WYOMING DEPARTMENT OF TRANSPORTATION

QUARTERLY PROGRESS REPORT

Project title: Pooled Fund for the Development of Approach Guardrail Transitions for Box Beam and MGS

Project Number: TPF-5(393)

Progress period: 8/1/2022 – 10/31/2022

Principal Investigator and all others who have worked on the project (provide name and ORCID number): Roger Bligh (#0000-0001-5699-070X), Nauman Sheikh (#0000-0003-1718-4881), Nathan Schulz (#0000-0002-7527-9419), James Kovar (#0000-0002-1542-7010)

1. Please state whether the project is ahead of schedule, on time, or behind schedule:

The design of the box beam transition to concrete parapet took longer than expected to complete due to design challenges associated with the stability of the pickup truck. At the same time, the approval of Amendment #3 to the contract was delayed due to delays in WYDOT receiving federal funds. These time periods overlapped and were not additive but did result in a delay to the overall project schedule.

2. Percentage of overall work completed.

85% (Note that this percentage reflects completion of work for the adjusted scope of work under Amendment #3).

3. Activities and Accomplishments:

a. What are the major goals and objectives of the project?

The research objective is to develop non-proprietary approach guardrail transition systems from box beam and MGS guardrail to the Texas Department of Transportation (TxDOT) Type C2P bridge rail system that are MASH Test Level 3 (TL-3) compliant. An additional objective added to the scope of the project is to develop a box beam guardrail transition to a vertical concrete parapet. Shape transitions will be designed to transition the vertical concrete parapet to both a single slope barrier and a New Jersey profile barrier. The work plan for the project is divided into ten tasks. These include:

Task 1: Engineering Design and Drawing Development
Task 2: Finite Element Modeling & Simulation
Task 3: Test Installation Construction
Task 4: Crash Testing of the Box Beam Transition
Task 5: Crash Testing of the MGS Transition

Task 6: Concrete Transition Parapet Design and Analysis
Task 7: Development of Box Beam Transition to Concrete Parapet
Task 8: Full-Scale Crash Testing – Box Beam Transition to Concrete Parapet
Task 9: Final Report
Task 10: FHWA Eligibility Letter

b. Describe what was accomplished under these goals.

Task 1: Engineering Design and Drawing Development (previously completed)

Task 2: Finite Element Modeling & Simulation (previously completed)

Task 3: Test Installation Construction (previously completed)

Task 4: Crash Testing of the Box Beam Transition (previously completed)

Task 5: Crash Testing of the MGS Transition (previously completed)

Task 6: Concrete Transition Parapet Design and Analysis (previously completed)

Task 7: Development of Box Beam Transition to Concrete Parapet (previously completed)

Task 8: Full-Scale Crash Testing – Box Beam Transition to Concrete Parapet

MASH Test 3-20 on the concrete shape transition was performed on September 15, 2022. This test involved a 2,240-lb passenger car impacting the upstream end of the shape transition at a nominal speed of 62 mph and nominal angle of 25 degrees. The vehicle was contained and redirected, and remained upright throughout the test event. The maximum roll angle was 20.3 degrees. The occupant risk numbers were below the MASH thresholds. The test satisfied all MASH requirements.

The short 9-ft parapet section experienced some displacement during the test and had a permanent maximum deflection of approximately ¼-3/8 inch at the downstream end. This movement opened the construction joint where the traffic face of the barrier meets the slab to which it is anchored. It was also noted on the upstream end that there was a crack that extended downward into the slab at the approximate location of the tension side of the U-shaped anchorage bars. After inspection, the research team felt the structural capacity of the parapet had not been compromised and that the subsequent pickup truck test could be performed without repair or replacement of the parapet. The WYDOT technical representative was consulted on this decision and he concurred with the decision to move forward with the next test.

MASH Test 3-21 on the concrete shape transition was performed on September 28, 2022. This test involved a 5,000-lb pickup truck impacting the upstream end of the shape transition at a nominal speed of 62 mph and nominal angle of 25 degrees. The vehicle was contained and redirected, and remained upright throughout the test event. The maximum roll angle was 35.5

degrees. The occupant risk numbers were below the preferred values in MASH. The test satisfied all MASH requirements.

The short 9-ft parapet section experienced more displacement than during the passenger car test. The impacted parapet section had a maximum dynamic deflection was 3.7 inches and a permanent deflection of 2.3 inches at the top of the parapet. This might have increased the vehicle roll beyond what it would be for a more rigid parapet, but the vehicle was still redirected in a relatively stable manner. This parapet displacement also resulted in vehicle snagging on the exposed end of the downstream parapet section. This snagging contact resulted in the sheet metal being peeled back at the leading edge of the door. However, there is no perceived likelihood for occupant compartment intrusion based on the nature of the contact that created the vehicle deformation.

It was concluded that the concrete parapet should be repaired before attaching and testing the box beam transition. Unfortunately, the current budget does not include replacement of the concrete shape transition, which was expected to behave more rigidly and incur less damage. The WYDOT technical representative concurred that reconstruction of the concrete parapet should be completed prior to any further testing. The reinforcement details for anchoring the barrier to the moment slab reflect WYDOT details commonly specified by your Bridge Group. It was discussed that the anchorage details could be improved to mitigate need for repairs in the field. The technical representative suggested a modification to the project agreement to budget for the structural analysis of the anchorage reinforcement and parapet reconstruction.

