lateral displacement of a post, rail, vehicle, etc. away from the front face of the barrier. The dynamic deflection pertains to the distance between a rail or post location before and during the test. If a rail midspan location has the greatest lateral deflection and the rail becomes partially flattened at this location, then it could be possible for the working width to be only slightly greater than the dynamic deflection. However, I would think that this would be approximately 50% of the rail thickness added to the max. D.D. or 58.6 in. versus 57.3 in. We will have someone re-check the high-speed film to determine where the W.W. value of 57.3 in. was obtained.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

The working width point was determined at a midspan between two posts. There was a sign error in the calculation of the working width data. The working width should be 1489 mm or 58.6 inches.

Karla A. Lechtenberg, MSME, EIT
Research Associate Engineer

Problem # 15 – Thrie Beam Guardrail Transition

State Question:

Ron,

I am trying to upgrade our drawings to the MGS. I have some questions on the transition section as shown on our new drawing, RD613A (see att.). Initial thoughts were to keep our similar thrie beam section with the 6'6" post as shown on RD613 (original drawing) for the 31'-3" total length of transition. Note: all of our current post lengths are 6'6"; thrie or w-beam sections as shown on RD613. For our new MGS drawing (RD613A), do we need to update the post in the thrie beam section to 7' similar to your testing? At the thrie to w beam section of rail, your post were shown as 6' long and we are still showing 6'6". Should this change to 6'? I recall some conversations that states could keep their particular thrie beam transition section but wanted to verify some of these thoughts. Any help would be appreciated.

Thanks,
Scott King
KDOT

MwRSF Response:

Scott:

The original Kansas DOT thrie beam approach guardrail transition (RD613) utilized 12 ft – 6 in. of nested thrie beam and 12 ft – 6 in. of single thrie beam between the bridge end and the thrie beam side of the W-beam to thrie beam transition section. A 6 ft – 3 in. long W-beam to thrie beam transition segment was then used, followed by standard W-beam guardrail. A 1 ft – 6¾ in. post spacing was used through the nested thrie beam section, while a 3 ft – 1½ in. post spacing was used over the single thrie beam as well as the transition element. Steel and wood posts were denoted to be 6 ft – 6 in. long through and including the post at the midpoint of the transition element.

In comparison to several other NCHRP 350-approved thrie beam approach guardrail transitions, detail RD613 is a relatively long design which was intended to provide a gradual change in lateral stiffness for impacts near to and upstream from the bridge end.

In recent years, the Pooled Fund program sponsored the development and testing of a stiffness transition for the upstream end of the original thrie approach guardrail transitions. From this research, it was determined that the shorter transition designs may need to be extended in order to provide a more gradual change in lateral stiffness. However, we also observed a vehicle pocketing/rollover propensity when changes in thrie beam nesting, post spacing, and/or post type coincided.

In detail RD613A, it appears as though several posts were added beyond the W-beam to thrie beam transition section using a half-post spacing. Based on some of our prior examples for adapting the new stiffness transition to existing approach guardrail transitions, it would seem that several post could be removed beyond the W-beam to thrie beam transition segment such to have only 1 or 3 half-post spacings in this W-beam region. RD613A shows a 12 ft – 6 in. long segment of single thrie beam. Based on our adapted design variations, it would seem reasonable to utilize a 6 ft – 3 in. segment of thrie beam. Further, I may recommend that 6 steel posts be configured with a length of approximately 6 ft – 6 in. using a quarter-post spacing, similar to what is depicted in our draft transition report. It would also be worthwhile to use four shorter 6-ft long steel posts at quarter-post spacings and starting at your current post 7. All remaining steel posts would also use the 6-ft length. Section C-C depicts a 7-ft 6-in. long steel post. I believe you intended to depict it as a 6-ft 6-in. long steel post. In summary, it would seem reasonable to more closely match your detail to that proposed in Figure 96 of the draft transition report.

Please let me know whether you have any questions or comments concerning the information contained herein. Thanks!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 16 – H-Barrier

State Question:

Dr. Faller,

ODOT is talking about making this design a standard in MOT situations on structures that have limited cross sections. This predates me as a member of the pooled fund, but this barrier looks promising to us. Can you provide us with any addition information and the history of this project? Did you select this width because of the availability of H-piles? Do you think the width of this barrier could be reduced even more? Do you know any state are using this design? Thanks.

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/pdf/b117.pdf

Michael, Bline
OhDOT

MwRSF Response:

Michael:

From my recollection, MwRSF crash tested a free-standing version of Iowa's Steel H-Pile Temporary Barrier system in the late 80s. The Iowa DOT developed the H-Pile system and then hired MwRSF to conduct the compliance testing according to the AASHTO Guide Specifications for Bridge Railings. As I recall, one pickup truck test was successfully performed at the target impact conditions of 60 mph and 20 degrees. The joint detail between sections was both cumbersome but very strong. Steel angled plates were used to interconnect the sections using a large number of bolts which did not allow for much construction tolerance for misalignment and/or uneven surfaces. However, the joint detail did transfer load well across the joints to adjacent barrier segments. For free-standing applications, this barrier system with rigid joint detail resulted in dynamic barrier deflections of approximately 18 in.

Many years later, the IA DOT and the Pooled Fund program had MwRSF do some follow-on research with this general barrier system. This later study included a simplification of the joint detail as well as the incorporation of a tie-down system, then followed by full-scale crash testing according to NCHRP Report No. 350. Although the joint detail was simplified, the full-scale crash tests were only performed for the tied-down design variation. Upon completion of the testing, the modified design was shown to greatly reduce barrier deflections when subjected to a 2000P pickup truck impact at the target conditions of 62 mph and 25 degrees.

Two research reports have been prepared over the years to document the findings noted above. If desirable, MwRSF could send electronic copies of these to you. The later report would likely have been sent to Dean Focke shortly after the project was completed.

I am only aware of this barrier system being used in the State of Iowa. In order to obtain further information of its use, I have copied this email to our colleagues within the Iowa Department of Transportation with the hope that further light could be shed on its current use.

As noted previously, the sizing of the steel H-sections was made by the Iowa DOT. As I recall, the system width was approximately 14 in. wide. Thus, I am reasonably confident that a new or revised steel system (possibly with concrete ballast similar to this design) could be developed with a system width 1 to 2 in. narrower than used in the current Iowa design.

Please let me know if you have any other questions or comments regarding the information contained herein. Thanks!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Recently you crash tested the MGS at 34" that passed. Is it appropriate for me to say ± 3 " for all the applications?

Also what metric height did you test the 34" system at? I want to be consistent with actual measurement units in the RDG.

Problem # 17 – MGS Height Tolerance

State Question:

Recently you crash tested the MGS at 34" that passed. Is it appropriate for me to say ± 3 " for all the applications?

Also what metric height did you test the 34" system at? I want to be consistent with actual measurement units in the RDG.

Rod Lacy

MwRSF Response:

Rod:

MwRSF successfully crash tested the MGS at heights of 34 and 36 in. with the 1100C small car at TL-3 of MASH. This crash testing was at interior locations away from the end terminals. In addition, no 2270P crash testing has been performed. Our current concern is that the current end anchors may not be fully capable of handling the tensile loading imparting under TL-3 MASH conditions both at interior and end regions at the raised heights. Note that we already had increased foundation length in our existing anchorage hardware when the rail height increased from 27.75 to 31 in.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 18 – MGS Questions

State Question:

We are considering using the 31" Midwest guardrail system. We have been using the test data and drawings to develop our own standards, but I have a few outstanding questions about the applicability of this guardrail.

