Eleven-Year Performance of Two Precast, Prestressed Concrete Bridge Decks

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The widespread deterioration of bridge decks was recognized as a severe problem on Indiana highways in the 1960s. The concept that high-quality concrete would reduce the problem but is difficult to obtain in field-placement situations led to the development and evaluation of precast concrete bridge decks. Two decks that were precast and pretensioned were trucked to the construction sites. There they were erected, posttensioned, and connected to the supporting elements. One deck was a replacement on an existing structure. The other was on a new structure. Traffic ran on the surface of the concrete. No overlays were, or have been, placed on either structure. A careful survey of each structure after 11 years of service indicates that appearance and performance are little changed over this period of time. No spalling, cracking, or rust staining is apparent from the prestressing steel. Low maintenance, fast assembly or disassembly, and a good ride make the method worthy of consideration for many bridge deck applications.

This paper is a performance report on two precast, prestressed concrete bridge decks that have been carrying traffic for 11 years. The concrete surfaces are exposed to traffic and are giving good performance. One deck was a replacement for an old deck on an existing bridge and the other was placed on a new structure.

A completed deck consisted of precast concrete pieces. Each had a minimum thickness of 6 in, was as long as the transverse dimension of the bridge, and was at least 4 ft wide. The pretensioned slabs were placed transversely to the bridge girders and clamped to the top flanges of the girders by means of spring clips and bolts screwed into preset anchors in the concrete. A pretensioning stress was applied in the longitudinal direction of the slabs at a level intended to maintain compression stress in the concrete under full design load-bending stresses. The concrete slabs were posttensioned in the longitudinal direction of the bridge by using rubber-encased cables strung through preformed slab ducts. A thin neoprene sheet placed between the slabs minimized the stress concentrations due to surface irregularities. The neoprene sheet and the nominal posttensioning stress of approximately 80 psi were sometimes helpful in preventing water movement through the joints.

The concept of precast bridge decks was brought about because of the severe deterioration of concrete decks on many bridges in the State of Indiana. This was evident by the mid-1960s.

A major impetus for this work was the belief that the durability of bridge decks is greatly enhanced by high-quality concrete (i.e., concrete that has a low water-cement ratio), is well air entrained, well consolidated, well cured, and with steel accurately positioned. These requirements are frequently difficult to obtain under field-construction conditions; hence, precasting the deck would increase the probability of a high-quality product. The satisfactory performance of these two decks, which were exposed to traffic and routine winter maintenance, indicates that this belief is correct. The initial investigation toward the use of these decks commenced in 1967 as a Highway Planning and Research Program (HPR) study with a laboratory study of its feasibility (1).

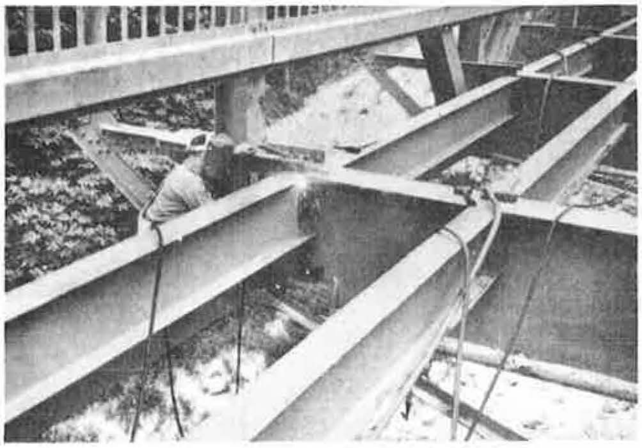
In 1969, the HPR study was extended to include construction of an experimental bridge deck in the field and to test, observe, and evaluate its performance over the next few years. It evolved that two decks were included in the investigation. The first was a replacement deck for an existing bridge on IN-37 near Bloomington, Indiana, and the other was a deck for a new bridge on IN-140 near Knightstown, Indiana. Both were installed during the summer of 1970. Both were periodically monitored through the use of strain gages until 1973.

Details of the installation and performance, as measured by the strain gages installed on the decks and supporting elements, were reported by Kropp in 1973 (2).

