Second Quarter 2007 Progress Report
Midwest Roadside Safety Facility
Mid-States Regional Pooled Fund
July 27, 2007

Request for Feedback from the States

Development of a Temporary Concrete Barrier Transition

Based on the results of the survey, a median transition from temporary barrier to permanent barrier will be developed for this study. Enclosed in the accompanying files (MedianBarrierTransition_drawing_R3) are schematic depictions of the alternative barrier transitions that are currently being considered for the study. Clearly, we will test one of the worst case situations to allow our design to be generally applied. We would like feedback on two issues in regard to this project. Please send responses to jrohde@unl.edu.

Two main questions:

1) The transition to barriers that are in excess of 32" in height will be a greater challenge. Note that approach guardrail transitions are normally designed to connect to 32-34 in. high barriers. A temporary barrier transition to a 42" high barrier would normally only be needed when a taller permanent barrier is planned to replace the temporary barrier. Is developing the transition for 42" barriers important?
2) If we are allowed to offset the center line of temporary barrier from the center line of the permanent barrier it will be easier to develop the transition, but will also make the transition asymmetrical. This is shown in the attached drawings. Asymmetrical placement should only be an issue if the temporary barrier is used to separate traffic flowing in the same direction, such as in a gore area. However, a barrier end treatment makes more sense in this type of application. Is this a significant enough issue to warrant keeping both sides symmetrical?

Projects with Full-Scale Crash Tests This Quarter

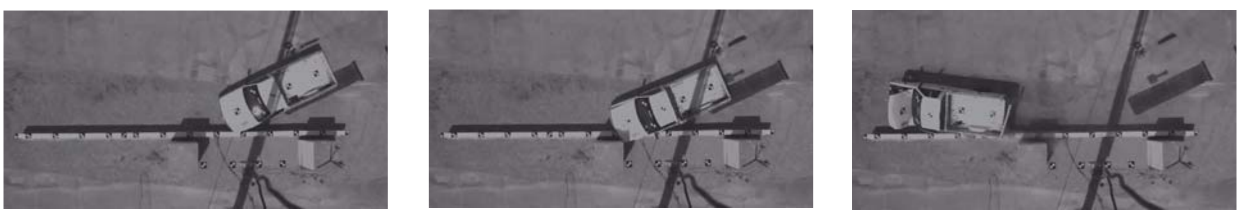
New TL-5 Median Barrier and Anchor

A full-scale crash test of the system was run on June 15th and again on July 12th. On June 15th, two runs were attempted. The tow cable broke due to the pulley system seizing up for the first attempt, and the guidance flag failed, causing the vehicle to impact too far downstream and at a low speed for the second attempt. The vehicle encountered minor damage and was repaired for the July 12th test. The vehicle impacted the barrier at 52.7 mph and approximately 15˚. The vehicle was safely redirected, and the test met all salient criteria. Barrier damage was limited to cracking with a minimum of spalling. Due to a wet spring and an under-estimated construction budget, additional funds will be requested to cover the costs of the vehicle repair and retest as well as the removal of the barrier system.



Termination of Temporary Concrete Barrier
The system, constructed utilizing 2 driven steel anchors from the existing cable system was tested on June 27th, with a 2270P vehicle. The vehicle impacted the barrier 4' 1 1/8" upstream of the joint between barriers 1 & 2 at 62.9 mph at an angle of 25.5°. Maximum deflection of the system occurred at the intersection of barriers 3&4 and was 64". Some concrete spalling occurred on the first 4 barriers. The test met all salient test criteria.

Concept Development of a Bridge Pier Protection System for Longitudinal Barrier
A full-scale test of the pier protection system was run on July 3rd. The 2000P vehicle impacted the system 64.8 mph and at 25.65° The vehicle had minimal contact with the pier and met all other salient criteria. The barrier as designed had minimal displacement and would be considered structurally adequate for the design impact.



Projects with Pending Full-Scale Crash Tests

Development of a Four-Strand, High-Performance Cable Barrier
A series of bogie tests were completed this Quarter to evaluate system hardware. Excavation work on the v-ditch has been completed. System construction is nearly complete. Three full-scale crash tests of the new system utilizing update vehicles (1 @ 1100C, 1 @ 2270P and 1 @ 10,000S) are planned to verify performance in a V-ditch.

