

INSTALLATION OF PRESTRESSED PANEL SUBDECKS

by

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Research Engineer

(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 report is concerned with the field installation of prestressed panel subdecks on the Rte 220 bridges over relocated 23rd St. in the city of Roanoke. These were the first bridges to be constructed in Virginia utilizing the precast subdeck panel construction technique. The field study was conducted as a follow-up to the original study which resulted in the recommendation to install the panels on a bridge on an experimental basis and record any problems occurring during the installation; and further to offer suggestions for the possible improvement of the technique. Details regarding the general features of the prestressed panels used on the Rte 220 bridges are given in the report. Based on observations made during the installation of the panels, certain recommendations are offered.

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INTRODUCTION

The use of prestressed panel subdecks for the construction of bridge decks was proposed to the Virginia Department of Highways and Transportation by the Research Council after a study conducted several years ago.⁽¹⁾ Fred Sutherland, bridge engineer for the Department, accepted the proposal and twin bridges carrying Rte 220 over relocated 23rd Street in the city of Roanoke were selected to be the first in Virginia to incorporate this innovation.

A working plan⁽²⁾ submitted to the FHWA on February 10, 1977, proposed that the construction of the two bridges be evaluated as an experimental features project. This plan was approved by the FHWA by letter from H. C. King dated April 19, 1977. This report on the project covers the installation of the prestressed panel subdecks. A performance report on the structure after one year, which was scheduled in the working plan,⁽¹⁾ will be prepared as a supplement to this report by August 1978.

The use of subdeck panels on bridge decks expedites construction by eliminating both the forming prior to concrete placement and the removal of the forms after the concrete has attained its required strength. In addition, less reinforcing steel and less concrete need to be placed in the upper portion of the deck, which tends to provide for additional savings of time and labor in the field.

Since the stripping of forms is a hazardous and time-consuming operation, the use of permanent forms has become an attractive alternative in the bridge construction industry as demonstrated by the growing popularity of permanent steel forms in recent years. As opposed to permanent steel forms, however, the precast panel subdecks serve as an integral part of the deck in a structural load carrying capacity. Furthermore, the potential for maintenance problems involving the possible corrosion of steel forms can be avoided when precast concrete subdecks are used.

Many of the advantages of using the subdecks during construction were observed during their installation on the Rte 220 bridges. This

report is concerned with the installation of the panels on these two bridges and is presented to supply information that could be of benefit on installations on other structures.

Past reports on the use of precast, prestressed panel subdecks in other areas of the country have indicated that deck cracking sometimes occurs directly above the joints between adjacent panel sections.⁽³⁾ Studies of this cracking have indicated that it terminates approximately half way through the cast-in-place portion of the deck, and no detrimental effects resulting from the cracking have been noted. The decks of the Rte 220 bridges will be inspected for cracking and other visible signs of distress, and the results will be reported in the supplemental report that will deal with their performance one year after construction has been completed.

GENERAL DESCRIPTION OF THE BRIDGES AND SUBDECK PANELS

The Rte 220 bridges over relocated 23rd Street in 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 bridge has a 18.3 m (60-ft.) roadway width and is 54.9 m (180 ft.) long. The bridges are built on a 10° skew. The spacing between the girders on the shorter spans is 2.84 m (9 ft.-4 in.) and 2.13 m (7 ft.) on the longer spans. The total minimum deck thickness (including the prestressed panels) is 216 mm (8-1/2 in.) on the shorter length spans and 204 mm (8 in.) on the longer. Plans for the bridges are available from the Bridge Division of the Virginia Department of Highways and Transportation and are designated under state project number 6220-128-105, B609 and federal project number FF-128-1(14).

The prestressed panel subdecks, which are shown later in several figures, were fabricated in two general sizes — one for the shorter length 9.45 m (31-ft.) spans having the wider spacing between girders and another for the 18 m (59-ft.) spans having a closer spacing between girders. For the former, the length of the subdeck panels was 2.6 m (8 ft.-6 in.) and for the latter they were 1.88 m (6 ft.-2 in.). The panels were cast in 2.44 m (8-ft.) sections for each size. The only exceptions to the panel sizes were at the ends of the bridge spans where shorter trapezoidal shaped panels were used to accommodate the 10° skew on the structure. Typical panel details and layout for the 18 m (59-ft.) spans are shown in Figures 1(a) and 1(b). The strand spacing, however, was changed slightly from that indicated to accommodate the fabricators' equipment. The number of strands and force applied was unchanged. The actual strand spacing modification is shown later in Figure 5. Except for dimensional differences, the details for the 9.45 m (31-ft.) spans were similar.

