ABSTRACT

Due to frequent accidental damage to prestressed concrete (P/C) bridges caused by impact from overheight vehicles, a project was initiated to evaluate the strength and load distribution characteristics of damaged P/C bridges. A comprehensive literature review was conducted. It was concluded that only a few references pertain to the assessment and repair of damaged P/C beams. No reference was found that involves testing of a damaged bridge(s) as well as the damaged beams following their removal.

Structural testing of two bridges was conducted in the field. The first bridge tested, damaged by accidental impact, was the westbound (WB) I-680 bridge in Beebeetown, Iowa. This bridge had significant damage to the first and second beams consisting of extensive loss of section and the exposure of numerous strands. The second bridge, the adjacent eastbound (EB) structure, was used as a baseline of the behavior of an undamaged bridge. Load testing concluded that a redistribution of load away from the damaged beams of the WB bridge was occurring. Subsequent to these tests, the damaged beams in the WB bridge were replaced and the bridge retested. The repaired WB bridge behaved, for the most part, like the undamaged EB bridge indicating that the beam replacement restored the original live load distribution patterns.

A large-scale bridge model constructed for a previous project was tested to study the changes in behavior due to incrementally applied damage consisting initially of only concrete removal and then concrete removal and strand damage. A total of 180 tests were conducted with the general conclusion that for exterior beam damage, the bridge load distribution characteristics were relatively unchanged until significant portions of the bottom flange were removed along with several strands. A large amount of the total applied moment to the exterior beam was redistributed to the interior beam of the model.

Four isolated P/C beams were tested, two removed from the Beebeetown bridge and two from the aforementioned bridge model. For the Beebeetown beams, the first beam, Beam 1W, was tested in an "as-removed" condition to obtain the baseline characteristics of a damaged beam. The second beam, Beam 2W, was retrofit with carbon fiber reinforced polymer (CFRP) longitudinal plates and transverse stirrups to strengthen the section. The strengthened Beam was 12% stronger than Beam 1W. Beams 1 and 2 from the bridge model were also tested. Beam 1 was not damaged and served as the baseline behavior of a "new" beam while Beam 2 was damaged and repaired again using CFRP plates. Prior to debonding of the plates from the beam, the behavior of both Beams 1 and 2 was similar. The retrofit beam attained a capacity greater than a theoretically undamaged beam prior to plate debonding.

Analytical models were created for the undamaged and damaged center spans of the WB bridge; stiffened plate and refined grillage models were used. Both models were accurate at predicting the deflections in the tested bridge and should be similarly accurate in modeling other P/C bridges. The moment fractions per beam were computed using both models for the undamaged and damaged bridges. The damaged model indicates a significant decrease in moment in the damaged beams and a redistribution of load to the adjacent curb and rail as well as to the undamaged beam lines.