How much shoulder is needed behind the 6' post to provide sufficient support? I trying to get a handle on appropriate uses for the 6' post vs. the 9' post.

Has there been any testing of type 12 anchors for the 31" guardrail?

Has there been any testing of double faced guardrail for median applications?

Thanks,

Brad Ehrman, P.E.
Design Group Manager
Georgia Department of Transportation

MwRSF Response:

Hi Brad

I have addressed you questions below.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer
Midwest Roadside Safety Facility
130 Whittier Building
Lincoln NE, 68583-0853
402-472-9064
rbielenberg2@unl.edu

We are considering using the 31" Midwest guardrail system. We have been using the test data and drawings to develop our own standards, but I have a few outstanding questions about the applicability of this guardrail.

How much shoulder is needed behind the 6' post to provide sufficient support? I trying to get a handle on appropriate uses for the 6' post vs. the 9' post.

For MGS guardrail:

1. Standard MGS guardrail placed adjacent to any slope with 2' of level soil behind the posts is acceptable.
2. For MGS guardrail placed 1'-2' adjacent to a 6:1 or flatter slope, standard 6' W6x9 posts at standard spacing are recommended.
3. For MGS guardrail placed 1'-2' adjacent to a 3:1 to 6:1 slope, 7' W6x9 posts at standard spacing are recommended.
4. For MGS guardrail placed less than 1' adjacent to a 3:1 or steeper slope, 9' W6x9 posts at standard spacing are recommended.

Has there been any testing of type 12 anchors for the 31" guardrail?

I am not sure what the type 12 anchor is without more details. I have attached the anchorage that we tested with and that we recommend for non-terminal locations.

Has there been any testing of double faced guardrail for median applications?

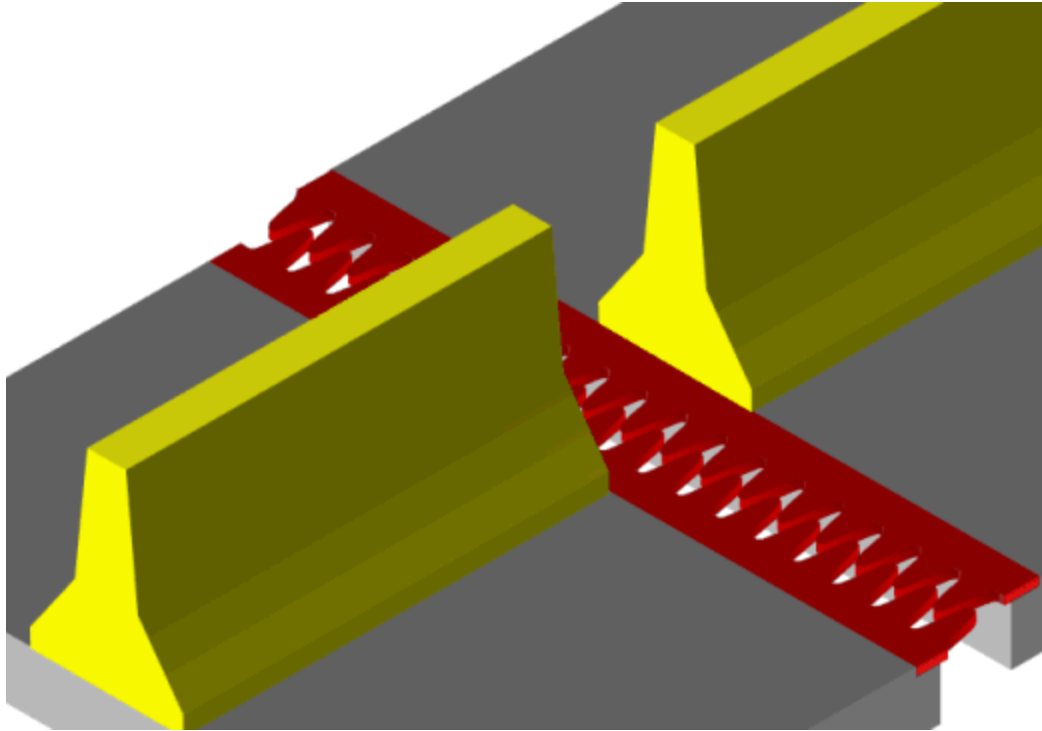
We have an FHWA approved median barrier version of the MGS. See the attached details.

Problem # 19 – Anchored PCB and Expansion Joints

State Question:

Ron,

Do you have a piece of hardware that will handle the transition between two pinned-down temporary installations of pin & loop F-barriers over an expansion joint. The joint probably has a 7 to 10 inch throw.



I spoke to Rory Meza and she showed me the Texas standard plan in which they simply cantilever one of the segments out over the joint. This would certainly allow for movement, but at full contraction, there would be a sizeable gap/snag point between the barriers, nor could the barriers be connected to one another. We've seen the state of Illinois use steel plates which cover the gap while one of the barriers slides independently. The plate is cast with studs into the other barrier.

This seems like a reasonable solution but I wondered how you have seen it handled.

I look forward to your response,

Joe Jones

MwRSF Response:

Joe:

MwRSF has not developed a stiffened cover plate system for protecting a large gap formed between two rigid barrier ends with an interior expansion joint in the deck surface. However, I do recall that the Kansas DOT has developed a system but not sure of the details. We provided some feedback years ago, but their bridge division personnel performed the FEA analysis and design work. I suggest that you contact Rod Lacy or Scott King to acquire their details for such a connection. However, note that longer lengths of the gap could greatly degrade performance of the existing design. I have copied Rod and Scott on this email so that they are aware of your inquiry of the cover plate system.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Hey guys,

Yes, we have an expansion joint barrier detail that was modeled by our bridge department like Ron indicated. Attached is that drawing in Microstation and Adobe formats. If you want to view the other concrete safety barrier details, you can download them for free at the website below in PDF or DGN format. Hope this helps!

KART service (free login):
<http://kart.ksdot.org>

Thanks,
Scott

Problem # 20 – Retrofit Transition

State Question:

Dear Dr. Faller and Scott,

I was doing some digging around and found this a TTI crash test for a TL-2 beam guard transition to rigid barrier. I was thinking of adding this as a retro fit option for some location where beam guard is directly attached to a rigid barrier.

I was thinking of using the following restrictions for its use:

45 mph or less

Rigid barrier does not slope downward.

Rigid barrier is NJ, F or vertical.

No curb and gutter is installed under the beam guard transition, or between the face of rail and edge of lane.

.

I was also wondering if WisDOT could use this transition as a retro fit for higher speed facilities (55 mph or less), under the assumption that providing a TL-2 system until a facility is fully reconstructed is a more viable option than tearing the whole thing out and installing a TL-3 transition.

What input MwRSF could provide would be appreciated.

Erik

Erik Emerson P.E.
Standards Development Engineer-Roadside Design
Wisconsin Department of Transportation

MwRSF Response:

Erik:

I am somewhat familiar with the TL-2 approach guardrail transition that you have identified. I am attaching a copy of a technical paper that was published on this topic in a Transportation Research Record. The general guidelines that you have noted seem reasonable. There may be situations where this design could be used on higher speed roadways if traffic volumes were sufficiently low, thus warranting the use of a TL-2 barrier system.

