MIDWEST POOLED FUND PROGRAM

Progress Report - Third Quarter 2009
July 1st to September 30th
Midwest Roadside Safety Facility
Nebraska Transportation Center
University of Nebraska-Lincoln

September 30, 2009

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

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

In the Third Quarter, dynamic bogie testing of wood posts embedded in soil was continued in order to determine a simplified wood post transition alternative. One post test was performed in a large, compacted soil, test pit placed in the concrete apron. In July 2009, one additional bogie test was performed on an 8-in. x10-in. by 6.5-ft long wood post placed in strong soil. From all prior post testing on this size and length, inconsistent post-soil behaviors were observed. In the Fourth Quarter of 2009, BARRIER VII computer modeling will be performed to evaluate system performance using the upper and lower post-soil characteristics. It should be noted that the 8-in. x 10-in. post size is being considered as a replacement for W6x15 steel posts used in approach guardrail transitions.

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. The vehicle was safely redirected. A draft report has been prepared and will be sent to the States in the Fourth Quarter. A TRB paper was presented at the 2008 Annual Meeting of the Transportation Research Board and published in TRR No. 2060.

During the report review process, it was noted some states desired a wood-post alternative for the MGS placed on a 2:1 slope. As such, a very limited dynamic bogie testing program (four tests) was initiated 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. On March 6, 2009, one dynamic test (test no. MGS2-1PT22) was performed using an 8-ft wood post within a confined soil pit. During the test, wood post fracture occurred with limited post rotation. Using limited contingency funds, the remaining bogie tests were planned for the Third Quarter.

In July 2009, one additional 6-in. x 8-in. by 8-ft long wood post was tested on a 2:1 fill slope but in a large soil test pit. Following this test, additional testing is planned for the Fourth Quarter of 2009 in order to finalize the wood post length for this 2:1 MGS application. The remaining test matrix consists of five additional tests – one 6-in. x 8-in. by 8-ft long wood post, two 6-in. x 8-in. by 7.5-ft long wood posts, and two W6x9 by 9-ft long steel posts. The two tests on steel posts will be used for comparison to the original research and development but now using the more current soil compaction procedures.

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

Performance Limits for a 6-in. High, AASHTO Type B Curb Placed in Advance of the MGS – Program Year 17

On April 8, 2009, a 2270P crash test (test no. MGSC-5) was performed on the MGS placed behind a 6-in. curb using an 8-ft lateral offset. The test was conducted according to the TL-3 conditions and requirements found in the MASH-08 guidelines. During the test, the pickup truck impacted the MGS with a slight upward trajectory of the right-front corner of the vehicle which later began to be redirected with moderate roll toward the barrier system. In this sequence, the right-front wheel was also removed and propelled along and under the truck. As the vehicle was traveling along the barrier system, the vehicle roll toward the barrier increased as well as the upward pitch of the truck's rear end. The vehicle's angular motions, combined with the wheel release and truck travel over an upright loose wheel, likely contributed to the vehicular instabilities and vehicle rollover upon exiting the MGS barrier. With vehicle rollover, the results from test MGSC-5 were deemed unsatisfactory. Documentation and reporting of the crash test results were completed in the Third Quarter of 2009, as part of a Phase II test report. The draft report was sent to the member states for review and comment.

Additional LS-DYNA computer modeling was performed following the test in order investigate: (1) 2270P impacts into the MGS placed 8 ft behind a 6-in curb using various rail heights, (2) 2270P impacts into a 37-in. tall, MGS relative to the roadway and at various lateral offsets behind the curb, and (3) 2270P impacts into a 6-in. curb at the TL-2 impact conditions - both without and with the MGS located behind the curb. In addition, MwRSF forwarded a letter to the sponsor states seeking guidance on how to proceed with the project. A majority of the member states chose to proceed with the project using the TL-2 impact conditions. In the Fourth Quarter, a 2270P crash test (test no. MGSC-6) will be performed at the TL-2 impact conditions on the MGS placed 6 ft behind a 6-in curb with a 37-in. rail height relative to the roadway. Since inadequate project funding remains within the project budget, existing contingency funds will be requested in the near future.

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

Initially, researchers investigated and examined the existing design configurations for post-socket foundations used with high-tension, cable barrier systems. Subsequently, a design limit or peak load condition was determined for the configuring future post-socket foundations. A prototype 12-in. diameter, reinforced concrete foundation system with a steel sleeve insert was designed using various embedment depths. Three preliminary specimens were constructed using 2, 3, and 5 ft lengths. For the project, all of test specimens are to be subjected to dynamic bogie testing in both weak and strong soil conditions. The bogie testing will evaluate the structural capacity and deformation of the loaded foundation systems.

In June 2009, three dynamic component tests were performed on the initial prototype foundation system when placed in a weak soil condition (sand). Concrete fracture was observed in the 5-ft long test specimen, while only concrete cracking of the shaft was observed in the 3-ft long specimen. The test results were evaluated in the Third Quarter, and design modifications were implemented. A revised test matrix was prepared for the 5-ft long specimen in a weak soil condition. One test is planned for the Fourth Quarter. Further testing will be performed pending the results from the upcoming test.

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

The initial design of the simplified bracket for attaching the cables to the support posts was completed in the Second Quarter of 2009. Final CAD details were sent to the Bennett Bolt Co. for ordering cable attachment prototypes for use in the dynamic component testing program. MwRSF received prototype samples in June 2009 in order to review and make changes, if necessary. Based on the review, the additional prototypes were ordered. Dynamic component testing was performed in the Third Quarter of 2009. Although ten (10) dynamic tests were planned and budgeted, thirty (30) tests [HTCUB-1 through HTCUB-30] were performed at various load angles. In addition, minor modifications of configuration were evaluated in terms of slot depth, placement of shaft in slot, burr thickness, and tightness of nut. Based on these initial test results, MwRSF began an LS-DYNA analysis effort to determine whether cable release could be predicted at the loads observed in the component testing effort.

In the Fourth Quarter, MwRSF will use continue with the LS-DYNA modeling effort and evaluate the effect of design modifications to the bracket. Additional dynamic component tests would be performed, if deemed necessary. If the computer simulations and component tests show promising results, the 1100C small car re-test would be scheduled for either the Fourth Quarter of 2009 or First Quarter of 2010.

 

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

Work on this project will commence after crash testing has been 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. Project funding has been made available to two program years.

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

Following discussions with FHWA and the Illinois Department of Transportation, it was determined that two low-speed, crushable-nose, pendulum tests were required on various luminaire poles in order to investigate the impact performance of a new, free-cutting, breakaway, brass coupling. The brass coupling is planned for use as replacement to existing, higher cost couplers.

The first pendulum test will be performed on a heavy steel pole and will provide the vehicle deceleration and velocity change characteristics for heavy poles. The 50-ft tall steel pole with twin 12-ft mast arms has an expected total assembled weight near 960 lbs. The maximum allowable weight for pendulum testing is 992 lbs. The second pendulum test will utilize a weaker, light-weight pole and will evaluate the brass couplings ability to breakaway before the pole bends. A 30-ft tall aluminum pole with a 6-ft mast arm has been selected for this pendulum test.

In the Fourth Quarter of 2009, the two pole systems will be acquired and tested. A detailed test report will be written to document the tests, data analysis, as well as the conclusions.

Maximum MGS Guardrail Height – Program Year 20

The literature search for this project has been started. The concentrated effort focused on finding W-beam guardrail tests conducted with a small car that showed any propensity to underride the barrier and/or have significant wheel snag. A comparison between the 1100C Kia Rio and the 1,100-kg version finite element model of the Dodge Neon was made to determine if the vehicle model is similar enough to the actual test vehicle in order to provide useful simulation. Based on the initial comparison, it was determined to begin using the Neon model for simulation. The first simulation to be conducted will be the MGS-small car, full-scale crash test to see how well both the vehicle model and the MGS model perform. From that simulation, areas of needed improvement will be identified. This work will be continued in the Fourth Quarter of 2009 as well into 2010.

Paper Studies

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

The analysis, evaluation, and documentation for treating culverts and trees have been completed. The analysis of bridges, slopes, and ditches for low-volume roadways was completed in the Third Quarter of 2009. A draft report of the analysis and evaluation was completed in the Third Quarter of 2009 and is currently under internal review.

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. Eighteen systems and fifteen components have been approved for the Guide over the last 2 years. The three additional systems are planned for review and discussion at the fall 2009 AASHTO Task Force 13 meeting. However, it should be noted that funding for this effort has been depleted as of November 2008, and additional funding will be needed to complete the currently planned effort. No additional funding was provided in the Year 20 Program.

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 weeklong investigation, more than 60 specific sites were visited, measured, photographed, and documented. In late August 2009, review and compilation of the field survey information was initiated and will be completed in the Fourth Quarter. Analysis of the compiled field information will take place in the Fourth Quarter of 2009. The RSAP analysis will be initiated later in the Fourth Quarter and continue into 2010.

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

An additional 6 years of accident data was collected and tabulated in the Third Quarter of 2009. The narrative and diagram for every additional single–vehicle accident was reviewed, and information extracted from those documents was compiled into the accident database. This information was then merged with additional driver, vehicle, injury, and roadway information that were initially categorized in different files, thus forming one large database. Due to the size of the data set, advanced analysis techniques will be required. It is currently proposed to suspend the study until the MwRSF can obtain access to more advanced statistical software and analysis techniques. It is anticipated that the delay will be no more than 3 months.

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 w/ Curbs and MGS on 2:1 Slopes; and (3) MGS w/ Culvert Applications. A fourth category, MGS Stiffness Transition, will be initiated after the simplified, wood-post transition project is completed. It is estimated that the MGS implementation effort will commence in the Fourth Quarter of 2009.