Development of a Guardrail Treatment at Intersecting Roadways - Year 3
Construction of a modified system is nearly complete and a full-scale test is anticipated early in the 3rd Quarter.

Testing of Cable Terminal for High Tension Cable (1100C & 2270P)
Work on this project will commence after testing of the high-tension system.

Performance Limits for 6-inch High Curb Placed in Advance in Advance of the MGS
A series of high-speed curb tests are planned in the 3rd Quarter to evaluate vehicle trajectory over a curb and at a variety of angles. This data will be utilized as input to the modeling effort for the project.

Paper Studies

Cost-Effective Measures for Roadside Design on Low Volume Roads
The first field trip was completed during the 3rd Quarter of 2006. We are currently looking at a second study site.

Submission of Pooled Fund Guardrail Developments to AASHTO TF-13 Hardware Guide
We have submitted the various perturbations of the MGS system to TF-13. We are continuing to work on the backlog of past developments over the next year.

Development of Warrants for Median Barrier System
No progress to date.

Cost Effective Upgrading of Existing Guardrail System
No progress to date.

Awaiting Reporting

Evaluation of Transverse Culvert Safety Grate
The culvert grate on a 3:1 slope performed well with both the 2000P and 820C vehicle. A report for this study is in progress.

Approach Slopes for W-Beam Guardrails Systems
As a conclusion of this testing, the MGS guardrail system can safely be located any offset distance from the travel way on slopes of 8:1 or flatter. A report for this study is in progress.

MGS W-Beam to Thrie-Beam Transition
Utilizing the fabricated 10-gauge welded asymmetrical thrie-beam section, two full-scale crash tests of this system were performed; a 2000P test and an 820C test. Both tests performed well, meeting all salient criteria. We have prepared a paper for the 2007 TRB meeting based on this project. A report for this study is in progress.

Evaluation of Rigid Hazards in Zone of Intrusion
Both TL-3 and TL-4 tests of a luminarie pole mounted on the top of a 32" single slope barrier and behind that same barrier successfully passed full-scale testing with the qualification that the impact condition for the pole mounted behind the rail was not "worst case". A report for this study is in progress.

Retest of the Cable End Terminal
A report of the tests performed on this system is in progress.

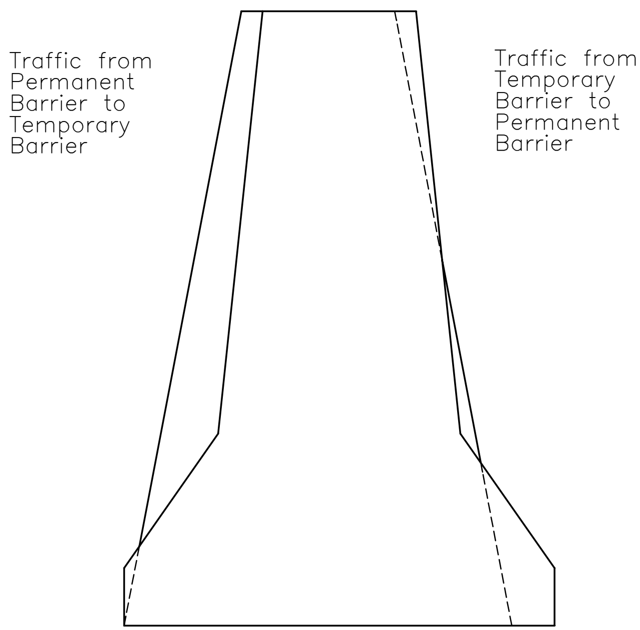
Long Span Design for the MGS Guardrail System
This system incorporates a 25' clear span, three BCT posts with standard 12" MGS blockouts adjacent to the free span in either direction, and no nested rail. Two successful tests of this system provide evidence of structural capacity and the applicability of the system location with the back of the posts in-line with the traffic side face of the head wall. We have prepared a paper for the 2007 TRB meeting based on this project. A report for this study is in progress.