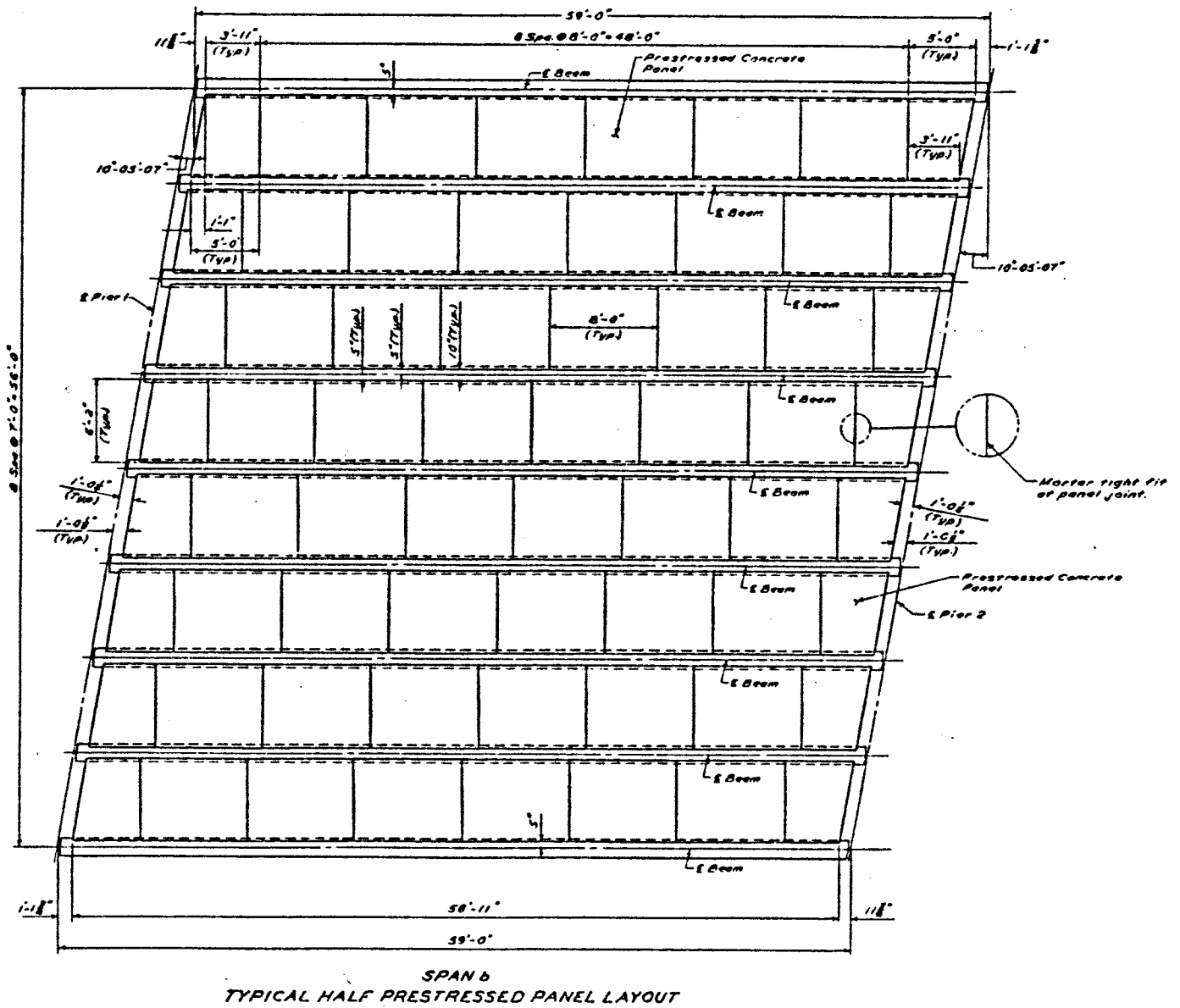
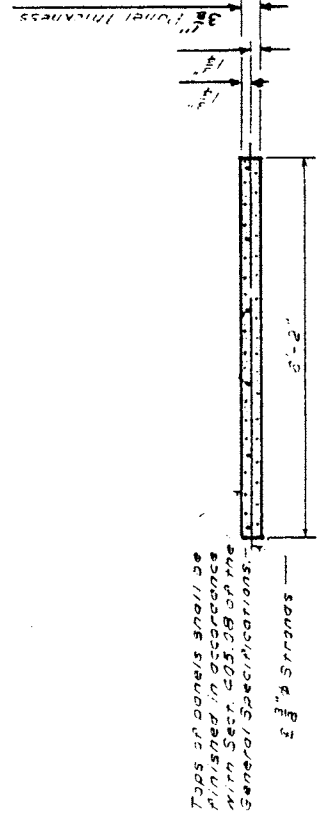
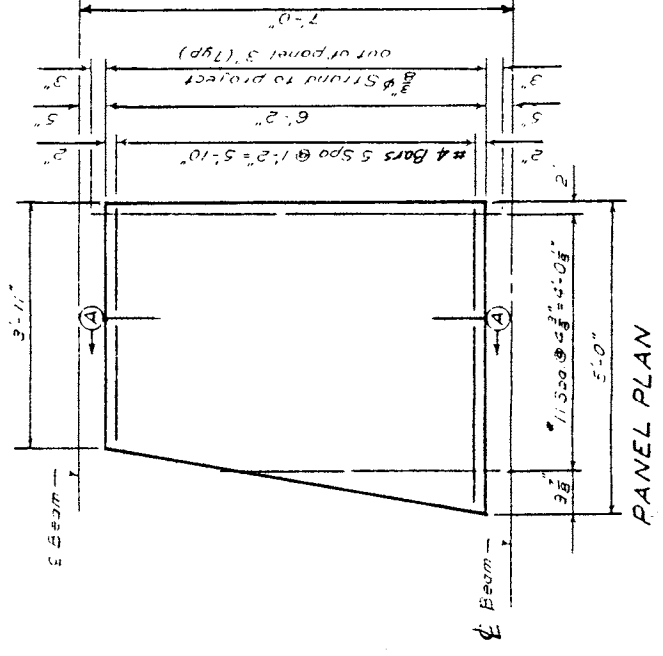
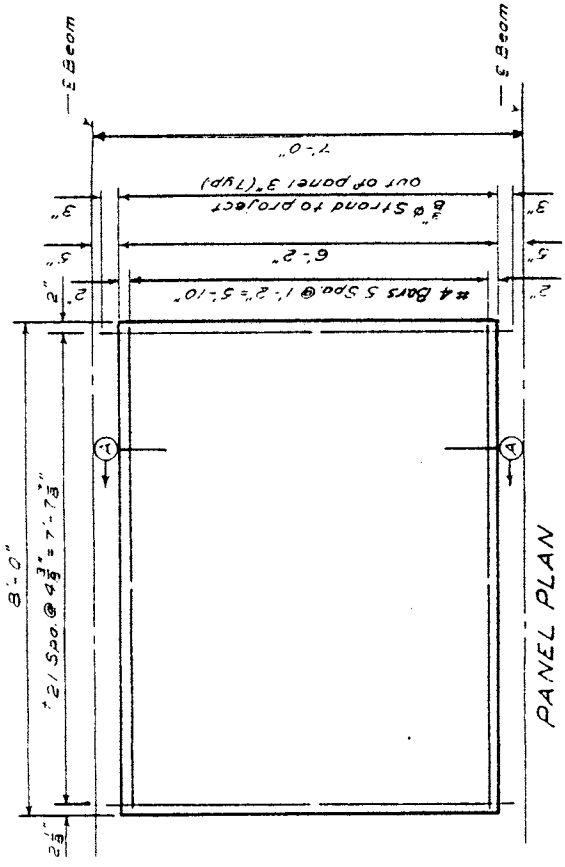


