**Progress Report**
**Fourth Quarter 2007 through First Quarter 2008**
Midwest Roadside Safety Facility
Mid-States Regional Pooled Fund Program
March 17, 2008

## Projects with Full-Scale Crash Tests in Past Quarters

### Development of a TL-4, Four-Cable, High-Tension, Barrier System for 4:1 V-Ditch Applications

Two full-scale tests were completed on the high-tension cable barrier system during the 4$^{th}$ Quarter of 2007. Excavation of the v-ditch and construction of the barrier system were completed. Three full-scale crash tests were planned to verify the safety performance of the new system in a V-ditch while utilizing update vehicles (1 @ 1100C, 1 @ 2270P and 1 @ 10,000S). The first test of this system was successfully performed on October 30, 2007 using a 2270P vehicle. The cable barrier system was reconstructed and made ready for a subsequent crash test. The second test was performed with an 1100C vehicle on November 15, 2007, where a significant longitudinal occupant impact velocity was encountered along with severe wheel rutting in the soil.

Previously, Pooled Fund members were asked for comment on 1100C test results. Per those discussions, MwRSF was recommended to seek preliminary FHWA approval of the system based on the current test results. Discussion has occurred with member states on whether to re-run the 1100C test in order to evaluate the propensity for vehicle underride with a more-firm soil condition or move on to other testing. MwRSF will await FHWA's response.

### Standardizing Posts and Hardware for MGS Transition

Phase I bogie testing was completed in this period and on W6x15 steel posts and 8"x8" wood posts. BARRIER VII computer simulation modeling of several prototype system designs was completed. Two designs were submitted to the States for review and comment as well as to obtain input as to which design variation to crash test. Per the States input, a more aggressive design option (Design K) was selected. On January 28, 2008, Test Designation No. 3-21 was conducted under the proposed Update to Report 350 (MASH 08) with a Dodge Quad Cab pickup truck impacting the simplified, steel-post transition design at a speed of 61.7 mph and at a target angle of 25 degrees. During this test, the upstream anchor released, thus resulting in vehicle pocketing which lead to excessive longitudinal occupant ridedown accelerations. As a result, the safety performance of this design was found to be unacceptable. Sequential photographs and documentary photographs are provided at the end of this file.

Following a review of the high-speed videos and damaged barrier hardware, several potential factors affecting the unsatisfactory outcome were observed. First, BCT wood post no. 1 was observed to release due to post fracture. A closer inspection of post no. 1 revealed significant checking through the wide faces of the post along with a critically placed knot on the upstream, back-side corner of the post, just above the steel cable anchor plate. Upon review of the test results, it is believed that the BCT post with checks and a critically-placed knot contributed greatly to the test failure. Second, the steel foundation tube supporting BCT wood post no. 1 was not found to have displaced during the test. This result could have been due to either inadequate load imparted to the foundation tube prior to wood post fracture or a stiffer than normal soil material compacted around the foundation tube. Although an overly stiff foundation tube could increase anchor loading, we believe that this condition would have had only a minor contribution to the failed post and test, since much higher anchor loadings have been observed during prior 2000P tests on the high flare rate MGS designs. Third, Detail K was selected by the States over Detail L due to it being a less costly design (one less steel post) even though it was a more aggressive design. When impacted, Detail K was predicted to result in increased barrier deflection and vehicle pocketing as compared to Detail L. With an increased propensity for vehicle pocketing, combined with greater barrier deflections, it is believed that the selection of the more aggressive design, Detail K, modestly contributed to the failed test. However, it should be noted that FEA modeling of the two modified designs revealed a propensity for both increased vehicle pocketing and barrier deflections as compared to the original acceptable design.

MwRSF recommends that a re-test be performed on a modified design yet to be determined. Project funding is only available for the 1100C sedan test and not a 2270P re-test. Therefore, MwRSF needs direction on whether to conduct the re-test using remaining project funds with the knowledge that new 2270P funds will be provided in the Year 19 Pooled Fund Program. Please note that the wood post alternative cannot be developed until the simplified, steel-post alternative has been successfully verified through crash testing.

## Projects with Pending Full-Scale Crash Tests

### Testing of Cable Terminal for High Tension Cable (1100C & 2270P)

Work on this project will commence after crash testing is completed on the high-tension, four cable barrier system. It is planned to adapt the breakaway cable lever arm technology, developed during the low tension testing, into the high-tension barrier system.

### Performance Limits for a 6-in High, AASHTO Type B Curb Placed in Advance of the MGS

Four high-speed vehicle tests into curbs were performed in October 2007 in order to evaluate vehicle trajectory. This test data was utilized as input to the modeling effort for the project as well as to determine the critical lateral offset for placement of the MGS behind the curb for both 1100C and 2270P vehicles. To date, an analysis of the test results has revealed that a 4-ft lateral offset be used for the first 2270P crash test and with using the standard MGS height relative to the toe of the curb. The first crash test is planned for early April 2008. Following this test, discussions on future testing will be required, hopefully occurring at the April Pooled Fund meeting.

### Phase I Development of a TL-3 MGS Bridge Rail

A literature review, brainstorming, and the development of preliminary design concepts had been completed in the First Quarter of 2008. CAD details are being prepared for two preferred concepts. Dynamic bogie testing of these concepts is planned for late March 2008. Refined concept development and bogie testing will occur in April 2008. Phase II project funding will be needed in the Year 19 Pooled Fund Program to continue this effort, including funds for the construction of the simulated deck, bridge rail, and full-scale crash testing program.

### Development of a Temporary Concrete Barrier Transition

After surveying the States, a 42” high, single-slope permanent concrete barrier was selected for this study. This barrier was deemed the practical worst case barrier for use in the crash testing program. CAD details for the transition design have been prepared. Currently, MwRSF is constructing the permanent single-slope barrier section to be used with F-shape TCBs. An asphalt pad has been placed for supporting and anchoring the TCBs. LS-DYNA FEA has been performed to determine the critical impact points for the 2270P tests. Two 2270P tests are planned for April 2008.

## Paper Studies

### Cost-Effective Measures for Roadside Design on Low Volume Roads

A field trip to document roadside hazards found along low-volume roads was previously completed in Kansas. More recently, additional field trips have been made to two Nebraska counties to find typical hazards on similar roads. Detailed documentation of the hazards has been performed. It is anticipated that RSAP analyses of 4 or 5 of the most common hazards can be completed under the current study. The first hazard to be evaluated is safety treatment of large cross-drainage culverts. Many of these culverts are currently treated with ineffective concrete post and beam bridge railings without any approach guardrails. Treatments to be considered for these hazards include removing any existing railing, erecting a long span guardrail system, and constructing culvert safety grates. An RSAP benefit-to-cost analysis has been undertaken to evaluate each of these three alternatives. Preliminary results on this feature type are expected by the end of April 2008. Other feature categories are to be analyzed in the 2$^{nd}$ through 4$^{th}$ Quarter of 2008.

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

To date 19 systems have been submitted to TF-13 for review and approval. Ten systems were approved for the Guide at the September meeting. Nine more were submitted for review in September. The MwRSF has still not received comments from TF-13.

### Development of Warrants for Median Barrier System

This project has encountered a number of setbacks. The primary problems have been related to quality control during construction of the original data base and difficulties associated with determining the numbers of unreported median crashes. Thorough cross checking and rechecking of the data base has been undertaken and will be completed shortly. It is believed that all quality control problems will then be resolved. The number of unreported median crashes is needed in order to estimate the number of barrier crashes that can be expected whenever a median barrier is installed. Unfortunately, it appears that the only way to produce this estimate is from an encroachment probability model such as RSAP. It is therefore proposed to utilize RSAP to estimate barrier impact frequencies. Barrier crash severities will be obtained from the Missouri DOT study of median barrier crashes. Note that the MoDOT data also provides a ratio of reported barrier crashes to numbers of barrier repairs. This information will be used to adjust average barrier crash severity to account for unreported accidents. Historical cross-median crash data from Kansas, RSAP barrier impact frequencies, and average barrier crash severities will then be combined to estimate the accident costs associated with unprotected and protected medians. It is estimated that this study will produce preliminary findings by the end of this quarter or early next quarter.

### Cost Effective Upgrading of Existing Guardrail System

The literature review of historical W-beam accident studies has been completed. A listing of W-beam guardrail installations has been obtained from Kansas for use in the RSAP study. These sites will soon be surveyed to document selected guardrail installations. The field investigation process is planned for April or May 2008.

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

### Iowa RSAP Analysis of Culvert Treatments

The RSAP analysis of safety treatments for cross drainage culverts has been completed. The analysis examined the safety performance of untreated culverts, extending the culvert out of the clear zone, installing safety grates, and shielding the hazard with W-beam guardrail. The variability in construction costs for extending culvert grates forced this study to focus on identifying accident costs associated with each treatment alternative. Accident costs for each alternative were tabulated for a wide variety of roadway and roadside characteristics. Highway designers can use these tabulated accident costs to calculate benefit-to-cost ratios for each of the safety treatments studied. The analysis appeared to indicate that the use of culvert safety grates was most appropriate for low and medium volume roadways, while culvert extension appeared to provide the most cost beneficial alternative for some high volume facilities. The draft final report is under review by the Iowa DOT.

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

The project objective is to develop a TL-4, aesthetic, open concrete bridge railing for use on cast-in-place decks as well as precast deck panels. Thus far, researchers have iterated through the design of several concepts based on input from sponsors, industrial partners, and design team members. This effort has taken much greater time and resources than envisioned to work toward the final open concrete rail detail. Subsequently, consideration was given to the connection detail between precast rail sections. Once again, much effort was expended in this design phase. Dynamic testing of two joint details was performed in September 2007. Following an analysis of the test results, it was determined that modifications were necessary to the initial joint concepts. Two modified joint details, along with a new concept, were configured for another round of bogie impact testing. Fabrication of the three joint details is in progress by the PCAN partners. Dynamic testing of these joints is planned for April 2008. Dynamic impact testing of a single rail section attached to a short section of cast-in-place deck is also planned. Construction of the bridge beam has been completed. The deck section should be cast in April or May 2008. Fabrication of the 16-ft long, single rail section is to occur following a meeting with NDOR officials, TAC members, PCAN partners, and MwRSF/UNL project team members.