Flare Rates for MGS W-Beam Guardrail
This testing has shown that the MGS can be installed at up to a 5:1 flare rate to the travel way. We have prepared a paper for the 2007 TRB meeting based on this project. A report for this study is in progress.

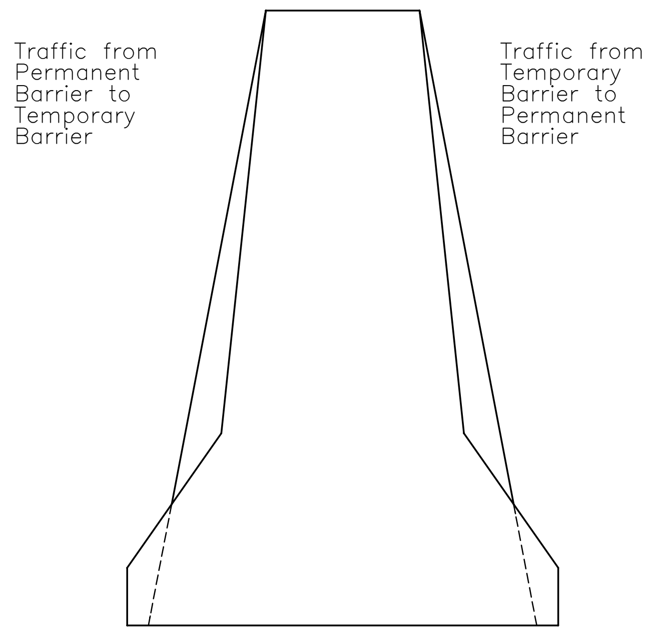
Midwest Guardrail System on Breakpoint of a 2:1 Slope
An MGS system utilizing 9’ W6X9 posts spaced at 75” was tested utilizing a 2270P update vehicle on 12/15/06. The vehicle was safely redirected. We have prepared a paper for the 2008 TRB meeting based on this project. A report for this study will be initiated.

Three-Cable Guardrail
The system utilizes non-tensioned cable, an offset distance of 48” from the breakpoint of the slope, and 4’ post spacing. The vehicle was safely redirected and the system met all salient criteria. A report for this study will be initiated.