Figure 1(a). Typical panel layout on a 59-ft. span
(1 ft. = 0.3048 m).

* 22 - 3/8" Strands. Total
Pressing force = 354, 200 lbs.



Tops of panels shall be
finished in accordance
with Sect. 005.08 of the
General Specifications.

Figure 1(b). Typical subdeck panel details for a 59-ft. span
(1 ft. = 0.3048 m).

The longer length panels, which were used on the 9.45 m (31-ft.) spans, contained thirty-one 9.5 mm (3/8-in.) diameter, 270 grade strands prestressed to 111 MPa (16.1 kips) per strand. The shorter length panels contained twenty-two 9.5 mm (3/8-in.) diameter strands — each prestressed to the same force as for the former panels. In each case, the panel thickness was 89 mm (3-1/2 in.), with the prestressing strands being located at the center of the depth. A welded, deformed steel wire fabric conforming to ASTM A497 and having a minimum yield strength of 483 MPa (70,000 psi) was also used in the panels. The design compressive strength of the panel concrete was 34.5 MPa (5,000 psi).

The top surfaces of the prestressed panels were required to be finished with a roughened texture to obtain bond between the panels and the cast-in-place deck.

INSTALLATION OF THE SUBDECK PANELS

The prestressed subdeck panels were installed on the Rte 220 bridges beginning at 7:30 a.m. on Wednesday, April 13, 1977, and ending at 6:00 p.m. on Thursday, April 21, 1977. During this seven-day working period, the panels were not set continuously. On two of the days very little time was spent setting the panels, and quite often during the installation period the operation was halted temporarily to allow performance of other tasks such as placing concrete for diaphragms. The total time spent in actually placing the approximately 1,877 m² (20,200 ft.²) of panels was 38 hours and 20 minutes. At the beginning of the operation the panels were set by four men, a foreman, and a crane operator. One of the four men was used to hook up the panels to the lifting cables (Figure 2). Another mixed mortar to be used for seating the panels on the beams and otherwise generally assisted in placing the panels. Generally, two or three men could guide the panels into position for placement on the bridge beams. On occasion, one or two additional people were involved in the placement operation. On other occasions, fewer people than in the original crew were involved.

In general, the placement sequence involves simply hooking the crane cables up to the panel lifting hooks (Figure 2) while the fresh mortar bed is being applied to the bearing surface on the top edge of the girders (Figure 3), lifting the panels out to the bridge (Figure 4), and gently setting them in position on the girders (Figure 5).



Figure 2. Prestressed panel is hooked for lifting onto the bridge superstructure.