**Evaluation of Box Beam Stiffening of Temporary Concrete Barrier (New York DOT)**

In 2007, three 2270P full-scale vehicle crash tests were performed on the NYSDOT temporary concrete barrier system using the proposed MASH 08 guidelines. Three barrier systems were evaluated. The first test used the NYSDOT TCB with 6-in. x 6-in. tubes across three joints and pins in the end barrier sections. The second test used the free-standing NYSDOT TCB with pins in the end barrier sections. The third test used the NYSDOT TCB with 8-in. x 6-in. tubes across six joints and pins in the end barrier sections and with the system placed 12-in. from a free edge. A comparison of barrier deflections was made. A final report is being prepared to include several rounds of comments from NYSDOT and is expected to be completed by mid-March 2008.

**Qualification of Type II and Type I End Terminals for Box Beam (New York DOT)**

In 2007, three 1100C full-scale vehicle crash tests were performed on two NYSDOT box beam terminal systems. For the first design, vehicle rollover resulted in an unsuccessful test. On the second design, two successful tests have been obtained thus far, with additional testing required in order to complete the certification process. Project funding has been nearly expended, while a draft report is in progress on the existing three tests.

**Universal Breakaway Steel Post for Guardrail (Minnesota DOT)**

A new, breakaway steel post option is under development and designed for use in thrie beam bullnose barrier systems as well as other longitudinal barrier applications, such as guardrail end terminals and long-span guardrail systems. The post would be considered an alternative to existing wood CRT posts. In order to better develop a steel post alternative, six dynamic bogie tests have been performed on CRT wood posts placed in a rigid sleeve and under varying impact orientations. Two bogie tests have been performed at each angle orientation – 0, 45, and 90 degrees. A report documenting these findings has been prepared and is under review and comment by the sponsor. In addition, several breakaway concepts have been brainstormed and designed, with CAD details prepared. Dynamic impact testing of the initial concepts is underway and should be completed by March $17^{th}$. Data analysis and concept refinement is planned for completion by the $2^{nd}$ Quarter of 2008. Two full-scale vehicle crash tests are planned for the $3^{rd}$ Quarter of 2008.

**Development of a Test Level 1 Timber Curb-Type Railing for Use on Transverse, Timber, Nail-Laminated Deck Bridges (West Virginia DOT)**

The project consists of adapting and modifying a crashworthy TL-1 timber bridge railing system for use on nail-laminated, transverse timber deck bridges, while using the proposed MASH 08 guidelines. A sloped end section is also to be developed for rural, low-speed, low-volume applications. Five static tests and one 2270P crash test are planned. Design details have been prepared and are under internal review. Selected construction materials have been ordered, including glulam rails, dimensional deck boards, and selected structural steel hardware. Construction of the timber bridge deck is planned for the 2nd Quarter of 2008. Static testing is also planned for the 2nd Quarter, while the 2270P full-scale crash test is planned for the 3rd Quarter of 2008.

**Development of a Test Level 2 Steel Bridge Railing and Transition for Use on Transverse, Timber, Nail-Laminated Deck Bridges (West Virginia DOT)**

The project consists of adapting and modifying a crashworthy TL-2 steel bridge railing system for use on nail-laminated, transverse timber deck bridges, while using the proposed MASH 08 guidelines. An approved TL-2 approach guardrail transition is to be implemented into the design. Four dynamic bogie tests on posts attached to nail-laminated timber deck bridges will be performed. Testing should demonstrate whether the alternative deck system can withstand the post loading without damaging the deck. Design details will be prepared in the 2nd Quarter of 2008. The bridge deck system used in the TL-1 project will also be used for this study. As previously noted, construction of the timber bridge deck is planned for the 2nd Quarter of 2008.

## Awaiting Reporting

**Evaluation of Transverse Culvert Safety Grates**

The culvert grate on a 3:1 slope performed well with both the 2000P and 820C vehicles. A draft report has been prepared and is under internal review. A TRB paper was presented at the 2008 Annual Meeting of the Transportation Research Board and accepted for publication.

**Approach Slopes for W-Beam Guardrail Systems**

At the conclusion of this testing program, the MGS guardrail system can now safely be located at a 5-ft offset distance from the edge of the traveled way on slopes of 8:1 or flatter. A draft report documenting this research is currently under internal review.

**Retest of the Cable End Terminal**

Based on successful testing of this low-tension, cable terminal system, a draft report of the project has been prepared and is currently under review by the Pooled Fund members.

**Flare Rates for MGS W-Beam Guardrail**

This crash testing program has shown that the MGS can be installed with flares as steep as 5:1, as measured to the traveled way. A report on this project has been prepared and is under internal review. We also prepared a paper for the 2007 TRB meeting based on this project.

**Midwest Guardrail System Placed at the Breakpoint of a 2:1 Slope**

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. The vehicle was safely redirected. A draft report has been prepared and is under internal review. A TRB paper was presented at the 2008 Annual Meeting of the Transportation Research Board and accepted for publication.

**Modified Three-Cable Guardrail Adjacent to Slope**

The low-tension, three-cable, barrier system, with an offset distance of 48 in. from the breakpoint of the 1.5:1 slope, and 4-ft post spacing was previously crash tested according to NCHRP Report No. 350. The vehicle was safely redirected. A final report has been prepared.

**Termination of Temporary Concrete Barrier**

An anchor system utilizing 2 driven steel posts and soil plates from the existing cable anchorage system was tested with a 2270P impacting 4' 3.6" upstream of the joint between barriers 1 and 2. The crash test met all salient test criteria. A test report documenting the results will be started in the 2nd Quarter of 2008.

**Development of a TL-3 Reinforced Concrete Bridge Pier Protection System**

A full-scale test of the bridge pier protection system was previously performed in Jul of 2007. The 2000P vehicle impacted the system at 64.8 mph and at 25.65 degrees. The vehicle had minimal contact with the pier and met all other salient criteria. The barrier was designed with a stand-alone concrete footing, design details for end and interior regions, to result in minimal lateral barrier displacement, provide adequate offset from the pier face to minimize vehicle snag, and be considered structurally adequate for the design impact condition. A draft report has been prepared and is currently under review by the Pooled Fund members.

**Draft Pooled Fund Reports Completed**

Rosenbaugh, S.K., Faller, R.K., Hascall, J.A., Allison, E.M., Bielenberg, R.W., Rohde, J.R., Polivka, K.A., Sicking, D.L., and Reid, J.D., Development of a Stand-Alone Concrete Bridge Pier Protection System, Draft Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-190-08, Project No. SPR-3(017)-Year 14, Project Code: RPFP-04-05, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 15, 2008.

Hitz, R.A., Molacek, K.J., Stolle, C.S., Polivka, K.A., Faller, R.K., Rohde, J.R., Sicking, D.L., and Reid, J.D., Design and Evaluation of a Low-Tension Cable Guardrail End Terminal System, Draft Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-131-08, Project No. SPR-3(017)-Years 11, 14, 15, Project Codes: RPFP-01-03, RPFP-04-07, RPFP-05-03, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 28, 2008.

**Final Pooled Fund Reports Completed**

Bielenberg, R.W., Faller, R.K., Rohde, J.R., Reid, J.D., Sicking, D.L., Holloway, J.C., Allison, E.M., and Polivka, K.A., *Midwest Guardrail System for Long-Span Culvert Applications*, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-187-07, Project No. SPR-3(017)-Year 15, Project Code: RPFP-05-04, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 16, 2007.

Eller, C.M., Polivka, K.A., Faller, R.K., Sicking, D.L., Rohde, J.R., Reid, J.D., Bielenberg, R.W., and Allison, E.M., *Development of the Midwest Guardrail System (MGS) W-Beam to Thrie Beam Transition Element*, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-167-07, Project No. SPR-3(017)-Years 11-12 and 16, Project Codes: RPFP-01-04, RPFP-02-05, and RPFP-06-04, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 26, 2007.

Stolle, C.S., Polivka, K.A., Bielenberg, R.W., Reid, J.D., Faller, R.K., Rohde, J.R., and Sicking, D.L., Phase III *Development of a Short-Radius Guardrail for Intersecting Roadways*, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-183-07, Project No. SPR-3(017)-Year 12, Project Code: RPFP-02-02, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 6, 2007.

Rosenbaugh, S.K., Sicking, D.L., and Faller, R.K., *Development of a TL-5 Vertical Faced Concrete Median Barrier Incorporating Head Ejection Criteria*, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-194-07, Project No. SPR-3(017)-Year 15, Project Code: RPFP-05-01, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 10, 2007.

Stolle, C.S., Faller, R.K., and Polivka, K.A., *Dynamic Impact Testing of S76x8.5 (S3x5.7) Steel Posts for Use in Cable Guardrail Systems*, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-186-07, Project No. SPR-3(017)-Year 14, Project Code: RPFP-04-01, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 19, 2007.

Wiebelhaus, M.J., Polivka, K.A., Faller, R.K., Rohde, J.R., Sicking, D.L., Holloway, J.C., Reid, J.D., and Bielenberg, R.W., Evaluation of Rigid Hazards Placed in the Zone of Intrusion, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-151-08, Project No. SPR-3(017)-Year 13, Project Code: RPFP-03-03, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, January 3, 2008.

Thiele, J.C., Bielenberg, R.W., Faller, R.K., Sicking, D.L., Rohde, J.R., Reid, J.D., Polivka, K.A., and Holloway, J.C., Design and Evaluation of High-Tension Cable Median Barrier Hardware, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-200-08, Project No. SPR-3(017)-Years 11, 14, 16, and 18, Project Codes: RPFP-01-05, RPFP-04-01, RPFP-06, and RPFP-08-02, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 25, 2008.

Terpsma, R.J., Polivka, K.A., Sicking, D.L., Rohde, J.R., Reid, J.D., and Faller, R.K., Evaluation of a Modified Three Cable Guardrail Adjacent to Steep Slope, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-192-08, Project No. SPR-3(017)-Year 13, Project Code: RPFP-03-04, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, March 4, 2008.