Reports Published this Quarter



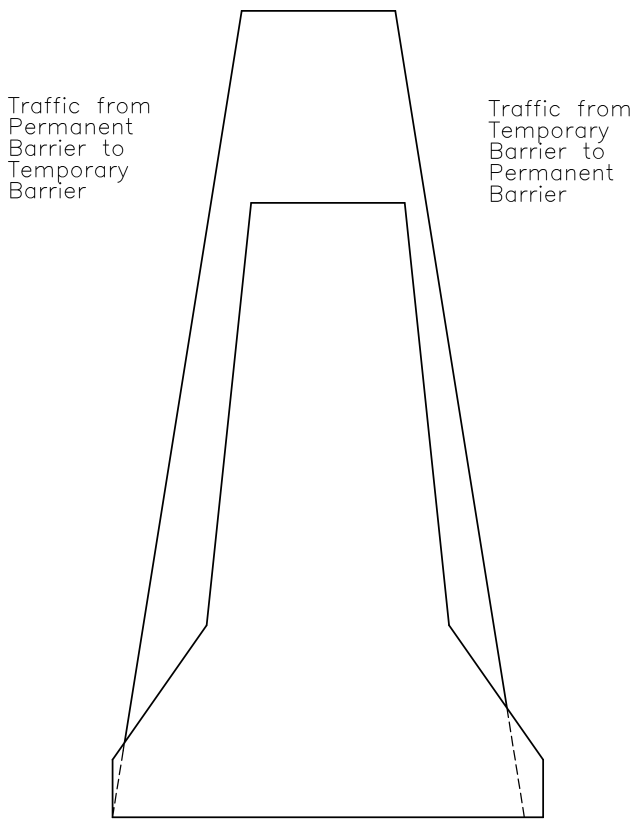
Traffic Faces of Barriers Aligned



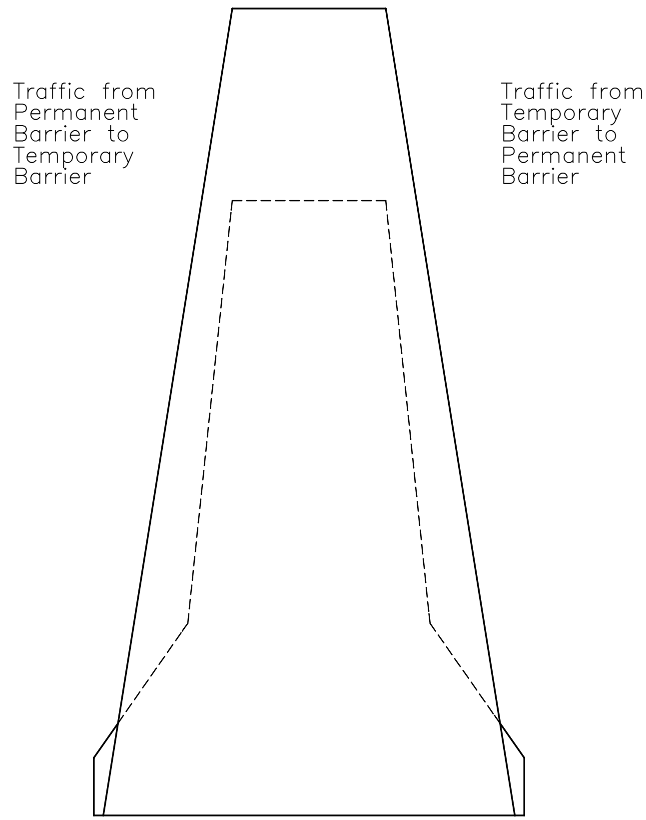
℄ of Barriers Aligned

Note: (1) The 32" temporary F-shape barrier is shown as the front barrier.

Midwest Roadside Safety Facility	Median Barrier Transition 32" Temporary F-Shape Barrier to 32" Median TX Single-Slope Barrier	SHEET: 6 of 22 DATE: 7/16/07 DRAWN BY: GRA
	DWG. NAME. MedianBarrierTransition_drawing_R3 / SCALE: None UNITS: Inches	REV. BY: KAP/RKF



Traffic Faces of Barriers Aligned



℄ of Barriers Aligned

Note: (1) The 32" temporary F-shape barrier is shown as the front barrier.

