Research Notes

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Capacity of Aging Bent Caps

Many conventionally reinforced concrete deck girder (RCDG) bridges were built in the United States during the construction of the interstate highway system in the 1950s. Designs followed the AASHO standard of the time, which were less stringent than current specifications. As a result of vintage design combined with increased traffic volumes and heavier truck loads, many of the interstate-era bridges exhibit cracking of the main girders and the short, deep beams called bent caps that support the girders. The implication of cracked girders was addressed in previous ODOT research, but the results of that research were not directly applicable to bent caps due to the dimensional differences between the two types of beams. Consequently, ODOT contracted with Oregon State University to investigate methods for estimating the capacity of cracked bent caps.

A major concern with the vintage bent caps was that the steel reinforcing bars that run the length of the beams could break free of the concrete where the straight ends terminate in the supporting columns. However, it was surmised that the weight that the columns support should provide a clamping force to help anchor the steel reinforcement. To test the likelihood of the steel bars pulling free of their anchorages, researchers constructed sub-assemblies of column sections with protruding steel rebar. The rebar was pulled from a column section while the ends of the column were squeezed together. The results showed that the force applied to the columns due to dead weight does appreciably confine the steel bars.

To investigate bent caps as a system, six full-size bent caps were fabricated with integral column sections and protruding stubs at the interior girder positions. Vintage details from the 1950s were replicated as much as possible including the overall geometry, reinforcement configuration, and material properties. Load was applied to the girder stubs incrementally up to failure while internal and external strains were measured and crack progression documented. To simulate the effect of 50 years of ambient traffic loading, 1,000,000 cycles of repetitive loading based on in-situ measured stress ranges from three in-service bridges was applied to one of the specimens prior to failure testing.

Bent cap with highlighted crack

Current US building and bridge design specifications do not account for the beneficial effects of clamping; therefore, they underestimate the available anchorage strength for bent caps. The research recommended a modification factor to the specifications to better predict actual capacity and still maintain safety. The research also concluded that no reduction factor was necessary due to exposure to traffic loading because the test specimen that underwent repetitive loading showed no appreciable loss of capacity.

The research evaluated several methods for predicting the capacity of bent caps by comparing the calculated values with measured capacities of the test bent caps. Though computer modeling provided the most accurate prediction, a simpler method that does not require specialized modeling skills was recommended. A spreadsheet application was developed to perform the calculations, and an example load rating was conducted.

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The final report for this project was published in September 2008 and is available on the Research Unit web page:
http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/2008/Bent_Caps_Report_Part_1.pdf