I believe that we provided a test level chart in one of our prior reports as a function of traffic volume and speed. That chart was based on work performed for NCHRP project no. 22-8. We may have published that chart in the ZOI-Barrier Attachment Report or the Guidelines for Bicycle-Pedestrian Facilities Report.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 21 – South Dakota Snow Gate Modifications

State Question:

Bob,

Our district staff would like to install a modified version of the South Dakota snow gate (See attached “SD Snow Gate.pdf” and “TRP-03-44-94.pdf”). However, they are proposing some modifications to the base:

1. They would like to use a screw-in Chance Lighting Foundation (See attached “11242ng4 Model (1).pdf”).
2. They would like to use the Transpo Pole-Safe – Model 4100 frangible bolts. (See attached “Pole-Safe 4100 Details.pdf” and “Pole-Safe Skirt Details.pdf”).

They have some other thoughts regarding signing and lighting attachments as well as an alternate method of storing the gate in its road open condition. I will pass along information for those items as I receive it, but they would like to begin installing the foundation next Monday.

Would you please review the attached “SD_SnowGate_Mod.pdf” and verify that these modifications will not affect the crashworthiness of the system? Please comment also on the grading as shown. (Sorry for the short notice).

Let me know if you have any questions.

We received the below response from Transpo. Do you have any comments on the information they’ve provided?

“The original model PoleSafe 201 had a tensile strength of 24 kips and the new 4100 has a tensile strength of 49.8 kips. Both models had a restrained shear strength of 5.5 kips. With this said what it means is that the new PoleSafe couplings are twice as strong in tension and have the same breakaway strength as the 201 couplings. The new couplings should actually perform better than the old 201 couplings in that they will be able to support the gate in the open position with much less stress on the couplings.”

Mike

Thanks,

Jonathan P. Marburger, P.E.
Road Squad Leader
KDOT-Bureau of Design

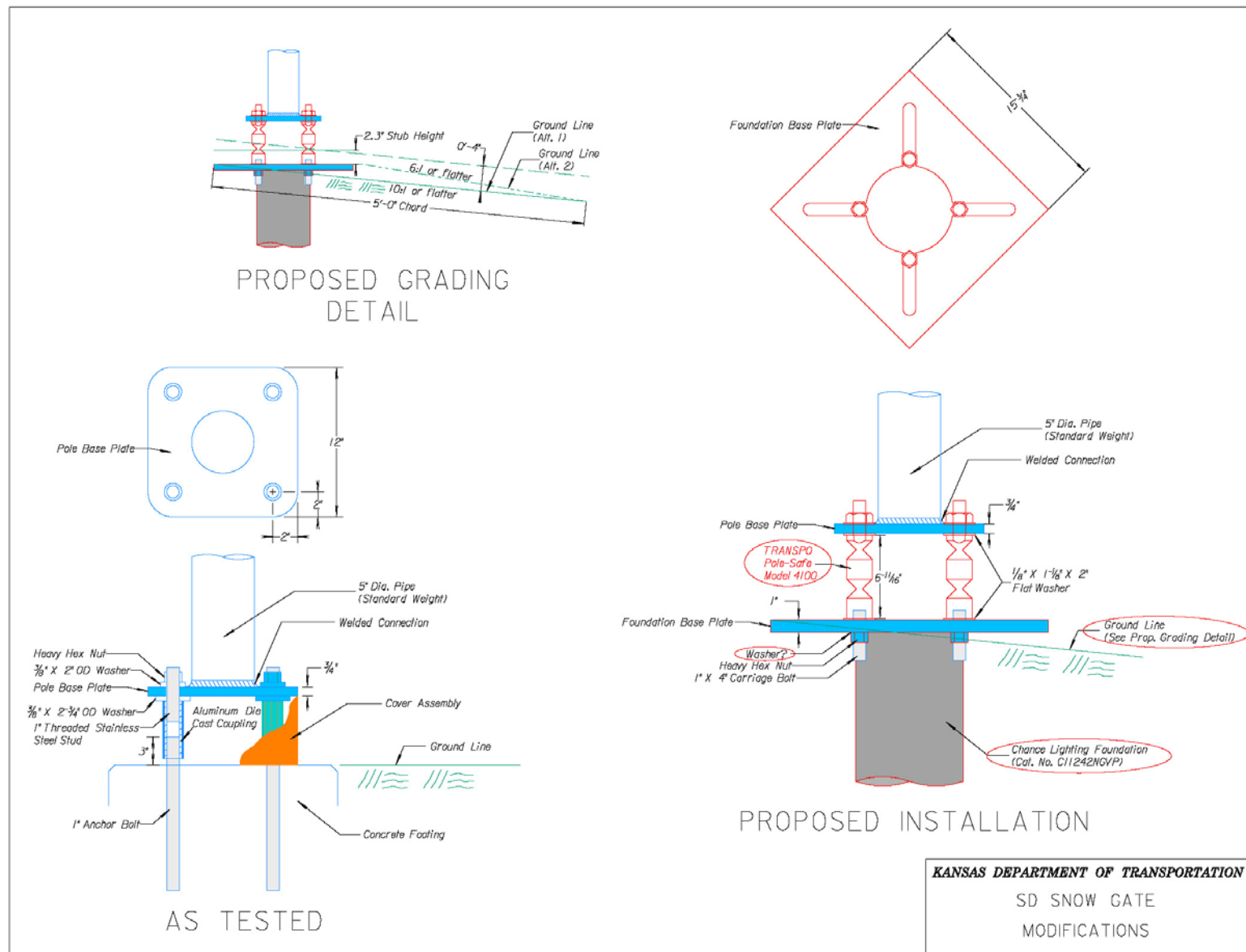


Figure 10. SD Snow Gate – Proposed Modifications

MwRSF Response:

Hi Jonathan,

I have reviewed your proposed changes to the snow gate design. The changes you propose create two main issues with respect to the performance of the snow gate.

1. Coupler equivalency - You are proposing to change from the Pole-Safer 201 couplers that were used in the tested design to the Pole-Safe 4100 design. In order to replace the couplers from the original tested design, we need to verify that the Pole-Safe 4100 couplers perform in a similar manner and would break away without increasing the occupant risk limits of the design. I have looked up the approval letters for both coupler designs, but they do not contain sufficient information to evaluate the couplers. As such, we would recommend that you contact Transpo for guidance on the replacement of the coupler. If they can show that the coupler design would work similar to the Pole-Safe 201 for a short, heavy break away device, then use of the Pole-Safe 4100 would be acceptable.

It appears that Transpo has stated that the Polesafe 4100 and 201 models have equivalent breakaway loads. Thus, it would be acceptable to use the 4100 model in your modified design. The only way to further evaluate this would be to compare the velocity change for tests of short, heavy poles from testing of both the 201 and 4100 couplers.

2. Foundation design – Your new design also replaces the original 2' diameter x 3' deep concrete footing with a 8.6" diameter x 5' long Chance Lighting foundation. The concern here is that the small diameter foundation may rotate in the soil prior to developing sufficient loads to cause the couplers to break. The original foundation was significantly wider and thus would be expected to develop the soil forces more quickly. There is some concern that movement of the foundation would affect the coupler performance and potentially impede the proper breakaway mechanism. In order to alleviate these concerns, we would recommend a foundation analysis (LPILE or some other method) to determine the relative stiffness of the two foundation alternatives. This should provide enough confidence to use the new foundation if the results are similar.

The use of the 10:1 grading shown is not a cause for serious concern in our eyes.

Thanks

Problem # 22 – Thrie Beam Height Guidance**State Question:**

Hi Ron,

Are you aware of any minimum and/or maximum allowable height guidance for thrie-beam guardrail?

Thanks,

-Chris

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Chris Poole, P.E.
Roadside Safety Engineer
Office of Design

MwRSF Response:

I am not aware of a documented height tolerance for thrie beam guardrail systems. Initially, one may attempt to argue that the minimum height could be as low as that corresponding to W-beam guardrail systems. However, I would suspect that mounting thrie beam with a top height of 27¾ in. would potentially increase the propensity for vehicle climb, barrier override, and/or rollover upon redirection due to the increase face below normal W-beam rail with same top height.