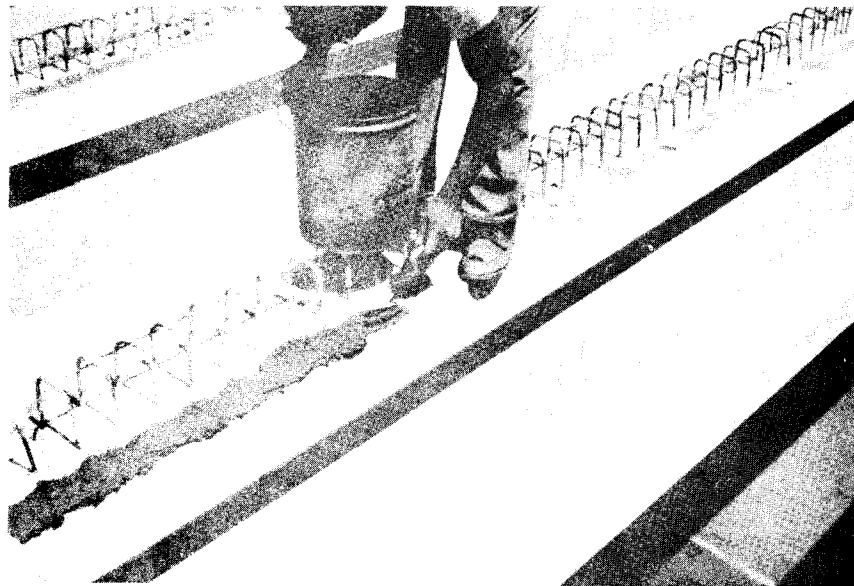


Figure 3. Fresh mortar being applied to the bearing area on the top flange of a girder.

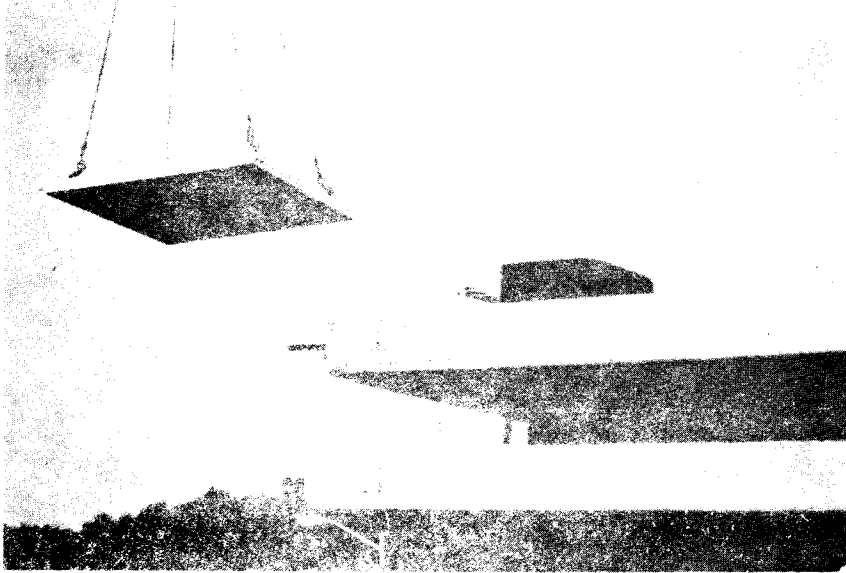


Figure 4. Panel being unloaded from the truck and swung out to the superstructure.

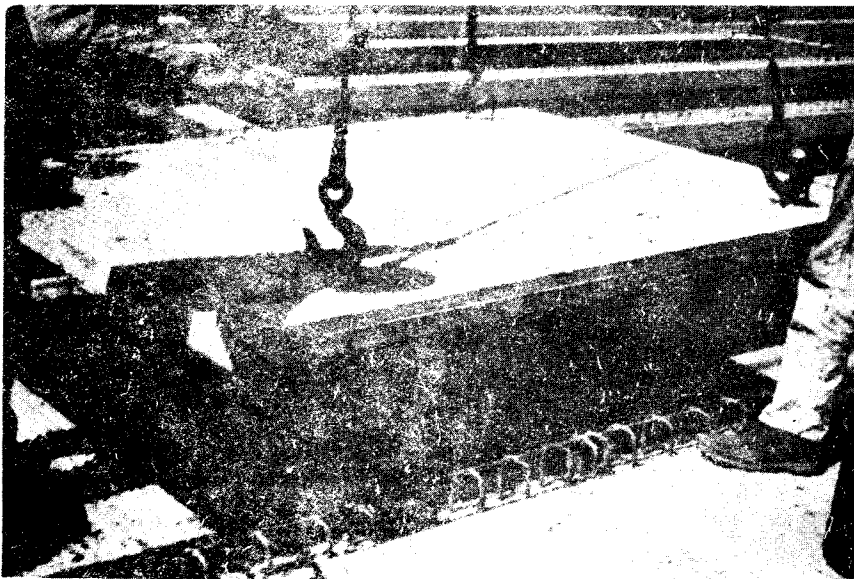


Figure 5. Panel being set in place on the bridge girders.

OBSERVATIONS

Mortar and Panel Placement

The first panels were set on the south end of span b of the NBL. The contractor apparently had been concerned about the edges of adjacent panels matching and had decided to use 38 mm x 25.4 mm x 13 mm (1-1/2 in. x 1 in. x 1/2 in.) thick steel shims under each corner of the panels. He also feared that without the shims the panels would be set too low, which would result in the need to place more concrete in the top course of the decks. It is possible, therefore, that many of the panels could have been supported by point loads at each corner, if the mortar bed was not high enough or if it shrank from contact with the underside of the panels. After the writer discovered that the contractor had started setting the panels on the small steel shims, their use was discontinued.