Midwest Roadside Safety Facility

Median Barrier Transition

32" Temporary F-Shape Barrier to 42" Median CA Single-Slope Barrier

SHEET: 9 of 22

DATE: 7/16/07

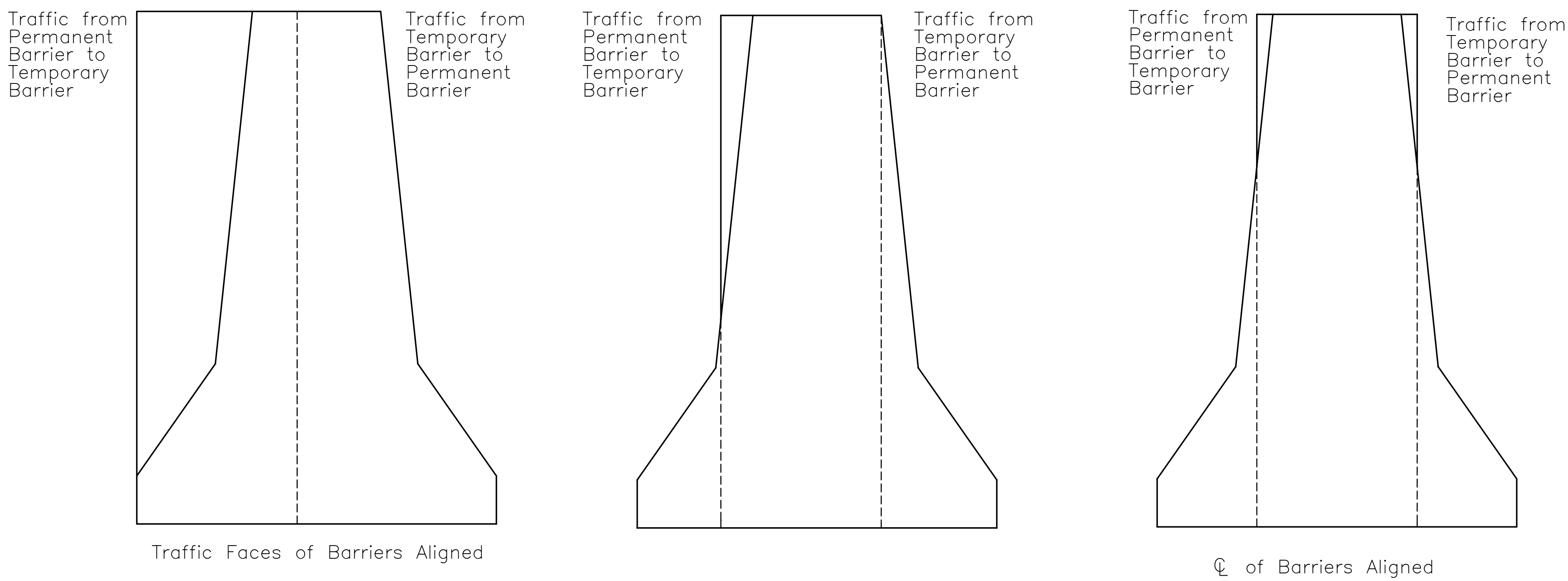
DRAWN BY: GRA

DWG. NAME. MedianBarrierTransition_drawing_R3

SCALE: None

UNITS: Inches

REV. BY: KAP/RKF



Note: (1) The 32” temporary F–shape barrier is shown as the front barrier.

Midwest Roadside Safety Facility

Median Barrier Transition

32” Temporary F–Shape Barrier to 32” Paraphet

SHEET: 10 of 22

DATE: 7/16/07

DRAWN BY: GRA

DWG. NAME. MedianBarrierTransition_drawing_R3

SCALE: None
UNITS: Inches

REV. BY: KAP/RKF

Pooled Fund Consulting Summary

Midwest Roadside Safety Facility
April 2007– July 2007

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 – Wooden Posts for Guardrail

State Question:

We have a couple of quick questions for you regarding minimum wooden post strengths/densities needed for guardrail. Here are is a brief summary of the issue:

Currently NDOR specifies that, wooden posts must meet a minimum of 1600 psi. Suppliers are having extreme difficulty providing this grade of wooden posts, and they want to understand why we require a grade so much higher than AASHTO standards. Some folks assert that the 1600 psi post is necessary to retain expected performance, in crashes when the ground is frozen, others think that requiring this grade of post may be unnecessary, expensive and leads to the primary use of steel posts. Replacement posts are also currently required to meet this specification. What are your thoughts...is it necessary to require 1600 psi for the system to perform as designed? Do you know generally what some of the other MWRSF states require?

Thanks

Amy Starr
NDOR

MwRSF Response:

Amy,

Recall that the MwRSF conducted a study of the strength of guardrail posts sampled from field sites across the state. This study, funded by NDOR, involved removing and grading more than 600 guardrail posts. A stratified random sampling technique was used to select test specimens from this group of posts and approximately 100 posts were tested, either statically or dynamically. Based upon this research, we concluded that Grades 2, 2D, 1, 1D, and DS-65 were all adequate for use as guardrail posts. At the conclusion of this process, we recommended that, in the interest of assuring the quality guardrail posts, NDOR should require Grade 1 or better Southern Yellow Pine (SYP) posts (SYP is the most common type of wood used for guardrail posts east of the Rockies). Note that this recommendation is consistent with AASHTO guidelines and assures that practically all wood posts would be Grade 2 or better which we found to be the actual minimum strength.

At the time that the MwRSF made this recommendation, NDOR chose not to relax its specification, but instead maintained the pre-existing requirement that all wood posts be SYP DS-65 or better (this is a very high grade that is very costly). I suspect that the decision to retain the requirement for DS-65 was, at least in-part, a reflection of NDOR dissatisfaction with the wood industry regarding its years long practice of supplying mill run quality SYP and certifying it as DS-65. Never-the-less, in response to the NDOR decision, the MwRSF did not include the recommendation for adopting Grade 1 SYP. Instead, as you can see the attached report (TRP-03-60-96) remains silent on the issue of the standard for new wood purchases.

