

FINAL REPORT
A FIELD INSTALLATION USING PRESTRESSED PANEL SUBDECKS

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

This final report is a supplement to an earlier report that covered the installation of the first precast, prestressed panel subdecks installed on a bridge in Virginia. The report discusses the inspection of the decks one year after they were completed and the relative ease of construction using the precast subdeck technique as opposed to permanent steel forms and conventional timber forming. Estimates of the relative costs between the three types of forming and consideration of the speed of construction suggest that the precast subdeck technique can reduce superstructure costs and save time and labor during construction.

The original bridge design incorporated epoxy-coated reinforcing steel in the cast-in-place upper portion of the decks. This provision was made to protect the reinforcing steel against the intrusion of chlorides since the deck was expected to crack over some of the joints between the subdeck panels. Hairline cracking was observed on some of the decks above the joints between the subdeck panels. There was no definite pattern to the cracking in some of the other spans, but this may have been due to lack of traffic loading on all but one lane of the twin bridges at the time of the final inspection. While similar cracking is often found in conventionally constructed decks, the joints between the subdeck panels appear to control the location of cracking that might otherwise occur at random locations.

It was recommended that the precast subdeck panels technique be considered as a viable alternative for use in the design and construction of bridge decks.

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INTRODUCTION

A working plan submitted to the Federal Highway Administration in early 1977 proposed that the installation of Virginia's first prestressed panel subdecks on the twin bridges carrying Rte. 220 over relocated 23rd Street in the city of Roanoke be evaluated as an experimental features project.⁽¹⁾ This plan was approved by the FHWA in April 1977. The prestressed panel subdecks were installed on the bridges that same month, and a report covering the installation was issued in July 1977.⁽²⁾ At that time it was planned that a final supplemental report would be prepared to describe the condition of the structures one year after the decks were completed. This report covers the one-year inspection of the structures and compares the estimated relative costs of the use of subdeck panels with that for conventional procedures for forming the typical highway bridge deck. Observations concerning the future use of the technique are also included.

The use of prestressed panel subdecks expedites bridge deck construction by eliminating both the forming required for concrete placement and its subsequent removal where wood and plywood forming materials might otherwise have been used. As indicated in the earlier report on the installation of the panels, only slightly more than 38 man-hours were required to place the approximately 1,877 m² (20,200 ft.²) of deck area. It would have required approximately this amount of time to form one of the eight spans involved if conventional wood forming had been used instead of the panel subdecks. While it is not known how long it would have taken to form the same decks using permanent steel forms, some comparisons with the time required to form other bridges are discussed in this report. In addition to time and labor savings, less reinforcing steel and concrete has to be placed in the field when the subdeck panels are used. The quantities of deck steel and concrete placed in the field are reduced by approximately 50% when subdeck panels are used in lieu of timber or permanent steel forming.

GENERAL DESCRIPTION OF THE BRIDGES AND SUBDECK PANELS

The Rte. 220 bridges over 23rd Street in the city of Roanoke are twin, prestressed concrete girder, simple span structures having two 18 m (59 ft.) central spans and 9.45 m (31 ft.) end spans. Each structure has a 10° skew, an 18.3 m (60 ft.) roadway width and a 54.9 m (180 ft.) length. The girder spacing on the shorter spans is 2.84 m (9 ft.-4 in.) and on the longer spans it is 2.13 m (7 ft.). The deck thickness is 216 mm (8-1/2 in.) and 204 mm (8 in.), respectively, on the shorter and longer spans.

Two general sizes of the rectangular shaped prestressed panels were fabricated — one for the longer spans and one for the shorter. On the shorter spans the lengths of the panels are 2.6 m (8 ft.-6 in.) and on the longer they are 1.88 m (6 ft.-2 in.). All of the panels were cast in 2.44 m (8 ft.) sections, except those placed at the ends of the span, where shorter length trapezoidal shapes were required to accommodate the 10° skew on the structures. Typical details for both the panels and the panel layout were included in the installation report.⁽²⁾ A view of one of the completed structures is shown in Figure 1.



