DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Capacity of Pin and Hanger Assemblies, Phase 1

Review the existing body of knowledge for each element within pin and hanger assemblies (pins, hanger plates and beam ends)

Geotechnical/ Structures

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Project Title:
Capacity of Pin and Hanger Assemblies, Phase 1

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WHAT IS THE NEED?

Pin and hanger connections (Figure 1) are not commonly used in modern practice, but are present in the aging steel bridge inventory of many transportation agencies, including many in Caltrans. Pin and hanger connections are generally considered to be fracture critical because failure of the pin or hanger can lead to collapse of the bridge, as was observed for the Mianus River Bridge in Connecticut. Determining the capacities for different pin and hanger components is necessary for load rating existing details and also for possible design of new hinges. Most existing hinges were designed with the Working Stress Design (WSD) method, which is no longer allowed for design or load rating. Inconsistencies are found between different design methods (WSD, LFD and LRFD design specifications) when evaluating the stresses at contact surfaces between pins and webs or pins and hanger plates. These inconsistencies make it difficult to establish the load carrying capacity of the component, especially considering the fracture critical status of the details and potential to impact the safety of the travelling public. Clear guidance for evaluation of pin and hanger connections is needed within the LRFD framework and extended back to the LFD approach.

WHAT WAS OUR GOAL?

The primary purpose of the first phase of this project was to review the existing body of knowledge for each element within pin and hanger assemblies (pins, hanger plates and beam ends). This literature review was used to identify areas requiring additional research in order to properly develop and evaluate rating methods for these assemblies. Where sufficient information was found in the literature review, existing rating

methods would be evaluated and, as needed, new methods recommended.

WHAT DID WE DO?

Literature Review Purpose:

- To provide a critical review of the available rating methods in past and present design specifications and guidelines for design and construction of pin and hanger assemblies.
- To provide a review of existing nondestructive evaluation methods used to assess the condition and properties of pin and hanger assemblies.
- Identify the historic materials used for the pins, hanger plates, and beam ends.
- To identify the available data from physical testing and analytical simulations on pins, hangers and beam ends.
- To identify areas requiring future research in order to evaluate and develop rating methods for pin and hanger assemblies.

Outcomes:

- The provisions available in the AASHTO specifications for the analysis of girder ends in pin and hanger assemblies are based on Euler-Bernoulli beam theory. Based on the complex and non-uniform stresses created by the concentrated load exerted by the pin, the application of these equations is questionable. No physical test data is available for beam ends similar to those found in these assemblies.
- The current hanger plate provisions provided in the AASHTO specifications appear to address proportioning of the hanger plate during design without explicitly accounting for all limit states. More accurate rating methods are required for hanger plates.
- Given the lack of data on large diameter pins, present strength prediction methods for pins is uncertain. Experimental data is needed to develop rational analysis methods and resistance models.
- Sources describing the current state of practice of nondestructive testing for pins are identified. Additionally, sources for methods to determine if an assembly is locked are identified along with recommendations for how to treat a locked assembly.
- Historic steels for pin and hanger assemblies are tabulated.
- Enough data exists from experimental studies conducted on hanger plates, to evaluate rating equations and to calibrate resistance factors.

Analysis of Available Hanger Plate Test Data
Purpose:

- To determine if available test data in the literature is representative of inservice hanger plates found in Caltrans' bridge inventory.

Methods:

- Test specimen dimensions and material properties are compared to a sample of 10 in-service Caltrans' hanger plates. The bridge sample was selected based on expert opinion to be representative of the bridge population in California.

Outcomes:

- Overall, based on the sample provided, the experimental specimens were of smaller scale than the hangers within the Caltrans' inventory.
- The relative proportions of the hanger plate test specimens correlate with Caltrans' inventory.
- There is limited data available for hangers made from high-yield strength plate.

Analysis of Hanger Plate Ultimate Strength Predictions
Purpose:

- To determine the accuracy and precision of various ultimate strength resistance equations for each hanger plate failure mode.

Methods:

- Test specimens are sorted into groups based on their mode of failure.
- Strength prediction equations specific to each failure mode are used to rate all specimens for the applicable failure mode.
- For each equation, the predicted capacity for each specimen is compared to experimentally determined capacities.

Outcomes:

- The accuracy and precision of each capacity prediction equation is evaluated through comparisons with experimental test data.
- Statistics are developed for use in the calibration of resistance factors.

Resistance Factor Calibration

Purpose:

- To develop AASHTO-LRFD calibrated resistance factors for each of the different hanger plate strength resistance models.

Methods:

- Monte Carlo simulations were conducted assuming normally distributed loads and lognormally distributed resistance.
- Load factors used were the Strength I, Inventory level load factors from the AASHTO Manual for Bridge Evaluation (MBE).
- Resistance factors were calibrated to a reliability index of 3.5.

Outcome:

- Resistance factors were calibrated to provide AASHTO-LRFD reliability levels for all strength resistance equations analyzed.

WHAT WAS THE OUTCOME?

- The literature review identified a lack of representative physical test data for beam ends and pins. Additional research is required to effectively rate pins and beam ends.
- Historic steels for pin and hanger assemblies were tabulated.
- Sources of information for in-service inspection of pin and hanger assemblies were identified.
- Revisions to the AASHTO MBE were recommended for the rating of hanger plates.

WHAT IS THE BENEFIT?

Prior to this study, the applicability of AASHTO rating equations to pin and hanger assemblies was uncertain. It was unknown whether alternative rating methods or experimental studies already existed for the elements of this connection assembly. From this study, the ultimate strength of hanger plates can be determined with greater confidence. Calibrated resistance factors allow for use of revised rating methods within the AASHTO LRFD methodology. Additionally, identification of knowledge gaps informs future studies on pins and beam ends.

IMAGES

FIGURE 1: Example pin and hanger assembly (Willamette bridge - Oregon)