At this time, the roadside safety community has considered the minimum top height for W-beam rail to be approximately 27¾ in., while the maximum top height for the MGS is 32 in. At the minimum W-beam top height, a thrie beam element would extend downward to 7¾ in., thus potentially creating new safety risks. Selected thrie beam guardrail systems have successfully met crash testing guidelines when installed with a top height of 34 in. As such, it is my opinion that the minimum height tolerance for modified thrie beam guardrail may be somewhere around 31 in. for NCHRP 350, while the top height tolerance may be closer to 39 to 40 in. at the TL-3 impact conditions.

Thrie beam has been successfully crash tested over the years. Below, I have provided a few of the test results but not those for the T-39 thrie beam guardrail system.

<u>Test No.</u>	<u>System Description</u>	<u>Top Rail Height</u>	<u>Result</u>
404211-5a	Modified Thrie Beam w/ 81" Steel Post & Tapered Block	34"	Passed 8000S TL-4 test
404211-11	Strong-Post Thrie Beam w/ 81" Wood Post & Wood Block	31.65"	Passed 2000P TL-3 test
404211-10	Thrie Beam w/ 81" Steel Post and Routed Wood Block	31.65"	Passed 2000P TL-3 test
471470-31	Thrie Beam (G9) w/ 78" Steel Post and Steel Block	32"	Failed 2000P TL-3 test
471470-30	Modified Thrie Beam w/ 81" Steel Post and Tapered Block	33.6"	Passed 2000P TL-3 test
Recent Test	Thrie Beam (G9) w/ 78" Steel Post and Full-Depth Wood Block	31.5"	Failed 2270P TL-3 test (MASH)

Although I have yet to see the results of the recent failed MASH test, it would seem reasonable that improved safety performance could be obtained by using a shortened wood blockout or the modified steel tapered (collapsible) blockout – both of which reduced climb and allow the lower corrugation to fold back.

Please let me know whether you have any questions or comments regarding the information contained herein.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 23 – Texas HT Barrier ZOI

State Question:

Hi Ron,

I am trying to establish a TL-5 ZOI chart for the Texas HT barrier, based on the 80,000 pound truck test that was performed by TTI back in 1984. Would you be able to provide me with such a chart, or supply me with the materials I would need to develop the chart on my own?

Thanks,

-Chris

Chris Poole, P.E.
Roadside Safety Engineer
Office of Design

MwRSF Response:

Chris,

The crash test for the 50 in. tall combination rail (test no. 2416-1) provides limited answers to the ZOI question. First, the barrier installation was not long enough to redirect the truck or allow it to stabilize before it reached the end of the system. As such, the cargo box continues to roll/ lean onto the barrier more and more until the barrier ends and the vehicle rolls onto its side. Thus, the maximum lateral extent can only be observed during the time of contact. Also, the camera views are not ideal as the overhead does not capture the downstream end of the barrier and the downstream camera is not directly in line with the barrier. This makes getting accurate distances from the test difficult and getting the vertical locations of the box as it rotates very difficult.

What I was able to gather from the test was a maximum lateral distance behind the barrier of approximately 4.5 ft. ZOI has typically been shown by dimension based on the top front of the barrier, so this extension would be 5.5 ft from the front of the steel tube (to be conservative you could use 6 ft).

Also, the height of the barrier prevented the bottom of the box from getting over and behind the rail, so the ZOI would not need to extend below the top of the rail as was recommended in the TL-4 ZOI.

I hope this helps. Sorry for the lack of information available on this issue.

Scott Rosenbaugh
Midwest Roadside Safety Facility (MwRSF)

University of Nebraska – Lincoln

Problem # 24 – Texas HT Barrier ZOI – Part II

State Question:

Scott,

Should I assume the 5.5-foot ZOI extends all the way up to 13.5 feet above the ground? Or do you think the maximum lateral extent of the truck occurred at some height below 13.5 feet?

We may consider limiting intrusion by raising the height to the top of the railing. Do you have any “rules of thumb” that we could use to estimate how much the intrusion would be reduced for each additional inch of barrier height?

Thanks,

-Chris

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Chris Poole, P.E.
Roadside Safety Engineer
Office of Design
Iowa Department of Transportation

MwRSF Response:

Chris,

The maximum lateral extent was lower than the top height of the box when the vehicle was at rest (I’m assuming that distance is the 13.5 ft you are referring to). However, the vertical position of the box is not easily obtainable from the test video. Also, since the box slid off the barrier and rolled onto its side before it had a chance to right itself (return to an upright position), the path of the box on its return is unknown – and very well could be more critical than the path to maximum extent. Therefore, I would recommend treating the max lateral distance as the boundary for all heights – ZOI would be a box of width 5.5 ft. We just don’t have enough data to better define the ZOI.

There is not a rule of thumb to adjust the lateral extent of the box. We simply do not have the data from multiple TL-5 tests at multiple heights to establish such a relationship. Also, be carefull raising the height of the barrier. Extending the height of the steel rail without raising the height of the concrete parapet with it (extending the rail support posts) will reduce the strength of the rail and possibly lead to failure of the support posts and/or anchor bolts.

Scott Rosenbaugh

Midwest Roadside Safety Facility (MwRSF)
University of Nebraska – Lincoln

Problem # 25 – Traffic Signal Pole Exemption and TCB Transition Cap

State Question:

Phone call from Erik Emerson. Response and questions addressed by email.

MwRSF Response:

Hi Erik,

I have some information on the items we discussed on the phone today.

First, you requested If we had any information on the reasoning behind traffic signal poles in the median having an exemption from requiring they be protected. While it would be best to protect all median hazards, there are some arguments that have been made to exempt traffic signals.

1. First, traffic signals serve to control accidents at intersections. Thus, if the signals were allowed to breakaway or disengage when impacted, the loss of the signal could cause secondary collisions that were more severe than impact of a single vehicle with the traffic signal support.
2. Second, if the intersection is functioning properly, the speeds of vehicles approaching the signal support would often be decreasing or reduced as compared to remainder of the roadway.
3. Third, traffic signal supports located in the median can only truly be shielded from one direction of traffic, shielding from both directions would require that shielding extend from the support into the intersection. This is not feasible.

I also looked into your questions regarding the overhanging piece of steel on the TCB median barrier approach transition cap. On the tested system, we designed the cap to match the slope of the sides of the PCB section. Because the tops of the PCB section and the median barrier were not aligned, the cap had an overhanging piece of steel on the oncoming traffic side. This piece is not required for cap designs that match up to barriers of different widths or heights. Changes in the height of the median barrier will require a different cap design. We would require the following.

1. All cap designs use the same vertical slope for the cap as the tested design.
2. The sides of the cap should match the side slope of the F-shape PCB segment.
3. If the cap is longer than the tested cap design, intermediate anchorage should be provided on the side of the cap at the midspan length to provide additional anchorage.

I have attached details for a representative cap for a transition from 32" PCB to the Wisconsin 56" single slope.