Figure 1. View of SBL lane bridge with only one lane open to traffic (July 1978).

PRECAST SUBDECKS VERSUS OTHER FORMING TECHNIQUES

One of the original purposes of the field observations of the first subdeck panel installation in Virginia was to determine whether there would be unexpected problems that would make the installation of the panels more difficult or more time consuming than the installation of permanent steel forming. The ease and speed with which the prestressed panel subdecks were placed on the study bridges suggest that this technique has several advantages over permanent steel forms. Among these advantages are the following.

1. No welding or fastening is required for the subdeck panels,
2. less deck concrete has to be place in the field,
3. less reinforcing steel has to be placed in the field, and
4. less time is required to place the subdeck panels.

The last noted advantage was determined from general estimates of the man-hours of time required to place permanent steel forms on three other structures. These data are given in Table 1 along with additional data showing comparisons of the cost for the installation of steel forming on the three bridge decks and that for the Rte. 220 bridge with the precast subdeck panels. For the three bridges that utilized permanent steel forming the area of forming placed per man-hour ranged from 2.6 m² to 3.6 m² (27.6 ft.² to 38.3 ft.²). This compares to 8.2 m² (87.7 ft.²) of precast subdeck panels that were installed per man-hour on the Rte. 220 bridges. If it is assumed that the average overall cost per man-hour was \$10 during 1977, the cost per square foot for installation would average about \$0.31 for the permanent steel forms as opposed to \$0.11 for the precast subdeck panels. Therefore, from the standpoint of the installation cost, the precast subdeck panels took about one-third the time and labor of that of the permanent steel forming installed on the three comparison bridges. In a related matter, there are fewer problems associated with the installation of precast subdecks, mostly because no welding of support chairs is required.

In order to compare the cost of constructing a superstructure utilizing permanent steel forming with that of the study bridges, the low bid costs of three additional bridges were obtained. These bridges were constructed in the same general area and during the same period of time as the study bridges. The bid costs are listed in Table 2 for comparison. Two of the comparison bridges, however, did not have epoxy-coated reinforcing steel in the decks as did the

Table 1

Installation Comparisons

Permanent Steel Forming Vs. Precast Subdeck Panels

Bridge	Length, Ft.	Width, Ft.*	Area, Ft. ²	Man-hours	$\frac{\text{Ft.}^2}{\text{Man-hr.}}$	$\frac{\text{Cost}^{**}}{\text{Ft.}^2}$
1	619	36	22284	720	31.0	\$0.32
2	542	36	19512	510	38.3	\$0.26
3	271	37.5	10163	368	27.6	\$0.36
Average					32.3	\$0.31
Study Bridges	180	112	20160	230	87.7	\$0.11
1 Ft. = .3048 m; 1 Ft. ² = 0.093 m ²						

*Excludes overhang areas of the bridge deck.

**Assumes an average cost of \$10 per man-hour.

Table 2

Bid Cost Comparison (Superstructure)

Permanent Steel Forming Vs. Precast Subdeck Panels

Bridge	Length, Ft.	Width, Ft.	$\frac{\text{Cost}}{\text{Ft.}^2}$ *	Remarks
1	190	78	\$5.46	Regular reinforcing steel
2	148	82	\$5.40	Regular reinforcing steel
3	176	82	\$6.68	Epoxy-coated reinforcing steel
Study Bridges	180	124	\$6.86	Epoxy-coated reinforcing steel

1 Ft. = 0.3048 m; 1 Ft.² = 0.093 m²

*Cost based on total width of bridge including parapet walls.

study bridges. Thus, the third bridge listed in Table 2 is the only one that can validly be compared with the study bridges. Based on the low bid costs per square foot of the total superstructure area, the unit cost of the precast subdeck panel construction was slightly higher. Even this comparison, however, may not be valid, since this was the first experience with the subdeck panel construction technique in Virginia and no other alternatives were allowed; i.e., it was required that the precast subdeck panels be used. The degree of uncertainty involved with the introduction of this technique in Virginia may have caused the bid cost submittals to be higher than might otherwise have been expected. In addition, bid cost comparisons like those shown in Table 2 can be misleading due to contractor's occasionally submitting unbalanced bids. Ideally, a more reliable way to compare the costs of different alternatives is to have bids for the use of each alternative on the same structure. Subsequent to the construction of the study bridges, two additional structures were designed using the prestressed panel subdeck technique as an alternate to conventional deck construction using timber forming. In each case the superstructure bids for the subdeck panel alternative were lower than those for the conventional forming as shown in Table 3. Savings in superstructure costs of 4.1% and 3.3% for bridges Nos. 1 and 2, respectively, were realized.

