MPC-501

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**Project Title**

Development of an Alternative to the Double Tee Bridge System

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**Research Needs**

Many bridges on the South Dakota local highway system need replacement due to deterioration or increased traffic demands. Local governments rely on the South Dakota Department of Transportation (SDDOT) to help replace them but, with limited resources, SDDOT can only help replace about 30 bridges statewide each year, causing a backlog of local bridges in need of replacement.

The current standard bridge used in these replacements is the double tee precast girder bridge for its relatively low construction cost, outsourced design, and short construction duration. The expected design life of these bridges was 50 to 70 years, but some built less than 40 years ago already need replacement. The most common problem is that longitudinal joints become damaged over time, most likely due to inadequate shear transfer between the girders, allowing water and debris to enter the joints. It is only a matter of time before the joint begins to spall, creating a path for moisture to reach the prestressing steel, initiate corrosion, and degrade the structural capacity of the bridge. It should also be noted that the double tee should be designed for girder continuity, often achieved by a reinforced concrete overlay or transverse post tensioning. Many local bridges are not designed for girder continuity, however, resulting in longitudinal joint deterioration and a non-redundant structure.

Routine maintenance of these bridges does increase the life span, but is not a feasible long-term solution. The amount of routine maintenance required to keep the joints sealed is too costly for local governments. Other methods, such as asphalt overlays, are also expensive and can cause increased damage over time by trapping moisture that eventually reaches the prestressing steel. Thus an alternative solution for this problem should be proposed at the design stage to reduce joint movements and increase girder continuity. The solution can be developed as a new connection detail between girders or a more robust precast girder prototype for precast bridges in South Dakota.

Bridges on the local system in the State of South Dakota carry millions of dollars of agricultural products to market, as well as tourists, outdoor adventurist, school buses, and everyday travelers. If budgets of local governments cannot increase and the cost of a bridge replacement does not decrease, the only option will be to close bridges, raising the cost of getting products to market will rise and increasing inconvenience to the traveling public. If fewer routes are available due to closed bridges, emergency vehicles will experience increased response times to rural incidents. The number of structurally deficient bridges on the local system only continues to grow due to the cost of replacement and limited local government budgets. These bridges are vital for agriculture and the traveling public and cannot be allowed to close without adverse effects on local communities. An immediate solution is desirable.

Due to the poor serviceability performance of longitudinal joints in precast double tee bridge girders on South Dakota roads, an experimental research project, SD2013-01, was conducted at SDSU to investigate the performance of the currently used longitudinal joint detail and to assess the adequacy of a proposed new joint detail for use with double tee girders (Konrad, M. 2014). The study involved fatigue and strength testing of two full-scale specimens, one representing the as-built conditions and the other representing a modified joint detailing. The fatigue load was determined using AASHTO specifications (AASHTO 2012). The modified joint detailing specimen involved overlapping the steel mesh in the joint region of adjacent girders. The grouted joint is 6 inches wide and requires some flat formwork during the placement of the grout. Results from fatigue and strength testing of the as-built and modified specimens revealed that the current joint detailing is severely inadequate if the bridge is to last for 50 years or more, while the modified joint detail provided adequate performance under fatigue loading equivalent to more than 70 years of service.

Currently, there is only one supplier for the double tee bridge girder system in South Dakota. Alternative precast concrete and other type bridge systems may prove to provide potential options for local governments when making a bridge type selection based on performance and cost. Therefore, a study is needed to identify potential alternative systems and assess the construction feasibility, structural performance, and durability of those systems that have potential for implementation in South Dakota.

**Research Objectives**

1. Determine bridge system alternatives to the double tee precast girder system meeting HL93 load requirements and 75-year design life for single span bridges less than 70 feet.
2. Perform ultimate and fatigue load testing on alternative bridge system(s).
3. Compare cost, construction process, and performance of alternative bridge system(s) to the revised double tee girder system from SD2013-01.

**Research Methods**

Through review of existing literature and practices at state and national level, this research will first establish potential bridge systems that could be used as alternatives to the double tee girder system. Then the researchers will survey and consult with local producers and contractors to identify the details of alternative systems that will be submit to the technical panel for discussion.

Once the proposed details are approved for testing by the technical pane, full-scale bridge girders will be constructed with the detail and tested under ultimate and fatigue loads at SDSU’s structures lab. Traditional double tee girder currently used will also be tested as the controlled case. The performance comparison will be made and recommendations will be made on the implementation of the proposed girder details.

**Expected Outcomes**

This research could potentially produce a new girder design for use by local governments for the construction of bridges. The new girder design should diminish longitudinal joint distress, extend the service life of bridges owned by local governments, and reduce maintenance costs.

**Relevance to Strategic Goals**

The expected outcomes of this project are directly related to the following goals: State of Good Repair and Economic Competiveness.

**Educational Benefits**

This project will provide a valuable learning experience to both graduate and undergraduate students. A master’s level graduate student will be hired to work on this project which will provide the material for a master’s thesis. Undergraduate students will also be hired to work on this project. Results from the study can be incorporated into courses on prestressed concrete and bridge design.

**Work Plan**

The proposed research work is divided into 12 Tasks. Following is a listing of the project tasks.

Task 1: Meet with the technical panel to review project scope and work plan.

Task 2: Perform literature review of bridge system alternatives to the double tee girder system that are low cost, single span less than 70 feet, applicable for use on local roads with service life of at least 75 years.

Task 3: Provide the technical panel with a technical memorandum explaining the results of the literature review from task 2.

Task 4: Meet with technical panel to discuss results of literature review and technical memorandum. Based on discussion, technical panel will decide which option(s), if any, will require structural testing.

Task 5: If directed by the technical panel, prepare a technical memorandum describing a complete instrumentation, construction, and testing plan for technical panel review.

Task 6: Upon approval of the plan by the technical panel, proceed with instrumentation and construction of test girders. Notify the technical panel of construction schedule to give the option to be present at time of construction.

Task 7: Perform and provide the technical panel opportunity to observe ultimate and fatigue loading of selected structure type.

Task 8: Compare results of testing to the results from SD2013-01 project to understand the construction and load capacity differences between bridge systems.

Task 9: Develop a recommendation to the SDDOT based on cost and performance of the alternative bridge system compared to the revised double tee section from SD2013-01.

Task 10: Meet with technical panel to review and accept results of investigation and proposed recommendations

Task 11: Prepare a final report and executive summary of the research methodology, findings, conclusions, and recommendations.

Task 12: Make an executive presentation to the SDDOT Research Review Board at the conclusion of the project.

**Project Cost**

Total Project Costs: $159,999

MPC Funds Requested: $74,999

Matching Funds: $85,000

Source of Matching Funds: SDDOT

**TRB Keywords**

Bridge girders; Prestressed concrete; Double tee

**References**

American Association of State and Highway Officials (AASHTO) (2012) *“AASHTO-LRFD Bridge Design Specifications.”* Sixth Edition. Washington, D.C.

Konrad, M. (2014) *“Precast Bridge Details for Improve Performance.”* A thesis in partial fulfillment of the requirements for Master of Science in Civil Engineering. South Dakota State University, Brookings, South Dakota.