The cement mortar used for the panel bearing seats was composed of 1 part cement to 2-1/2 parts sand. It was usually of stiff consistency, but occasionally too much water was added and the material was made more difficult to use for this particular purpose. For the first few panels that were placed, the mortar was applied to the top of the girders in a rather haphazard manner as can be observed in Figure 3. Since it was difficult to gauge the thickness of the mortar bed when it was placed in this manner, the contractor was requested to cut a 76 mm (3 in.) wide by 2.44 m (8 ft.) long strip of 16 mm (5/8 in.) thick plywood for use as an edge guide to help obtain the proper width and thickness of the mortar bed. This technique proved to work reasonably well since the 16 mm (5/8 in.) thick layer of mortar would normally settle to approximately the 13 mm (1/2 in.) thick layer desired.

Subdeck Panel Joints

As might be expected, placement of the panels on a fresh mortar bed did result in a number of mismatched joint edges between adjacent panels. Figure 6 shows a joint between panel sections that illustrates one of the most extreme cases; the edges are mismatched by approximately 19 mm (3/4 in.). In addition to differences in mortar consistency, other factors that contribute to mismatched joint edges are slight differences in the elevations of the bearing surfaces on the girders, slight warpage in the prestressed panels, and the ease with which the panels are set on the mortar bed. The last mentioned factor probably plays the most important role, since it is often difficult to ease the panel into its proper resting position on the girders due to conflicts between the prestressing strands and the stirrups projecting out of the girders (Figure 7).

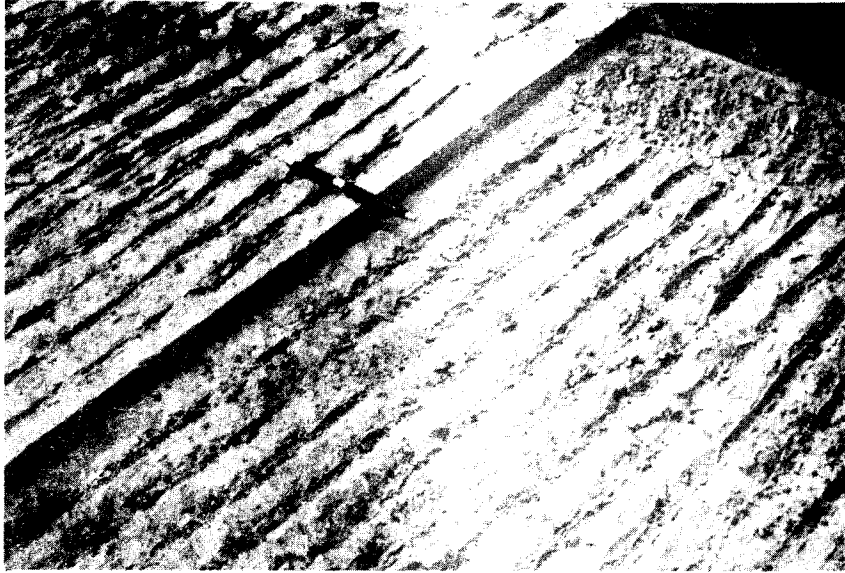


Figure 6. Example of a mismatched joint between adjacent panels.

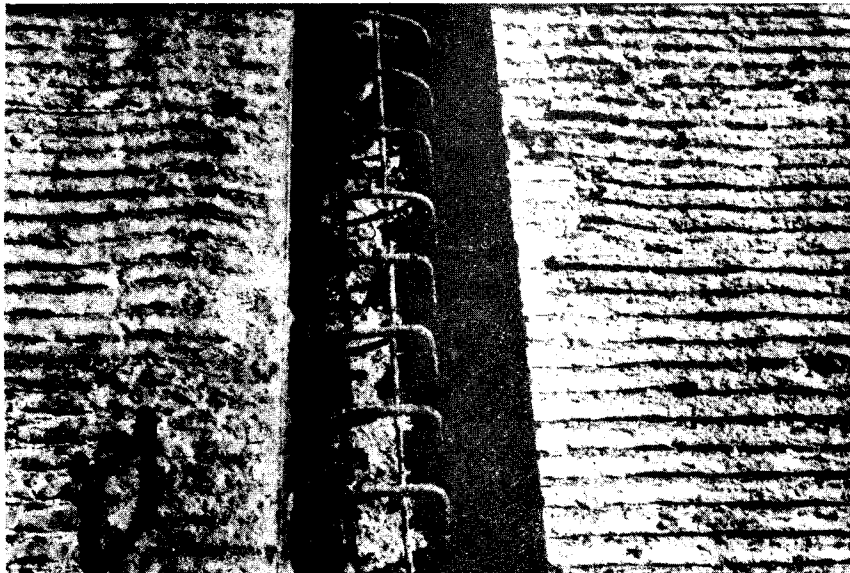


Figure 7. View of prestressing strands projecting into girder stirrups.

Several elements contributed to the problem. First, the prestressing strands projecting out of the panels were often longer than the 76 mm (3 in.) anticipated on the plans. Secondly, if the first panel that is set at the beginning end of a span is only slightly out of skew, the error will be magnified proportional to the length further down the span as the succeeding panels are set. Therefore, if an attempt is made to keep the panel edges in line, there will be a gradual shifting of the panels that will result in an increased bearing area on one girder and a decreased area on the other. Thirdly, slight variations in the linear alignment of the beams or the stirrups can contribute to the problem. When conflicts between the panel prestressing steel and the girder stirrups arose during the panel placement, the stirrups were bent to the side as shown in Figure 8. The consequent jostling and maneuvering of the panels would often result in the panels being set down a little harder than desirable, or the shoving motions involved would disrupt the mortar bed — all of which are related to the mismatched joints shown earlier in Figure 6.