The testing of the box beam transition has been delayed until the parapet anchor design and reconstruction can be completed.

Task 9: Final Report

The interim report is still in the publication process. A decision whether to publish the report as a standalone Phase I report rather than an interim report is still pending.

Task 10: FHWA Eligibility Letter

Comments were received from FHWA on May 18, 2022 regarding the funding eligibility package for the C2P bridge rail that was submitted to FHWA by the Texas Department of Transportation (TxDOT). A revised FHWA Office of Safety Form to Request Federal Aid Reimbursement Eligibility of Safety Hardware Devices (version 10.0) and revised report were submitted to FHWA on June 29, 2022. The eligibility letter is still pending.

Draft eligibility request forms for the box beam and MGS transitions to C2P bridge rail were previously developed and submitted to WYDOT for review and approval. Submittal of the funding eligibility packages for both systems can be completed once approval to submit the interim report is received.

c. What opportunities for training and professional development has the project provided? If the research is not intended to provide training and professional

development, state "Nothing to Report". Otherwise, describe opportunities for training and professional development, training activities, and professional development.

Nothing to report.

d. How have the results been disseminated to communities of interest? Describe what results have been disseminated and in what manner, including publications, conference papers, and presentation. Please list ALL derivative reports/publications which were generated from this project, and provide an electronic copy of the report/publication.

Nothing to report.

e. What do you plan to do during the next reporting period to accomplish the goals and objectives? Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.

Task 8: Full-Scale Crash Testing – Box Beam Transition to Concrete Parapet

Further testing of the box beam transition to concrete parapet has been postponed until reconstruction of the damaged concrete parapet can be completed. A modification request for the redesign and reconstruction of the concrete parapet will be prepared and submitted to WYDOT for consideration.

Task 10: FHWA Eligibility Letter

The FHWA funding eligibility packages for the box beam and MGS transitions to C2P bridge rail will be submitted upon WYDOT approval of the interim report documenting the full-scale crash testing of these systems. In addition to the interim report, the FHWA eligibility request package for the transition systems will include FHWA Office of Safety Form to Request Federal Aid Reimbursement Eligibility of Safety Hardware Devices (version 10.0), drawings of the test installations, high-speed and real-time video of the crash tests performed, and photographs of the test installation and test vehicle before and after each test.

An eligibility request form will be initiated for the concrete shape transition, which successfully completed the MASH crash testing matrix. Because the upstream end of the box beam transition required modification from the previously tested version, an eligibility request cannot be submitted for the box beam transition. However, a professional opinion for the system based on the finite element simulations will be prepared upon successful completion of the MASH crash testing on the downstream end.

f. List any products resulting from the project during the reporting period. Include in this list:

1. Publications, conference papers, and presentations.
2. Website(s) or other internet sites (List the URL).
3. Technologies or techniques.

4. Inventions, patent applications, and/or licenses.
5. Other products, such as data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments or equipment.

Nothing to report.

g. Impact:

1. How will this project impact WYDOT?
2. How will this project impact other agencies?

WYDOT's Mission Statement is to "provide a safe, high quality and efficient transportation system." One of the goals within the mission statement is to "improve safety on the state transportation system." Successful implementation of the transitions developed under this project into WYDOT's standard plans will provide an improved level of safety. The transitions will provide continuity of motorist safety from MASH guardrail systems to MASH bridge rail systems. Full implementation of MASH compliant roadside safety devices, including transition systems, will provide an enhanced level of safety that will help reduce the severity of lane departure crashes that represent over 75% of highway fatalities in Wyoming. Additionally, the AASHTO/FHWA MASH Implementation Agreement requires state DOTs to provide MASH compliant roadside safety features to obtain federal funding reimbursement on projects. The results of this research will be useful to other agencies. This project is being funded as a pooled fund effort between WYDOT and Montana DOT. It will provide transition details that will be immediately implementable by both of these agencies as well as other agencies that use similar guardrail and bridge rail systems.

h. Changes to Scope of Work. Provide the following changes, if applicable:

1. Scope of work or objectives of the project.
2. Changes in key persons.
3. Disengagement from the project for more than three (3) months, or a twenty five (25) percent reduction in time devoted to the project.
4. The inclusion of costs that require prior approval.
5. The transfer of funds between line items in the budget.
6. The subawarding, transferring or contracting of work.
7. Changes in the approved cost-sharing or match.

As noted in this report, the damaged concrete parapet requires reconstruction prior to further testing of the box beam transition. The reconstruction of the concrete parapet was not anticipated and has not been budgeted in the current project scope. A modification request will be prepared to cover the reconstruction of the concrete parapet. The modification scope will also include redesign of the anchorage details between the concrete parapet and underlying simulated approach slab. The tested anchorage details reflect WYDOT practice. Although the testing of the concrete parapet satisfied MASH requirements, redesign of the anchorage reinforcement would mitigate repair needs of field installations. Further, at the request of the WYDOT technical representative, the modification scope will also include the design and development of an independent, stand-alone foundation system for the concrete parapet that can be used independent of an approach slab.