LS-DYNA Modeling Enhancement Funding – Program Year 18

Modeling efforts continued on investigating the 930,000 element model of the 2270P Chevrolet Silverado developed by the NCAC. With the updated UNL tires, the model seems to perform fairly well riding over a 6-in. high, AASJTO Type B curb and then impacting the MGS guardrail. At this time, this vehicle model is considered good-to-go for various simulations needed by the MwRSF. Certain impact scenarios, such as striking a concrete barrier, have not yet been performed. Thus, it is possible that the vehicle model may need to be revisited in the future. Such scenarios will be performed on an as-needed basis.

An ASME conference paper was written describing the mass scaling effort performed over the past year. Mass scaling is a very useful technique in limiting cpu requirements by adding mass to the model. Due to the complexity of this issue, further details are not presented herein. The goal of the research was to better understand mass scaling and to more effectively apply it to our larger models that require extensive cpu power. As part of the research effort, a reasonable mass scaling recommendation for the new 2270P Chevrolet Silverado vehicle model was determined. The paper will be presented at the ASME conference in November 2009.

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)

The original project objective was to develop a TL-4, aesthetic, open concrete bridge railing for use on cast-in-place decks as well as precast deck panels. Due to many factors, existing project funds are insufficient to complete the research study. MwRSF-UNL researchers have been seeking funds to complete this research from alternative sources. In March 2009, an NCHRP IDEA proposal was submitted to seek additional project funds. In June 2009, it was learned that the NCHRP IDEA proposal would not be funded. As such, MwRSF will continue to seek alternative funding sources in the future, such as from the FHWA highways for Life Program.

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. Previously, a draft test report was prepared, submitted to NYSDOT, and edited. In 2008, a continuation project provided funding for additional crash testing. Three 2270P and one 1100C crash tests were performed. The reporting and documentation for the last four crash tests was added to the original test report. The combined, internal draft report was reviewed by New York personnel in the Second Quarter of 2009. A draft final report, incorporating all of the NYSDOT comments for the last four crash tests was completed in the Third Quarter.

In the Third Quarter of 2009, MwRSF began the third phase of the crash testing program. Two full-scale vehicle crash tests were performed on the modified Type IIA box beam end terminal system according to the MASH guidelines. On July 15, 2009, an 1100C small car test (NYBBT-8) was conducted according to the TL-3 impact conditions. On August 6, 2009, a 2270P pickup truck test (NYBBT-9) was conducted according to the TL-3 safety performance guidelines. Both tests successfully met the MASH criteria. The reporting of the test results was initiated in the Third Quarter. A draft research report containing the results from NYBBT-1 through 9 is planned for completion in the Fourth Quarter.

Universal Breakaway Steel Post for Guardrail (Minnesota DOT)

Two full-scale vehicle crash tests were planned for the Fourth Quarter of 2008. Test no. USPBN-1 was performed on November 26, 2008 using a 2000P pickup truck according to test designation 3-38 of NCHRP Report No. 350. During the test, the vehicle was being slowed and redirected. However, the vehicle later overrode the rail and rolled over within the thrie beam bullnose system. After the failed test, MwRSF researchers studied the results and provided recommendations on how to proceed with the project using two different plans.

MnDOT committed to providing an additional $10,000 to supplement the existing project funds in order to re-run the 2000P crash test into a modified barrier system. The re-test was planned for the Third Quarter of 2009. MwRSF will prepare for the test once final agreements have been completed.

In the Second Quarter of 2009, an internal draft report was prepared to document the component testing of breakaway post concepts as well as the first 2000P crash test. The draft Phase I research and test report was submitted to the sponsor in the Third Quarter of 2009. After comments are received, a final report will be prepared in the Fourth Quarter.

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

The project consisted 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. Documentation and reporting of the research project has been completed. A final research report was submitted to the West Virginia DOT in the Second Quarter of 2009. A formal request seeking FHWA acceptance was prepared in the Third Quarter of 2009. The research project ended on August 31, 2009.

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 consisted 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. Documentation and reporting of the research project has been completed in the Third Quarter of 2009. A request seeking FHWA acceptance was also completed in the Third Quarter of 2009. The research project ended on August 31, 2009.

Dynamic Testing and Evaluation of a New TCB for FRP Bridge Deck Applications (Kansas DOT)

The project consisted of the crash testing and evaluation of a vertical-face, precast concrete parapet attached to an FRP composite bridge deck system. The research effort was performed according to the Test Level 3 safety performance guidelines found in the Manual for Assessing Safety Hardware 2008 (MASH-08). On March 13, 2009, one 2270P pickup truck test (test no. KSFRP-1) was successfully performed at the target impact conditions of 62 mph and 25 degrees. For this test, the vehicle was safely contained and smoothly redirected in a stable manner. Documentation and reporting of this crash test was continued in the Second Quarter of 2009. A draft report was sent to the sponsor in the Third Quarter of 2009. At this time, MwRSF is waiting for comments and suggested edits for the report from the sponsor. A final report will be prepared in the Fourth Quarter 2009.

Dynamic Evaluation of New York State's Pinned Temporary Concrete Barrier (New York DOT)

The project consisted of the crash testing and evaluation of New York State Department of Transportation's New Jersey shape, temporary concrete barriers attached to a concrete slab using vertical pins on the back-side face. The research effort was performed according to the Test Level 3 safety performance guidelines found in the Manual for Assessing Safety Hardware 2008 (MASH-08). On January 9, 2009, one 2270P pickup truck test (test no. NYTCB-4) was successfully performed at the target impact conditions of 62 mph and 25 degrees. For this test, the vehicle was contained and redirected. However, it should be noted that significant barrier deflections were observed in two segments. In addition, one barrier joint ruptured after the vehicle's rear end impacted the barrier and had exited the region. In the Second Quarter of 2009, a draft report was prepared and submitted to the NYSDOT for review and comment. In June 2009, NYSDOT provided comments for consideration in the report. MwRSF published a final test report in the Third Quarter of 2009.

In addition, a follow-on study was funded to re-test the TCB when continuously pinned along the back-side barrier face. In the Third Quarter of 2009, the TCB segments were acquired. On September 4, 2009, one 2270P pickup truck crash test (NYTCB-5) was successfully performed according to the MASH guidelines.

Dynamic Evaluation of New York's State's Aluminum Pedestrian Signal Pole (New York DOT)

In the Third Quarter of 2009, all of the construction materials for the aluminum pole and signal system were acquired. On September 2, 2009, one low-speed, crushable-nose, pendulum test was conducted according to test designation no. 3-60 of NCHRP Report No. 350. An aluminum pole and base was evaluated without the use of a traditional breakaway assembly. During the test, the welds which attach the pole to the base plate assembly fractured, and the pole was dislodged away from the base. The accelerometer data was analyzed and indicated that the impact event resulted in acceptable levels of occupant risk, deceleration, and change in velocity. However, the remaining stub height of the base plate measured 4.5 in., thus violating the 4-in. threshold value established by FHWA and AASHTO. Approximately 0.5 in. of the 4.5 in. stub height pertained to the thickness of the leveling nuts.

At this time, MwRSF is working with the sponsor to determine how to proceed with the project. In the Fourth Quarter, the test results will be documented with the preparation of a letter-type report.

Awaiting Reporting

Phase I & II Development of a TL-3 MGS Bridge Rail – Program Years 18 and 19

The MGS bridge railing and reinforced concrete deck systems, including the upstream and downstream semi-rigid guardrails and simulated end terminals, were constructed in the Second Quarter of 2009. Two full-scale vehicle crash tests were conducted according to the TL-3 impact conditions found in the MASH guidelines. On June 18, 2009, a 2270P pickup truck impacted the MGS bridge rail with satisfactory results. Following the test, the barrier was reconstructed. On June 26, 2009, an 1100C small car test was successfully performed. Pre- and post-test photographs for the two crash tests are provided below.

Originally, the concrete deck system was scheduled for removal in the Third Quarter of 2009. However, this effort was delayed while MwRSF contacted the KsDOT to determine whether interest existed for the possible future development of a TL-2 bridge railing. In that case, the concrete deck may remain in place until the Pooled Fund meeting is held in April 2010.

During the Third Quarter, additional computer simulation modeling, crash data analysis, evaluation, and test reporting occurred. The reporting of this research project should be completed in the Fourth Quarter.

Development of a Temporary Concrete Barrier Transition – Program Year 16

Two pickup truck crash tests were successfully performed on a transition between temporary concrete barrier and permanent concrete median barrier. The evaluation was performed using the MASH-08 guidelines. A draft report should be submitted to the Pooled Fund members for review and comment in the Fourth Quarter of 2009.

Draft Pooled Fund Reports Completed

Thiele, J.C., Lechtenberg, K.A., Reid, J.D., Faller, R.K., Sicking, D.L., and Bielenberg, R.W., Performance Limits for 152-mm (6-in.) High Curbs Placed in Advance of the MGS using MASH Vehicles Part II: Full-Scale Crash Testing, Draft Report to the Midwest States' Regional Pooled Fund Program, Transportation Research Report No. TRP-03-221-09, Project No.: SPR-3(017)-Year 17, Project Codes: RPFP-07-03, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, August 24, 2009.

Final Pooled Fund Reports Completed

Not Applicable

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

Arens, S.W., Sicking, D.L., Faller, R.K., Reid, J.D., Bielenberg, R.W., Rohde, J.R., and Lechtenberg, K.A., Investigating the Use of a New Universal Breakaway Steel Post, Draft Report to the Minnesota Department of Transportation, Transportation Research Report No. TRP-03-218-09, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, August 3, 2009.

