HR-310 Precast Prestresssed Concrete Panel Subdecks in Skewed Bridges

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ABSTRACT

Precast prestressed concrete panels have been used as subdecks in bridge construction in Iowa and other states. To investigate the performance of these types of composite slabs at locations adjacent to abutment and pier diaphragms in skewed bridges, a research project which involved surveys of design agencies and precast producers, field inspections of existing bridges, analytical studies, and experimental testing was conducted.

The survey results from the design agencies and panel producers showed that standardization of precast panel construction would be desirable, that additional inspections at the precast plant and at the bridge site would be beneficial, and that some form of economical study should be undertaken to determine actual cost savings associated with composite slab construction.

Three bridges in Hardin County, Iowa were inspected to observe general geometric relationships, construction details, and to note the visual condition of the bridges. Hairline cracks beneath several of the prestressing strands in many of the precast panels were observed, and a slight discoloration of the concrete was seen beneath most of the strands. Also, some rust staining was visible at isolated locations on several panels. Based on the findings of these inspections, future inspections are recommended to monitor the condition of these and other bridges constructed with precast panel subdecks.

Five full-scale composite slab specimens were constructed in the Structural Engineering Laboratory at Iowa State University. One specimen modeled bridge deck conditions which are not adjacent to abutment or pier diaphragms, and the other four specimens represented the geometric conditions which occur for skewed diaphragms of 0, 15, 30, and 40 degrees. The specimens were subjected to wheel loads of service and factored level magnitudes at many locations on the slab surface and to concentrated loads which produced failure of the composite slab. The measured slab deflections and bending strains at both service and factored load levels compared reasonably well with the results predicted by simplified finite element analyses of the specimens. To analytically evaluate the nominal strength for a composite slab specimen, yield-line and punching shear theories were applied. Yield-line limit loads were computed using the crack patterns generated during an ultimate strength test. In most cases, these analyses indicated that the failure mode was not flexural. Since the punching shear limit loads in most instances were close to the failure loads, and since the failure surfaces immediately adjacent to the wheel load footprint appeared to

be a truncated prism shape, the probable failure mode for all of the specimens was punching shear.

The development lengths for the prestressing strands in the rectangular and trapezoidal shaped panels was qualitatively investigated by monitoring strand slippage at the ends of selected prestressing strands. The initial strand transfer length was established experimentally by monitoring concrete strains during strand detensioning, and this length was verified analytically by a finite element analysis. Even though the computed strand embedment lengths in the panels were not sufficient to fully develop the ultimate strand stress, sufficient slab strength existed.

Composite behavior for the slab specimens was evaluated by monitoring slippage between a panel and the topping slab and by computation of the difference in the flexural strains between the top of the precast panel and the underside of the topping slab at various locations. Prior to the failure of a composite slab specimen, a localized loss of composite behavior was detected.

The static load strength performance of the composite slab specimens significantly exceeded the design load requirements. Even with skew angles of up to 40 degrees, the nominal strength of the stabs did not appear to be affected when the ultimate strength test load was positioned on the portion of each slab containing the trapezoidal shaped panel. At service and factored level loads, the joint between precast panels did not appear to influence the load distribution along the length of the specimens. Based on the static load strength of the composite slab specimens, the continued use of precast panels as subdecks in bridge deck construction is recommended.