Investigating Hybrid/Dual Grade Steel Plate Girders Utilizing Stainless Steel

BACKGROUND

Research Need Sponsor: AASHTO T-14 Structural Steel Committee
https://bridges.transportation.org/technical-committees/t-14-structural-steel-design/

The corrosion of steel bridges is an ongoing concern for bridge owners due to maintenance and replacement costs. Recently, there have been successful corrosion resistance tests performed on ASTM A709 Grade 50CR (stainless) steel in plate girder bridges. Before stainless steel's adoption into ASTM A709 the steel was marketed under ASTM A1010 and has currently been used in 5 states (OR, CA, IA, PA, VA) and Canada.

Utilizing stainless steel (Grade 50CR) for the portion of the steel girder near bridge deck joints and Grade 50, 50W, etc. for the remainder of the girder, provides a means to mitigate deterioration in areas exposed to run-off from failed deck joints. Targeting the use of Grade 50CR to portions of the bridge requires bolting or welding stainless steel to conventional steel. The dual grade plate girder created by connecting stainless steel to conventional steel provides a reduction in the life cycle maintenance costs and increases the service life of the steel plate girder bridge. However, the connection of the dual grade plates may be prone to galvanic corrosion or require fabrication processes that differ from conventional plate girder fabrication processes. To take advantage of the corrosion resistant cost savings of a dual grade girder, research is needed to address the galvanic corrosion and fabrication of the dual grade connection.

OBJECTIVE

The objective of this research is to examine the feasibility of connecting bridge-construction approved ASTM stainless steel (currently only Grade 50CR is approved) to conventional steel (Grade 36, 50, 50W, etc.) through welding or bolting and to develop guidelines to assist designers and fabricators when connecting stainless steel plates to conventional steel plates in the superstructure of highway bridges. The guidelines would be considered a supplemental document to the AASHTO *LRFD Bridge Design Specifications* and the AASHTO *LRFD Bridge Construction Specifications*.

The research would, at a minimum, consider the following:

- Welded connection (submerged arc weld and fillet weld) and bolted connection feasibility.
- Welded connection requirements that can be included in AASHTO/AWS D1.5 "Bridge Welding Code".
- Bolted connections that meet the slip-critical assumptions in the AASHTO *LRFD Bridge Design Specifications.*
- Galvanic corrosion and mitigation strategies.
- Design aspects that may change when transitioning to stainless alloys.
- Documented guidelines covering:
    - Design details
    - Fracture toughness
    - Fatigue resistance
    - Installation/fabrication practices that meet performance criteria
    - Stainless steel materials most relevant for bridge construction

- Stainless steel bolt grades that produce equivalent material and service requirements as regular high-strength bolts

The results of the research should answer key questions regarding mechanical properties of the dual grade girder joints and any concerns with galvanic corrosion. Consumables (bolts/nuts/washers or welding wire) must also demonstrate they can be procured domestically to meet Buy America requirements.

SCOPE OF WORK

The proposed project is focused on the design details, fabrication, and performance of dual grade steel girders. The project's work plan is divided into three main research tasks.

Task 1 – Literature Review

3 Months ($50,000)

Conduct a current literature review of sources that have published mechanical and corrosion properties of stainless-steel plates connected to conventional steel plates. With a complete literature review, gaps in research can be identified to guide the Task 2 research effort of bolted and welded dual grade joints.

Task 2 –Connection Testing & Verifying Design/Fabrication Details

24 Months ($300,000)

The Research Team proposes to the Technical Advisory Committee (TAC) of contributors a work plan for research to fill the gaps identified in Task 1. This will lead to mechanical property evaluation of complete joint penetration and fillet welds, along with bolted joints. Pending the findings from Task 1, the second task will include:

- Development of AASHTO/AWS D1.5 *Bridge Welding Code* Welding Procedure Specification(s) and a Procedure Qualification Record (PQR).
- Development of refined nondestructive evaluation procedures for dual grade welded joints.
- Assessment of dual grade welded joints to stress corrosion and galvanic corrosion
- Determining the appropriate grades of bolts to use in a dual grade joint to minimize or eliminate the effects of galvanic and pitting corrosion.
- Determining the appropriate grades of stainless bolts to use in dual grade joints that could achieve minimum installation pretension and the procedure to attain the minimum installation pretension.
- Determine if a dual grade bolted connection can attain slip-critical design loading.

Task 3 – Final Report & Guidelines
6 Months ($50,000)

Provide a final report that, at a minimum, provides:

- A summary of the literature review
- Documented tests, test results, summaries, and conclusions from Task 2 activities
- A cost analysis with recommendations to reduce dual grade girder connection costs
- A cost analysis procedure tool for bridge designers
- Guidelines covering the design details, fabrication, and installation of dual grade plate girders.

The Research Team will also develop an educational program to instruct steel bridge fabricators on the proper procedures to weld conventional grade steel to stainless steels and qualified UT procedure meeting D1.5 requirements.

Grade 50CR STEEL REQUIREMENT (anticipated to be provide by ArcelorMittal)
FHWA In-Kind Research/Activity
TOTAL FUNDING REQUIREMENT **$400,000**