Stolle, C.S., Polivka, K.A., Bielenberg, R.W., Reid, J.D., Faller, R.K., Rohde, J.R., and Sicking, D.L., Phase IV Development of a Short-Radius Guardrail for Intersecting Roadways, Final Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-199-08, Project No. SPR-3(017)-Years 12 and 18, Project Codes: RPFP-02-02 and RPFP-08-04, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 29, 2008.

**Draft Reports – Projects Funded by Individual State DOT and Routed Through NDOR and/or Pooled Fund Program**

Arens, S.W., Faller, R.K., Rohde, J.R., and Polivka, K.A., Dynamic Impact Testing of CRT Wood Posts in a Rigid Sleeve, Draft Report to the Minnesota Department of Transportation, Transportation Research Report No. TRP-03-198-08, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, January 18, 2008.

Albuquerque, F.D., Sicking, D.L., and Polivka, K.A., Evaluation of Safety Treatments for Roadside Culverts, Draft Report to the Iowa Department of Transportation, Transportation Research Report No. TRP-03-201-08, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 25, 2008.

Stolle, C.J., Polivka, K.A., Faller, R.K., Sicking, D.L., Bielenberg, R.W., Reid, J.D., Rohde, J.R., Allison, E.M., and Terpsma, R.J., Evaluation of Box Beam Stiffening of Unanchored Temporary Concrete Barriers, Draft Report to the New York State Department of Transportation, Transportation Research Report No. TRP-03-202-08, Project No. C-06-17, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, March 3, 2008.

**Pooled Fund Consulting Summary**

Midwest Roadside Safety Facility
November 2007– January 2008

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 –Slopes Near End Terminals**

State Question:

Dear MwRSF,

Earlier this week I had the opportunity to drive through various construction sites that were retrofitting energy absorbing terminals (See attached pictures). One question I had was about the slope just off of the gravel widening near the terminal. In this case the slope is approximately 1.5:1 and the terminal platform is approximately 2' higher than the grass slope. The grass slope is typically 4:1 or flatter. Figure 5.1b, of the Roadside Design Guide would indicate that this is acceptable (see page 2).

Given the instability of a vehicle during impact with the terminal, should this slope be permitted at the terminal?

<<terminal grading question.pdf>>

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MwRSF Response:

Eric,

The attached figure contains current FHWA guidelines for grading around terminals. The green area must be 3:1 or flatter. Our research would suggest that the orange region could be as steep as 3:1, even though FHWA gives a more conservative recommendation. We do not believe that 1.5:1 is acceptable under any circumstance.

Dean


Figure 1. End Terminal Slope

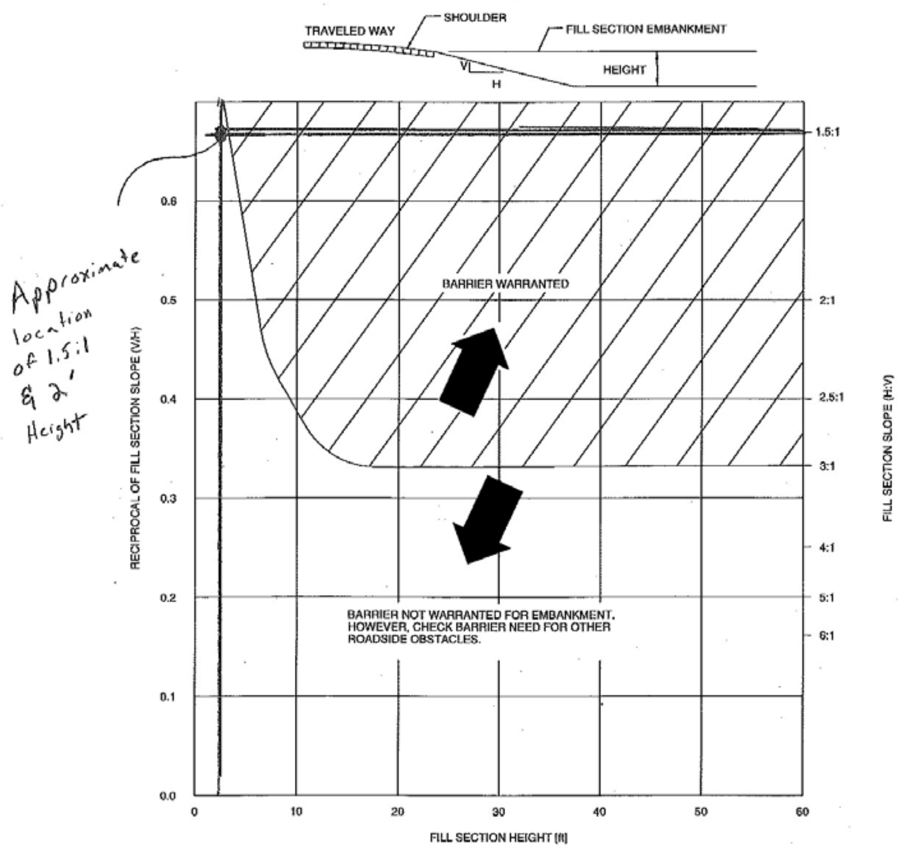



**FIGURE 5.1b Comparative risk warrants for embankments [U.S. customary units]**

cases, the conventional criteria presented in the previous sections cannot be used to establish barrier needs. For example, a major street, highway, or freeway may adjoin a schoolyard, but the boundaries are beyond the clear distance. There are no criteria that would require that a barrier be installed. If, however, a barrier is installed, it could be placed near the school boundary to minimize the potential for vehicle contact. Reference should be made to Section 5.6.1 for lateral placement criteria. Consideration might also be given to installing a barrier to shield businesses and residences that are near the right-of-way, particularly at locations having a history of run-off-the-road crashes.

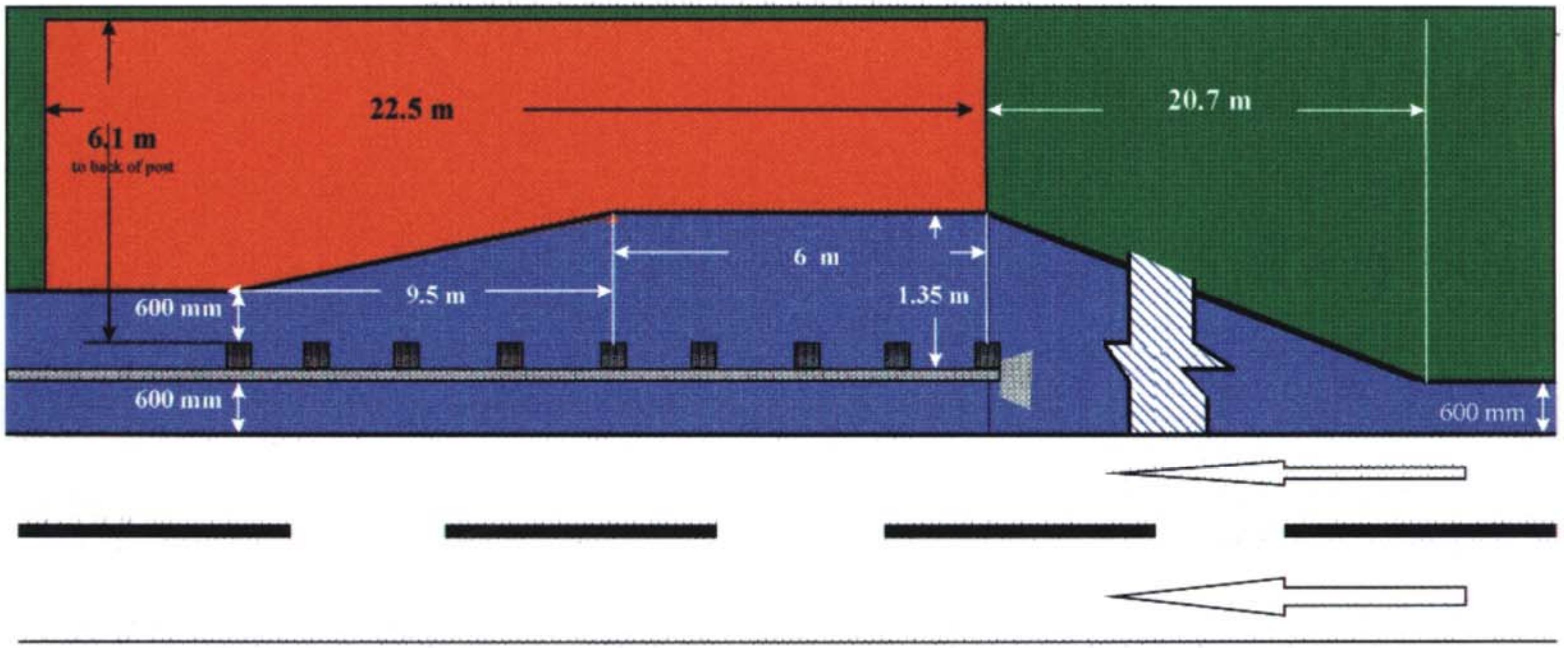
Pedestrians and cyclists are another category of concern that should be given design consideration. The most desirable solution is to separate them from vehicular traffic. Since this solution is not always practical, alternate means of protecting them are sometimes necessary. As in the case of bystander warrants, there are no objective criteria to draw on for pedestrian and cyclist barrier warrants. On low-speed streets, a vertical faced curb will usually suffice to separate pedestrians and cyclists from vehicular traffic. However, at speeds over 40 km/h [25 mph], a vehicle may mount the curb for relatively flat approach angles. Hence, when sidewalks or bicycle paths are adja-





Figure 2. RDG Slope Guidelines

## TANGENT END TREATMENT
## ROADSIDE APPLICATION




1 :4 Traversable Clear Zone (*22.5 m x 6.1 m*)

1:10 Flat Traversable Clear Zone (*preferred 1:15 slope*)

**References:** U.S. Department of Transportation, Federal Highway Administraiton, Technical Advisory T 5040.33 (February 9, 1993)
U.S. Department of Transportation, Federal Highway Administraton, Information: Site Grading Details for Selected Guardrail Terminals (May 22, 1996)

Figure 2. Terminal Slope Guidelines

**Problem # 2 – Establishing Best Practices for the Soil Support for Guardrail Posts on Slopes**

State Question:

Hi Dean,

Since we do not have any standards in the above area outside the needed 2' of soil support behind the guardrail posts, I am trying to establish the best practices for Metro District for guardrail posts adjacent to various slopes.

