BRIDGE DECK CRACKING INVESTIGATION ON THE THREE CONTINUOUS SPANS OF B01 of 73101E
(I 675/Saginaw River)

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BRIDGE DECK CRACKING INVESTIGATION ON THE THREE CONTINUOUS SPANS OF B01 of 73101E (I 675/Saginaw River)

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In his letter of March 31, 1971 to Max N. Clyde, M. Rothstein indicated that cracking had occurred in the three continuous spans (Nos. 9, 10, and 11) on both roadways of B01 of 73101E (I 675 over Saginaw River). He requested assistance in determining the cause of the cracking and what steps might be taken in the future to prevent a similar recurrence on other bridges.

The investigation of the problem was assigned to the Research Laboratory, and on May 14, 1971 an inspection party traveled to Saginaw, met with District 6 construction personnel, and closely inspected the deck of the subject bridge. The inspection revealed that both prominent and hairline transverse cracks were present in spans 9 and 10 on the northbound and southbound roadways; that no cracking occurred in span 11 of either roadway; and that most of the cracks seemed to follow directly above one of the top transverse reinforcing bars. With the Swiss Pachometer, an instrument used to locate steel reinforcing bars and estimate their depth of embedment in concrete, the depth of concrete cover over the top bars was measured in several places selected at random. The instrument did not indicate less than 2-1/2 in. to the center of the bar in the areas tested.

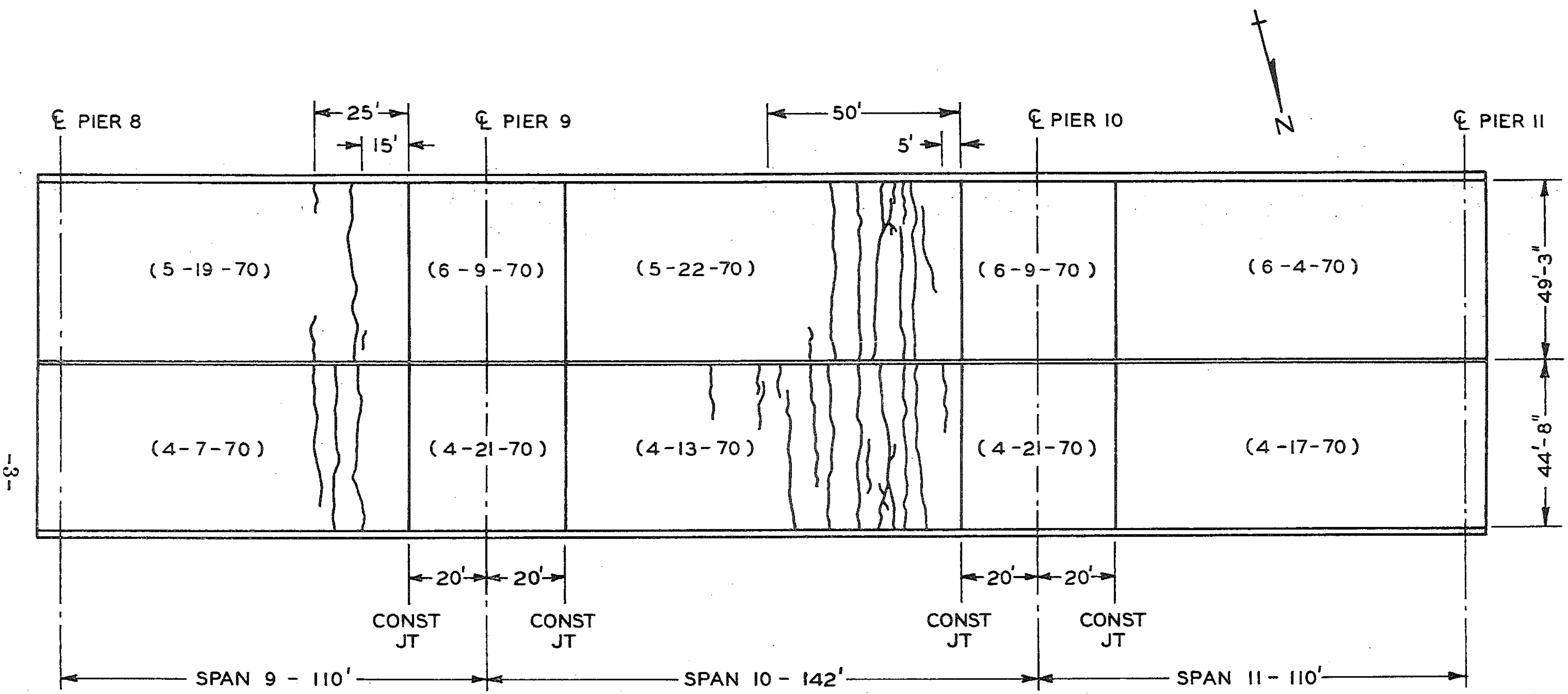
Figure 1 is a plan view diagram of the three continuous spans showing the locations of the transverse cracks. Since the cracks are not uniformly spaced across spans 9 and 10, and are completely absent in span 11, it becomes apparent that they are not caused by shrinkage restraint alone. When the sequence of pour dates is considered, it would appear that each subsequent pour caused variations in the girders elastic curve which caused cracking in the preceding pour. This effect can be illustrated in a line sketch as shown in Figure 2. Construction records indicate that a water reducer-retarder was used with a longitudinal finishing machine and the concrete was cured by wet burlap for all pours.