The previously described problems are of a very practical nature, and though occasional bending of the girder stirrups is not a desirable procedure no serious consequences of the operation were apparent. The best way to avoid the mismatched joints would probably be to use a preformed material on all or a portion of the bearing area, cut the prestressed strand projections to the plan length, and exercise considerable care in setting the first panels at the end of a span. While setting the first panel accurately is desirable, this too is not a crucial problem provided, of course, the error is not great. Small errors can be compensated for by setting succeeding panels to obtain the required bearing width on the beams and by not attempting to keep the bearing edges of adjacent panels in line. An example of this off-setting technique can be seen in the center portion of Figure 9.

One would expect that the mismatched joints between panels would contribute to cracking in the surface of the completed deck. Therefore, several of these locations were referenced and will be inspected for cracking after the bridge is approximately one year of age.

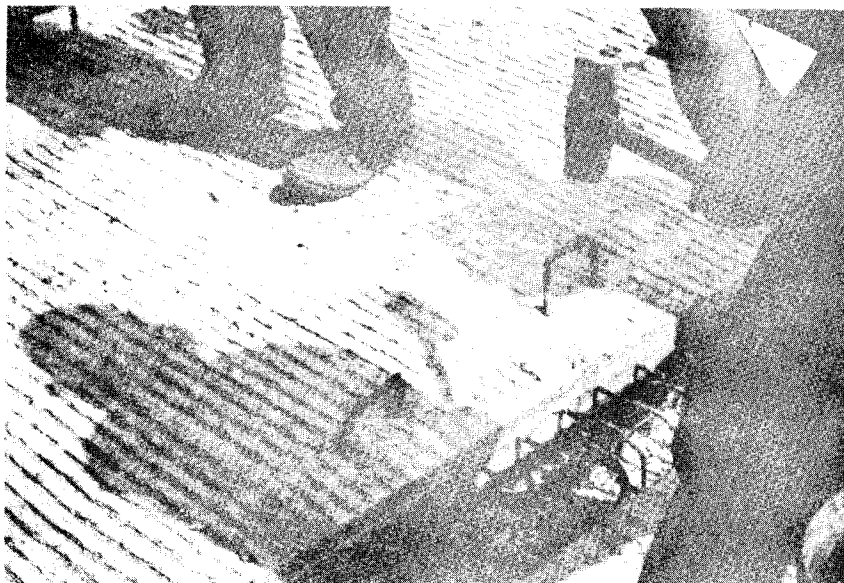


Figure 8. Sledge hammer being used to bend the girder stirrups so prestressed panel can be placed in proper position.

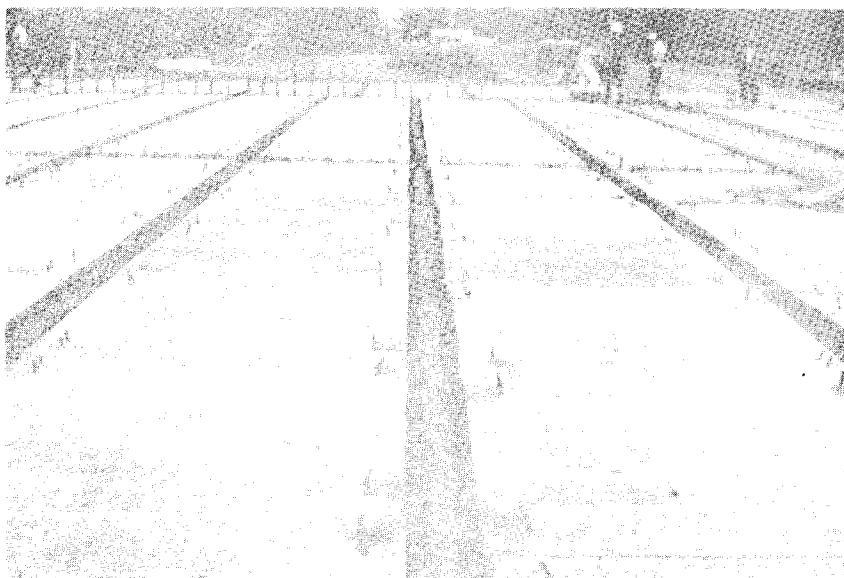


Figure 9. Partial view of superstructure showing subdeck panels in place (the lifting hooks have been cut off).

Lifting Hooks

Ideally, the lifting hooks could simply be left in the panels after they have been placed. On the Rte 220 bridges, however, the hooks had to be cut off since they would conflict with the placement of the reinforcing steel for the cast-in-place deck. Attempts were made to bend the hooks over, but since high strength prestressing tendons had been used for the hooks, bending did not prove to be feasible. If possible, the lifting hooks should be of a more ductile steel that could be left in place. Figure 9 shows a view of the subdeck after the hooks were cut off. In most cases, approximately 51 mm (2 in.) of the vertical portion of the hooks were left projecting from the panels.

