Precast, Pretensioned, Post-Tensioned Concrete for Bridge Decks

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INTRODUCTION

The problem of concrete bridge deck deterioration on many of our newer as well as older bridges is severe, somewhat perplexing as to cause, and difficult to solve. Furthermore, the cost to highway agencies for their repair, and the cost of delay to the highway user, can be extremely large.

The use of precast, prestressed concrete for bridge decks is a concept of construction or reconstruction which we hope will contribute considerably to the durability of concrete bridge decks and greatly reduce the time required for replacement of deteriorated bridge decks.

A NEW CONCEPT

The origin of this concept is directly related to the spalling of bridge decks. The Joint Highway Research Project, at Purdue University, with the Indiana State Highway Commission has long been concerned with the durability of concrete. The highway commission, and most other highway agencies, have through the development of adequate designs, specifications, inspections and testing achieved high quality concrete with adequate durability for all highway applications except bridge decks. Their lack of success in this case is often dramatic and always obvious to the traveler over such a bridge.

When considering the problem, we find that several conditions exist on bride decks which are seldom found elsewhere. First, the construction situation and environment are frequently the worst ever accepted for placing concrete. What may have been excellent concrete when mixed may be subject to unanticipated delays between mixing and placement. Water may be added by those who like high slumps and by those who do not understand that the slump of concrete is not a measure of its water content, i.e., a low slump does not necessarily justify the addition of more water.

The placement, finishing, and curing of the concrete on bridge decks all too often involves hand labor, poor finishing techniques, high winds, extreme temperatures and questionable curing. It is small wonder that the product resulting from placing concrete in bridge decks has not been of the best quality.

These undesirable field construction conditions are difficult to control and it was while pondering ways of negating these—to improve the resulting concrete—that the idea developed of taking the concrete to the environment rather than the environment to the concrete. This led to the concept of precasting the concrete bridge deck. It is possible, under the controlled conditions of a precast plant, to obtain the highest quality concrete and steel placement.

It is well to realize, however, that simply because the product is manufactured in a plant there is no guarantee that high quality will automatically result.

Proper control must be exercised by all involved. No longer are there unavoidable reasons for poor concrete.

The initial planning for this research project started in early 1967 with it developing into an approved HPR research project in cooperation with both the Indiana State Highway Commission and the Bureau of Public Roads in October 1967. The initial feasibility study soon

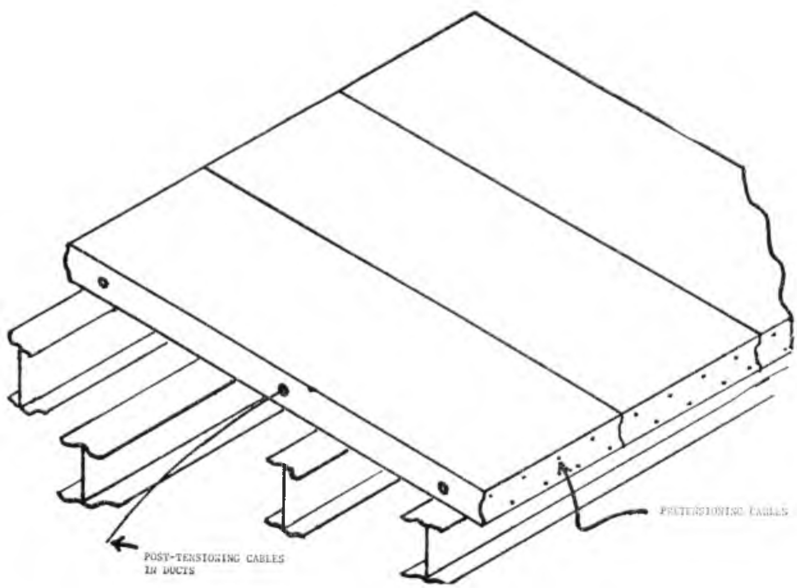

Fig. 1. Precast Deck Slabs on Bridge Beams.

showed that the project had promise and that a laboratory investigation of certain aspects was both warranted and technically desirable.

The concept, as further developed in the feasibility study, is to use precast and pretensioned slabs which are placed on top of the girders, then post-tensioned and tied mechanically to the underlying girders to achieve a deck of satisfactory structural characteristics.

Figure 1 illustrates the concept. Precast deck slabs are placed on the bridge beams. The slabs have been pretensioned transverse to the center line of the bridge and beams. As the slabs are placed on the beams, post tensioning cables are fed through conduits cast in the slabs. After the slabs are in place they are post-tensioned together in a direction parallel to the center line of the bridge.