Schmidt, J.D., Faller, R.K., Lechtenberg, K.A., Sicking, D.L., and Reid, J.D., *Development and Testing of a New Vertical-Faced Temporary Concrete Barrier for Use on Composite Panel Bridge Decks*, Draft Report to the Kansas Department of Transportation, Transportation Research Report No. TRP-03-220-09, Project No.: SPR-3(017) Supplement #57, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, August 6, 2009.

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

Howard, C.N., Stolle, C.J., Lechtenberg, K.A., Faller, R.K., Reid, J.D., and Sicking, D.L., *Dynamic Evaluation of a Pinned Anchoring System for New York State's Temporary Concrete Barriers*, Final Report to the New York State Department of Transportation, Transportation Research Report No. TRP-03-216-09, Project No.: TPF-5(193), Supplement #8, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, September 8, 2009.

Terpsma, R.J., Faller, R.K., Reid, J.D., Sicking, D.L., Bielenberg, R.W., Rosenbaugh, S.K., Lechtenberg, K.A., and Holloway, J.C., *Development of a TL-2 Steel Bridge Railing and Transition for Use on Transverse, Nail-Laminated, Timber Bridges*, Final Report to the West Virginia Department of Transportation, Transportation Research Report No. TRP-03-212-09, Project No.: WV-09-2007-B2, Sponsor Agency Code: SPR-3(017) Supplement #52, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, August 13, 2009.

Pooled Fund Consulting Summary

Midwest Roadside Safety Facility
July 2009 – September 2009

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 –Concrete Barrier Alignment

State Question:

I was reading the quarterly reports that indicate that a 4" gap between barriers with chamfering may consider to be acceptable. Has there been research on far one face of barrier can be out of alignment to the an adjacent face (see picture)?

Erik Emerson P.E.
Standard Development Engineer
Wisconsin Department of Transportation

MwRSF Response:

Hi Eric,

With regards to permanent concrete barrier, we would recommend keeping the lateral offset or alignment offset minimized to eliminate snag. Variations of 1” or less would be preferred.

For the temporary barrier installation shown in your photo, we would prefer that the alignment gap be 1” or less, but we believe that gaps as large as 2” are likely permissible. The rationale behind the larger alignment gap allowance is that temporary barrier segments will move when impacted and cause changes in the alignment gap as the impacting vehicle reaches the barrier joint. Thus, a joint that has a given initial alignment will move change alignment as the barrier is impacted. This allows for more tolerance for the temporary barrier gap. Alignments gaps larger than 2” would indicate problems with the temporary barrier joint and would require investigation.

Thanks

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

Figure 1. Barrier Alignment

Problem # 2 –MGS Guardrail Repair

State Question:

Here's some feedback from the field on the MGS. In this case the rail was hit from the back and popped off a longer run. I don't think this is surprising, but would appreciate any comments.
One question this raises, is about re-using the rail element. The only damage appears to be a little deformation around the bolt hole where the button head pulled through. This could probably be straightened in the field.

David L. Piper, P.E.
Safety Design Engineer

MwRSF Response:

Dave:

Thanks for the guardrail damage photographs. From the photographs, I only can see some minor deformation around the guardrail bolt slots. As long as there are not any fractures or cracks around the slotted holes, I am not too concerned about reusing the rail by re-mounting it to the posts/blocks. However, you may consider using the downstream side of the slot if the downstream hole can be used on each blockout/post.

Ron

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

Figure 2. MGS Guardrail Damage

Problem # 3 – New Jersey Shape PCB Anchorage

State Question:

Here are the drawings for New Jersey shaped PCB that is anchored on our structures. These standards are followed on structures or if there is limited deflection.

The run of New Jersey shaped PCB before anchored pieces do not have to be anchored and have a deflection of 5.5'. Here is the drawing for that.

I will not be in the office very much this week, no hurry on this. Thanks for your time. Let me know if you need any additional information.

Respectfully,

Michael Bline, P.E.
Standards and Geometrics Engineer
Office of Roadway Engineering
Ohio Dept. of Transportation

MwRSF Response:

Hi Michael,

Ron Faller asked me to respond to you regarding approach transitioning to your tied-down NJ shape PCB. We developed just such an approach transition for the Kansas F-shape PCB. I have attached the report detailing that transition.

While the transition we designed worked successfully with the Kansas F-shape barrier, we have concerns with regards to how it will function with your PCB design. I will try to lay out these concerns below.

1. First, we do not believe that the anchorage system on your PCB is equivalent to the anchorage used in the transition we developed. Your barrier uses 1” dia. high-strength steel rods embedded 6.5” into the concrete with a grout mixture. Our experience with this type of anchorage is that it is not sufficient to develop much of the strength of a 1” dia. high-strength steel rod. We believe that these anchors will pull out of the concrete surface much more easily than the anchors we tested with. This will change the stiffness and deflection of the anchored barriers as compared to the ones use in the transition we tested.
2. We did recognize that you have more anchors than use used in our anchored barriers, but that is another cause for concern. We do not recommend placing anchors on the backside of barriers. There are concerns that placing anchorage on back side of the barrier can induce increased vertical rotation of the barrier segments which could increase the potential for vehicles to climb the sloped barrier face and become unstable. Thus, we would recommend no anchorage on the backside of your barrier.

3. Barrier reinforcement in your barrier is not sufficient to derive the full strength of the 1" dia. high-strength steel rod used. In our anchored barriers, the anchor pockets have reinforcement loops that go around the packet to contain the anchors. Without this type of reinforcement, we do believe your anchors will fracture through the anchor pocket and become ineffective.
4. I also noted that you allow the use of JJ-Hooks barrier segment connections with your PCB. We would not recommend this connection for use in an anchored barrier system. The JJ-Hooks connection is fine for free-standing systems. However, to be safely used in an anchored barrier or approach transition, the barrier joints must have comparable or greater torsional rigidity about the longitudinal barrier axis when compared to that of the as-tested configuration. JJ Hooks connection is not similar in torsion to the Kansas barrier joint, and the JJ Hooks connection is also non-symmetric in that it has different capacities depending on the direction it is loaded.

At this time, if you need to have anchored barrier sections and an approach transition from free-standing barrier, we would suggest using the Kansas F-shape design and the transition and tie-down systems we have tested with it.

In order to adapt your barrier to safely use the approach transition, we would recommend that you change your current barrier and anchorage system to:

1. Remove backside anchors.
2. Increase anchorage of front anchors to develop the full strength of the threaded rods.
3. Reinforce the anchor pockets.
4. Disallow the use of JJ-hooks in the anchored configuration