We stand by our original recommendation that NDOR adopt a wood post specification that requires Grade 1 or better SYP. We could even support adopting a requirement for Grade 2 or better SYP, provided this change came with a review and possible upgrading of wood post inspection procedures.

I hope this reply solves your problem. I would be happy to meet with you or your people, if you think it is needed.

Dean

Problem # 2 – MGS Long Span Length

State Question:

I have a question regarding proper anchorage for the long span system. We are working on a project that will use the long span design along an interstate (traffic approaching from one end only). We will be using the FLEAT-MGS at the approach end, but I'm unsure how to lay out the trailing end anchorage. Can we start our anchorage immediately following the third CRT post after the culvert? And if we use our standard design (attached), it appears that we will end up with an extra post as part of the transition from MGS to our end anchor. Is this what we'll have to do, or do you have any other recommendations?

Thanks,

Chris Poole
IaDOT

MwRSF Response:

I have some comments regarding you MGS Long Span questions. The question you raise is a good one. Because you have traffic from only one side, you won't need a terminal on the downstream end as you have suggested, but the length of the downstream end and the anchorage are critical to proper performance of the system.

The first question address should be is there a minimum length of guardrail that is required to ensure that the guardrail system adequately contains and redirects the impacting vehicles?

Most of the strong-post, W-beam guardrail systems have been crash tested using a system length of approximately 175 ft. For these lengths, it has been demonstrated that the barrier system will meet impact safety standards and allow the designer/researcher to gain knowledge on dynamic barrier performance. Whether or not the system's performance or deflection is adversely affected by an installed length shorter than the tested length is unknown. For an impact closer to the barrier system ends, dynamic barrier deflection may actually increase when impacted at the same 25-degree angle. However, the LON test on the terminal is currently conducted at 20 degrees instead of 25 degrees. In the Update to NCHRP Report No. 350, this LON test will become 25 degrees, potentially requiring modifications to be made to existing terminal anchors.

Flared systems or systems such as the long span system can actually further increase the loading of the barrier system and create higher anchor loads and affect the length of the system and the anchorage. Although it is likely that guardrail lengths shorter than 175-ft can redirect 2270P vehicles impacting at the TL-3 conditions, there is no crash test data to support or recommend the use of shorter lengths at this time.

In addition, trailing-end guardrail treatments are typically used to anchor the downstream end of strong-post, W-beam guardrail systems when vehicular impacts are not expected on the system end. These trailing-end designs consist of varying configurations using blunt ends or spoons, turned-down terminals, tension rods with concrete anchors, etc. In addition, these downstream anchorage devices are often located longitudinally near to the hazard that is shielded by the roadside barrier system. To date, no trailing-end (downstream) terminals have been evaluated according to the NCHRP Report No. 350 guidelines. There are concerns that vehicle impacts slightly upstream of the trailing-end terminals may induce rollover or severe snagging on the anchor system. Further, if the downstream anchor proves to release too quickly, vehicles impacting a short distance upstream of the terminal may be allowed to penetrate through the guardrail and strike the shielded hazard.

There exists a need to standardize the trailing-end, guardrail anchorage systems that are capable of meeting current impact safety standards.

There will be proposals to better address these issues at the upcoming Pooled Fund Meeting.

That said, we do not believe that you can install the downstream anchorage immediately following the third CRT post on the downstream end. Due to the concerns listed above, we would recommend that the downstream length of the installation including the end anchorage be no less than 62.5 ft beginning at the third CRT post. This length is based on the 175 ft system length that was tested. We believe that we may be able to reduce this distance based on the proposed pooled fund studies mentioned above.

Please let me know if you have any comments or questions.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

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Problem # 3 – MGS Long Span with a Flared End Terminal

State Question:

With regards to the MGS Long Span, the TRB paper recommends installing tangent guardrail for 62.5' from the unsupported rail or 50' from the last CRT prior to flaring the guardrail. In addition, the overall system length is recommended to be 175' which makes for a minimum of 75' of guardrail from the end of the unsupported span or 62.5' from the last CRT.

If we want to install a FLEAT terminal on the system, following the flare guidelines forces the system length to be greater than 175'. Is this necessary?

