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Caltrans Division of Research, Innovation and System Information

Research Results

Evaluating the Shear Strength of End Panels in Steel Bridge Girders

Proposed shear design equations eliminate the need to retrofit steel bridges or restrict loading

Geotech/ Structures

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Project Title:
Shear Resistance of End Panels in Steel and Steel-Concrete Composite Plate Girders

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WHAT IS THE NEED?

When calculating shear strength, many of California's steel bridges, designed based on previous editions of the American Association of State Highway and Transportation Officials (AASHTO) specifications, consider the contribution of the post-buckling tension-field action for the girders' end web panel. Because the maximum shear occurs at the support, the end web panel becomes the controlling component for steel girder design, evaluation, and load rating. The current AASHTO load and resistance factor design (LRFD) and load and resistance factor rating (LRFR) specifications limit the shear strength of a web end panel to either the shear yielding or shear buckling without considering the tension-field action. Based on the specification change, numerous steel girder bridges with end shear controls have a rating factor below 1.0, requiring Caltrans to strengthen the bridge or restrict vehicular loading. However, AASHTO specification commentaries recognize that the current shear design strength for end panels is overly conservative, for example, the contribution of the concrete deck is ignored when evaluating the shear strength. To avoid unnecessary and costly retrofitting or load restrictions, more accurate and practical shear capacity equations that include the potential contributions from both tension-field action and the concrete slab are needed.

WHAT WAS OUR GOAL?

The goal was to develop realistic and practical shear rating provisions for the end web panel of steel girder bridges to use in Caltrans' rating program and recommend for adoption in the California amendments to the AASHTO LRFD and LRFR specifications.

WHAT DID WE DO?

Caltrans, in partnership with the University of California, San Diego Department of Structural Engineering, tested two steel and two steel-concrete composite girder specimens to investigate the shear resistance of the end panels. The researchers then conducted nonlinear finite-element analyses to simulate the test results and performed a parametric study to identify factors affecting the shear strength of end panels. Based on the observed failure mode from both testing and finite-element simulation, the team developed an analytical model to simulate the collapse mechanism. The researchers used plastic analysis to derive a predictive shear strength equation for the end panels. In a second phase, the team tested four more specimens with different panel width-to-depth ratios and depth-to-thickness ratios, using the results to verify the adequacy of the proposed shear strength equation.

WHAT WAS THE OUTCOME?

All specimens showed much higher shear capacity than as predicted by the current AASHTO specifications. The shear over-strength varied from 1.60 to 2.56 in the first phase, and from 1.15 to 2.57 in the second phase. These results indicate that a large amount of post-buckling strength exists in the end panels and should be considered in determining their shear capacity. The proposed shear strength equation is similar to the one used in the AASHTO specifications, but it includes a coefficient to account for the partial tension-field action in the end panels. The proposed equation was applied to 17 test specimens—4 large-size specimens from the research and 13 small-scale specimens from literature—and 99 finite-element models with different parameters and provided an accurate prediction of the shear strengths. Additional testing is required to more accurately estimate the shear contribution of the concrete slab.

WHAT IS THE BENEFIT?

The current AASHTO specifications for the shear design and rating of plate girder end panels are overly conservative and require unnecessary rehabilitation of existing steel girder bridges that have provided satisfactory service for several decades. The proposed shear design equation can reduce the need to either retrofit bridges or restrict vehicular loads. Both options are costly and affect the traveling public in terms of congestion and the trucking industry by restricting load capacity.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2015/CA15-2316_FinalReport.pdf

IMAGES

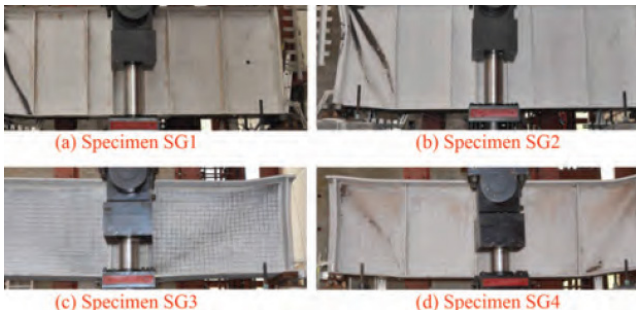

IMAGE 1: Failure modes of the steel girder specimens

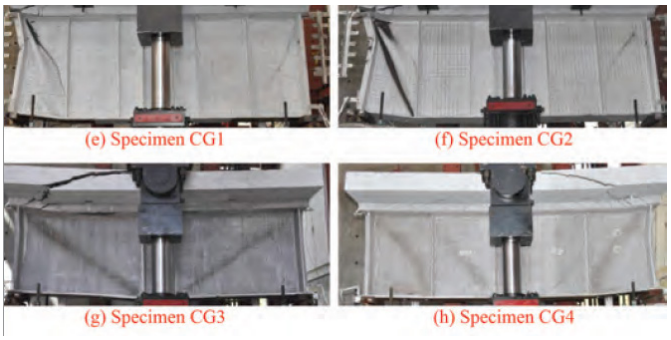

IMAGE 2: Failure modes of the composite girder specimens