Sometimes due to the site limitations, we cannot provide the 2' of soil support behind the posts therefore, we need to establish a consistent approach to this issue for the District staff. Andy Halversen came up with the below draft guideline for use in standard soil:

For slopes 1:6 or flatter use 6' posts with 6'-3" post spacing
For slopes steeper than 1:6 to 1:3 use 7' posts with 6'-3" post spacing
For slopes steeper than 1:3 - with posts 1' from shoulder PI use 7' posts with 6'-3" post spacing
For slopes steeper than 1:3 - with posts at the shoulder PI use 7' posts with 3'-1.5" post spacing

Do you agree with the above?

How should we change the above if we have weak soil?

Your input is greatly appreciated.
Mohammad

MwRSF Response:

Hi Mohammad,

Dr Sicking asked me to reply to your questions regarding guardrail installed adjacent to slopes.

We would recommend the following guidelines.

For standard W-beam guardrail:

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

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.

With regards to adjusting the installations for weak soil, we do not recommend adjusting guardrail installations for weak soil types.

Thanks

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**Problem # 3 – Dynamic Impact Testing of W6x9 Steel Post on 2:1 Slope**

State Question:

Dear MwRSF,

I was reviewing our standard drawings for beam guard and reading TRP-03-165-07 "Dynamic Impact Testing of w152x13.4 (W6x9) on 2:1 slopes". In that report, it is recommended that the W6x9 should be embedded 76 inches into the ground for the MGS system when the 2:1 is flush with the post.

This has generated two questions:

1. Should this embedment depth be used on non-MGS systems installed on 2:1?
2. Would this also apply to wood post installed on 2:1?

My first guess is that the embedment depth would be 76 inches for non-MGS systems, and for wood post installed on a 2:.

As always, thank you for your help.

Erik Emerson P.E.

Standards Development Engineer
Wisconsin Department of Transportation
4802 Sheboygan Ave.
Madison, WI 53707-7916
608-266-2842
608-267-1862 (FAX)

MwRSF Response:

Erik:

For non-MGS systems (i.e., standard metric height W-beam guardrail), the center of the W6x9 steel post is to be placed at the slope break point using 7-ft long posts spaced 3-ft 1 1/2-in. on centers. The MGS design utilized 9-ft long posts at the standard post spacing. In order to make the argument for wood posts, I believe that it would be important to perform a limited number of dynamic bogie tests using 7, 8, and 9-ft wood post lengths in a sloped soil pit.

Ron

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

Midwest Roadside Safety Facility (MwRSF) University of Nebraska-Lincoln
527 Nebraska Hall
Lincoln, Nebraska 68588-0529

(402) 472-6864 (phone)
(402) 472-2022 (fax)
rfaller1@unl.edu

**Problem # 4 – MGS construction project issue**

State Question:

Ron,

We happened upon the following issue on one of our MGS construction projects last week (see photo). The existing guardrail posts are bolted into the "retaining wall" below the pavement (plans of the wall are attached). This was designed to allow for a narrow ditch section directly behind the edge of pavement, with drainage allowed through openings in the curb.

This situation exists for approximately 200 feet, and MGS is being installed continuously on both sides of this location. This is in an area of shallow bedrock, which the retaining wall is keyed into.

I am seeking your opinion on how to address this situation.  Would you recommend bolting the MGS posts to the wall, as was done previously?  Or would we be able to place the posts independent of the wall?  Would thrie-beam be appropriate here, or would standard W-beam be sufficient?

Thanks for any help you can provide.

Chris Poole
IaDOT

MwRSF Response:

Chris:

At this time, I cannot recommend attaching the MGS to the headwall as our MGS bridge rail project has not been completed. Actually, we are only beginning the Phase I part of that effort in the Year 18 program.

As an alternative you could attach the MGS using an adaptation of the guardrail culvert system that was previously developed for culvert slabs. We discussed this system in the first three topics of the MGS implementation discussions that occurred before I left on medical leave. Did you or Deanna receive those emails? I am not sure as many of the Pooled Fund State members have not commented on the noted topics.

If that option is not possible, then I suggest using a thrie beam bridge railing detail that already has been crash tested. Also, one would then use the asymmetrical w-beam to thrie beam transition section in conjunction with approved transition designs. MwRSF is currently revises details for the transition to exisitng transitions as well.

Ron

Figure 4. Guardrail Adjacent to Retaining Wall

**Problem # 5 – Guardrail Adjacent to Culvert Repair**

State Question:

Bob this is a follow-up to our conversation today regarding the repair of a guardrail on US-56. The existing guardrail is protecting a triple 20'x20' box culvert. The guardrail is non-blocked out on concrete posts. The maintenance repair options we have will result in narrowing of the shoulder or extension of the box culvert to accommodate a low-fill guard rail attachment. Both of these options are not likely for a maintenance activity. Do you know of any designs that allow guardrail posts to be bolted to the outside edge of the culvert headwall? I could not find any details. However Dale said that he found a little info from West Virginia DOT. The sheet is called "Guardrail Installation on Box Culverts and Bridges" I have not had a chance to look at this yet.
Let me know what you find out.

Currently we are considering to replace in kind as a maintenance activity based on approved agreement that we have with the FHWA regarding guardrail maintenance.

Let me know what your thoughts are.

Rod Lacey
KsDOT

MwRSF Response:

Ron and I looked through your photos and have the following comments:

1. It appears that there is some room between the edge of the roadway and the culvert edge. As such, it would appear that you could install the guardrail attached to the top of the culvert previously designed by MwRSF through the pooled fund. However, if you cannot move the guardrail in, then that may not be a viable option.

2. No 350 approved or tested design exist that we know of consisting of posts mounted to the side or edge of the culvert. I looked at the West Virginia designs, but I have never seen testing of those designs.

3. Another option would be to install a steel bridge rail on the culvert. There are several steel bridge rail options with side mounted posts. The two issues with this option are ensuring that the culvert structure has sufficient capacity for mounting the bridge posts, and the steel bridge rail would require an approach transition.

4. This problem would be a good extension of the current pooled fund project to develop an MGS bridge railing that was funded last year. If the MGS bridge railing development is successful, it would be fairly straightforward to develop the technology to culvert applications as a second phase of the project.

I hope this addresses some of your questions. Let me know if you need more information or if I forgot to address something.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer
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Figure 5. Guardrail Adjacent to Culvert

**Problem # 6 – TL-2 Concrete Barrier with No Reinforcement**

State Question:

Hi Bob,

Ohio has issued an arbitrary five year phase out period for our older portable concrete barrier (not compliant to 350) ending as of January 1st, 2008. After that date, all of our unreinforced pin and loop barrier has to be off of projects.

With the approaching date, all sorts of contractor questions have arisen, leading ODOT to review all remaining unreinforced barrier use and deciding on a case-by-case basis if the units really do have to be removed from pending projects. One final question is if our unreinforced barrier can be used for another year in a TL-2 urban situation.

I know there is no FHWA mandate to remove the barrier, and it is ODOT's own arbitrary deadline, but do you believe unreinforced barrier would meet TL-2 criteria?

Our 350 crash tested barrier has FHWA Acceptance letter B-93 (design is attached as rm42.pdf) and differs from the previous barrier design (attached as unreinforced 32 inch pcb.pdf) in only the internal rebar cage in lieu of the previous design's wire mesh. The pin and loop connection remained unchanged.

I would be of the opinion that if the rebar cage reinforced barrier meets 350 TL-3, then the same design with the wire mesh would be crashworthy to TL-2. What do you think? Your answer will influence our decision to on whether or not to keep this particular barrier run in place for another year.

I did ask Nick in DC, but have not received a response.

Thanks,
Dean
Ohio

MwRSF Response:

Hi Dean,

We have looked at the unreinforced barrier section that you sent. It appears that that design does have some reinforcement in the form of a wire mesh in the center of the barrier. The connection design of the barrier seems adequate. Because the design does have some minimal reinforcement, adequate connections, and the fact that the anticipated loads for a TL-2 urban installation will be much lower than the TL-3 impact loads, we believe that this barrier, as shown on the detail you submitted, should be adequate for use in TL-2 urban installations.

One addition note on the detail is the tapered end section details. The TL-2 tested tapered end-section has been tested and required a 20’ length. Thus, it appears the end section on your detail does not have sufficient length. We would recommend that you use an extended tapered end section if possible.

