TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): North Carolina DOT

INSTRUCTIONS:
Lead Agency contacts should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *TPF-5(493)*	**Transportation Pooled Fund Program - Report Period:** ☐ Quarter 1 (January 1 – March 31) X Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)	
TPF Study Number and Title: TPF-5(493) – Investigation of Dual Grade/Hybrid Steel Plate Girders Utilizing Stainless Steels		
Lead Agency Contact: Jason Provines	**Lead Agency Phone Number:** (434) 293-1917	**Lead Agency E-Mail:** Jason.provines@vdot.virginia.gov
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:** 2/13/24
Original Project Start Date: 2/13/24	**Original Project End Date:** 11/13/26	**If Extension has been requested, updated project End Date:** N/A

Project schedule status:

X On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Funds Expended This Quarter	Percentage of Work Completed to Date
$400,000	$18,524	24%

Project Description:

Corrosion is a major concern for steel bridges, and if not properly designed for or mitigated, can lead to costly maintenance or service failures. One such option for making steel bridges more corrosion resistant is by using a dual grade girder, in which ASTM A709 Grade 50CR (50CR) plate is welded or bolted to conventional steel bridge girder components. In this case, the 50CR could be placed in a more corrosive environment, such as under a deck joint, and the conventional steel bridge material would be placed in other areas to allow for cost savings. However, there are still several unknowns related to welded and bolted dual grade connections.

This project will address those unknowns through experimental testing and analysis. Dual grade welds will be fabricated with different welding parameters, and PQR tests will be conducted to evaluate the welds for their structural performance. NDE research will be conducted to determine the suitability of eddy current to be used for weld inspection and to refine UT techniques to account for the high attenuation of austenitic weld metals and the different ultrasonic velocity and high anisotropic ratio of 50CR. Corrosion research will be conducted to assess the galvanic, stress, pitting, and crevice corrosion performance of dual grade connections. Results from that corrosion research will then be used to determine appropriate bolt types to be used in bolted dual grade connections. Additionally, torqued tension testing of stainless steel bolts will be conducted to determine tabulated values for installation pretension and installation criteria (such as rotation requirements for turn-of-nut installation).

After the experimental testing and analysis are complete, a final report will be developed. It will include recommendations for additions or revisions to be made in the AASHTO LRFD Bridge Design Specifications, AASHTO Bridge Construction Specifications, and AASHTO/AWS D1.5 that will allow welded and bolted dual grade connections to be designed, fabricated, and constructed successfully.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Task 1 – Literature Review

No work was done on this task. 100% completed.

Task 2 – Connection Testing & Verifying Design/Fabrication Details

Task 2A – Welded Dual Grade Connections

Specimens G1 through G8 have been welded by the fabricator and shipped to VTRC. Samples from all of these plates have been cut out and shipped to their respective testing agencies. The fabricator has begun welding the remaining specimens and is awaiting NDE results before proceeding.

VTRC has completed side bend and fillet weld break tests on all of the received samples. Analysis of these results is still ongoing. Supplies have been ordered for the stress corrosion cracking tests on dissimilar metal welds. Samples will be subject to 16 ksi initial stress measured using digital image correlation and will then be placed into a corrosion chamber for testing. This testing is expected to begin over the next month.

Utah State University is preparing for the remaining mechanical testing and corrosion testing of welds. A corrosion chamber was recently delivered and is being assembled for use on the corrosion testing. They anticipate to begin in the coming weeks. Additional literature is being reviewed on welding of dissimilar metal welds and galvanic corrosion testing.

University of Missouri has machined their ultrasonic test (UT) samples to prepare flat surfaces for accurate ultrasonic testing. prepare flat surfaces for accurate ultrasonic testing. Ultrasonic shear and longitudinal velocities for the base materials, 50W and 50CR steels, were measured using contact transducers, and the corresponding incidence angles were calculated using Snell's Law. The measured velocities and angles were then used to guide initial immersion tank scans that examined wave propagation behavior, both shear and longitudinal, and the effects of the weld on signal amplitudes at 1 and 2.25 MHz. Additional literature is also being reviewed to better interpret ultrasonic wave behavior across the dissimilar weld zone.

Task is 20% completed.