Let me know if you have further comments or concerns

Thanks

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

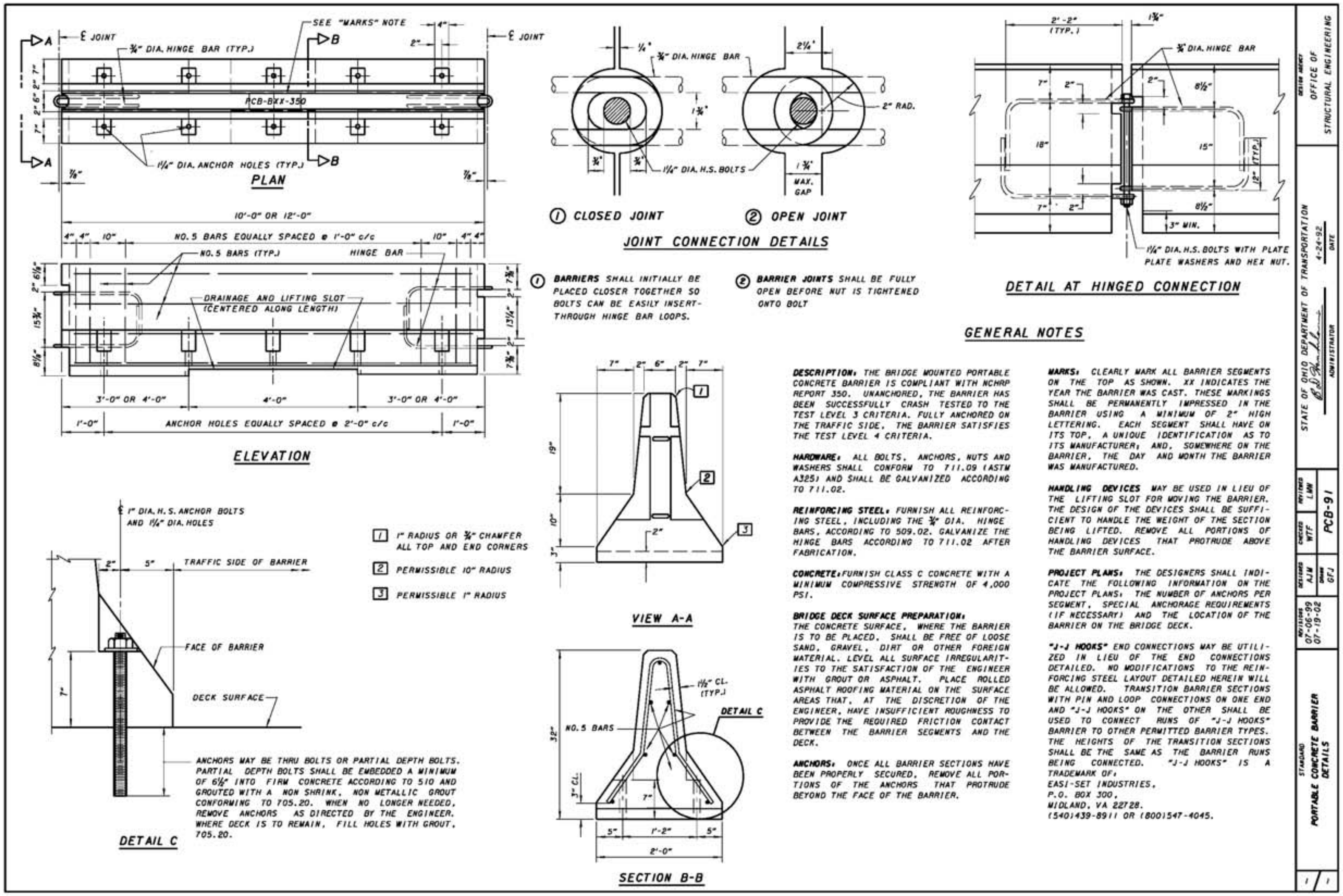

Figure 3. Ohio Anchored New Jersey Shape PCB

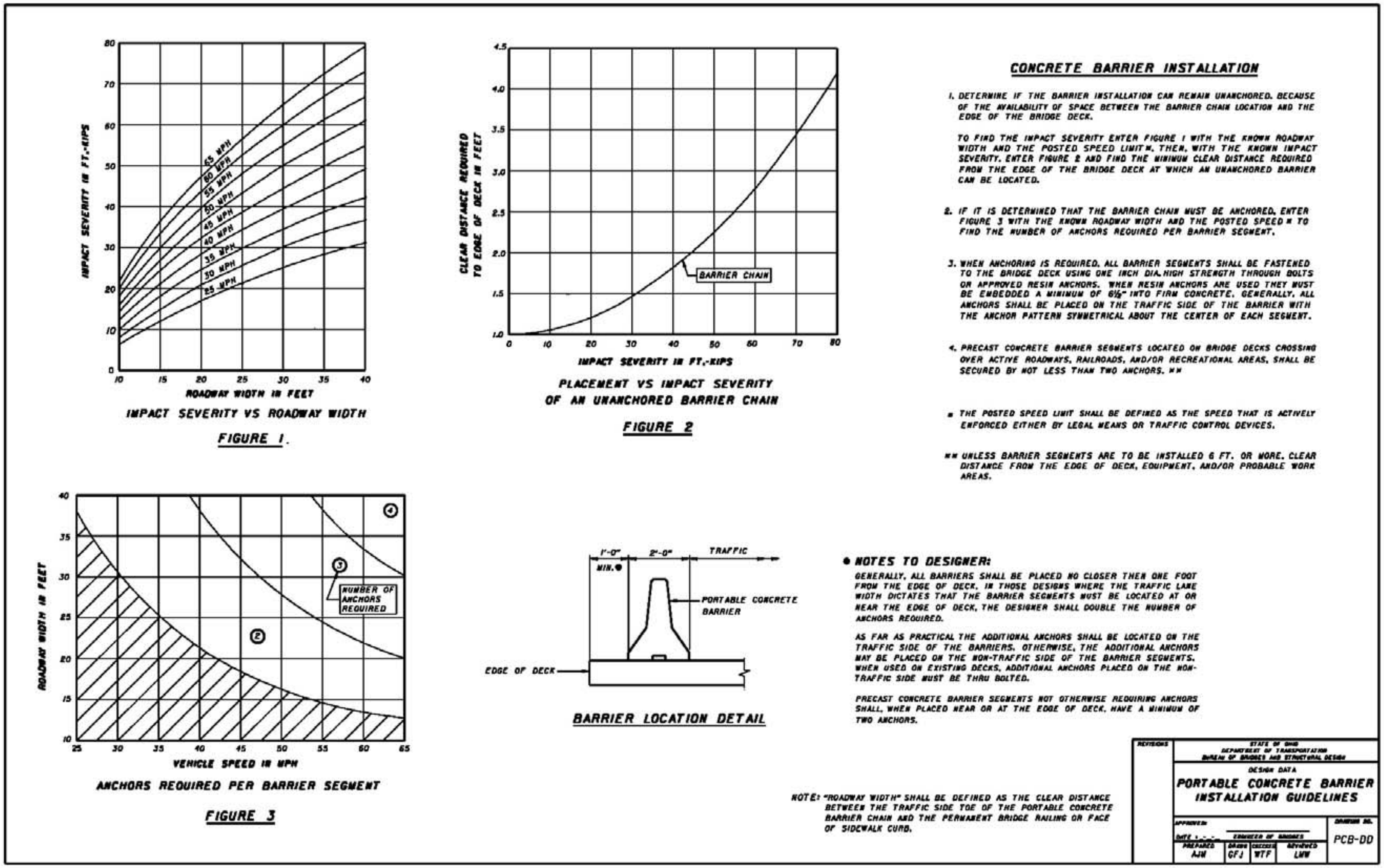

Figure 4. Ohio Anchored New Jersey Shape PCB

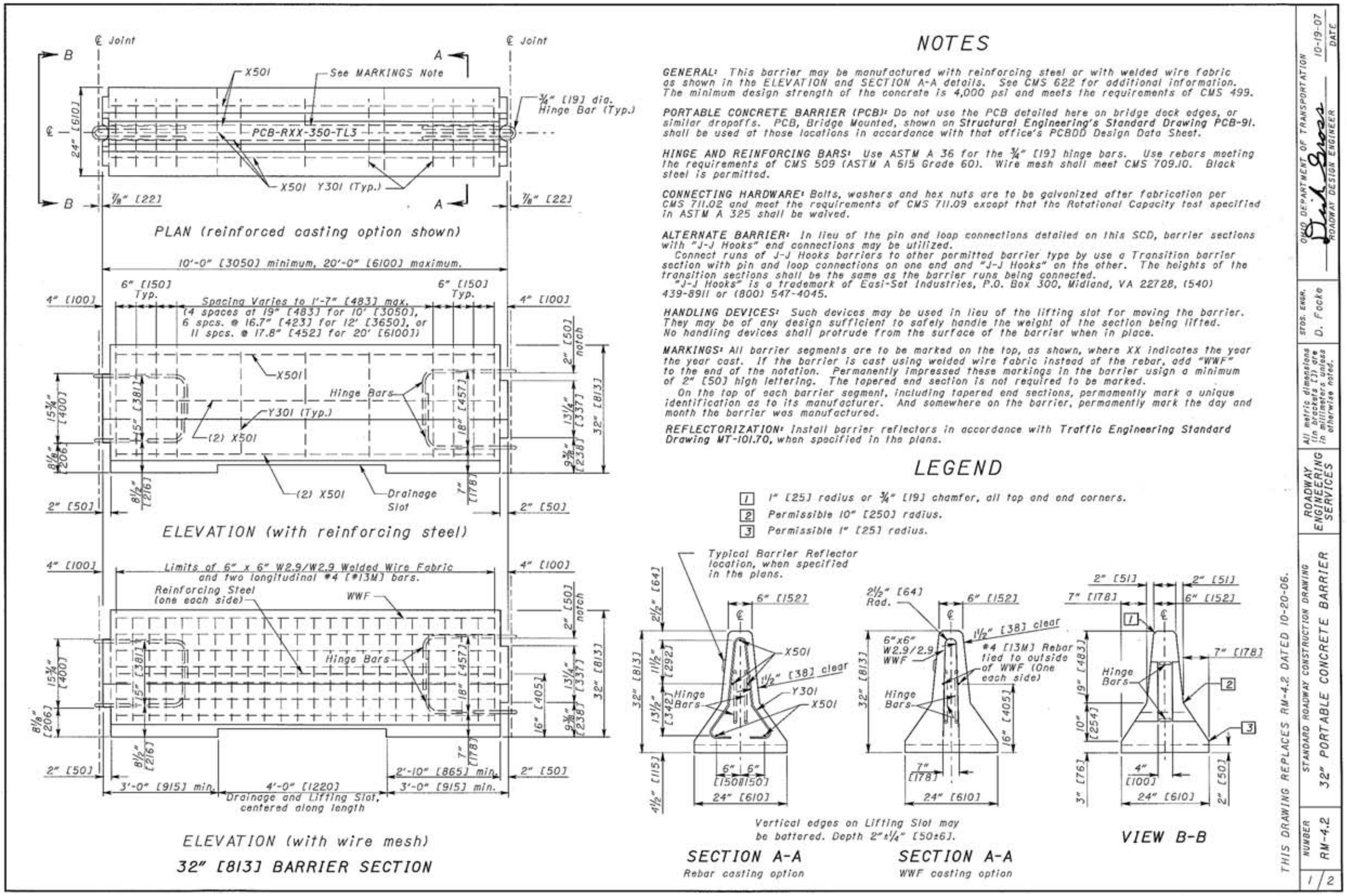

Figure 5. Ohio Anchored New Jersey Shape PCB

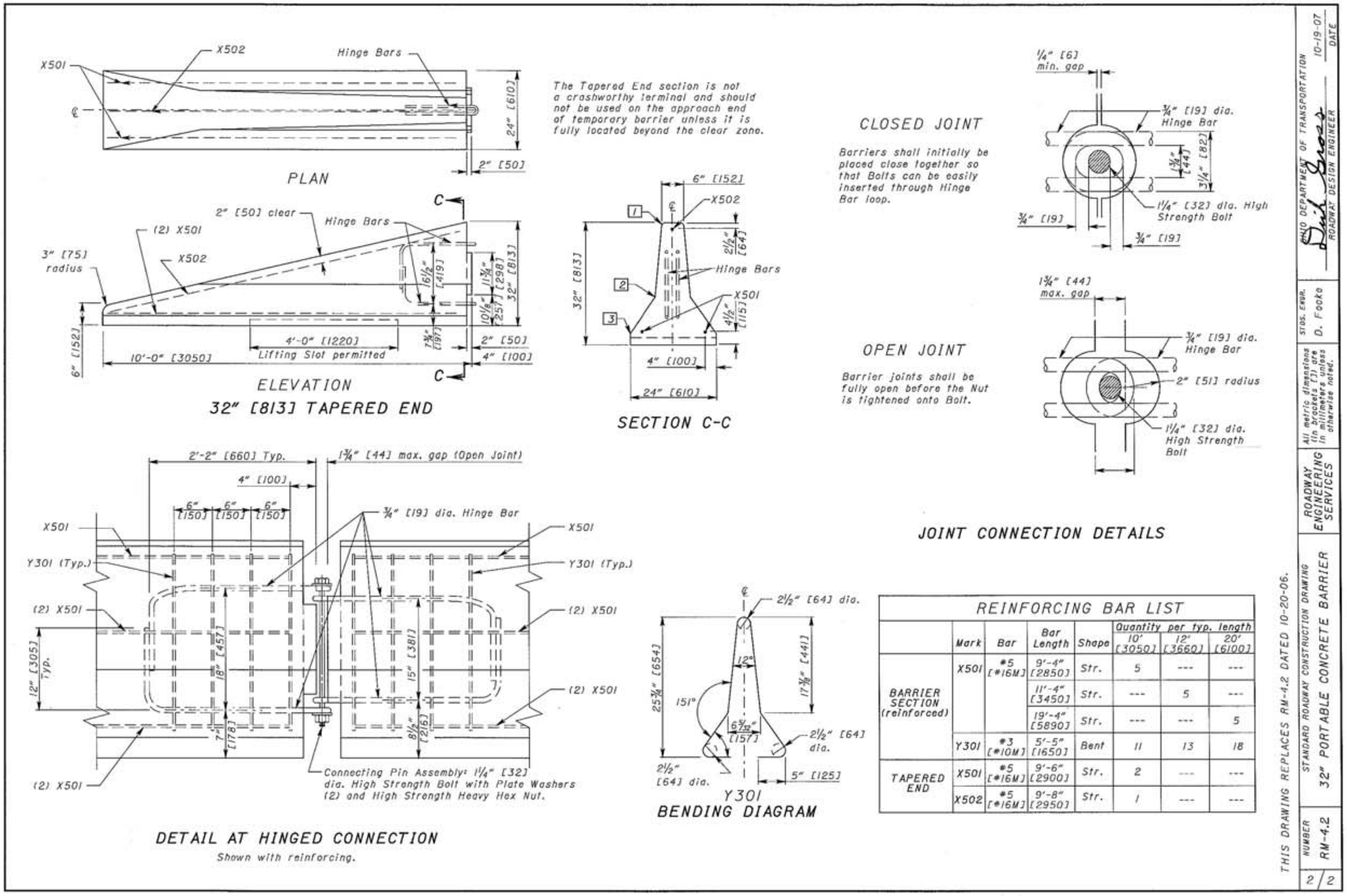

Figure 6. Ohio Anchored New Jersey Shape PCB

Problem # 4 – MGS Blockout Depth

State Question:

Ron,
An issue has come up concerning the size of wood blockouts used with the MGS for IDOT and the Illinois Tollway. We have a contractor that has placed 2-piece wood blockouts that measure 11.5" from back of rail to front face of steel post. The standard clearly shows that this dimension should be 12".

The contractor is throwing around nominal versus actual and construction tolerances. What is your opinion on this? I would assume that it would test ok, but how much wiggle room is there in the dimensions?

It is my opinion that they should be replaced with the correct size, but the contractor is obviously resisting.

Thanks for any input.

Tracy Borchardt
AECOM
GEC for the IL Tollway

MwRSF Response:

Tracy:

Recently, I have received many calls and emails on this topic in Illinois from the DOT, guardrail installers, fabricators, etc. From what I have noted to all of them, MwRSF addressed this issue in 2007 during an email discussion regarding the implementation of the MGS. In that email discussion, MwRSF noted the following:

October 19, 2007

“Therefore, it would make sense to specify a timber blockout with the full 12-in. depth or two blocks – one 6x8 and the other 6x4. MwRSF researchers also believe that the reduced depth of 11 ¼ and 11 5/8 in., as determined for fabricated and single rough-sawn blocks, would provide acceptable performance within the MGS. However, crash test results with reduced-depth blocks in the MGS are not available at this time. A reduction of ¾ or 3/8 of an inch in blockout depth may fall within the noise level in performance and may not allow us to discern much difference if multiple tests were performed. In any event, we feel that the 12-in. blockout depth provides the safest alternative of the three depth options (i.e., 12, 11 5/8, and 11 ¼).”