Thanks

Bob Bielenberg, MSME, EIT
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402-472-9064
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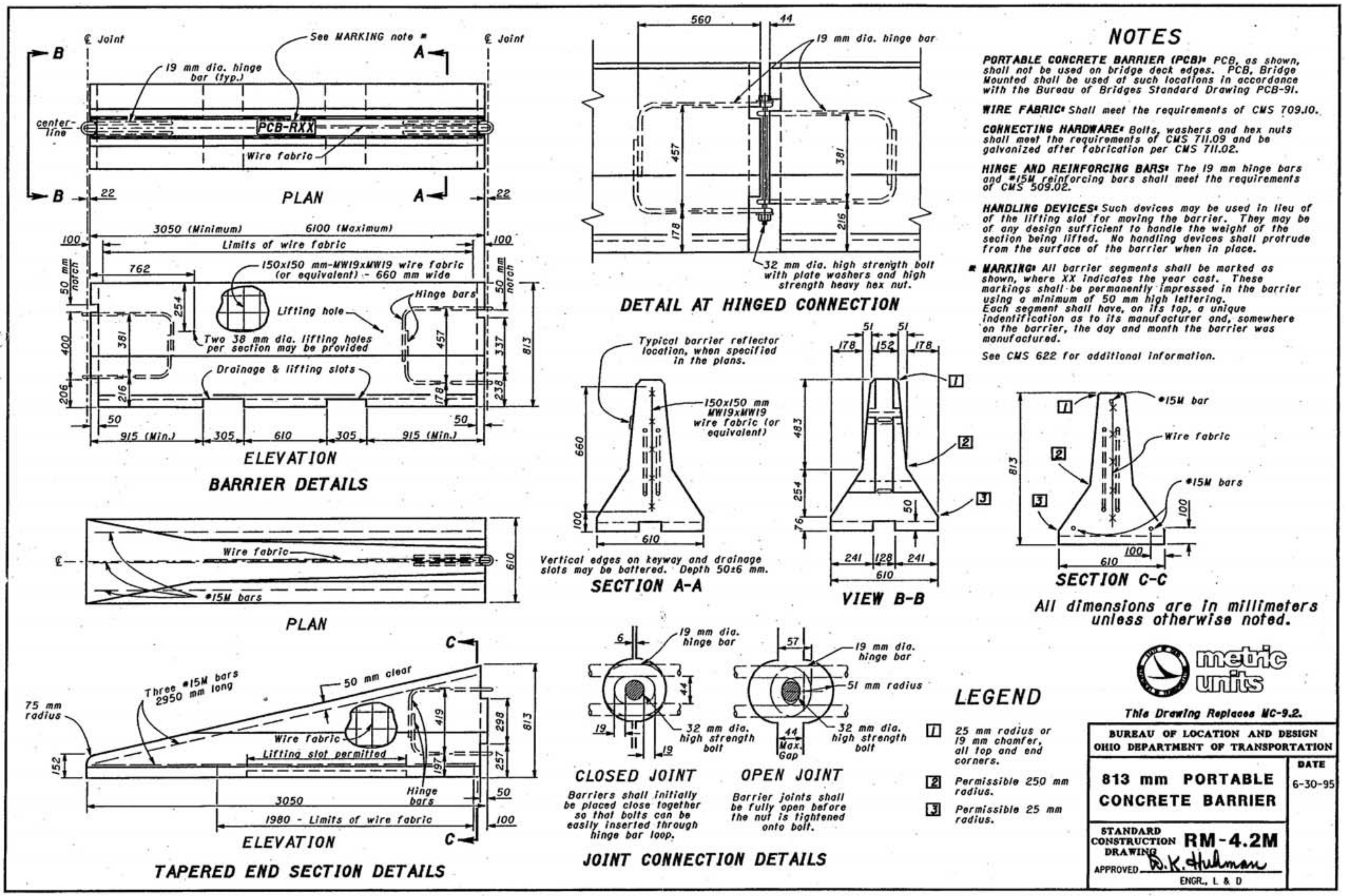


Figure 6. Unreinforced PCB

**Problem # 7 – Traversable Pipe Detail**

State Question:

Dear MwRSF,

I was contacted yesterday by FHWA about a construction project that will be bid on in February. The FHWA had some concerns about some of the roadside safety devices being used on this project.

As I looked at the plan, I found out that the designer has developed a special detail to install steel bars to make a box culvert traversable (see attached details).  I believe that the safety pipe runner s spacing is correct.  The inside diameter of the safety pipe runners are slightly over sized.

My concerns are:

1. Does the Schedule 40 steel pipe have adequate structural strength to allow a vehicle to traverse the culvert?
2. Are the structural connections of the safety pipe runners adequate to allow a vehicle to traverse a culvert?
3. Does this detail have enough detail to be built?
4. Does MwSRF believe that this design is NCHRP 350 compliant?

I know that MwRSF tested a traversable safety runner design for a culvert.
Would it be possible to get a copy of the report (I probably have one buried somewhere in my files, but given the time frame for response, I do not know if I will have a chance to look at it).

Thanks for your time.
<<traversable culvert pipe.pdf>>
Erik Emerson P.E.
Standards Development Engineer
Wisconsin Department of Transportation
4802 Sheboygan Ave.
Madison, WI 53707-7916
608-266-2842
608-267-1862 (FAX)

MwRSF Response:

Hi Erik,

I am not sure I have enough details from what you sent to answer all of your questions completely, but I will start with answering what I can and then we can move forward from there.

To answer the questions below:

1. The Schedule 40 pipe listed on your plans is sufficient for allowing the vehicle to transverse the culvert. The table in your plans is developed from testing done at TTI in 1980 and was later adopted as an AASHTO guideline. Furthermore, we conducted a test of the culvert pipes with the largest spacing and size in the table on a 3:1 slope with the 2000P vehicle and the 820C vehicle and found that the specified pipes and spacing were adequate.
2. I cannot fully evaluate the structural connections for the pipes from your plans. The bolt grades are not listed and no details of the culvert wall reinforcement are listed. I don't fully understand the detail for section C-C. This appears to be a detail for additional crossbars on culverts with over 20' spans. The overall details have no guidance on the location and so it is hard to evaluate. Cross bars should not be necessary on culverts with spans of 20' or less. Do you expect to install culvert grates on culverts larger than this?
3. I would add the bolt grades and the details for the cross bar installation location if necessary. Your design appears to be identical to the Iowa DOT culvert detail. There detail is more complete in terms of specifying the cross bar details and such. You may want to look at their details for further guidance.
4. If the connections for the pipes to the headwall are structurally sufficient, this design should be NCHRP 350 compliant.

Thanks

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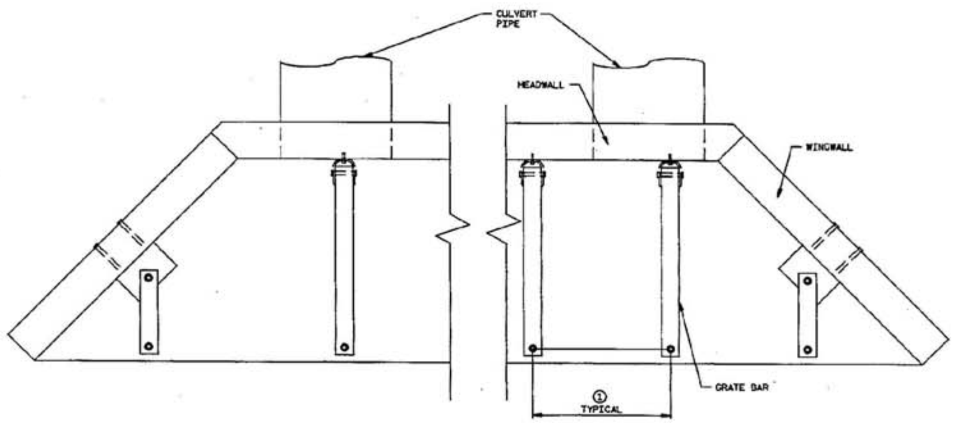


| GRATE & CROSS BAR SIZE REQUIREMENTS | | |
|---|---|---|
| LENGTH OF SPAN (FT.) | NOMINAL PIPE SIZE ② (IN.) | O.D. SIZE ④ (IN.) |
| 0-12 | 3.0 | 3.5 |
| 12-16 | 3.5 | 4 |
| 16-20 | 4.0 | 4.5 |

NOTES:

SAFETY GRATE BARS SHALL BE FABRICATED FROM SCHEDULE 40, STEEL PIPE.

REINFORCING STEEL MAY BE ENCOUNTERED WHEN DRILLING THROUGH EXISTING STRUCTURE WALLS.

① EQUAL SPACES 24" MINIMUM, 30" MAXIMUM EDGE OF WINGWALL TO CENTER OF BRACKET OR CENTER TO CENTER OF BRACKET.

② CROSS BAR DIAMETER SHALL EQUAL OR EXCEED THE GRATE BAR DIAMETER.

③ DIMENSIONS SHALL BE VERIFIED AT THE SITE BY THE CONTRACTOR BEFORE FABRICATION OF THE GRATE. THE CONTRACTOR IS RESPONSIBLE FOR USING THE CORRECT PIPE DIAMETERS AND CORRECT DIMENSIONS TO ASSURE PROPER FIT OF THE SAFETY GRATE.

④ ALL GRATE BARS USED IN A CONCRETE ENDWALL SHALL BE OF THE SAME DIAMETER.

| PROJECT NO: 1104-10-70 | HWY: USH 41 | COUNTY: FOND DU LAC | CONSTRUCTION DETAILS | SCALE, FEET 0 N/A | SHEET 11 | E |
|---|---|---|---|---|---|---|

DESIGN FILE IS H:\46025000\46025003\Dgn\321002_CD.dgn DATE OF PLOT - 11/7/2007 PLOT NAME - P:\LASER\321002_CD.prf PEN TABLE - \Plot\pen_tables\level.tbl Created By - edp Plot Scale: 1" = 230.000001 WISDOT/CADDS SHEET 42