Task 2B – Bolted Dual Grade Connections

VTRC has received all of the stainless steel bolts, nuts, and washers for developing the pretension values and installation criteria. A few preliminary tests have been conducted and the test setup and procedure have been finalized. Testing will follow the guidance provided in the upcoming AISC/RCSC Stainless Steel Bolting Design Guide (of which PI Provines was an author). These tests are expected to be completed within the next month. Pretension values and

installation criteria results will be used to inform the corrosion tests of bolted connections conducted by Utah State University.

Task is 20% completed.

Task 3 – Final Report & Guidelines

No work was done on this task in this report period. 0% completed.

Virginia Transportation Research Council (VTRC)/University of Virginia (UVA) Dissimilar Metal Welding Research Project

Accelerated corrosion chamber testing is completed. Specimens are currently being cleaned of the corrosion product so that mass and thickness measurements can be compared to initial values. Once these measurements have been taken, analysis of general and galvanic corrosion can be made.

Electrochemistry testing is ongoing. Results show galvanic corrosion occurring on both sides of the weld and pitting corrosion occurring on the 50CR side of the weld.

Preliminary analysis on saltwater droplet samples suggests that galvanic corrosion only occurs on the carbon steel side of the weld, with an increase of about 40-80%. Galvanic corrosion is not present on the 50CR side of the weld. Recall these tests were conducted in a less aggressive environment than corrosion chamber testing. The corrosion pits were also analyzed. On the carbon steel side, pit width to depth ratio decreased by 20-60% due to galvanic corrosion, which means pits are deeper. No significant change in pit ratio was observed on the 50CR side of the weld. Continued analysis on these samples is underway.

This project will end in October 2025.

Anticipated work next quarter:

Task 1 – Literature Review

This task has been completed. No additional work planned.

Task 2 – Connection Testing & Verifying Design/Fabrication Details

Task 2A – Welded Dual Grade Connections

Additional welded plates are expected to be delivered to VTRC from the fabricator. Once plates are received, VTRC will begin cutting samples out of the plates and samples will be delivered to the testing agency.

VTRC will complete analysis on the side bend and fillet weld break tests. They also anticipate beginning the stress corrosion cracking tests.

Utah State University expects to begin mechanical tests in the near future. Once the corrosion chamber is assembled, corrosion testing will begin.

University of Missouri will continue the UT evaluation.

Task 2B – Bolted Dual Grade Connections

VTRC will complete pretensioning tests on stainless steel bolts, nuts, and washers using two different lubricants. Results will be provided to Utah State University for use in the corrosion testing of bolted connections.

Task 3 – Final Report & Guidelines

No work is planned on this task in the next report period.

VTRC/UVA Dissimilar Metal Welding Research Project

Samples from the corrosion chamber tests will be cleaned and analyzed. Electrochemistry testing will continue and results will be analyzed. Analysis of the saltwater droplet tests will also continue. The final report is currently being written since this project will end in October 2025.

Significant Results:

Due to the early stages of this project, no significant results have been found yet.

VTRC/UVA Dissimilar Metal Welding Research Project

- According to welder observations, it is much easier to make good, quality welds using FCAW compared to SMAW.
- FCAW and SMAW welds made using a 309L consumable can pass PQR tests using typical welding parameters.
- Solidification and cold cracking can be alleviated in the SAW welds by using a single vee with backgouged joint at a low heat input.
- ATI 412 is a viable alternative to 50CR. It has similar properties and much shorter lead times. Dissimilar metal welds made with ATI 412 should be made with a cored 309L filler. This type of filler is more resistant to cracking than the traditional solid wire 309L.
- Galvanic corrosion appears to occur on the carbon steel side of these dissimilar metal welds. Galvanic corrosion does not appear to be present on the 50CR side of the weld.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The primary research product will be the final report as developed in Task 3. Recommended changes to the AASHTO LRFD BDS/BCS and AWS D1.5 will be included in appendices within the report and will be based on the combined results from this research and the VTRC/UVA research dual grade welding research. Recommended changes will be written in a similar format to the specifications for which they are intended (i.e., recommendations for AASHTO specifications will follow a two-column specification/commentary format, and recommendations for D1.5 will follow a two-chapter specification/commentary format.). Using a similar format to existing specifications will allow these revisions to be more easily balloted and adopted.

The research team will present at conferences, meetings, and the AASHTO/NSBA Collaboration as well as develop journal publications to disseminate research findings to the steel bridge community. The research team will also present recommendations to the AASHTO Steel and Metals committee for review/adoption into the AASHTO LRFD BDS/BCS and to the Joint AASHTO/AWS Bridge Welding Subcommittee for review/adoption into AWS D1.5.