An analysis was performed to determine the likely magnitude of the tensile stresses that developed in the concrete deck that was in place when concrete was poured in an adjacent continuous span. In the first case considered, the deck in the dead-load positive moment portion of span 9 was assumed to be in place and acting compositely; the remainder of the three continuous spans was assumed to act non-compositely. A uniform load equal to the weight of the center pour in span 10 was then assumed to be applied, and the tensile stresses that would be induced in span 9, the tail span, were estimated. In the second case, it was assumed that the deck had been placed in the center span in addition to that in tail span 9 and that these portions of the spans would act compositely under additional load; the remaining portions of the three continuous spans were assumed to act non-compositely. It was then assumed that the concrete deck was placed in the positive dead-load moment portion of span 11 and the resulting tensile stresses in the span 10 deck were investigated.

The maximum tensile stress in the concrete in span 9 was found to be 270 psi. The maximum tensile stress in the concrete in span 10 was found to be 240 psi. The location of the maximum computed tensile stresses coincided with the areas in the deck where cracking was observed. Considering that the concrete had been in place from four to seven days prior to pouring concrete in the adjacent spans, it is assumed that the concrete would have attained an ultimate tensile strength of about 200 psi. However, the stress analysis indicated that stresses as high as 270 psi could have occurred. It seems reasonable, therefore, to conclude that the observed cracks in the deck were probably caused by the construction loading conditions that have been discussed.

In order to prevent flexural cracking of composite, three-span continuous bridge structures, where shoring is not practical, it is recommended that pre-loading be used and that the concrete pouring sequence be changed. Generally, the positive dead-load moment areas in the tail spans should be poured first with a pre-load in place in the center span. For simplicity, the weight of the pre-load may be chosen equal to that of the concrete deck to be poured in the center span. Removing the pre-load prior to placing the center span concrete would induce compressive stresses in the concrete in the tail spans which would offset the tensile stresses induced when the middle span concrete is placed.

The required pre-load could be greatly reduced if the time interval between pours and curing methods could be controlled to insure the development of a specified minimum value of tensile strength in the concrete in the tail span prior to pouring the center span. For example, considering the subject Saginaw River bridge, if it is assumed that a tensile stress of 150 psi could have been carried by the tail span concrete at the time of placing the center span concrete, then a pre-load equal to about 40 percent of the concrete pour weight would have prevented flexural cracking.