Figure 7. Traversable Culvert Grate

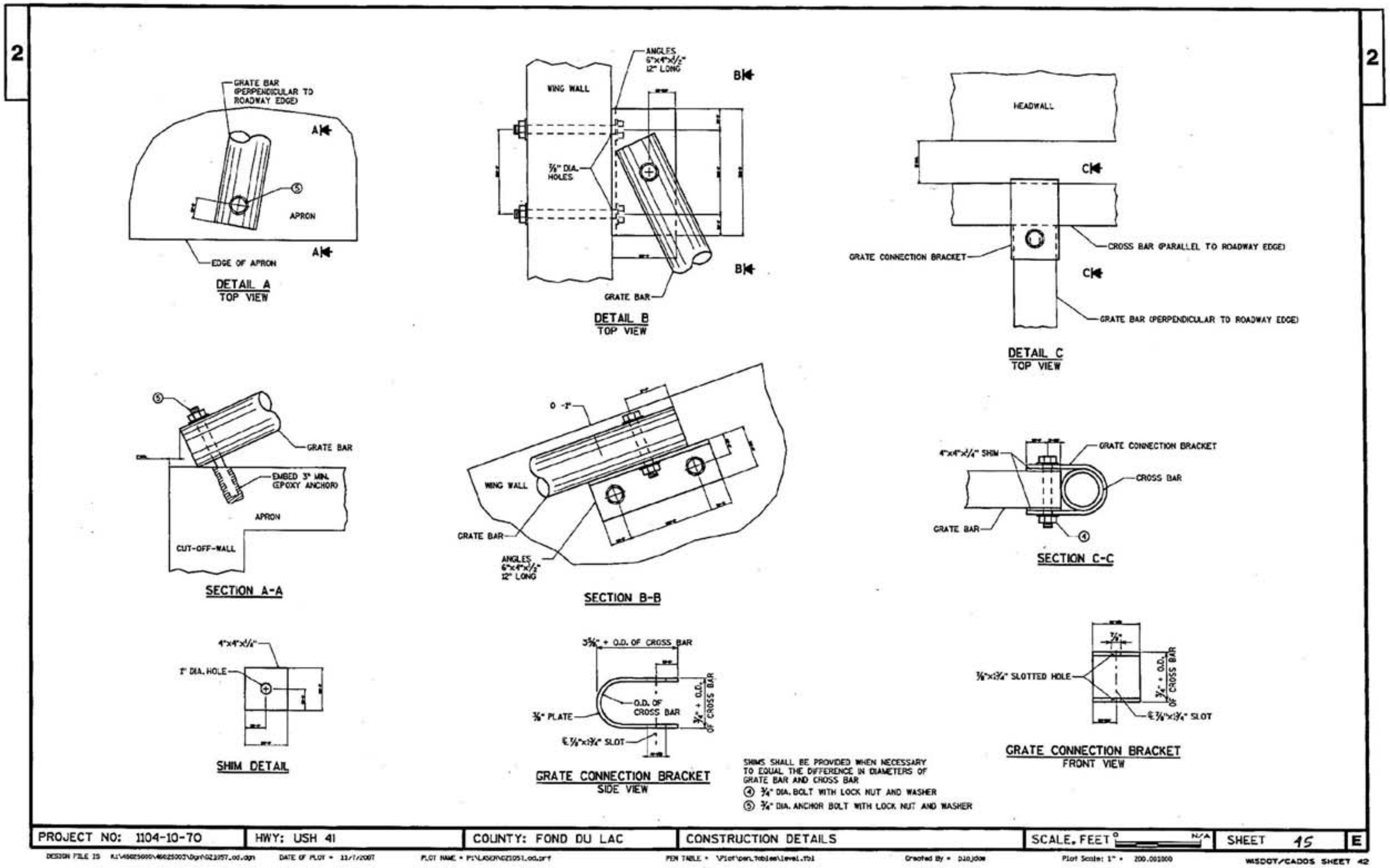


Figure 8. Traversable Culvert Grate

**Problem # 8 – Guardrail Adjacent to Slope**

State Question:

Dear MwRSF,
I received the following email from one of our designers (see below). I have include my initial response back to the designer in the attached word document. If MwRSF could provide additional guidance on this topic to me, it would be greatly appreciated.

<<011807 eoe response to jason.doc>>
> -----Original Message-----
>
> Hello-
>
> The subject project is a 3R resufacing project with 7 intersection
> realignments. The typical is 12' lanes with 6' shoulders (3' paved).
> The project is at about a 60% level right now.
>
> The question I have is regarding the use of longer beam guard posts
> and the use of "Beam Guard Retaining Walls". The PDF is a scan of the
> detail sheet and Misc Quant sheet from the 1988 As-Built, when the
> project was last resurfaced.
>
> <<Beam Guard Retaining Wall detail.pdf>>
>
> The current project is milling 1.5" of HMA and paving 4.25"-5.25",
> making the new vertical profile of STH 144 @ 2.75" to 3.75" higher than existing.
> All of the existing beam guard is being replaced. With the additional
> shoulder gravel that will be required due to the profile change, I
> foresee problems with erosion at shoulders in the beam guard areas.
> Either asphaltic curb and flumes will need to be installed under the
> beam guard to control the erosion, or the foreslopes will have to be
> paved. Do you have any recommendations on this?
>
> Also, the existing foreslopes are very steep (and long), and many of
> the existing posts are installed down the foreslope a foot or more.
> In other words, the face of beam guard was installed at or near the
> shoulder grade break. This is apparently why 8' or even 12' posts
> were specified in some locations on the 1988 As-Built - so the posts
> were embedded enough to develop full strength. The "Retaining Walls"
> were used to help prop up the shoulders near areas of culverts/box
> culverts/cattle passes where there was no room to build up the shoulders.
>
> Due to the nature of this project, we would like to avoid having to
> fill in the slopes. A lot of earthwork would be required to fatten
> these slopes because they are so long. I have heard that other

> regions sometimes use similar details to solve these types of
> problems.  Do you have any ideas for dealing with these problems, or
> any construction details that other regions use?  If not, we may just
> use a modified version of the old detail that was used last time on this project.
>
> Attached are some pictures of the areas in question.  As you can see,
> many of the posts lean backwards due to the settling of the foreslopes
> over the years.  However,  I believe that the leaning posts were
> installed at the standard 6' length and not the 8' or 12' lengths.
>
>  <<MVC-743F.JPG>>  <<MVC-002F.JPG>>  <<MVC-003F.JPG>>
> <<MVC-735F.JPG>>
>
> Any help would be appreciated.
>
> Thanks,
> Jason Zemke
> WisDOT SE Region
> PDS
> 262-548-8734
>

MwRSF Response:

Erik:

For fill slopes as steep as 2:1, MwRSF researchers have developed two strong-post W-beam guardrail systems for use at the slope break point. The first system utilized metric height W-beam rail (27-3/4" or 706 mm) with 7-ft long, W6x9 steel posts spaced on 3-ft 1-1/2-in. centers. The second system utilized the MGS with a 31-in. top height along with 9-ft long, W6x9 steel posts spaced 6-ft 3-in. on centers. For 2:1 slopes, both guardrail systems can be used. Additional discussion on this topic has been provided in the MGS Implementation discussions that I led last fall. I believe that we also provided recommendations for slopes less than 2:1. I will see if I can provide that here as well.

MwRSF: Recently, the Mn DOT requested guidance for placement of standard and MGS guardrail adjacent to slopes of various configurations. In response to this request and using available crash test data as well as engineering judgment, Dr. Dean Sicking and Mr. Bob Bielenberg prepared the preliminary guidance, subject to refinement in the future. It is as follows:

For standard W-beam guardrail:

1. Standard W-beam guardrail placed adjacent to any slope with 2' of level soil behind the posts is acceptable.
2. For w-beam guardrail placed 1'-2' adjacent to a 6:1 or flatter slope, standard 6' W6x9 posts at standard spacing are recommended.

3. For w-beam guardrail placed 1'-2' adjacent to a 3:1 to 6:1 slope, 7' W6x9 posts at standard spacing are recommended.
4. For w-beam guardrail placed less than 1' adjacent to a 3:1 or steeper slope, 7' W6x9 posts at half spacing are recommended.

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.
5.

In the photographs and design details that you provided, discrete W-beam rail segments were shown bolted to the face of guardrail posts both above and below grade and for retaining soil. We do not believe that this practice should be used. In addition, when asphalt overlays are placed in advance of the guardrail without placing new fill behind the posts, the post-soil behavior is altered. An even greater concern is whether the long, wood posts can rotate at the appropriate load without fracturing. In the past, we have developed recommendations for such cases for the Missouri DOT and with using steel posts. This recommendation was based on the best available data and engineering judgment – no testing. I can find that recommendation if you desire it.
In several of your photographs, the guardrail posts are tipped backward. If subsequent work were to occur in these areas, it would be suggested that the guardrail systems be adapted to meet those noted above and that the posts be placed vertical to reduce any tendencies for vehicle climb and override.

Other photographs also reveal the use of buried, turned down end terminals that are not in a back-slope. If modifications are to occur to these guardrail systems, you will need to review the WsDOT policies for replacing these terminals when certain 3R or roadway surfacing activities are scheduled. I assume that WsDOT has a policy on when guardrail terminal upgrades are to occur. Once again, it is highly recommended that you review this policy before doing any work around these terminals to ensure that you follow your long-range implementation plan for certain roadway classifications.

Please let me know if you have any questions or comments regarding the enclosed information. Also, I ask my colleagues to provide additional comment and clarification if I have misspoke.

Thanks!

Ron
Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor
Midwest Roadside Safety Facility (MwRSF)

Figure 9.  Guardrail on Slope Installation

**Problem # 9 – Concrete Median Barriers**

During January and February 2008, MwRSF personnel have been assisting Wisconsin DOT staff with the design of concrete median barriers for use along the I-94 system. The analysis and design of F-shape concrete median barriers were detailed for both level terrain as well as for stepped medians, both using a reinforced concrete footing. In addition, a transition was detailed for attaching and shielding two median bridge rail ends at different grades. Draft design details have been prepared by WsDOT staff and will be included herein upon final review.