Table 3

Superstructure Bid Costs

Precast Subdeck Panels Vs. Conventional Forming

Bridge No.	Bid Costs		Savings Dollars	%
	Subdeck Panels	Conventional Forming		
1	\$738,929.00	\$770,189.80	\$31,260.80	4.1
2	\$224,451.00	\$232,041.00	\$ 7,590.00	3.3

Since the cost comparison for these two bridges did not include the alternative of using permanent steel forming, additional information was obtained from a contractor who regularly uses permanent steel forming in lieu of timber forming on his bridge construction projects. This information revealed that permanent steel forming and timber forming are considered to be about equal in cost, assuming that the timber can be used three times. Under normal circumstances, timber forming is removed one to two weeks after construction of the deck is complete and is used three or four times. Therefore, the costs of decks utilizing permanent steel forming could be considered approximately equal to those

for decks using timber forming, and accordingly, savings similar to those shown in Table 3 should have been realized had the alternative been between precast subdeck panels and permanent steel forms. It should be noted, however, that the length and width of the bridge as well as other design features will influence bid costs. In addition, prevailing economic conditions relating to the availability of various materials will greatly influence costs at any given time; so drawing conclusions concerning the economy of any construction technique is risky. Based on the nature of the economy during 1977, at any rate, it would appear that the use of the precast subdeck panel technique would result in savings in construction costs.

DECK INSPECTION

The one-year inspection of the bridge decks was made on July 19, 1978. At that time only one lane on the southbound lane bridge had been opened to traffic. This lane had been under traffic for approximately two weeks. The northbound lane bridge had not been opened to traffic at that time.

Before the bridges were built it was expected that cracking would develop in the deck surface above the joints between subdeck panels. For this reason epoxy-coated reinforcing steel was used in the upper cast-in-place portion of the deck for protection against the intrusion of chlorides. Fine hairline cracking was observed to some degree in all the spans. In several spans, the cracking in the bridge deck was located approximately above the joints between adjacent subdeck panels. In other spans there was no clear relationship between the location of the cracking and the location of the subdeck panel joints. This could have been due in part to the fact that the bridges had not been subjected to traffic loading (with the exception of the one lane for the two-week period) and also due to the very fine nature of the cracking rendering it difficult to detect. A typical view of one of the more prevalent hairline cracks is shown in Figure 2. This type of cracking is often found in conventionally placed bridge decks. With the subdeck panel type deck, however, the joints between adjacent panels appear to control the location of cracking which otherwise might occur at random.

The fact that much of the cracking is controlled by the location of the subdeck panel joints is suggested by a tendency of the cracked areas to follow the 10° skew of the bridge deck. In areas where the corners of laterally adjacent panels were offset by the effects of the skew, the cracking appeared to move diagonally forward to follow the joints between the panels. During the inspection the most extensive cracking was noted on the southernmost span

