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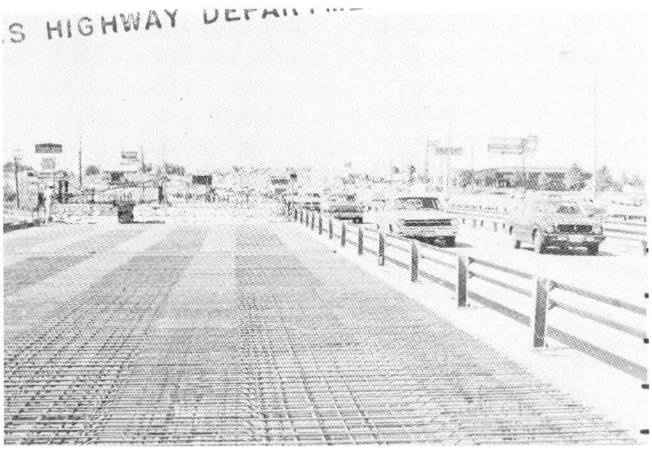

Traffic Flows During Bridge Slab Work

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Bridge Slab Concrete Placed Adjacent to Moving Live Loads

by

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Bridges undergoing deck replacement, repairs, or widening usually maintain their flow of traffic during construction. The movement of this traffic adjacent to newly placed concrete causes deflections and vibrations that are carried over to the fresh concrete. The effects of these disturbances on the fresh concrete are not known, and the study reported here was carried out to develop information on the subject.

It is recognized that the longitudinal beams in a span will deflect different amounts at a given section when a vehicle rolls over the span. This results in transverse bending of the deck slab in the fresh concrete region as well as in the part of the deck that is in service. The new concrete, through the plastic and solid states, must accommodate these recurring movements. If it can do so without destruction of the internal structure, without cracking, and without destruction of bond with the reinforcing steel, it will probably come out to be a good, serviceable deck slab. If it cannot do so, cracks, debonding, and poor quality material will destroy its effective service.

This study was directed toward determining whether any or all of the destructive actions occur in decks cast and cured adjacent to moving traffic. The three major phases of the study were:

1. A visual inspection of widened bridges that have been in service for periods of a few months to several years.
2. Measurement of deflections and vibrations of bridges under widening or staged deck replacement, and studying cores taken from the new concrete in these bridges.
3. Study of cracking and reinforcing steel behavior in laboratory beams constructed and tested to simulate a transverse strip of bridge deck slab.

Thirty bridges that had been widened while carrying traffic were visually inspected. Some had continuous steel beams, some simple slabs, and others simple beams of steel, reinforced concrete, and prestressed concrete. The spans ranged between 25 ft and 110 ft. Particular attention was given to areas at midspan and at the joint between old and new concrete. The inspection found no deterioration that could be blamed on movement of traffic during the placement and curing period.

Deflections and vibrations were measured on beams, reinforcing steel, and fresh slab concrete. It was found that the frequency and amplitude of vibrations of all elements were the same. Deflections measured at midspan provided data necessary to calculate transverse curvature of the new deck slab as traffic moved adjacent to it. It was found that the curvature was not great enough to cause cracking of the fresh concrete. Normal bridge traffic moved unhindered over the bridge in the lane adjacent to the new concrete, except in some cases it was moved away one lane during placement to provide working space. Measurements were made prior to, during, and 24 hours after placement of the concrete. Nothing was found on the site during that period that was troublesome or indicated that problems might develop later from the placement of the new deck.

Cores were taken from the disturbed areas — vicinity of midspan and near the joint — and from areas not disturbed — near piers — in nine bridges. There were 109 nominal 4 in. diameter cores, all coming from bridges with steel or prestressed concrete beam bridges. Each core was inspected through a handheld 2X glass for evidence of deterioration. About half of them were cut and polished and studied further under a 20X microscope, and then treated with a fluorescent crack detector. This revealed microcracks in all cores that were treated in that way, those from undisturbed areas of the deck as well as those from disturbed areas.

Twelve core segments containing reinforcing steel were cut into approximately 3 in. lengths and subjected to negative pressure while immersed in diluted red ink. After 4 hours under that pressure they were removed and split along the steel to determine if debonding of the steel had developed. Two cases were found where puddling and voids had developed in the concrete when the reinforcing bar that crossed over from the old to new concrete moved as traffic crossed the bridge. Usually the dye penetrated into the core along the steel only a fraction of an inch. In two or three cases it penetrated along the full length of the bar embedded in the core, but sharp and distinct bar imprints in the concrete, and particles of mill-scale adhering to the embedment area indicated that bond was good. The study of the cores indicated that there was no problem of cracking of the concrete. On one job the dowels were bent 90 degrees horizonally upon emerging from the old concrete. Wallowed out void areas were found at the bend of some of these dowels. All others, being straight, showed no bond problems at all. Compressive strength tests and pulse velocity tests showed no significant differences between the disturbed area cores and those from nondisturbed areas.

Laboratory beam studies were made to provide information on flexural cracking of very early age concrete, and further information about relative movement of reinforcing steel and fresh plastic concrete. Five beams 12 in. wide × 7 in. deep × 10 ft-8 ½ in. long were flexed continuously from the time of placement until they were 24 hours old. Four of these beams were reinforced with top and bottom longitudinal steel to simulate a transverse strip of bridge deck slab. They also contained transverse bars to simulate distribution steel, and dowels running out one end attached to the deflecting end member to simulate action at the joint between old and new concrete in the deck. One beam had no steel except the dowels. The supports, one at the unloaded end, one at midspan, and one at the loaded end were flexible to simulate bridge beams. An end deflection was supplied at 5-minute intervals in each beam. In addition to that deflection, one of the beams carried a continuous superimposed 6 Hz vibration of ±0.020 in. amplitude over the 24-hour period. End deflections were 0.25 in. for four beams, one of which carried the continuous 6 Hz vibration, and 0.15 in. for the fifth beam.

Each beam cracked at and in the vicinity of the central support. The cracks were first visible at approximately four-hour age, the time of setting of the concrete. The cracks in the plain concrete beam extended through the full depth. They extended to the level of top steel in the beam with 0.15 in. end deflection and below the top steel in the three that had 0.25 in. end deflection. Curvatures in all of the beams exceeded that found in the bridges. These tests and the results found by Hilsdorf and Lott (1) in very early age flexure indicates that there was not enough transverse curvature in the bridge decks to cause longitudinal cracking of the fresh concrete deck slab. Cores from these beams showed no evidence of debonding of the steel.

The overall results of the study show that there are no recognizable harmful surface effects to deck concrete that is placed and cured adjacent to a lane of normal traffic on bridge spans up to about 100 ft. when straight dowels from the old concrete to the new portion of the deck are used.

References

(1) Hilsdorf, H. K. and Lott, J. L., "Revibration of Retarded Concrete for Continuous Bridge Decks", NCHRP Report 106, Highway Research Board, Washington, D.C., 1970 (67 pgs.).

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