Bob Bielenberg, MSME, EIT
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rbielenberg2@unl.edu

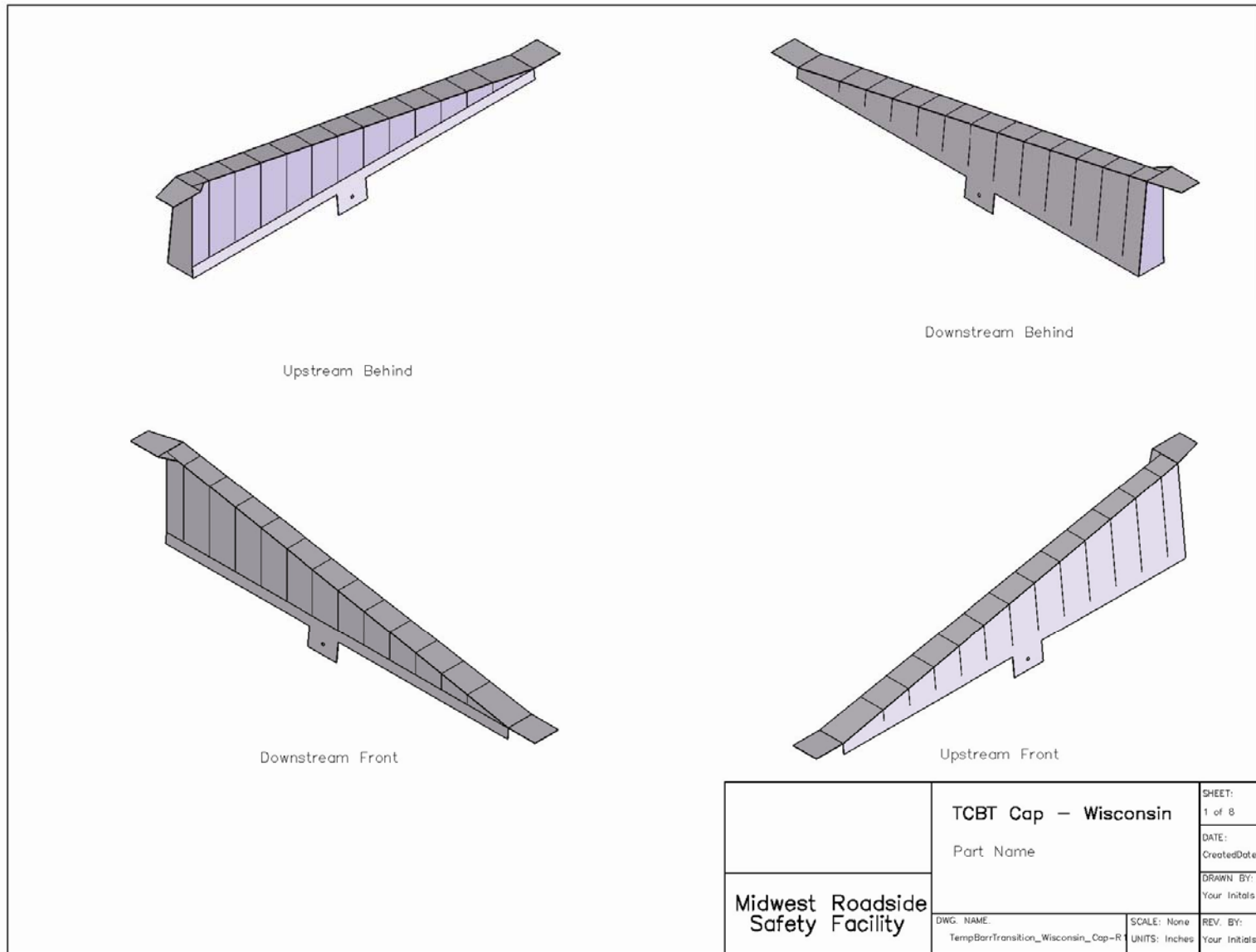


Figure 11. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier

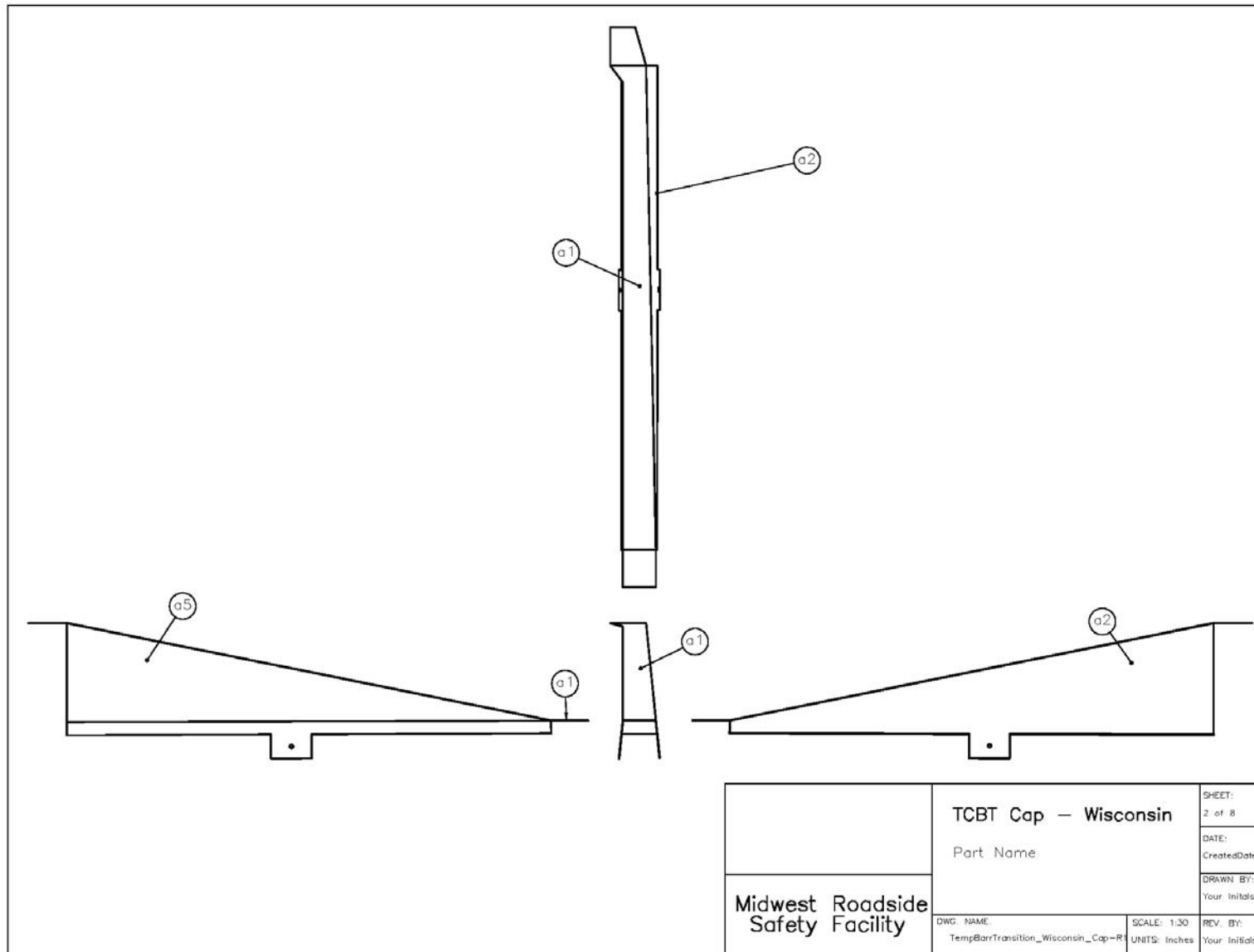