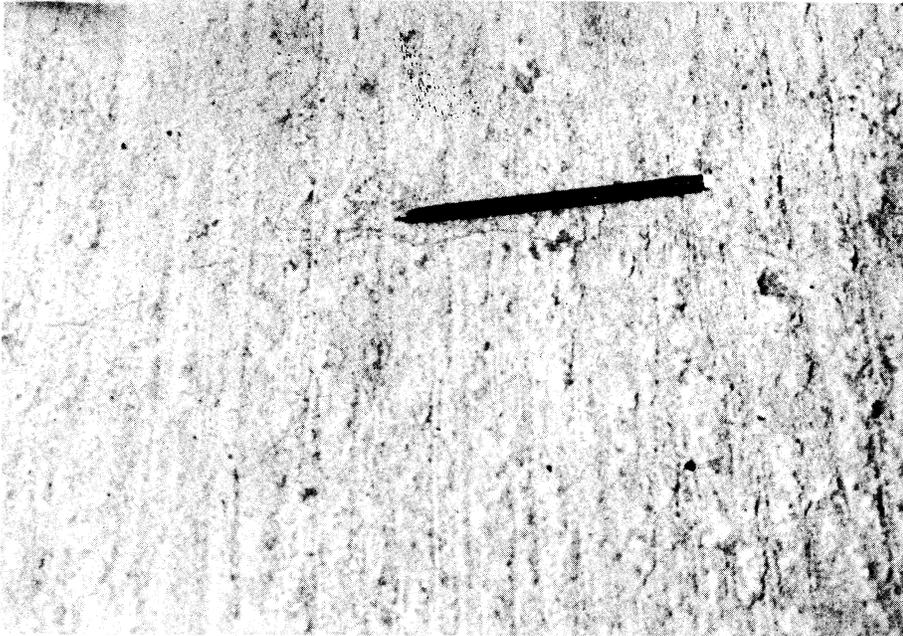


Figure 2. Typical hairline cracking observed at some locations on the surface of the bridge decks.

of the southbound lane bridge. This span, which was one of the four shorter spans on the bridge, had cracking above each of the three joints between the four panels spanning the distance between adjacent girders. This type of cracking has been observed in other studies,⁽³⁾ however, and was found to extend only to the depth of the top reinforcing steel in cores removed from the cast-in-place portion of the deck.

During construction of the bridges, a number of the panel subdecks were sandblasted to correct some slick spots on their surface. The locations of several of these panels were referenced and examined during the one-year inspection. Soundings taken with a hammer revealed nothing unusual; i.e., no delaminations between the subdecks and the cast-in-place portion of the deck were apparent.

No distress was observed either on the surface or on the underside of the bridge decks at the time of the inspection. Consequently, it appears at this time that the bridge decks will perform in a

satisfactory manner. Additional inspections should probably be made after the bridges have been under traffic for several years, however, to evaluate the bond between the subdeck panels and the upper cast-in-place concrete. Of particular concern would be the bond to the panels which were sandblasted to improve the unsatisfactory surface texture obtained during their fabrication.

CONCLUSIONS

The following conclusions are intended to supplement those of the earlier report,⁽²⁾ and are drawn from the field observations and construction cost data presented in this report.

1. Precast, prestressed subdeck panels can be installed in about one-third the time required to install permanent steel forms and there are fewer problems associated with the installation. Therefore, the precast subdeck panels can be used in the construction of conventional bridge decks with greater ease than can the permanent steel forms.
2. Bid cost data indicate that the precast subdeck panels can lead to savings in superstructure costs on the order of 3% to 4%, depending upon the size of the structure involved.
3. As expected, some hairline cracking on the surface of the decks was observed one year after the bridges had been completed. The cracking appeared to occur approximately above some of the joints between adjacent subdeck panels in some of the spans. In other spans very little cracking was noted, but this absence of cracking might have been due to the lack of traffic loading and to the fineness of the cracking rendering it difficult to observe. It should be noted that the bridges were designed with epoxy-coated steel in the upper portion of the deck to prevent corrosion problems that might be associated with the expected cracking.
4. Since only one lane of the southbound lane bridge was under traffic at the time of the one-year inspection, it is difficult to say whether the cracking will become more extensive under traffic loading over a period of time.
5. Because of the generally favorable results obtained on the study bridges, future use of the subdeck panel technique on other bridges should be considered as a viable alternative.

RECOMMENDATIONS

It is recommended that precast, prestressed concrete panel subdecks be considered as a viable alternative for use in the design and construction of bridge decks. The use of the technique would be particularly useful in situations where it is desirable to reduce construction time and to decrease traffic delays associated with the construction of certain bridges.

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