From my recent discussion and email correspondence with David Piper and Bernard Griffin of the ILDOT, it now appears that the DOT will be contacting fabricators in order to obtain input before determining the acceptable tolerance on blockout dimensions. Although it is desired to use a 12-in. offset, it is also important to request a product that is economically reasonable. The ILDOT is beginning this investigative effort now.

In terms of your comments and questions noted below, it is correct to say that the blockout dimensions may vary depending on whether the blocks are supplied at full sawn, rough sawn, or dressed. However, it still would be preferable to utilize the full, 12-in. lateral offset purely from a safety performance perspective. If the MGS has been installed with a 11.5-in. blockout, I would not be inclined to swap out those existing blocks with deeper 12-in. blocks.

On another note, I am aware of a plastic block manufacturer having its routed block crash tested with the MGS. I believe that the block was 12-3/8-in. with a 3/8-in route on the post side, thus resulting in a true 12-in. lateral offset.

Ron

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

Problem # 5 – MGS with Gutter Curb

State Question:

I have another question about the MGS. see attached for the IL Tollway standards for gutter used adjacent to MGS. On our mainline high-speed sections, G-3 gutter is used where necessary to handle the pavement drainage and/or to prevent sideslope erosion. we currently offset the guardrail post 6" behind the back of gutter, which means that the distance from the flowline to the face of rail is 11.75". What are your thoughts on this configuration versus the 6" high curb with a 6" offset that was tested?

For your information, the post used to be at the back of gutter and we used a 6" blockout for the guardrail. When we switched to the MGS, we decided to keep the offset to the rail the same as it was and push the post back.