Figure 12. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier

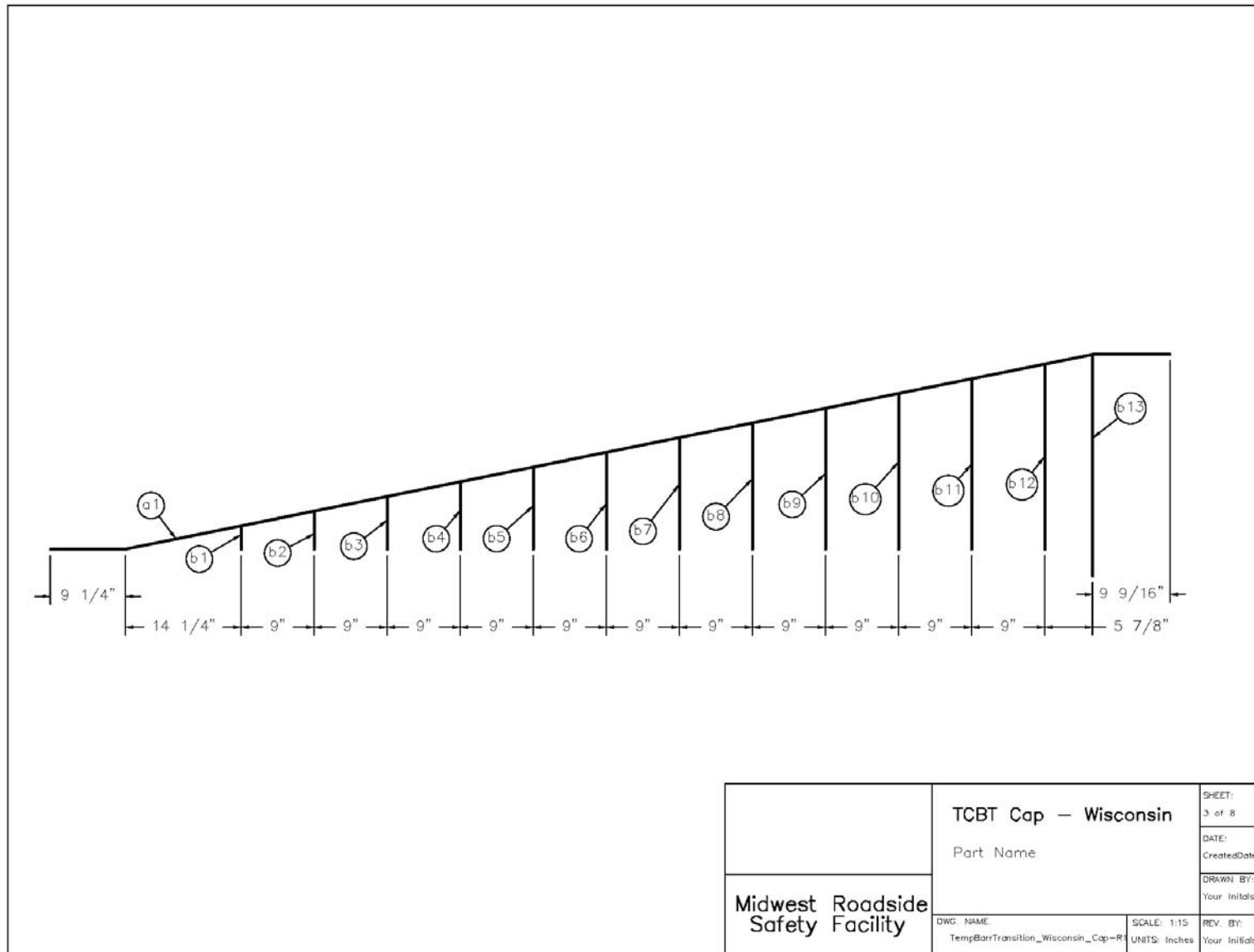


Figure 13. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier

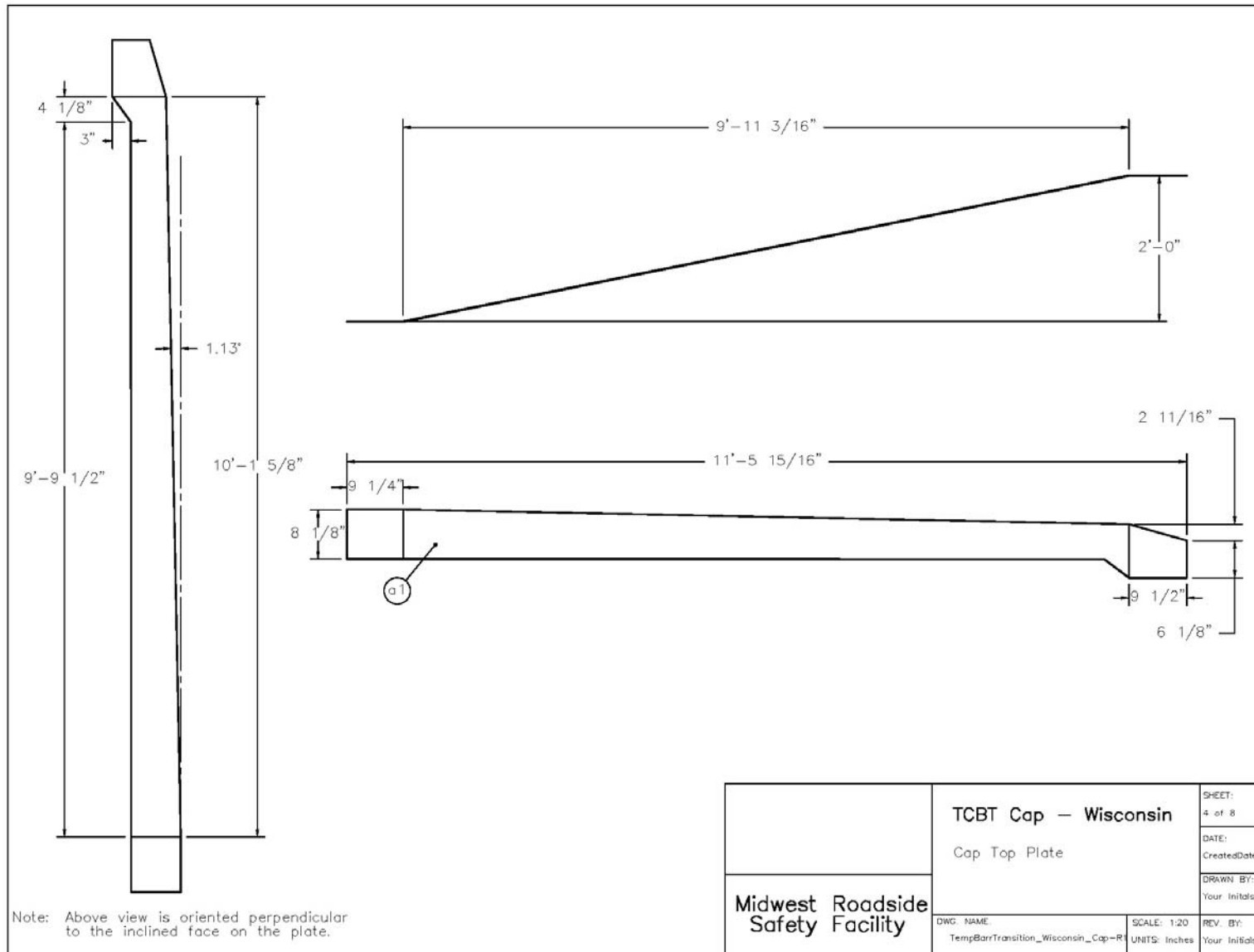