MwRSF Response:

The FLEAT has been tested in the flared region, so we know that the system works when impacted under NCHRP 350 conditions in the flared region. Our recommendation in the report was based on general flares for tangent end terminals that we had no real test data for. Because the FLEAT has been tested to 350 in the flared region, we believe that you can count it as part of the "tangent" length. The same would not be true for tangent terminals installed on flares.

That said, the second factor for this question deals with the overall system length needed for anchorage that you had touched on before. We cannot recommend system lengths less than 175' at this time. Thus you must have 75' outside the unsupported span or 62.5' outside of the CRT post for anchorage purposes. This is 12.5' longer than our flare recommendation. However, as mentioned above, the FLEAT is special as it was designed and tested as a flared system, and thus, we don't believe that the flare starting distance applies to the FLEAT. The anchorage length limit still applies however. Thus, the setup for an MGS long span installation with the FLEAT would require 37.5' or tangent rail adjacent to the unsupported span or 25' of tangent rail adjacent to the end of the CRT posts and then the 37.5' FLEAT terminal. This would yield the anchorage length required, but would waive the flare recommendation due to the use of the FLEAT.

Use of standard tangent terminals installed on recommended flares would require that the flare criteria be met, because these systems have not been tested on a flare. Also, these recommendations only apply with respect to the MGS long span and not the old version with nested guardrail. The old version with nested rail would require that both the flare and anchorage requirements be met due to the use of the nested guardrail, even for the FLEAT.

Problem # 4 – Low Profile Bridge Rail

Ron,

Kimball Olson from the Office of Bridges & Structures at IaDOT, gave me your name. We are considering using the Low-Profile Bridge Rail (see attached PDF) on the 9th St. bridge in downtown Des Moines (over I-235). This would act as a pedestrian/traffic barrier. However, there are intersections right at the end of the bridge. This is preventing us from using the 108" End Section. I was wondering if this end section could be shortened to 2.1m (83") and still meet TL-2 requirements for 30 mph. I've also attached a PDF of the details we have on this barrier. Do you have any other detail sheets? It seems we're missing a few details.

Thanks for your help.

S. Sinclair Stolle, P.E. | Transportation Engineer
Iowa Department of Transportation – Office of Design
800 Lincoln Way | Ames, IA 50010
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sinclair.stolle@dot.iowa.gov
www.i235.com

MwRSF Response:

Sinclair:

The low-profile bridge rail was developed by MwRSF/UNL several years ago as part of the Pooled Fund Program. Details of this barrier system are contained in the report TRP-03-127-03. Although it may seem that there are few details, it was not that complicated of a system. However, I will check to see whether we have any other details.

In your email, you mentioned that you desire to change the end slope and section length from 108 in. to 83 in. Actually, the report details show the end section length to be 180 in. As such, your proposed change is fairly drastic in terms of changing the end slope. In addition, our developed effort focused on the interior design and structural capacity. The geometry of the end section was adopted from the TTI low-profile barrier since they crash tested their end section. We did not crash test our end section but use their geometry to avoid the need to do so. If the end section is changed, I believe that you would be required to crash test the new proposed end section according to the NCHRP 350 requirements.

Second, I believe the adaptation of the low-profile bridge rail into urban situations still required research to address its use. I think Iowa submitted a problem statement last year that was written into a research proposal (attached) but unfunded in the Year 17 program. Originally, the low-profile bridge rail was developed for situation where farm implement equipment could pass over rural bridges. For urban applications, many issues come up, including how to deal with pedestrians, how long of end treatment or bridge rail is needed to shield the hazard, are there sidewalks near the end, etc. These issues were raised in another Pooled Fund report using our best engineering judgment and standard practices. I have a feeling that this material has not yet been widely reviewed nor implemented. However, I highly recommend that you review this report (TRP-03-127-03) when attempting to implement this bridge rail in the situation noted in your email. It certainly will show you what research remains needed in the future.