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

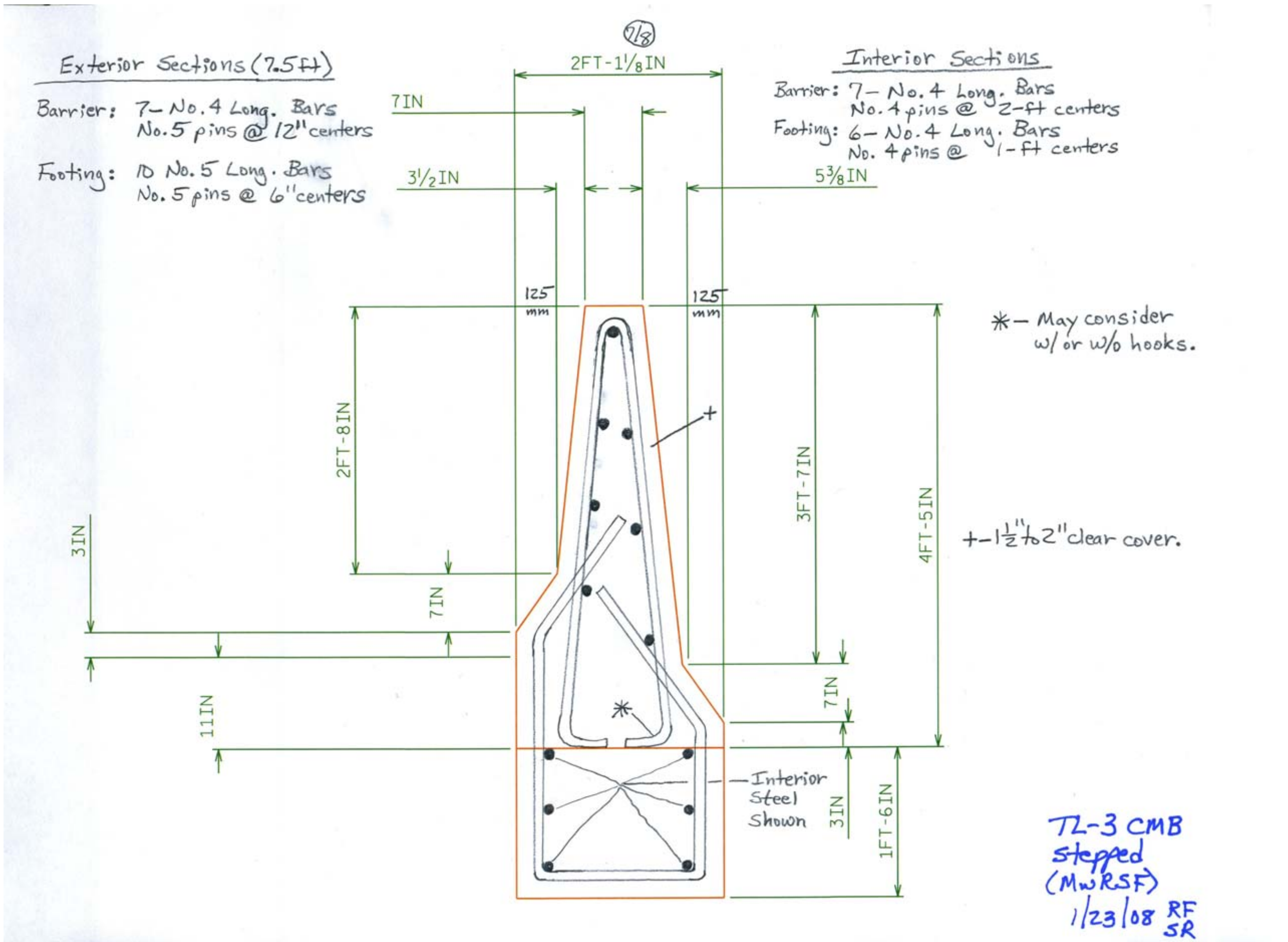


Figure 10. TL-3 Concrete Median Barrier

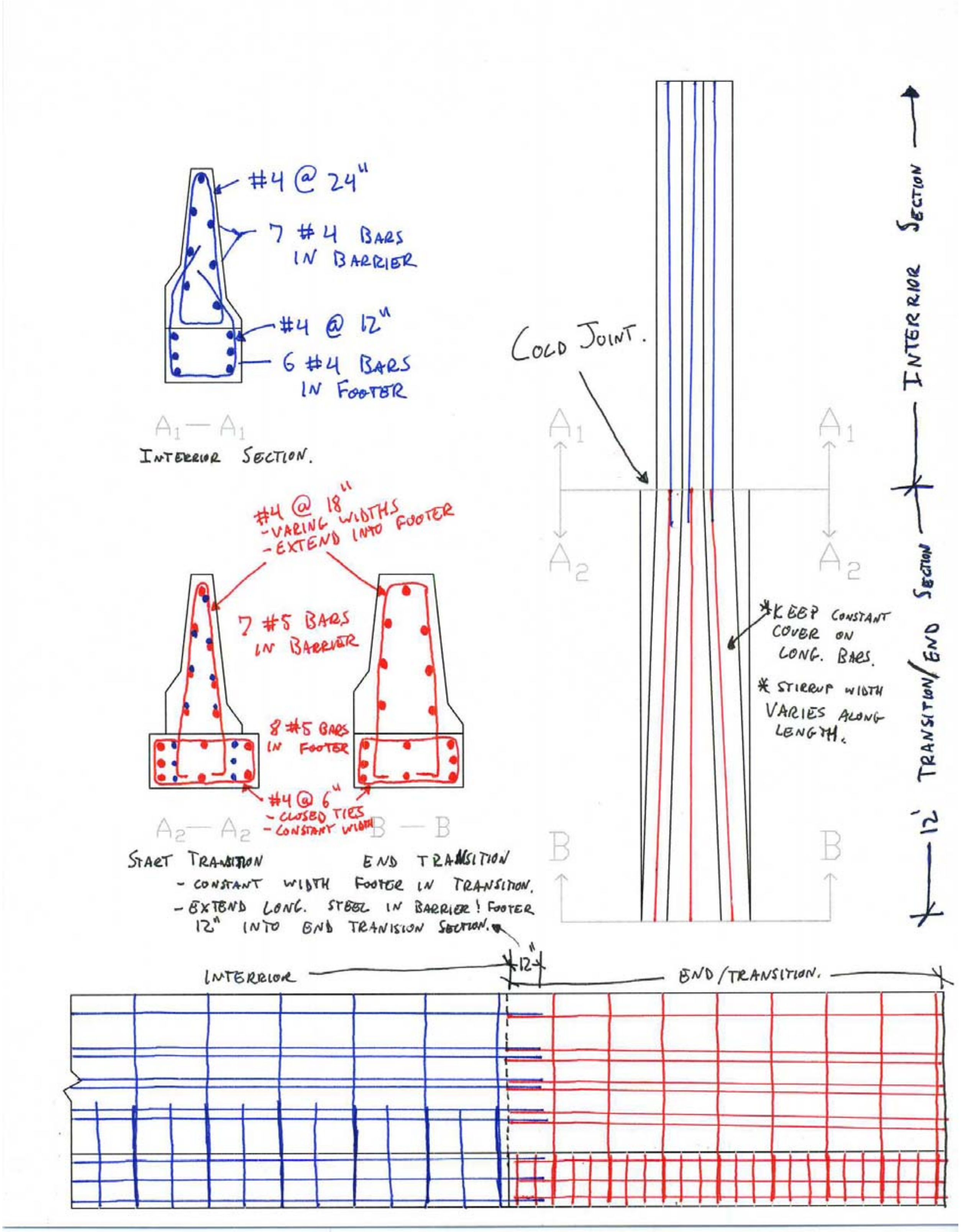


Figure 11. TL-3 Concrete Barrier Transition

**<u>Pooled Fund Consulting Summary</u>**

Midwest Roadside Safety Facility
January 2008– March 2008

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 –Drainage Openings Through Concrete Barrier**

State Question:

Dear MwRSF,

A regional engineer has a project where the roadway profile is zero and they need to install concrete barrier (they will have extreme difficulties providing longitudinal drainage on the median shoulder). The regional engineer wants to place an opening in the concrete barrier wall to provide roadway drainage.

Regional maintenance staff has indicated that they want to have an 8" tall and 18" wide opening (so they can fit a shovel into the opening and clean it out). I have indicated that this size of opening is not preferred because it could cause a vehicle to snag or roll over during impact.

Setting aside MwRSF's concerns about barrier reinforcement, has there been research into geometry drainage openings that go through concrete barrier?

In addition, some engineers are adjusting the front lower face of the barrier to accommodate drainage inlets. Has there been study on how to adjust the front face of concrete barrier to account for drainage inlets?

Erik Emerson P.E.
Standards Development Engineer
Wisconsin Department of Transportation
4802 Sheboygan Ave.
Madison, WI 53707-7916
608-266-2842
608-267-1862 (FAX)

MwRSF Response:

Erik:

Thanks for your email inquiry regarding drainage inlets in RC barriers.

For vertical-face parapets, the inlet opening that you note may be manageable as long as the steel reinforcement above and adjacent to the opening was adequate and the small car doesn't snag on the downstream edge of the opening. A 4 to 6-in. opening height would seem reasonable for vertical parapets. For safety shape parapets, this opening size may be extreme and accentuate small car wheel snag. A 3-in. tall opening may seem reasonable for safety shape parapets. However, I am unaware of any research devoted to designing safe inlets for crashworthy barrier applications.

Actually, this may be another reason for moving Wisconsin closer to using vertical, or near vertical, concrete parapets.

Ron

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

**Problem # 2 – Transition From Free Standing to Rigid Concrete Barrier**

I have report TRP-03-180-06, "Development of Tie-Down and Transition Systems for Temporary Concrete Barrier on Asphalt Road Surfaces." From this, we do need to make some updates to our TCB design, and also consider new Standard(s) to implement transitions.

However, I have an immediate question from one of our districts regarding a transition to an existing bridge parapet. In this case the parapet end is curved away from traffic, making connection of the TCB problematic. There is no ready way to adapt to a pinned connection, and also spanning the back side of the joint with the thrie beam is not possible without removing part of the parapet end.

There seem to be a couple possibilities – remove and recast the end of the parapet to work with the TCB, or perhaps fabricate a triangular steel shape to bolt to the face of the parapet and provide a connection point and also fill over the curved portion. This latter idea still leaves the question of how to span the back of the joint.

Do you have any comments on either of these ideas, or other likely approaches?

This is the type of bridge parapet/wingwall. The bridge is a Jersey or GM shape. The wing curves away.

We do have reinforcement around the holes for the anchor pins, but it is not as substantial as what is used in the testing of the transition. Ours is #4 bars, where the testing used #6.

The curved wingwall does extend above grade.

There is no guardrail between the parapet end and the PCB sections. They propose to abut them and bridge the gap with a section of guardrail with end shoes at each end.

Traffic is one-way, from the PCB's toward the bridge parapet.

I'm not certain of the shape of the bridge parapet, but the curved end and wingwall near the connection, appears to be a vertical wall.

This is all for temporary (3 months use). The bridge will receive new parapet and wing with a permanent thrie beam transition to the approach guardrail.

Pouring a block for attachment seems to make this easier. We talked about making the block such that a PCB could be pinned to it, but we note that this would still not allow for the thrie beam panel on the back of the joint.

David L. Piper, P.E.
Safety Design Engineer
Bureau of Safety Engineering
2300 South Dirksen Parkway
Springfield, IL 62764
Phone 217-785-0720
Dave.Piper@illinois.gov

MwRSF Response:

Hi Dave,

Based on the photo and the sketch that you sent earlier, I think we can make this installation work.