Casting of the concrete decks was done in beds designed for box girders; thus, the widths were limited. The joints were a modified tongue and groove and were formed by casting against sheet-metal

Figure 1. Old deck is broken up and dropped onto underlying creek bed.

Figure 2. Existing beam and stringers were adjusted in elevation to accommodate flat-cast deck segment.



forms. The resulting irregularities resulted in imperfect fits; hence, water would later leak through some joint locations and, in extreme cases, spalling due to high stress concentrations occurred during posttensioning. Although it was a concern at the time, it has not progressed or caused further problems over the 11 years of service.

To better understand the concept of the precast, prestressed concrete bridge decks, Figures 1 through 15 detail their fabrication, erection, and performance over the past 11 years.

The Knightstown deck had an epoxy sealer applied to it by maintenance forces during the first summer. This material is now flaking away from the shoulder area and is no longer apparent within the wheel paths. Concrete quality is good, and the only deterioration in the decks is small spalls at the lips of the joints. Many of these were damaged at the time of construction, as has been mentioned earlier, but the repairs have not held up as well as those at Bloomington. Minor repair is needed at several locations. One spall due to steel corrosion occurred, but it is not connected to the prestressing steel. Rather, it appears to be a bar, which was possibly used to position the small tubes that were later to accommodate the posttensioning steel. This single location needs a repair in excess of the bituminous cold mix that had been placed to smooth out the spalls at the lips of the joints.

The performance of the concrete and the deck system has been successful for the past 11.5 years. No indications of severe distress in the near future have been found on these structures.

It is concluded that precast decks offer an excellent method of obtaining quality concrete and quality deck performance. The construction sequence is such that the method could be used for rapid replacements of decks, if that was desirable. Also, many operations could be done simultaneously.

Load tests conducted over the first 2.5 years of deck service indicated no significant changes in the performance of the decks. The decks do not have a rough or objectionable ride. Drivers do not realize they are passing over a unique deck system. Also, these decks could be overlaid and likely will be in future years.

Figure 3. Precast deck elements are placed as deck replacement. End elements had blockouts to accommodate posttensioning anchors, and were later filled with epoxy mortar.

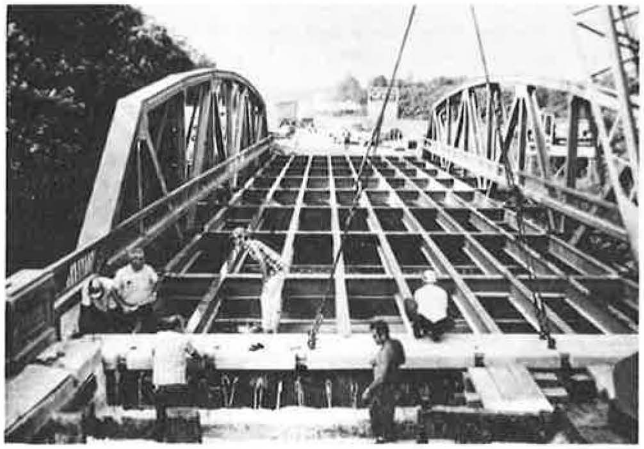


Figure 4. Precast, prestressed deck elements are positioned directly from delivery truck.

Figure 5. Completed deck near Bloomington prior to opening to traffic, 1970.

Figure 6. Precast deck near Bloomington after 11 years of service. No wearing surface or protective coating has been applied to deck. Rubber expansion joint shown here has performed well; however, southbound lane's joint has been damaged, probably by a snow plow.

Recommendations for further implementation of this concept are that flat butt joints be used to reduce spalling at joints and that, when replacement decks are urgently needed, the contractors be provided with incentives for rapid removal of old concrete, placement of new deck elements, and preparation of the approaches.

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Figure 7. End element showing epoxy-mortar-filled blockouts as it appeared after 11 years of service.

Figure 8. Minor damage to lips of female joints occurred during construction when a steel-wheeled roller placing asphalt on the approach backed onto bridge. Epoxy repair is still performing well.