Slabs are fastened to the underlying beams by rail clips bolted to the bottom of the slab. An end view of this arrangement is shown, in figure 2.

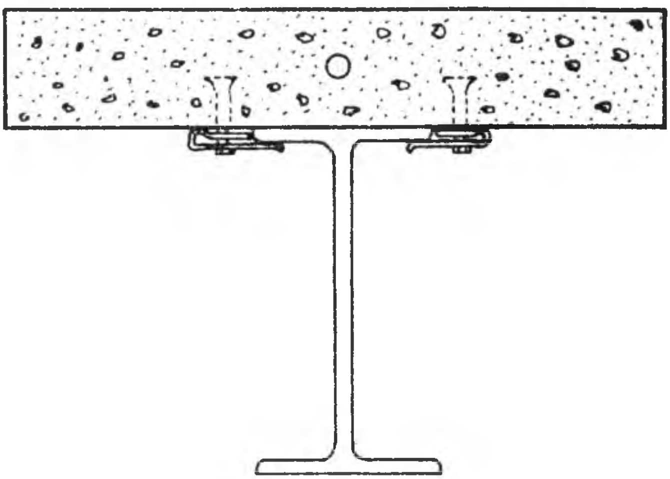

Fig. 2. Typical Cross Section at Tie-down.

LAB TESTING

Initial laboratory tests were concerned with the design of the joint between the slabs and with joint materials. Two small test slabs, 6 in. thick, were subjected to over two million load repititions with the joint closed under an average pressure on the order of 50 psi. Initially, asbestos cloth with asphalt used as an adhesive on the male joint, was used as a joint material. Later tests of water tightness showed that $\frac{1}{16}$-in. neoprene sheets worked well for a joint material.

Two sets of larger slabs, with four slabs in a set, were designed according to AASHO specifications. In each set two slabs were designed for 4-ft beam spacing and had eight, $\frac{7}{16}$-in., 250-kip strands for the pretensioning; the other two slabs were designed for 8-ft beam spacing and had 12, $\frac{7}{16}$-in., 250-kip strands for pretensioning.

The casting bed for the first set is shown in figure 3.

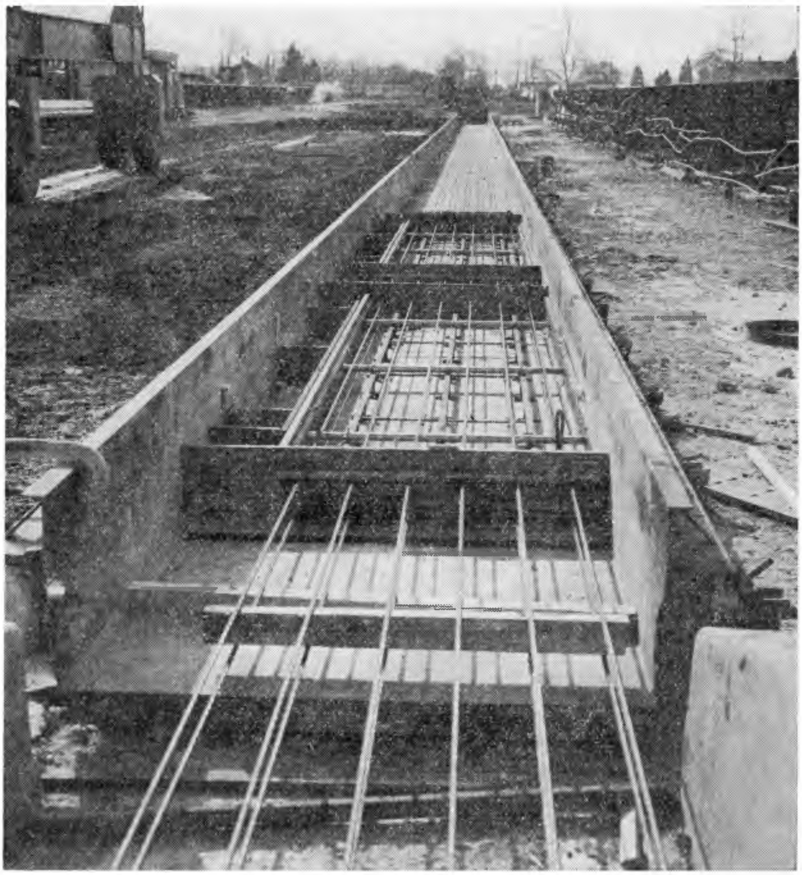

Fig. 3. Casting Bed for First Set of Deck Slabs.