Thanks,

Tracy

Tracy Borchardt
AECOM
GEC for the IL Tollway

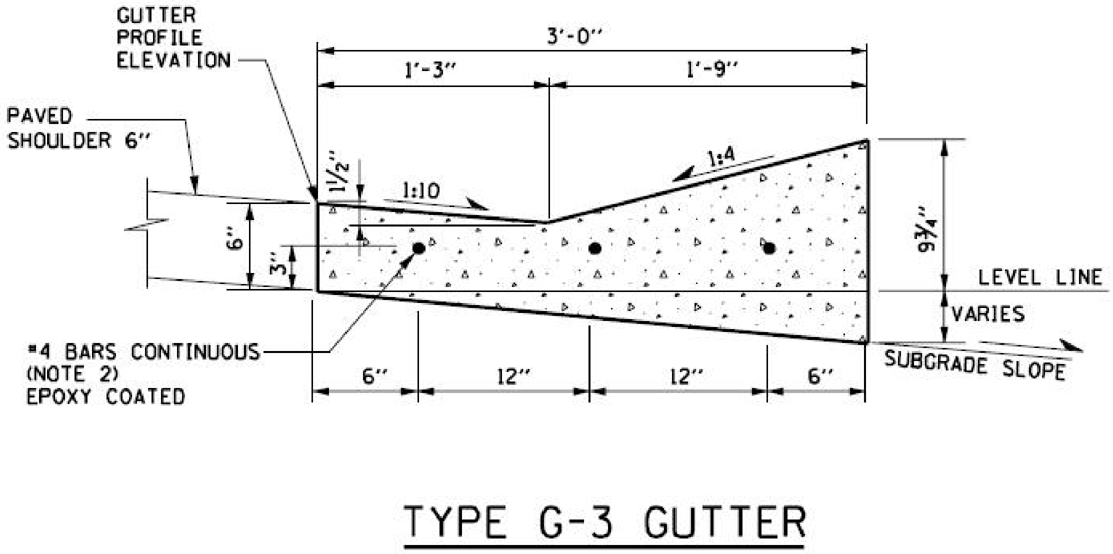

Figure 7. G-3 Gutter

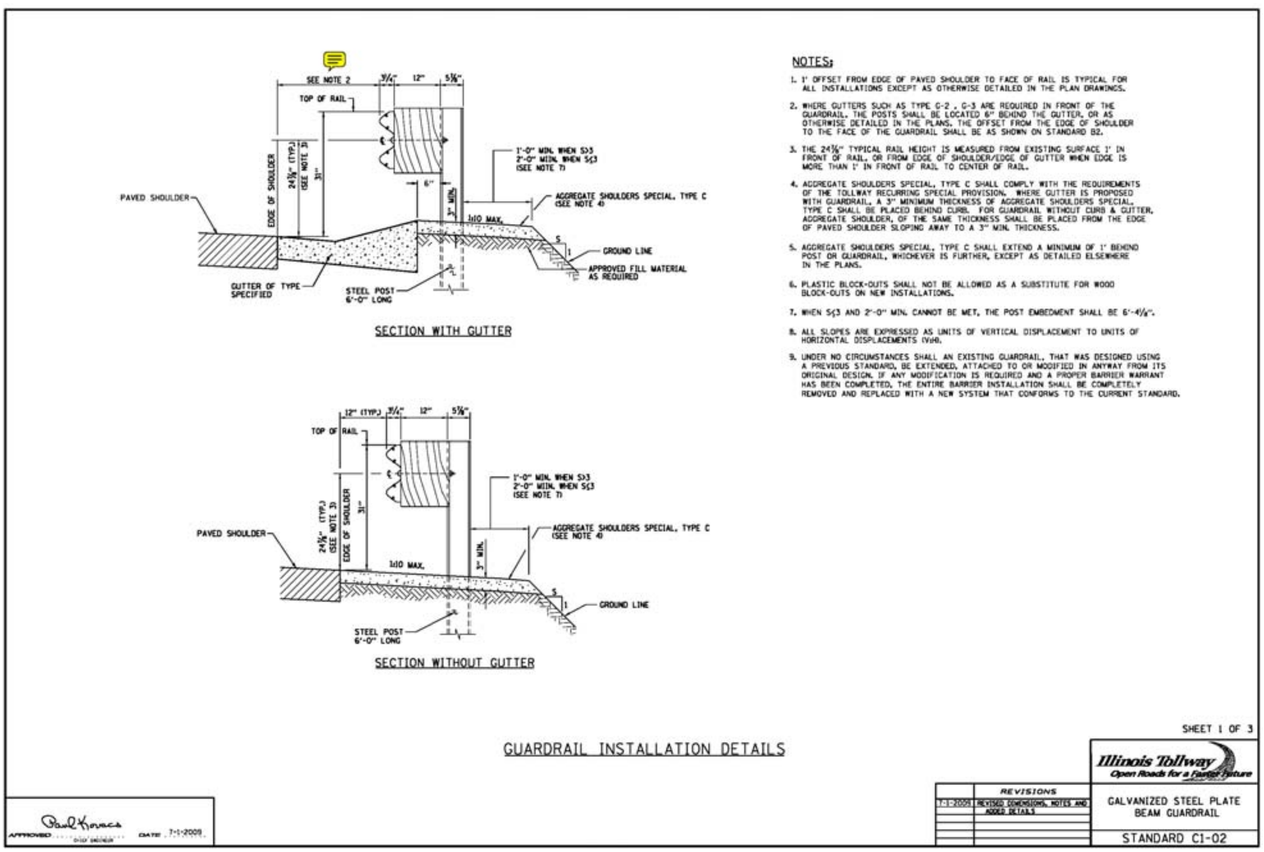

Figure 8. MGS with G-3 Gutter

MwRSF Response:

Dean Sicking, John Reid and I have reviewed the attached CAD details that pertain to the MGS with alternative curbs used within the Illinois Tollway. As you recall, the MGS was successfully crash tested with a 6-in. tall, AASHTO Type B curb. In this scenario, the MGS was installed with the rail face placed 6 in. behind the midpoint of the curb face, or 7 in. behind the curb toe. The rail height was 31 in. above the level roadway surface.

In the IL Tollway detail, the MGS rail face is positioned 11.25 in. behind the toe of the G-3 gutter. In addition, the top of the rail is positioned 32.5 in. above the roadway relative to the bottom of the curb or swale. The curb height is 5.25 in. tall, as measured between the curb toe and the back of the curb.

Although there are slight differences between the successfully crash-tested system and the IL Tollway detail, we believe that the noted system with MGS in combination with the G-3 curb would provide a crashworthy system. However, we do not have physical or scientific evidence to support this opinion and would like to conduct a brief analysis to investigate the alternative scenario. As such, we used LS-DYNA to evaluate and compare the two scenarios since we have experimental data to validate the 6" Type B curb cases.

Dr. John Reid has made a very brief comparison between the two noted curb geometries – the 6-in. tall AASHTO Type B curb and the Illinois Tollway's wedge-shaped curb. This initial investigation included both an examination of vehicle trajectories and motions with and without the guardrail in place behind the curb. From this study, the use of the wedge-shaped curb in combination with the MGS (located per your prior CAD details) does not appear to degrade barrier performance over that observed for the MGS with the 6" Type B curb. As such, MwRSF is not concerned with placing the MGS behind the wedge-shaped curb using the previously noted details.

Respectfully,

Ron

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

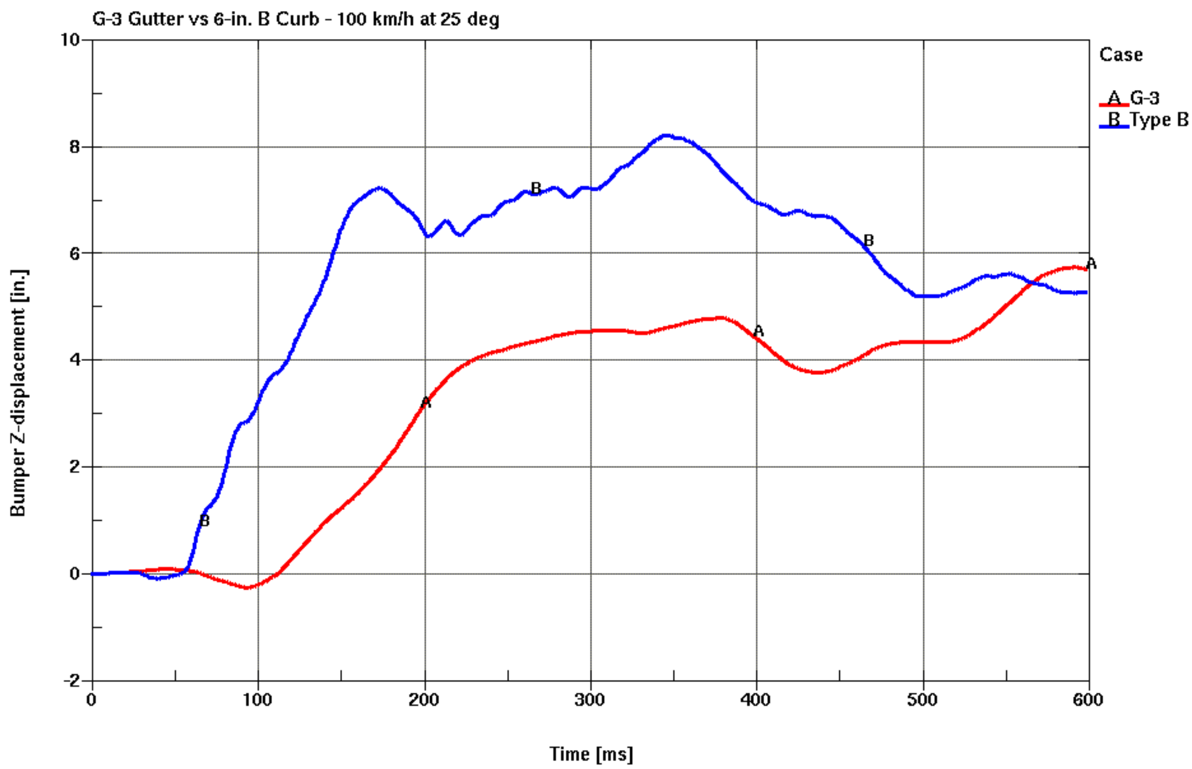

Figure 9. Vertical Bumper Displacement for 6" Type B Curb and 3" G-3 Gutter

Problem # 6 – Guardrail Over Culvert Weld Detail

State Question:

Bernie and I have a question about the weld detail for the guardrail attached to the top of a culvert slab. I understand Karla is away from work right now, and she has been very helpful. I'm wondering if we have misinterpreted the intent of the weld detail. The intent is to attach the post to a ½ inch plate such that the plate is deformed during a crash. A strong weld was needed for this, and we understand that this is a three pass 5/16 inch weld. Is the three pass 5/16 inch weld intended to express the total final dimension? We had interpreted it as three passes, each 5/16. We are getting industry feedback suggesting that this is a problem. (See below.)

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

MwRSF Response:

From my recollection on this issue, a single pass weld was used in some of the early dynamic component tests. For some of these tests, the posts tore off of the base plate due an inadequate weld. Later, a three pass weld was utilized in the dynamic component testing program, thus resulting in the post remaining attached to the plate as well as the ability for plate deformation and energy dissipation.

I have reviewed the CAD details and photographs from the successful dynamic component test, test no. KCB-7. I have attached selected photographs from this bogie test as well. From the photographs and CAD details, it is my opinion that the intent was to utilize a 3-pass weld to achieve a weld size that would meet the 5/16" size in total for the front and back edges of the front (traffic-side) flange. This same weld detail was used for the steel posts that were attached to the actual concrete box culvert for the crash testing program. However, I am unable to determine the size of the three individual weld passes that were used to complete the weld process. Due to the results obtained from the original seven bogie tests, MwRSF cannot recommend the use of the single pass weld at this time. If a single pass weld is desired in the future, MwRSF would need to perform similar bogie testing on the post-plate assembly fabricated according to your alternative design to ensure that similar behavior is provided.

Ron

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

Problem # 7 – Wood and Steel Posts in a Run of Beam Guardrail

State Question:

Dear MwRSF,

In our current specifications we do not permit the mixing of wood and steel post within a run of beam guard. I have not found published guidance indicating that the mixing of steel and wood post is a problem. Is there an issue in mixing wood and steel post within a run of beam guard? My first guess is that the wood and steel post react differently during an impact and mixing them could cause a potential pocketing situation, but I don't know for sure.

We require the EATs and the Thrie Beam Structure Approaches to use only wood post. This can lead to wood being installed at the ends of a beam guard run that uses steel posts. If we shouldn't allow the intermixing of wood and steel within a beam guard run, switching back to wood for the EAT and the Thrie Beam Structure Approach appears to be problematic.

For the EAT, I could see that we need the post to fail during a head on impact with the EAT and therefore break a way post would be needed. I just don't know if there is a similar argument for the Thrie Beam Structure Approach.

Any insight that MwRSF could provide would be greatly appreciated.

