Research Summary

South Carolina Department of Transportation | Office of Materials and Research

Project Information

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FIELD TRIALS FOR COST-EFFECTIVE STRENGTHENING OF SC LOAD POSTED BRIDGES

The transportation infrastructure in South Carolina includes many bridges that are load posted due to structural considerations (e.g., outdated design loads, members whose capacity is difficult to assess) resulting in substantial costs to the public. The significant number of posted bridges has an adverse effect on travel and commerce in South Carolina. Efficient bridge strengthening methods for precast flat slab and channel girder bridges were developed to mitigate these effects. The goal is provide a means for reducing the number of load-posted bridges through efficient

Installation of carbon fiber biscuits to improve lateral load distribution

Problem

The transportation infrastructure in South Carolina includes many bridges that are load-posted due to structural considerations (e.g., outdated design loads, members whose capacity is difficult to assess), resulting in substantial costs to the public. Previous research projects, including SPR 752 – Safe and Cost-Effective Removal of Load Postings for South Carolina Bridges, have helped to cost effectively reduce the number of load postings in South Carolina without the need for strengthening.

In some cases, bridge superstructure systems will still require strengthening to achieve a sufficient load rating value. This report documents the exploration, selection and implementation of cost-effective and rapidly deployable bridge strengthening methods. The SCDOT recently completed a multi-year effort to load rate its inventory of over 9,400 bridges. Findings from the effort identified both precast flat slabs and prestressed concrete channel girders as superstructure types of interest. Many precast flat slabs and channel girder bridges are understrength with respect to rating vehicles and will require intervention in the form of posting, strengthening, or replacement.

Research

The research addressed approaches to load carrying improvement for both precast flat slabs and skinny leg channel girders.

The baseline structural response of skinny leg channel girders salvaged from

decommissioned bridges was assessed in the laboratory through full-scale load tests. Twelve channel girders were tested to evaluate baseline moment capacity and behavior including the influence of aging and deterioration. Damage was classified into three categories based on strand corrosion and measured moment capacity: low, medium, and high.

A strengthening scheme utilizing externally bolted aluminum structural shapes was developed and evaluated for channel girders. Aluminum was chosen for constructability reasons as it is light in weight, readily available, easy to handle in the field, and its corrosion resistance offers durability benefits.

Laboratory and field tests were conducted to evaluate the effect of transverse post-tensioning (XPT) and latex-modified concrete (LMC) toppings on load distribution in skinny-leg channel bridges. SC channel girder bridges were designed and built with steel tie rods that ran transversely through the top flanges. The tie rods were removed, leaving ducts for installing post-tensioning reinforcement.

Due to encouraging results in laboratory tests, XPT and LMC were evaluated on an out-of-service skinny leg channel girder bridge. Both concepts improved load distribution in the test bridge relative to the unmodified condition.

In the final phase of the project, field tests were conducted to evaluate two concepts for retrofitting flat slab panel bridges. Both concepts were conducted from above as opposed to the more conventional approach of retrofitting from beneath the bridge. Retrofitting from above was pursued due to the relative ease of construction from above the bridge, which includes cost and time savings associated with scaffolding, snooper trucks, and other means of access associated with retrofitting or strengthening from below. The first concept tied adjacent panels together using carbon fiber 'biscuits', a technology that has been successfully deployed to tie components together in precast concrete parking garages. Biscuits were installed in grout-filled saw cuts made across adjacent panels. The intent of the biscuits is to improve load distribution. The second concept involved near-surface mounted (NSM) bars placed as negative moment reinforcement over the bent caps to reduce moment demand by tying spans together as continuous members (as described in SPR 752).

Skinny leg channel girder strengthened with aluminum channels

Results

The moment capacity of the channel girder specimens varied depending on their state of deterioration. Channel girders with exposed and corroded strands exhibited lower flexural capacity in comparison to channels with no visible corrosion damage.

Aluminum channel sections were attached to skinny leg channel girders using epoxy or bolting improve the flexural capacity by 9% to 33% relative to baseline girders. The specimen with aluminum channels attached by bolts along the entire span provided the best performance in terms of strength and ductility.

For interior girders the post-tensioned and latex modified overlay retrofits improved load distribution by 15 to 29%, with improvements of 5 to 15% for exterior girders. It is estimated that similar retrofits could improve the load ratings of selected bridges to a satisfactory level.

Field results from the precast flat slab bridge indicated that the carbon fiber biscuits and near-surface mounted bars were both effective, with the biscuits more easily deployed.

Value & Benefit

The findings of this research offer a solution to reduce the number of bridge load postings in SC through improved understanding of behavior and cost-effectively increasing strength. The study focused on identifying efficient and cost-effective approaches to retrofits and strengthening.

Means of improving load ratings from above included carbon fiber biscuits, near-surface mounted bars, transverse post-tensioning, and latex modified concrete overlays. Strengthening with aluminum shapes was approached from below. The implementation of the approaches outlined has the potential to improve the structural integrity of bridges and extend their useful life, thereby reducing the need for bridge load postings.

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