I believe that you can use the asphalt pin tie-down transition with this installation as long as you butt the end barrier up against the curved wing wall as shown in the sketch. The installation should consist of the 4 barrier transition detailed in the report (1 pin, 2 pins, 3 pins, and 3 pins) with the final barrier butted up against the wing wall. A 12.5' section of nested 12 gauge or 10 gauge thrie beam should be used to span the traffic side face of the transition between the temporary concrete barrier and the wing wall. By butting the back of the TCB against the wing wall, it should provide the additional constraint to motion of the final barrier that the thrie beam across the back of the joint would have provided in a more standard installation.

Because you don’t have two way traffic in this installation, we don’t need to be concerned about making a special connection piece to prevent snag for reverse direction impacts.

Just a reminder that the transition was designed for use on asphalt surfaces and thus a pad would need to be poured for the transition to work effectively.

This will be simpler than installation of a thrie beam region between the PCB and the parapet or wing wall.

Thanks

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

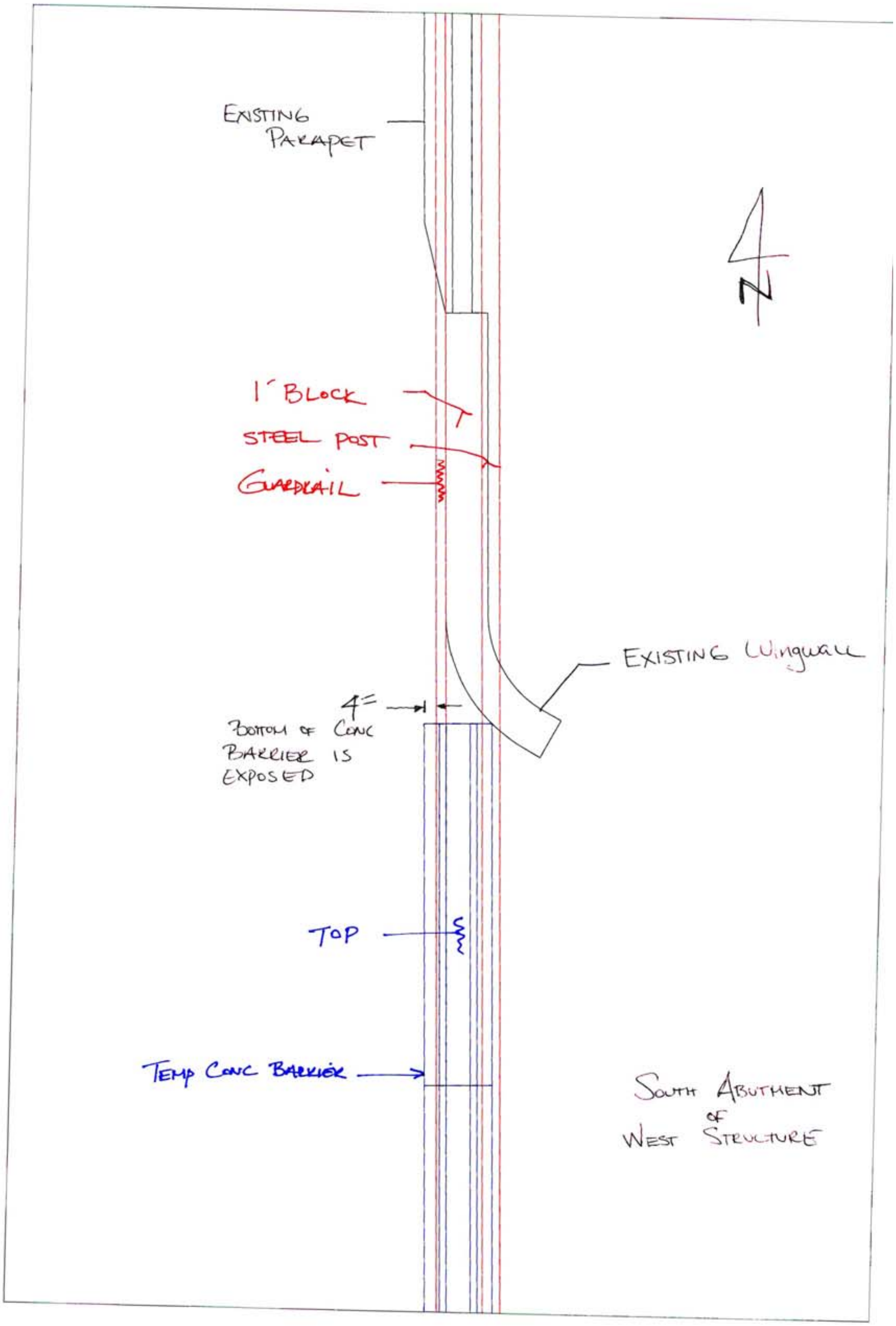


Figure 1. Illinois PCB to Rigid Barrier Transition Schematic

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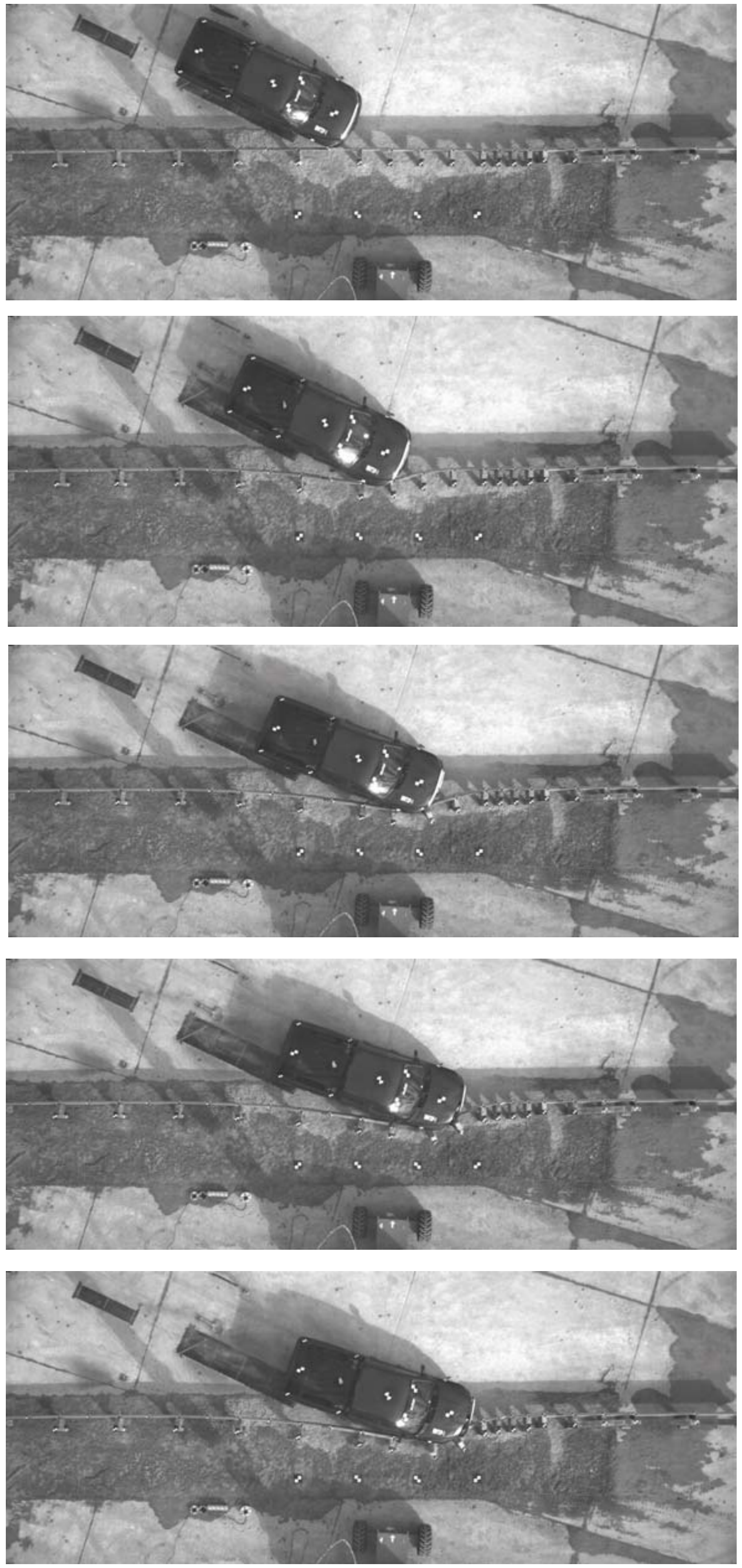

Figure 1. Time-Sequential Photographs - Overhead View - Test MWTSP-1

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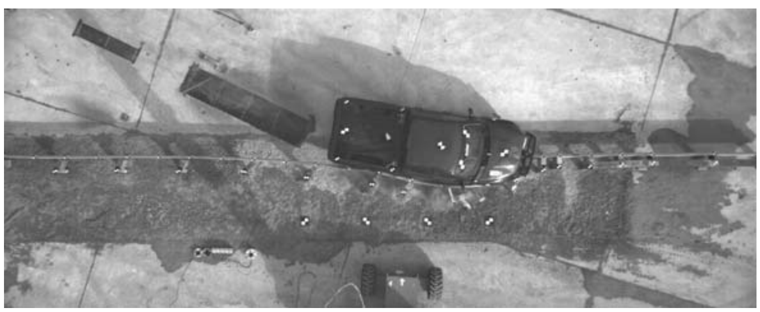

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Figure 1. Time-Sequential Photographs - Overhead View - Test MWTSP-1 (cont’d)

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Figure 2. Time-Sequential Photographs - Upstream View - Test MWTSP-1

Figure 3. Approach Guardrail Transition - Test MWTSP-1


Figure 4. Upstream Anchorage System - Test MWTSP-1

Figure 5. Damage to Upstream Anchorage System - Test MWTSP-1

Figure 6. Damage to Approach Guardrail Transition - Test MWTSP-1


Figure 7. Damaged BCT Wood Post - Test MWTSP-1