Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Development and Evaluation of Crashworthy Approach Guardrail Transition with Increased Span Length between Concrete Bridge Rail and First Transition Post – Phase I

Research Objectives

The objective of this project is to develop and evaluate the standard 34-in. tall NDOT thrie beam MASH AGT system with increased span length between the concrete buttress end and the first transition post to accommodate a wide range of obstructions that prevent proper installation of posts, including bridge abutments and wing walls, as well as drainage and utility structures. The research and development effort will identify various critical obstructions near bridge ends through a survey of the NDOT district engineers and seek feedback on the desired maximum span length for the AGT. The project will develop numerous design concepts by exploring various mechanisms, such as surrogate post (i.e., continuous horizontal beam, cantilever beam, and grade-mounted post), and stiffening and increasing moment capacity of AGT rail elements to mitigate large deflections, vehicle instabilities, pocketing, and snag associated with the increased span length. Evaluation of the 34-in. tall NDOT AGT with increased span length designs will include dynamic analysis of impacts near the upstream W-to-thrie beam stiffness transitions and the downstream thrie beam to rigid buttress transition using LS-DYNA finite element analysis computer program. The AGT system would be designed to meet the MASH TL-3 impact safety requirements. Full-scale testing may be recommended to evaluate the new AGT system in a follow-up phase.

Research Benefits

Development and evaluation of the 34-in. tall NDOT thrie-beam AGT system with increased span length between the concrete bridge end and the first transition post would provide NDOT with crashworthy and cost-effective solutions for avoiding installation issues adjacent to the bridge end where various obstructions (i.e., drains, foundations, utilities, etc.) could prevent proper post placement. The new AGT system would be developed to satisfy MASH TL-3 performance criteria while accommodating a wide range of obstructions by providing increased span length. Additionally, developing the AGT system with an increased span length will provide roadside designers with crashworthy solutions for non-ideal installation sites and reduce the costs associated with relocations of the previously noted obstructions.

Principal Investigator

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Background

The Midwest Roadside Safety Facility (MwRSF) has recently conducted multiple research projects to develop crashworthy retrofits or design alterations for Approach Guardrail Transitions (AGTs) when the site conditions prevent the as-tested design configuration from being implemented. These research projects have mainly focused on issues that obstruct AGT posts from being properly installed (i.e., wing walls, drainage structures, utilities, and reduced grading). Most of these obstructions are located near the bridge railing end at the AGT's downstream region, where the posts are spaced closely together. Designing a new MASH crashworthy AGT that incorporates a large span length between the bridge rail end and the first transition post would avoid these obstructions and prevent the need for design retrofits. In 2020, a MASH TL-3 crashworthy AGT was created by the MwRSF for a steel-tube bridge rail for the Illinois and Ohio DOTs. This AGT had a 9-ft span length between the first bridge rail post and the adjacent transition post, which was designed to extend over ground obstructions near the bridge end. This AGT design used two HSS6x6x1/4 transition rail elements to match the specific steel-tube bridge rail configuration. However, a similar AGT could be developed using strong rail elements to prevent large deflections.

Conclusion

This study developed and evaluated a 34-in.-tall Nebraska Department of Transportation (NDOT) thrie-beam approach guardrail transition (AGT) with an increased span between the concrete buttress end and the first transition post. The objective was to accommodate a wide range of common obstructions near bridge ends, including abutments, wing walls, drainage features, and utilities. A survey of NDOT districts identified critical obstruction geometries and informed design criteria. Most NDOT districts indicated that a maximum span of about 4 ft would be sufficient, and some preferred spans up to 6 ft. To accommodate a wider range of obstructions, the first transition post was set 8 ft-51/4 in. from the concrete buttress, more than twice the post spacing used in other MASH transitions. A validated LS-DYNA model of the standard 34 in. NDOT AGT system supported concept design screening under the Manual for Assessing Safety Hardware (MASH) Test Level 3 (TL-3). The selected configuration used a double-tube design with HSS 4 in. × 4 in. × 1/4 in. members based on performance, handling weight, and connection demand. Simulations for MASH test designation nos. 3-21 and 3-20 showed stable vehicle behavior, acceptable occupant risk measures, and component stresses below yield and ultimate limits. Critical impact points were 89 in. upstream of the concrete buttress for MASH test designation no. 3-21 and 65 in. upstream of the concrete buttress for MASH test designation no. 3-20. Reverse direction and upstream impacts showed no significant pocketing or snag. Overall performance matched the standard NDOT 34-in. tall AGT system. The long-span design provides a crashworthy and practical option for non-ideal sites. Full-scale vehicle crash testing is required to confirm compliance and support FHWA eligibility.

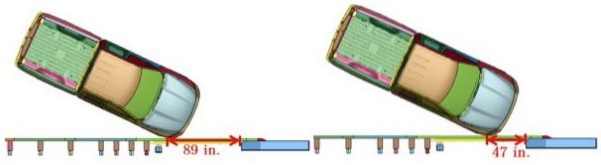

Figure 1: Impact Points for MASH Test Designation, Conventional Impact Direction

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NDOT Recommendations Based Off Research Project – 2026 – RRL3

Phase I of this research addressed the need for a MASH-compliant AGT that uses an increased span between the concrete bridge rail end and the first transition post at the concept and simulation level. Simulations showed the proposed long-span design provides a crashworthy and practical option, with similar performance to the standard NDOT 34-in. tall AGT system. Federal acceptance of this new roadside safety hardware requires full-scale MASH TL-3 crash tests, which Phase II SPR-FY27(070) addresses.

- *As provided by Austin White, Lead TAC Member*

Research Readiness Level (RRL) Assessment

RRL 3

Level 3: Development

Review upon completion of Phase II, SPR-FY27(070), in 2028.

Technology Transfer

Principal Investigator did not have any technology transfer for this research project.

This brief summarizes Project SPR-FY24(030)
"Development and Evaluation of Crashworthy Approach Guardrail Transition with Increased Span Length between Concrete Bridge Rail and First Transition Post – Phase I"
Nebraska Department of Transportation Research Program