Sincerely,

Erik Emerson P.E.
Standard Development Engineer
Wisconsin Department of Transportation

MwRSF Response:

Erik:

Generally speaking, W-beam guardrail systems have been crash tested with one post type placed throughout the major length of the barrier system. For each test, either wood posts or steel posts were likely used and not the combined or alternating use of wood and steel posts within the impact region. Many of these W-beam barrier systems have been found to have similar dynamic performance. If barrier performances were found to be similar when using the steel and wood posts, then I would not be too concerned with allowing the replacement of damaged posts with a post of an alternative material type, wood for steel and steel for wood assuming the post performances were found to be similar. For approach guardrail transitions, the same general philosophy would be used, but it is important to try to match the post-soil behavior to that used in the original system. For guardrail end treatments, the use of alternative post materials should be addressed by the manufacturer since most of these systems are proprietary.

Ron

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

Problem # 8 – TL-2 - Low Profile Barrier

State Question:

Wisconsin was interested in installing a TL-2, low profile bridge rail that will be backfilled with soil and were looking for guidance pertaining to the foundation/anchorage requirements. The barrier in question was the TL-2 concrete barrier designed by MwRSF in report TRP-03-109. It was planned for use in both median or roadside applications. The backfill was expected to be 21 feet in median applications, and the roadside application may place a 6:1 on the backside. The roadway in question was being reconstructed. In the median, the expected barrier placement was at least 2' from edge of lane, and on the roadside the region is pushing for 10' shoulder on the outside, but may not get it.

MwRSF Response:

Erik,

To adapt the low profile, TL-2, concrete bridge rail to roadside applications, I see three options. These options are shown in the PDF file in the folder noted below. Also, 2 digital videos of the full-scale crash test are in the folder.

(1) Place the barrier on top of the shoulder and tie the vertical steel directly into the shoulder slab. This, to me, seems like the easiest and most efficient method. Even if the shoulder slab is only 6" thick (shorter than the development length of the rebar, and shorter than the 8" embedment depth used during the crash test), the combination of overturning resistance provided by the rebar and the resistance provided by the soil backfill should create adequate strength to redirect a vehicle. Also, the rebar ties should prevent the barrier from lateral and rotational movement due to lateral soil pressure. Again, I would recommend this method.

(2) Place the barrier adjacent to the shoulder slab, extend the barrier downward, and tie in the internal steel to the slab through the end. This should also provide adequate strength to resist impacts and lateral movement due to soil pressure. However, the internal steel reinforcement must be designed correctly to carry the load and it will be more difficult to cast with the bends.

(3) The barrier is not in contact with the shoulder in any way. For this method, the barrier must be attached to a footer, as shown. The footer would need to be at least 12" in depth and run the length of the barrier. Calculations for the necessary internal steel can be done using the design method described in the MwRSF report – "Development of a Stand-Alone Concrete Pier Protection System" Report No. TRP-03-190-09. This will proof to be the most costly design.

I hope this helps. Let me know if you have any further questions. See the link below for the drawings and videos.

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

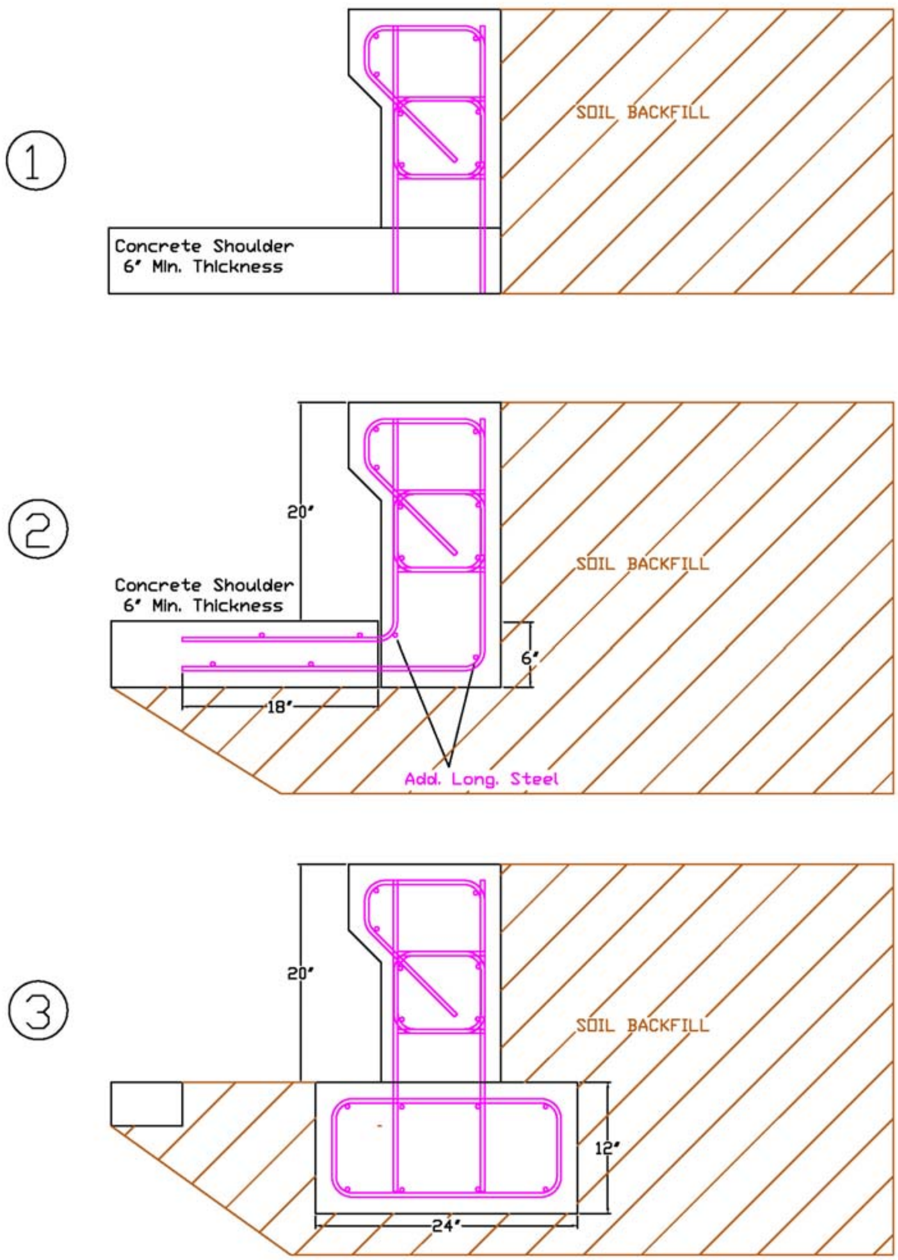

Figure 10. TL-2 Barrier

Problem # 9 – MGS Posts in Asphalt

State Question:

Ron,
We have a Weigh-in-motion enforcement site being constructed along I-90. The designer proposed essentially widening the asphalt shoulder by 30' for the State Police to use to pull overweight vehicles over to check with portable scales. This area has tapers on each end and is several hundred feet long. The State Police had requested that the area be "protected" with guardrail, so the designer proposed a run of guardrail parallel to the mainline, between the mainline shoulder and the enforcement area. The pavement is 9" asphalt and they are proposing to drive the posts thru it.

questions: will the guardrail react properly when placed in that thick of pavement? I thought that the posts needed to be able to rotate in the soil to absorb the energy. That is why we are telling all of the designers that the posts cannot be placed in concrete. Wouldn't they just snap off or bend at the top of pavement?

If 9" of pavement is too much around the posts, how much is acceptable? has this been tested?

Thanks for your help.

Tracy Borchardt
AECOM

MwRSF Response:

Tracy:

Prior testing of W-beam guardrail systems with thick asphalt (or rigid concrete) surrounding the posts has been shown to degrade guardrail performance. Several years ago, TTI researchers developed a methodology for placing guardrail posts in a cutout to allow for adequate post rotation (Report No. 1 and ASCE Paper). Details for this method are contained in the attached FHWA acceptance letter (B64b.pdf). Within this letter, FHWA also included details for placing posts in situations where subsurface rock is encountered, per a research study by MwRSF (Report No. 2). In the MwRSF study, additional details were provided for the configuring the size of asphalt leave-outs.

More recently, TTI researchers have continued to develop leave-out alternatives for guardrail posts placed in mow strips. Although that research is continuing or recently completed, I will try to find either a recent progress report and/or draft report that summarizes the most recent findings and acceptable practices for posts placed in mow strips or over subsurface rock (Report Nos. 3 and 4).

You are correct in noted that it is desirable for guardrail posts to rotate in the soil and dissipate a portion of the vehicle's kinetic energy. When premature wood post fracture occurs, other behavior may occur, such increased barrier deflections, vehicle pocketing, or vehicle instabilities upon redirection. Similarly, steel posts may yield with limited displacement at the ground line, thus changing the loading to the rail as well as the rail movement while deflecting. For steel posts, rail rupture can occur as well as barrier override. For now, we must provide leave-outs in the rigid pavement in order to allow the posts to behave as they would in compacted soils. TTI has developed some alternative leave-outs that may be worth considering, as presented in the latter reports. Finally, you are correct in noting that 9-in. asphalt pads are excessive and would result in wood post fracture or immediate steel post yielding and twisting.

If you have any questions on these topics after you have reviewed the noted materials, please feel free to contact me at your earliest convenience.

Ron

Problem # 10 – Kearney Bypass Crash Cushion/Impact Attenuator

State Question:

Hi Dean,

I am working with Lou Lenzen and Syed Ataullah on the Kearney Bypass project. I believe they've discussed with you our concern with head-on crashes at an interchange on this project. I have attached some drawings of the area.