Prestressing Strands

In addition to some of the prestressing tendon projections being greater than 76 mm (3 in.), as discussed earlier, the trapezoidal shaped panels had very short lengths of prestressing strands near the acute corner of each panel. In some isolated cases, minor cracking was noted in the acute corner area and was probably related to the short lengths of strands. Part of the problem may have been due to the change in tendon spacing. While the original details (Figure 1) called for a minimum of 253 mm (9-7/8 in.) from the corner to the first strand on the short span panels and 204 mm (8 in.) on the longer spans, the actual distance was on the order of 127 mm (5 in.) on the longer span panels. The strands located near the acute corner of skewed end panels should be omitted or wrapped or coated to prevent bonding. If during fabrication the entire bed is used for skewed end panels, the strand near the acute corners could be omitted. The minimum distance from the corner to the first strand would, of course, be dependent upon the degree of skew involved.

Although the prestressing strands were very nearly uniformly spaced, it has been found by others that cracking in the panels is related to nonuniform spacing of the strands.⁽⁴⁾ Ideally, uniform spacing should be used whenever possible. No problems, however, were noted except for the revised spacing contributing to the short strands and probably to the cracking noted at some of the acute corners of a few skewed end panels.

Panel Surface Texture

The surface texture (see Figures 6 and 7) produced by the disc rake appeared to be adequate, although it varied between panels. One group of panels were very slick on some areas of the surface. This was apparently due to a combination of rain and the protective covering making contact with the surface of the concrete during fabrication. The panels involved were sandblasted in-place on the bridge superstructure. A view of a slick surface area after it had been sandblasted is shown in Figure 10.

The disc raked surface texture was not used on the panels installed on the short spans on the north end of the structure; these had a broomed surface. While it is not expected that a difference will be noted after one year between the performance of the spans having different textures on the subdeck panels, it may be of interest to closely examine the different decks after a number of years of service.



Figure 10. Surface texture of panel after sandblasting of slick area.

As can be noted in the earlier figures showing the disc raked surface texture, the grooves run perpendicular to the bridge girders. If this type texture is used on future applications, some further consideration could be given to whether the grooves should run parallel or perpendicular to the bridge girders. From the results of recent work conducted in Pennsylvania, the researchers recommended that the scoring on the top surface of subdeck panels be made parallel to the bridge girders.⁽⁴⁾

Mortar Leakage Through Panel Joints

The joints between panels were of the simple butt type. No sealing or caulking compound was used on the joints prior to the placement of the cast-in-place portion of the deck. Since the subdeck panels were wet down prior to and during the deck placement operation, some water leaked through the joints. From observations of the underside of one of the spans during deck placement, however, there appeared to be only a minor amount of mortar seeping through. As might be expected, the joint leakage was random — some joints had no noticeable leakage whereas others obviously allowed the mortar to pass through as shown in Figure 11. In general, however, leakage through the panel joints appeared to be less than that which normally occurs when wood or permanent steel forms are used.

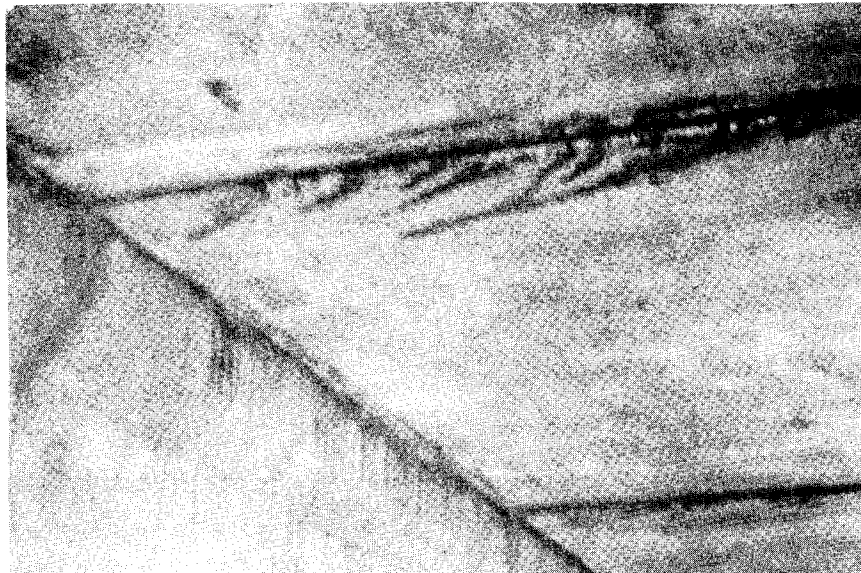


Figure 11. Leakage through joint between subdeck panels.

General Observations

The subdeck panels used on the Rte 220 bridges did not include a design that could be used to cantilever over the exterior girders to assist in the construction of this area of the deck. Since the deck overhangs at the edges of the roadway had to be formed in a conventional manner, complete advantage of the subdeck panel approach was not obtained.

The construction superintendent estimated that it would have taken eight men approximately one week to form each of the eight spans on the structure, including the overhang areas. An additional two days would be required to remove the forms from the underside of the decks. Quite obviously, a considerable amount of field time and labor were saved by using the subdeck panels since all were placed in 38 hours and 20 minutes. Even more time could have been saved had cantilevered panels been used at the exterior girders. While purposely omitted on the Rte 220 bridges, the first structures to utilize the subdeck panels in Virginia, use of the cantilevered panels at the exterior girders would be a logical step in any future use of this technique.