Figure 14. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier

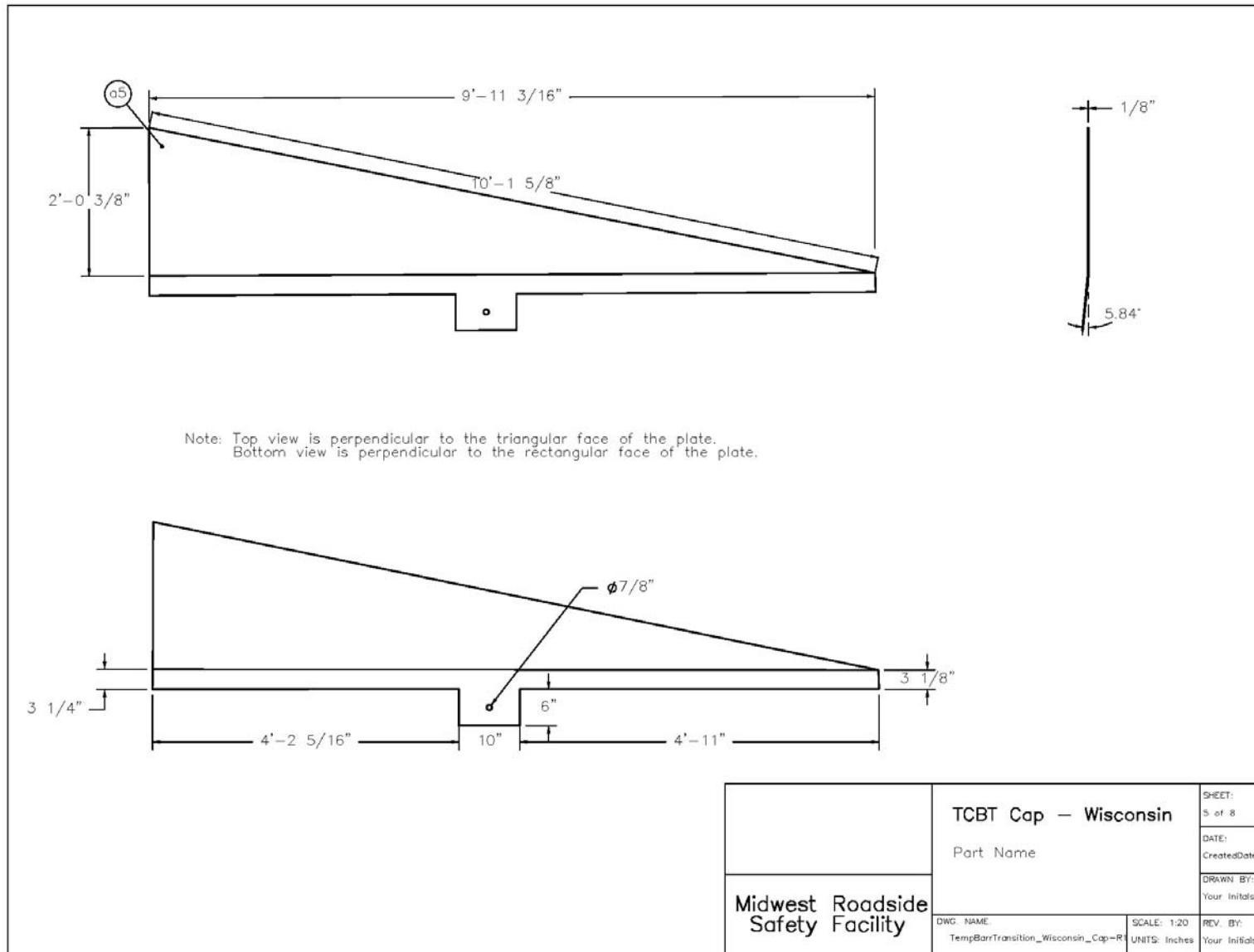


Figure 15. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier

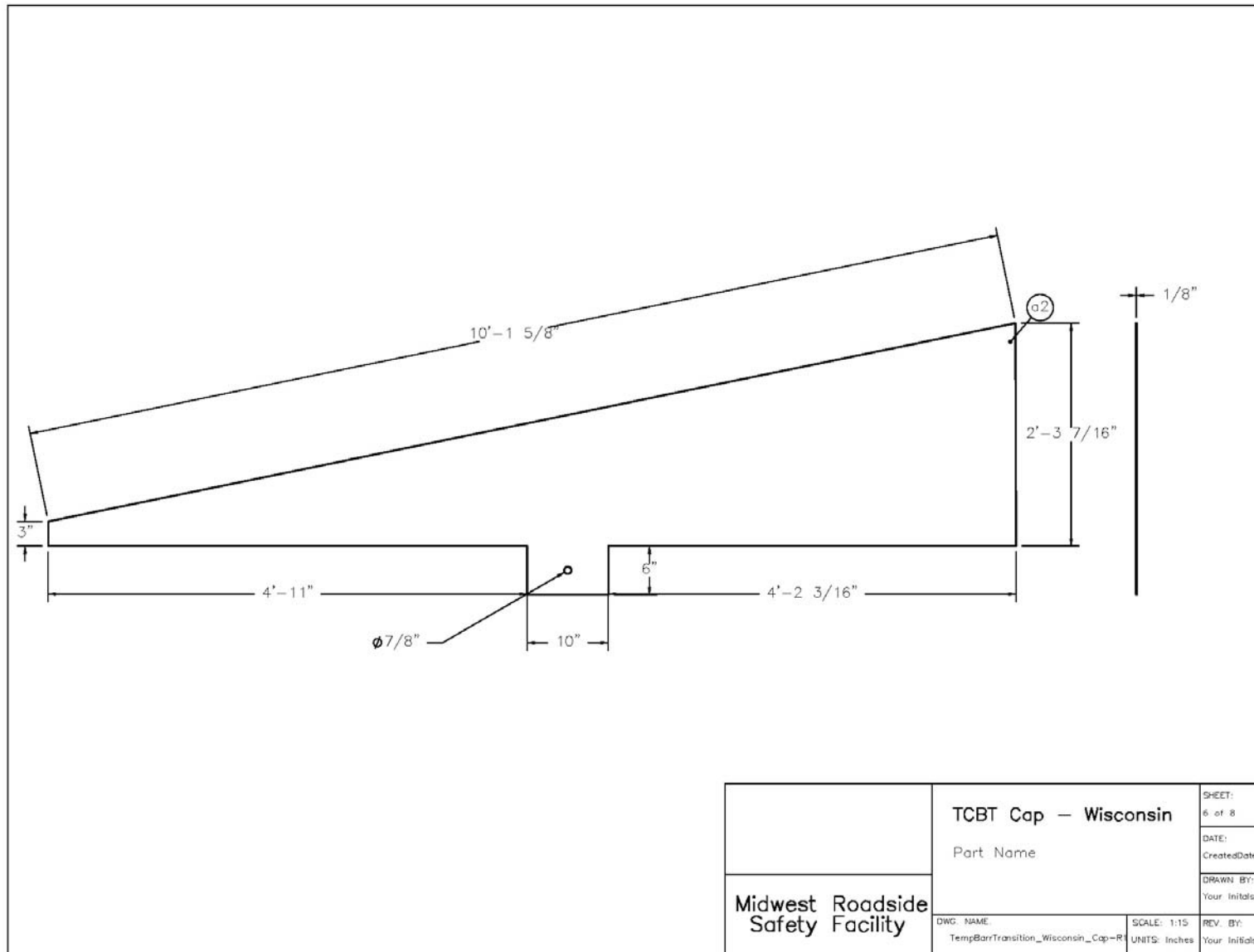


Figure 16. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier

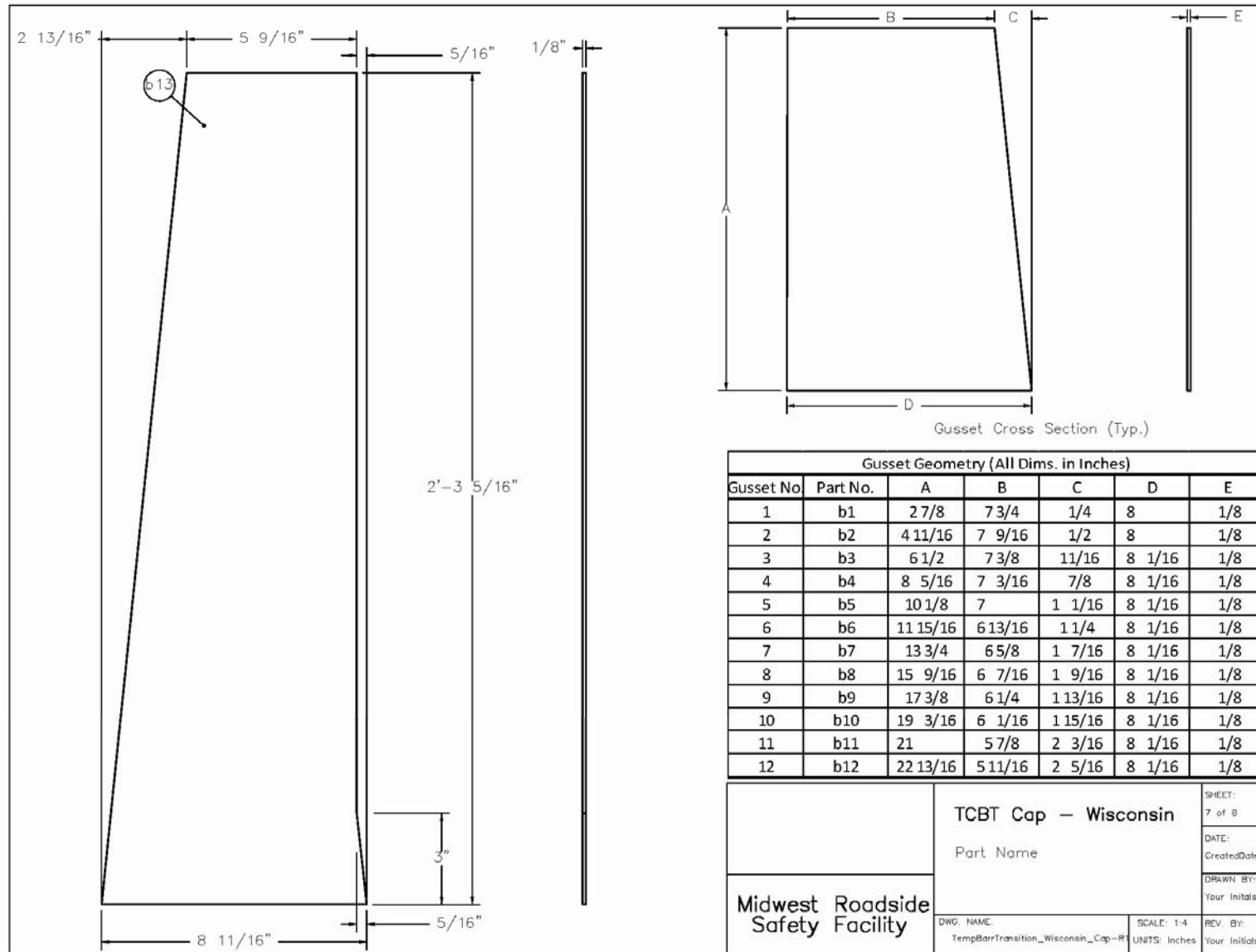


Figure 17. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier

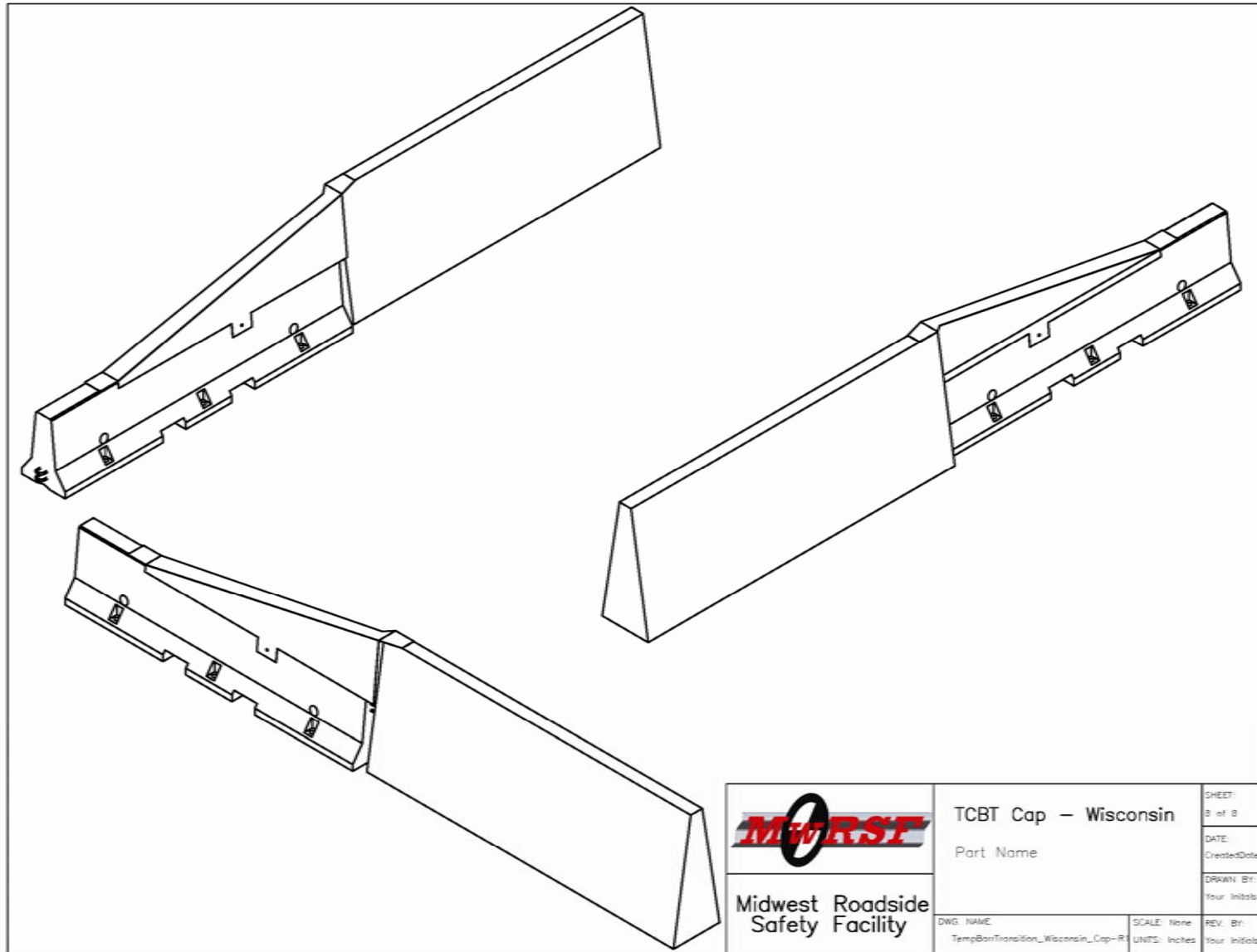


Figure 18. Transition Cap for 32" PCB to the Wisconsin 56" Single Slope Median Barrier