A description of the pdf files is given below:

- Kearney Bypass 60 scale.pdf is a plan view of the area at a 60 scale. This exhibit has a few dimensions and leaders describing the linework.
- Kearney Bypass 30 scale.pdf is a plan view of the area at a 30 scale.
- Kearney Bypass section.pdf shows sections of the roadway as a truck is traveling south over the bridge and to the 3-way intersection. The first section (option 7) shows what we are proposing – a jersey barrier on the outside of the shoulder, but probably with a reinforced slope of 1:1.5.

Grading and paving of the current design may be flexible to achieve the distance we need for the crash cushion/impact attenuator.

The attached drawing (at a scale of 1:40) is a simplified sketch of the south section of the interchange. In order to allow for WB-62 truck turning movements, the current design provides about 21' for a crash cushion/impact attenuator in front of the jersey barrier. Please let us know if there is a device that will protect or lessen head-on impacts within this limited space.

Please let me, Lou or Syed know if you have any questions or need additional information. Thank you!

Melissa Egelhoff, P.E.
Nebraska Department of Roads

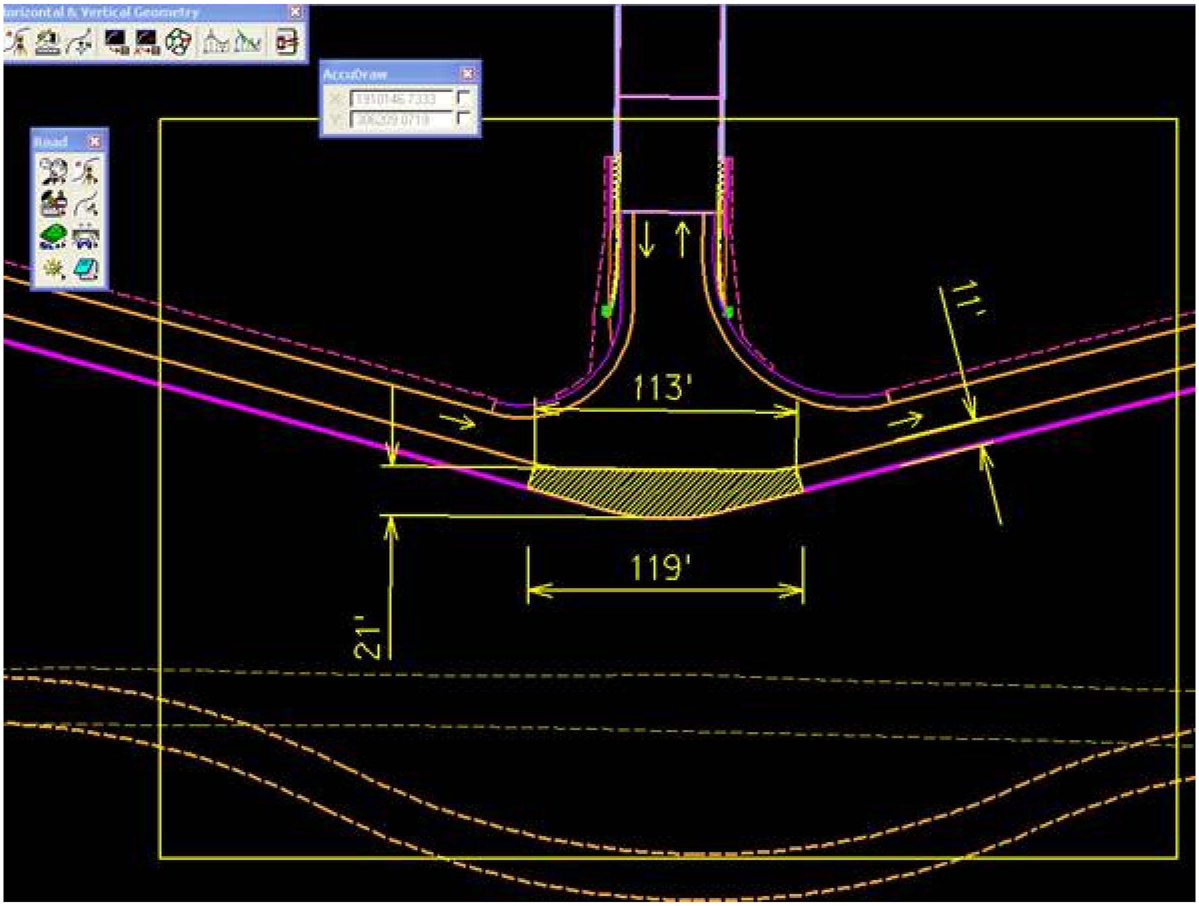

Figure 11. Kearney Bypass

MwRSF Response:

Melissa,

I've attached my recommended configuration for the sand barrel crash cushion. It takes a lot of barrels to protect such a wide area!

Some key items to note:
(1) Barrels are 3 ft in diameter and should be spaced 6 in. apart.
(2) The gray line in the drawing represents the 24 in. clear space recommended between sand barrels and the hazard .

(3) The black line has the same dimensions as the yellow hatched area on your drawings.
(4) The head-on impact scenario requires 6 rows of barrels to safely stop errant vehicles – thus the 21 ft length shown in your drawing (yellow hatching) needs to be extended 1.5 ft to 22.5 ft.
(5) Most rows contain only 1 type (weight) of barrel, but there are 2 exceptions. Rows 2 and 3 have lighter barrels on the ends. This is designed for end in impacts (not necessary for on ramp, but included to make system symmetric.

The rows break down as follows

Row 1: 31 – 200 lb. barrels
Row 2: 31 – 400 lb. barrels and 2 – 200 lb. barrels (1 on each end)
Row 3: 29 – 700 lb. barrels and 2 – 400 lb. barrels (1 on each end)
Row 4: 23 – 1400 lb. barrels
Row 5: 15 – 2100 lb. barrels
Row 6: 7 – 2100 lb. barrels

If you have any questions, please ask.

Thanks,

Scott Rosenbaugh
Midwest Roadside Safety Facility (MwRSF)
University of Nebraska - Lincoln

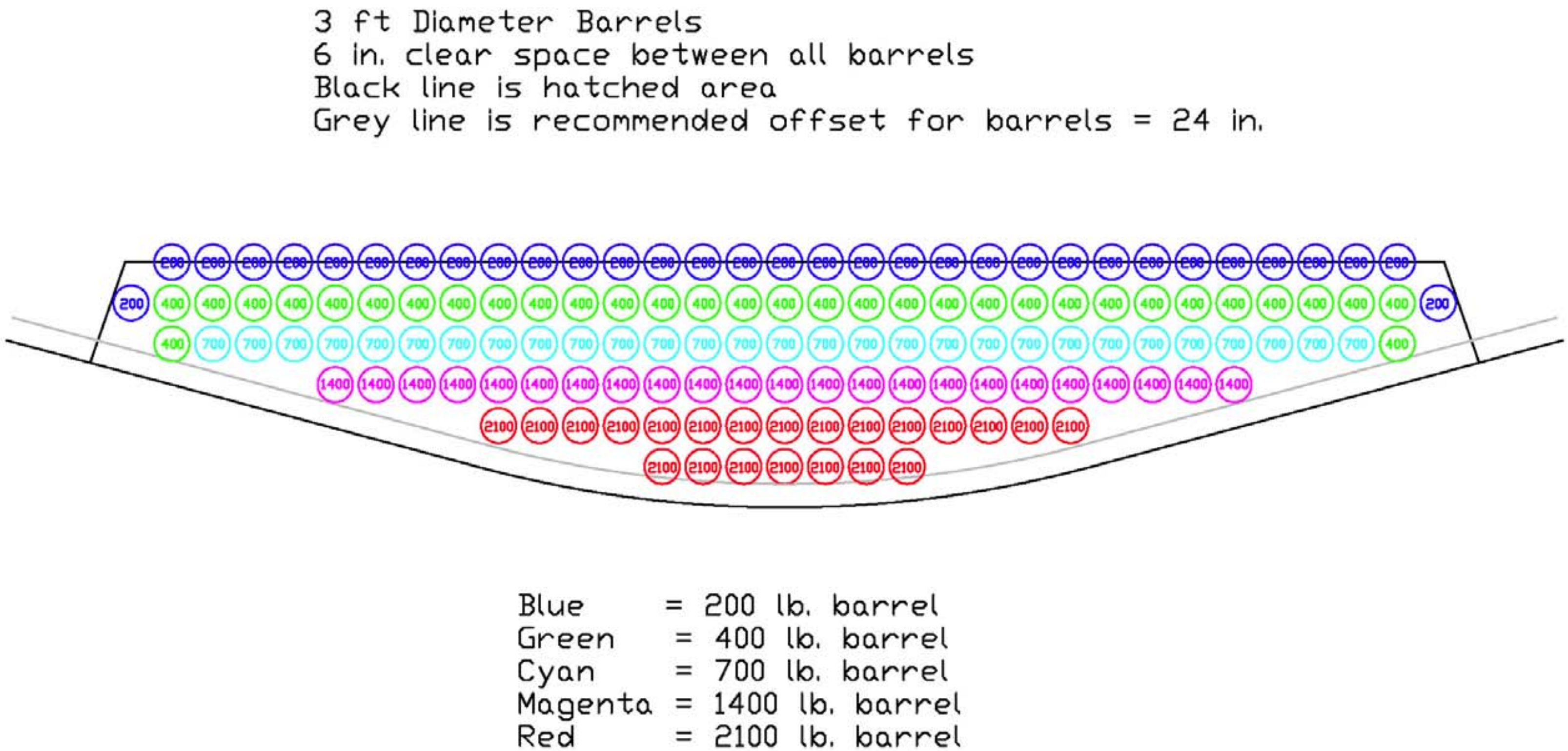

Figure 12. Kearney Bypass Sand Barrel Layout