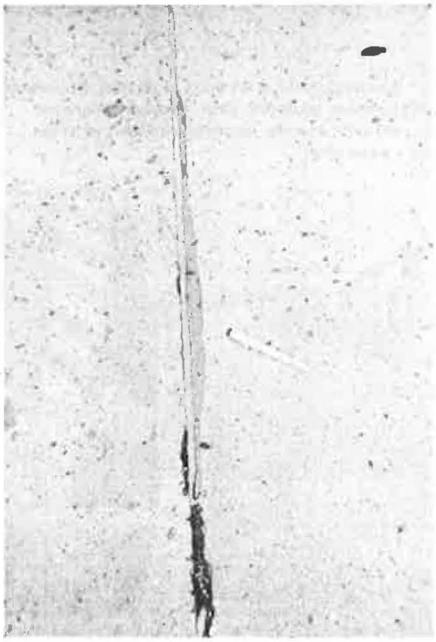


Figure 9. Only deck area that has required maintenance is a small spall. Filled lifting points are also visible.

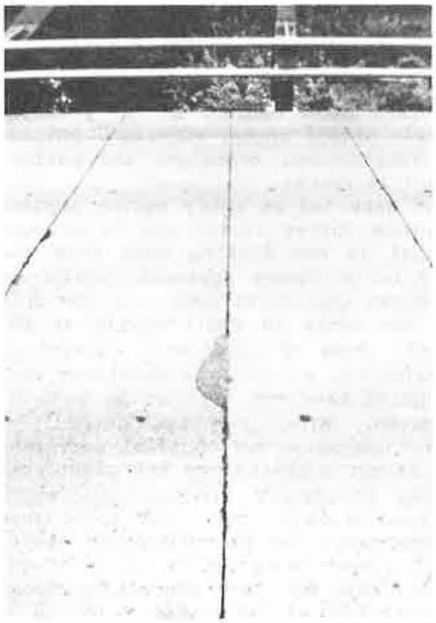


Figure 10. Knightstown deck was designed with built-in crown and with stirrups at ends of each slab to accommodate cast-in-place curb.

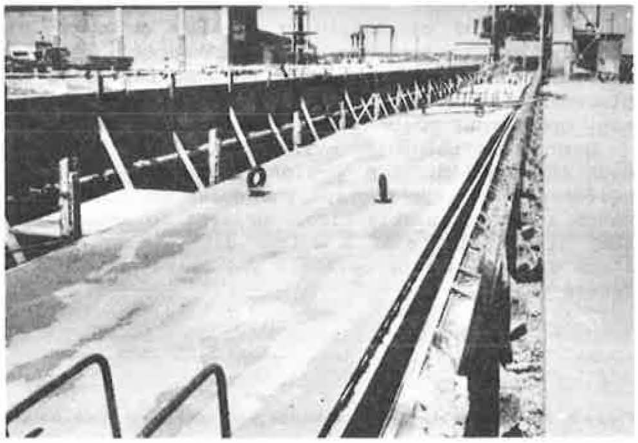


Figure 11. Erection of Knightstown deck was started at center of span; lifting was done with one crane, but two were used for positioning elements.

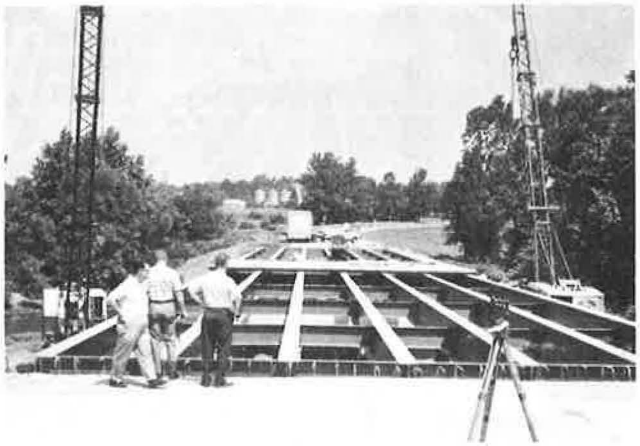


Figure 12. Slabs were fastened to underlying steel with rail clips. Clips were not entirely placed or tightened until posttensioning was completed.