P.S. – I will look for additional CAD details in the near future. Also, Iowa DOT implemented this system several years ago on a curved on-ramp or off-ramp. I believe Will Stein (formerly at IA DOT) was the individual who used it. See attached files.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Associate Engineer

Problem # 5 – Temporary Barrier Tie-Downs – Part I

State Question:

Ron and Bob,

My first, broad question is this: Do we have any recommended method for tying down temporary barrier to a concrete pavement/bridge deck that has been overlaid with asphalt? I've read some reports where tying down through an asphalt overlay is not recommended. But I haven't come across any reports that say such practice is allowed.

As a follow-up, do you believe that the asphalt pin tie-down could be used on a concrete pavement that has been overlaid with asphalt, if the pavement was first drilled (say with a 1.625" bit) down to the subbase to allow for pin penetration?

Finally, is it possible to constrain the barrier through the vertical bolt holes with drop-in anchors or screw-in anchors?

Thanks for your help.

Chris Poole, P.E.
Assistant Methods Engineer
Office of Design
Iowa Department of Transportation

MwRSF Response:

Hi Chris,

I have some short answers for your questions.

1. We have not tested any systems for tying down temporary barrier to a concrete pavement/bridge deck that has been overlaid with asphalt. The strap tie-down and the bolted tie-down will not work in this situation due to bending loads on the anchor bolts.

2. We do believe that the asphalt pin tie-down could be used with concrete pavement with an asphalt overlay. This would be stiffer that what we originally tested, but we think it is the best option at this time. The pins should not fracture, but would tend to bend and pull up. We do believe that they will constrain the barriers. Kansas DOT has asked about this previously and we have allowed it.
3. We do not believe that you can constrain the barrier through the vertical holes with drop-in anchors or screw-in anchors. Use of these types of anchors would results in the anchor having approximately 4" exposed inside the vertical hole. This would limit the anchorage depth for the screw-in anchors and would create large bending loads in both types of anchors that will cause them to fail and thus result in a loss of anchorage. The drop-in anchors or screw-in anchors also do not have the capacity of the larger threaded rods used in the bolt through design.

Let me know if you have further questions.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Problem # 6 – Temporary Barrier Tie-Downs – Part II

State Question:

Do you have any recommendations on what size of drill bit should be used to pre-drill the concrete for the asphalt pin?

As a follow-up to my previous question – would it be feasible to use the asphalt pin tie-down directly on top of full-depth PCC pavement (no asphalt overlay)?

Chris Poole, P.E.
Assistant Methods Engineer
Office of Design
Iowa Department of Transportation

MwRSF Response:

Hi Chris,

With regards to you first question about the size of the dill bit used for the asphalt pin, I would recommend that it be only 1/16" to 1/8" larger than the pin diameter. This would be a maximum bit size of 1.625". The hole in the pavement needs to be kept as small as possible to make the pin engage as soon as possible during the impact. For installation, it may be easier to set the barriers down and then drill through the existing holes in the barrier as guides to make sure the pins will fit.

Your second question asked if it would be feasible to use the asphalt pin tie-down directly on top of full-depth PCC pavement. We think that this might be acceptable if it was just being used on a roadside installation, but we would rather see you use the bolted tie-down option we developed for concrete. This option has been tested and we know how it will perform. We think that the asphalt pins may work as well, but they will not provide as effective restraint as the bolted tie-down. We would definitely recommend using on the bolted tie-down on a bridge installation.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Problem # 7 – Transition Replacement Posts

State Question:

We would like to use the Wyoming transition to two-tube bridge rail design, but we would like to use wood posts instead of the used 6'-6" W6x9 steel posts used in the design. Is there an acceptable wood post substitute that can be safely used in this transition.

Bernie Clocksin
SDDOT

MwRSF Response:

Hi Bernie,

I have some answers for your transition post replacement question. You noted that the Wyoming transition to 2 tube bridge rail used 6'-6" W6x9 steel posts and you wanted to know what the equivalent wood post would be. The steel posts in question were 6'-6" long with an embedment of 49". It should be noted that the embedment is a little higher than expected due to the use of different blockouts to reduce snag.

The Wyoming transition to 2 tube bridge rail is based off of our previous Iowa transition design. This design was made with both steel and wood post options. Thus, we believe that you can substitute 6"x8" wood posts in the design safely. The wood post used in the Iowa design that you should substitute into the Wyoming design is a 6"x8"x7' long wood post. We believe that this should work.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer