RESEARCH
Oregon Department of Transportation

Research Notes

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Capacity of Cracked Reinforced Concrete Beams

Oregon has several hundred reinforced concrete deck girder (RCDG) bridges built in the late 40s to the early 60s that now exhibit diagonal cracks. The Oregon Department of Transportation contracted with Oregon State University to evaluate methods to accurately estimate the load capacity of cracked girders and to develop a procedure to load rate the girders. The investigation encompassed field testing, laboratory testing, and analysis that provided a reliability-based load rating methodology.

The responses of three in-service bridges were monitored under ambient traffic conditions as well as controlled loading. Field measurements showed that the repetitive stress cycles produced in the shear stirrups (vertical steel bars) due to traffic are unlikely to cause metal fatigue (high cycle fatigue, HCF) of the stirrups. The field measurements also showed that the American Association of Highway Transportation Officials (AASHTO) factor used to describe how much load is spread across adjacent girders is conservative; consequently, additional calculated capacity is possible by using load distribution factors representative of an individual bridge.

Laboratory tests were conducted on forty-four large-scale girder elements designed to represent as near as possible 1950's construction practice. Loading protocols included incrementally increasing load amplitudes, repeated loading up to two million cycles, and a moving load along the length of the girders.

Girder testing in the laboratory

Key results included the following:

- Adequate anchorage of flexural steel reinforcement (horizontal steel bars) so that the steel bars did not slip in the concrete was crucial to achieve higher ultimate capacity.
- Crack width alone should not be used to indicate the level of damage to the beam.
- Metal fracture due to HCF is inconsequential.
- Other fatigue damage mechanisms that could lead to debonding between the stirrups and concrete or metal fracture are also unlikely to be a factor in the safe performance of RCDG bridges in Oregon. However, until a set of bridges are analyzed, the research outlined a procedure to incorporate fatigue into the capacity analysis.

Based on the laboratory tests, an analysis method was established for estimating the load capacity of cracked beams. The load capacity was incorporated into a reliability assessment methodology that calculates a reliability index (β) for each critical section of a girder. The girder location, with the smallest reliability index controls the capacity of the bridge.

After applying the reliability assessment methodology to a set of bridges to calibrate β, a minimum β that represents an acceptable level of risk can be selected for Oregon's RCDG bridges.

The reliability method will allow transportation personnel to rationally establish load restrictions, prioritize bridges for replacement or repair, and identify specific segments of bridges requiring repair.

Moving load apparatus with cantilever supports

Request a copy of the CD *"Capacity of Cracked Reinforced Concrete Beams"* from the Research Unit by phone, e-mail, or in person

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