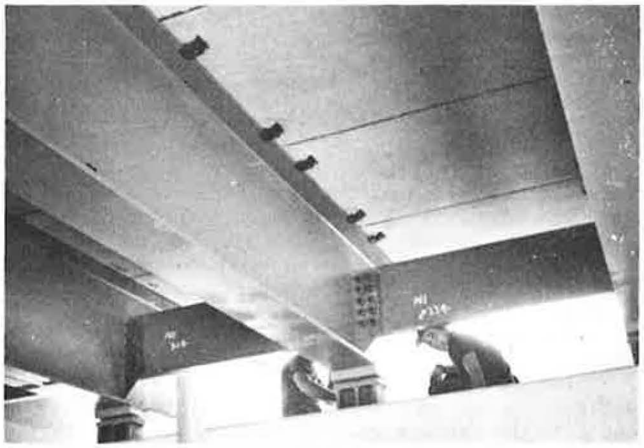
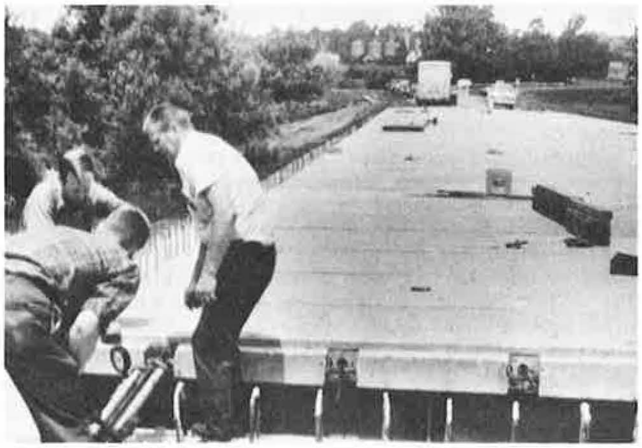


Figure 13. View of final posttensioning operation taking place in 1970.



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REFERENCES

1. J.H. Ford. Use of Precast-Prestressed Concrete for Bridge Decks. Joint Highway Research Program, Purdue Univ., West Lafayette, IN, Rept. 20, July 1969.
2. P.K. Kropp. Use of Precast-Prestressed Concrete for Bridge Decks. Joint Highway Research Program, Purdue Univ., West Lafayette, IN, Rept. 7, March 1973.

Figure 14. Northbound view of Knightstown bridge deck after 11 years of service.

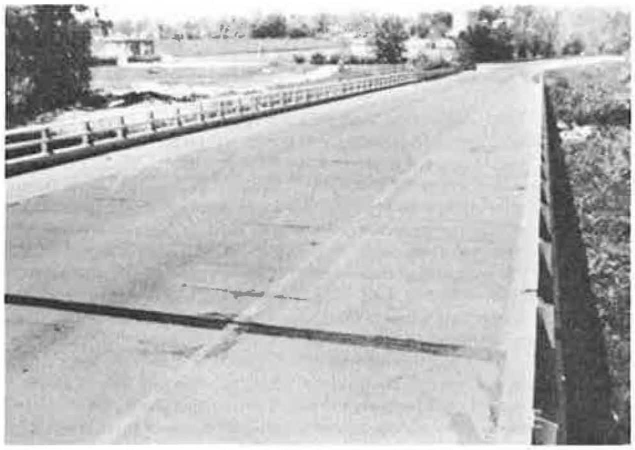
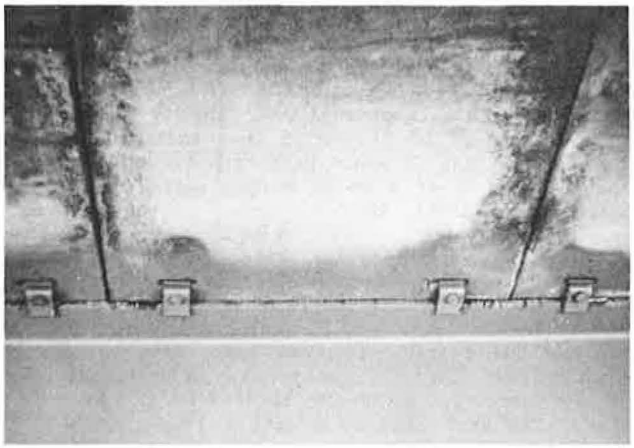


Figure 15. Underside of precast, prestressed, posttensioned deck elements at Knightstown shows clips and water stains on bottom of slabs. Neoprene strips and joint filler were not effective in preventing water from passing through joints.



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