Conduits between prestressing layers allow for post-tensioning cables which were stressed to various levels in the test program. Two slabs were cast at a time.

The first set of slabs were tested under repetitive loading and finally under static loading to failure.

The second set of four slabs is shown in figure 4 as they are presently set up. They have undergone more than eight million cycles of loading. A cycle is a 10,000-lb load applied alternately on opposite sides of a joint to stimulate the passage of a wheel.

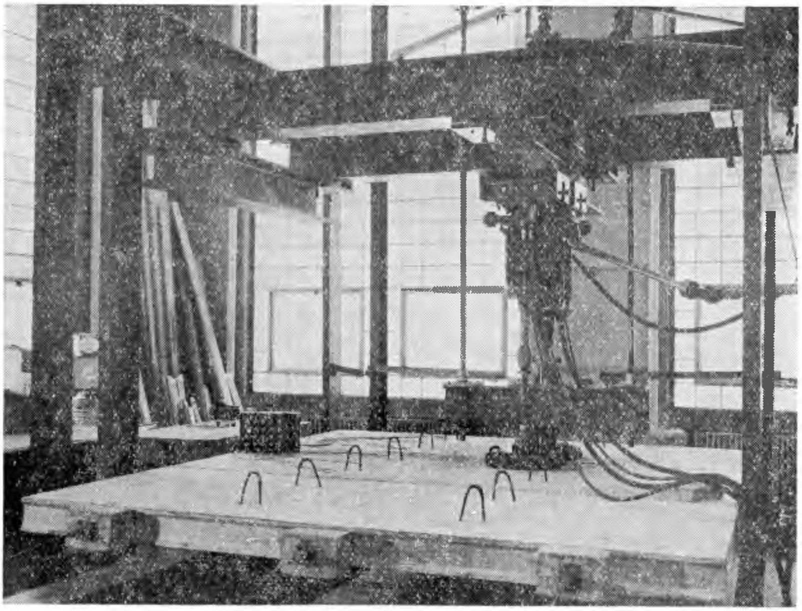

Fig. 4. Slabs Undergoing 8,000,000 Cycles of Loading.

The slabs are instrumented with strain gages. Readouts from these gages are collected in a data acquisition system. This system is portable to the extent that it can be carried in the back of a panel truck and used to collect data from field installations.

FIELD INSTRUMENTATION

A part of the research project is the instrumentation of a prototype structure and the evaluation of both its construction and performance. We wanted to try it on a structure with moderate traffic and preferably a steel beam bridge. The cooperation of the highway commission was of course needed for this phase and they have been of great help. Never-the-less the best structure we could obtain for this project was a 126-ft, 8-in. panel, through-type, pony truss on State Road 37 crossing Bean Blossom Creek north of Bloomington. This is a deck replacement job. The stringers on this structure are at 3 ft 9 in. Thirty-three separate precast slabs, 32 ft in length will be used on the structure.

The design of this replacement deck was done as part of the project with excellent assistance from Wayne Walters of the Indiana State Highway Commission. The contract has been let and the construction schedule calls for the removal of the old deck during the last week of May and the placing of the precast deck starting June 1 or shortly after.

This bridge will be instrumented in part before the existing deck is removed hence we will be able to compare a before and after condition.

Separate from this research project is another precast, prestressed and post-tensioned deck being placed on a new structure south of Knightstown over the Big Blue River. After completion it will be instrumented as part of the project. This structure will be a three-span, 201-ft, steel beam bridge with beams at 6-ft centers. A total of 51 individual precast slabs, 38 ft in length, will be used on this bridge. These slabs have a built-in crown with their thickness varying from 7 in. at the edge to 10½ in. in the center.

This is in contrast to the Bean Blossom Creek bridge on SR 37 where the slabs will be of uniform thickness and deflection of the slab under the rail clip fastener will cause the precast slabs to conform to the crown of the existing stringers.

Both of these structures are on steel. However, the concept is applicable to concrete with adaptation of the rail clip.

CONCLUSION

Much will be learned from the construction of these field installations this summer and from further evaluations in the future.

The concept is promising, and with the fine cooperation being given to us by the engineers of the highway commission and the contractors, we hope that these will be the first of many, more durable, and more economical bridge decks for our highway system.