Once the overhang areas at the exterior girders were formed, the placement of the cast-in-place portion of the deck appeared to move rapidly. Placement of the overhang forming, the epoxy coated steel, and concrete for the entire deck area of the twin bridges were accomplished in 26 working days. Attempts were made to record the time required to place the reinforcing steel (Figure 12) in two of the spans, but the work was not conducted in an orderly and efficient manner due to inexperienced labor and varied use of the workmen for other chores. Therefore, the data recorded would be of little value if used to compare with the man-hours normally required to place steel in a conventional deck. Extensive time-motion studies that would have required considerable time on this project plus another constructed in a conventional manner were beyond the limited scope of the effort originally proposed.⁽²⁾ From a number of years of experience with bridge deck construction, however, the writer is of the opinion that the steel placement would normally take approximately 75% to 85% of the time required for a similar sized span having a conventional deck.

The time required for placement and screeding of the cast-in-place portion of the deck did not appear to be substantially reduced, since the screeding and finishing operation is the same as that used on conventional decks. Some time is saved due to the lower volume of material being placed, but it is probably of little consequence.

Further observations of the decks will be made at a later date and reported upon as a supplement to this report.

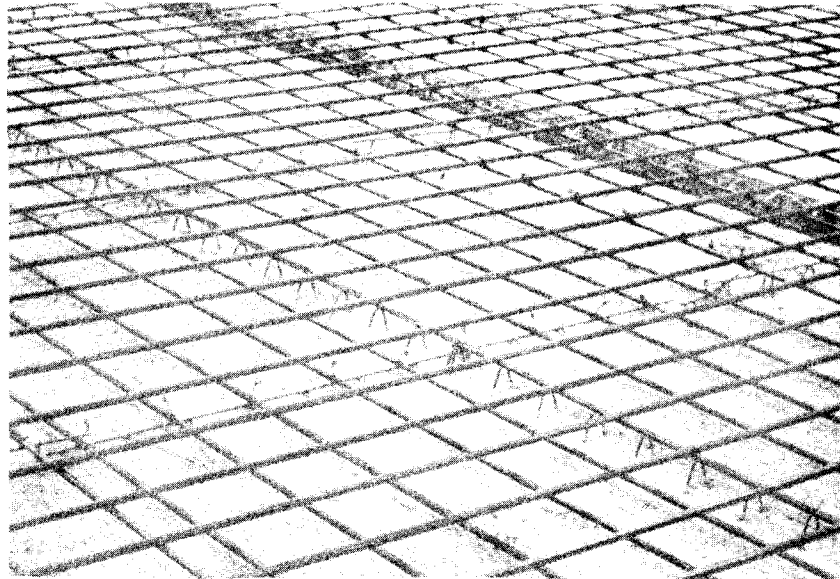


Figure 12. Epoxy coated reinforcing steel in place above subdeck panels.

FINDINGS AND RECOMMENDATIONS

The foregoing observations were presented at this time to provide information that may be of value on installations of pre-cast, prestressed subdeck panels on other bridge decks. From these observations, the following recommendations are offered for consideration.

1. Consideration should be given to placing a note on future plans for prestressed panels that will discourage the use of small shims under the corners of the panels, a practice used to obtain the exact clearance in the bearing area between the bridge girder and panel.
2. The prestressed panel fabricators should be advised to make a more diligent effort to cut the stressing tendons to the projection lengths specified on the plans, and to keep the stirrups in the prestressed girders as linearly even as possible to avoid unnecessary conflicts with the prestressed tendons during placement of the panels.

3. The mortar bed used for setting the subdeck panels on the bearing area provides an adequate, even bearing surface, but it is difficult to maintain the desired thickness of the bed and to prevent mismatched edges at the joints between panels. Contractors should be encouraged to improvise a template to obtain an accurate width and thickness of the mortar. The template should be designed to prevent mortar from dropping off the edge of the girder onto the lower flange.
4. Contractors and inspection personnel should be advised of the importance of having a rough surface texture on the subdeck panels so that any having an unsatisfactory surface will be identified and corrected prior to placing the upper portion of the deck.
5. The material used for the lifting hooks in the subdeck panels should preferably be ductile so that the hooks can be bent if necessary and left in place.
6. Prestressing strands that are located near the acute corners of skewed panels should be omitted or debonded during fabrication. The distance from the corner to the first prestressing strand will depend upon the degree of skew involved, but tendon lengths (within the concrete panel) less than 914 mm (3 ft.) probably should be avoided if possible. Some skewed end panels were observed with bonded tendon lengths of less than 305 mm (1 ft.) near the acute corners of the panels.
7. Uniformly placed stressing tendons should be used whenever possible. It should be noted, however, that the several breaks in the uniformity of the tendon spacing used on the Rte 220 panels did not appear to cause a cracking problem, except at the acute corners of the skewed end panels.
8. If the grooved or scored surface texturing is to be used on subdeck panels, consideration should be given to whether the grooving would be more effective running parallel to the bridge girders rather than perpendicular.
9. If adjacent panels are abutted as closely as possible, the joints do not appear to present a severe leakage problem. If esthetics of the underside of the bridge deck are considered to be important, caulking of the joints should be specified on the plans.

10. The speed and relative ease with which the subdeck panels were placed on the Rte 220 bridges suggest that for future structures, the exterior bay panels should be designed to cantilever out over the exterior girders to minimize the forming work required for the overhung areas.

ACKNOWLEDGEMENTS

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