NOTE: BRIDGE SLAB POUR DATES ARE SHOWN IN PARENTHESIS

Figure 1. Bridge deck crack pattern on I 675 / Saginaw River.
B01 of 73101E

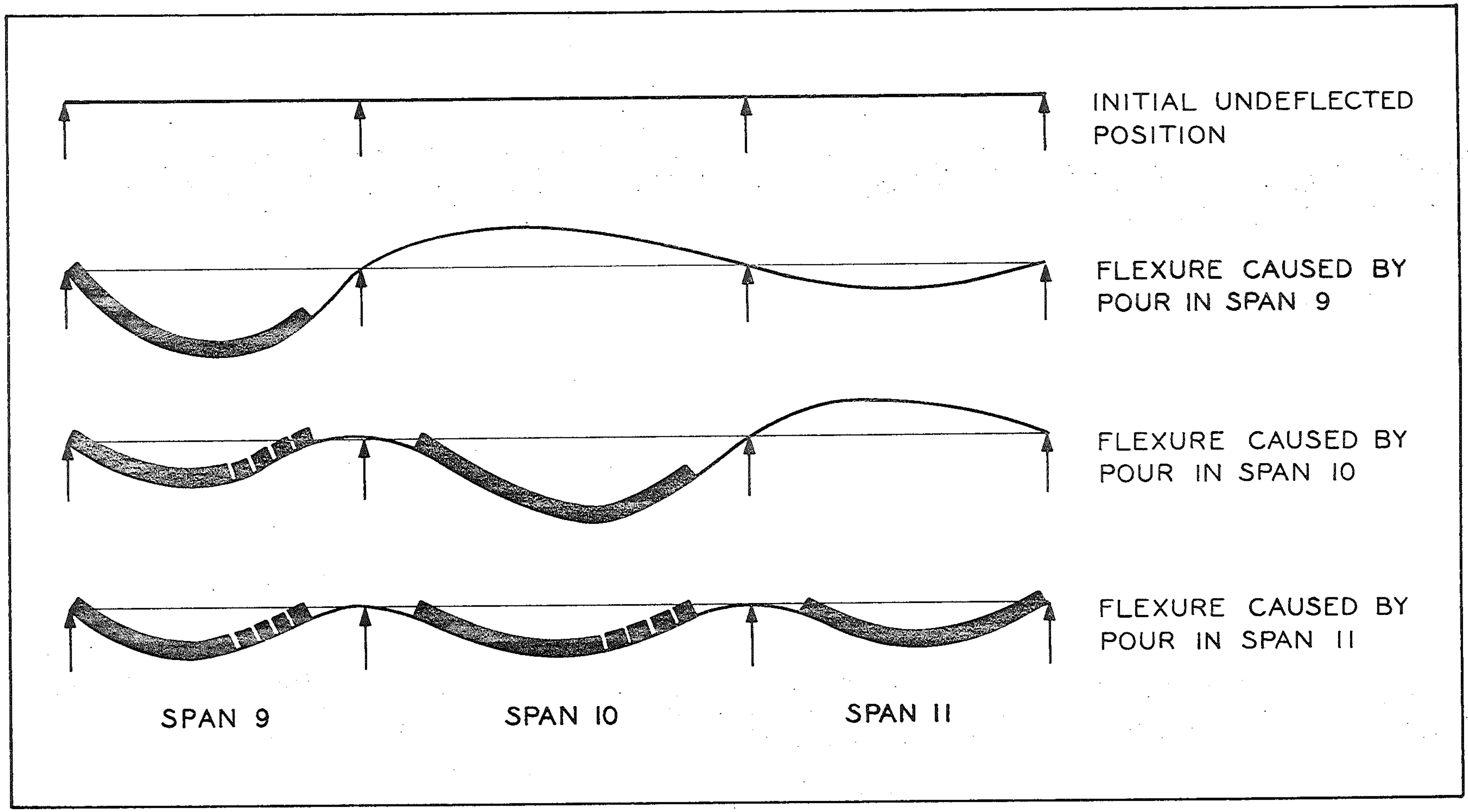


Figure 2. The exaggerated sketch shows the sequential positions of the continuous girder's elastic curve after successive slab pours in spans 9, 10, and 11.