Research Summary

Improved Load Rating Procedures for Deteriorated Steel Beam Ends with Deteriorated Stiffeners

Research Need

To ensure public safety, authorities perform periodic bridge inspections, during which point thickness measurements are obtained in an effort to quantify the section loss due to corrosion. This research attempts to evaluate the current provisions based on real corrosion data, and ultimately to provide new closed form equations for more accurate capacity estimations.

Goals/Objectives

The identification and quantification of the most common corrosion topologies. During the first step of this work, the current deterioration condition of bridges with plate girders is studied through MassDOT inspection reports of viaducts that have experienced beam end corrosion.

To experimentally investigate the failure mechanism of corroded stiffened girders. Two specimens are tested based on naturally corroded rolled girders obtained from decommissioned bridges in the state of Massachusetts.

The calibration of a high-fidelity composite girder-level finite element model.

To define the parameters which significantly affect capacity reduction.

To provide new sets of equations for more accurate capacity assessment.

Methodology

The research will provide new methodologies to determine the remaining load carrying capacity of steel bridges with deteriorated beam ends with deteriorated stiffeners based on real corrosion data. In this project:

1. Real corrosion data have been acquired through inspection reports across all the districts of the state and corrosion patterns were studied and identified.
2. A new experimental configuration has been built in the Brack Structural Testing Lab at UMass Amherst to test real corroded steel beams with stiffeners.
3. High-fidelity finite element modeling and analysis simulations are conducted to validate the experimental observations and findings.
4. Based on the findings from experiments and simulations, a new methodology is developed to accurately assess the capacity.

Key Findings

Part I: Most common corrosion topologies – Data collection

210 corroded stiffened ends were examined in detail. Based on this real data, numerous parameters were defined and quantified through an extensive statistical analysis. Similarities at the corrosion topologies of beams with one or two bearing stiffeners were noticed. No data are usually reported for stiffeners condition.

Part II: Experimental testing

Regarding the experimentally obtained failures, both specimens were characterized by instant capacity drop governed by large displacements developed at peak load. The analytical provisions, currently in use by MassDOT, encapsulate the corrosion effect on a damaged end with a unique value describing the gross area above the support. For both specimens, the average thickness of the points located within the defined area of interest obtained with 3D laser scanning was calculated. For the stiffened specimen, the numerically obtained capacity overestimated the actual one by 24% while for the partially stiffened one, analytical provisions provided an estimation lower by 25%.

Part III: Computational results – Parametric analysis:

The stiffeners section loss was found to have a very harmful effect on the bearing strength compared to web thickness loss, highlighting the need for extensive bearing stiffener condition documentation for field girders. The initial geometric imperfection had a slight effect on the numerically obtained capacities. This finding is consistent with the literature of plate buckling and stiffened plate buckling.

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Project Information

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Use of Findings

Building on the current procedures and by integrating findings from this study, we proposed new closed form equations for the capacity estimation of plate girders with corroded ends. The proposed modifications regard 3 main aspects:
(1) The linearity of the equation,
(2) the area over which the beam condition is examined, and finally
(3) the remaining thickness calculation.
A set of parameters is proposed for each one of the three examined general corrosion patterns. It is worth noting that the evaluation of the proposed procedures based on numerical end experimental data highlighted demonstrated improved the efficiency and reduced errors compared to the equations currently in use.

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