EXPERIMENTAL CONCRETE AND BITUMINOUS SHOULDER
CONSTRUCTION REPORT
(Experimental Work Plan No. 4)

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

EXPERIMENTAL CONCRETE AND BITUMINOUS SHOULDER CONSTRUCTION REPORT
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Introduction

This report covers construction of experimental shoulders on Interstate 69 in Michigan to compare certain design improvements using both concrete and bituminous materials. The work is being done by the Michigan Department of State Highways as a "Category 2" experiment, in cooperation with the Federal Highway Administration.

Many paved shoulders develop longitudinal cracks near the pavement edge, probably due to frost action and traffic. Research Laboratory studies have indicated that the cracking may occur either during the first winter, due to moisture present in the base at the time of construction, or may occur later, probably due to water penetration at the shoulder-pavement joint. Although these cracks may be present for many years before repair is necessary, repairs may be required at an earlier date due to progressive raveling of the outside edge of the shoulder when lateral constraint of the base course no longer is present.

There are several possible remedies for the problems that exist, and the main question to be answered is how much additional initial expenditure is required and justified to reduce subsequent shoulder maintenance to a reasonable minimum.

The purpose of this study is to evaluate the cost and performance of experimental concrete and bituminous shoulders in comparison with the standard shoulder for Michigan Interstate freeway construction.

Scope

An experimental unreinforced portland cement concrete shoulder design, two experimental bituminous shoulder designs, and the Michigan standard shoulder for Interstate construction were installed in a test area on a rural freeway. Three test sections approximately 1/2-mile long of each type were constructed. Only the outside shoulders were included in the experiment.

General Information

The site of the experimental installation is on I 69 in southern Eaton County, between Charlotte and Olivet. Design details are shown in Figures 1 and 2, and the random arrangement of the various test sections is shown in Figure 3. Main line pavement and the concrete shoulder sections were placed during September and October of 1971. These shoulders were the first of their type to be placed in Michigan. Concrete for the job was

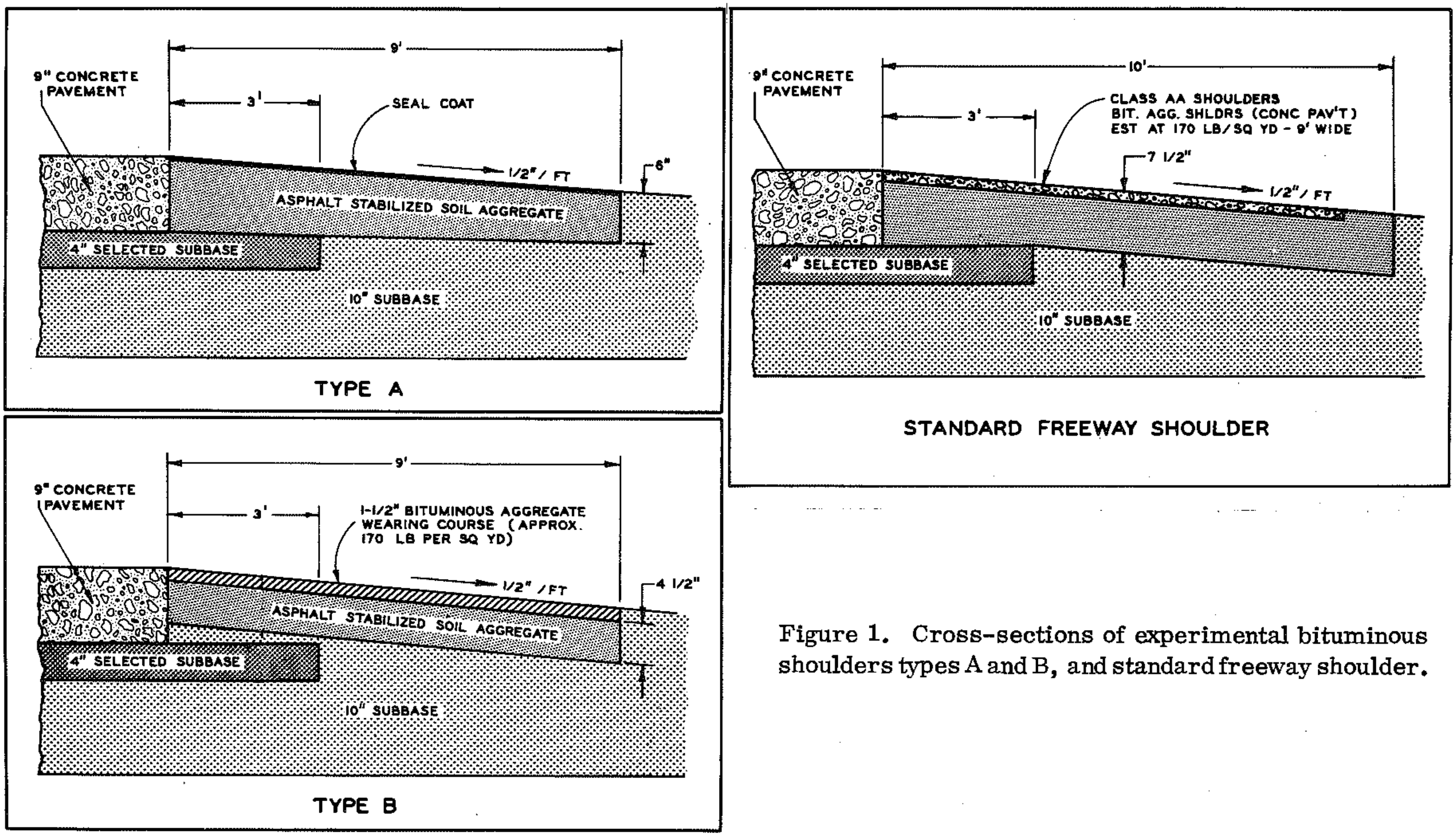


Figure 1. Cross-sections of experimental bituminous shoulders types A and B, and standard freeway shoulder.

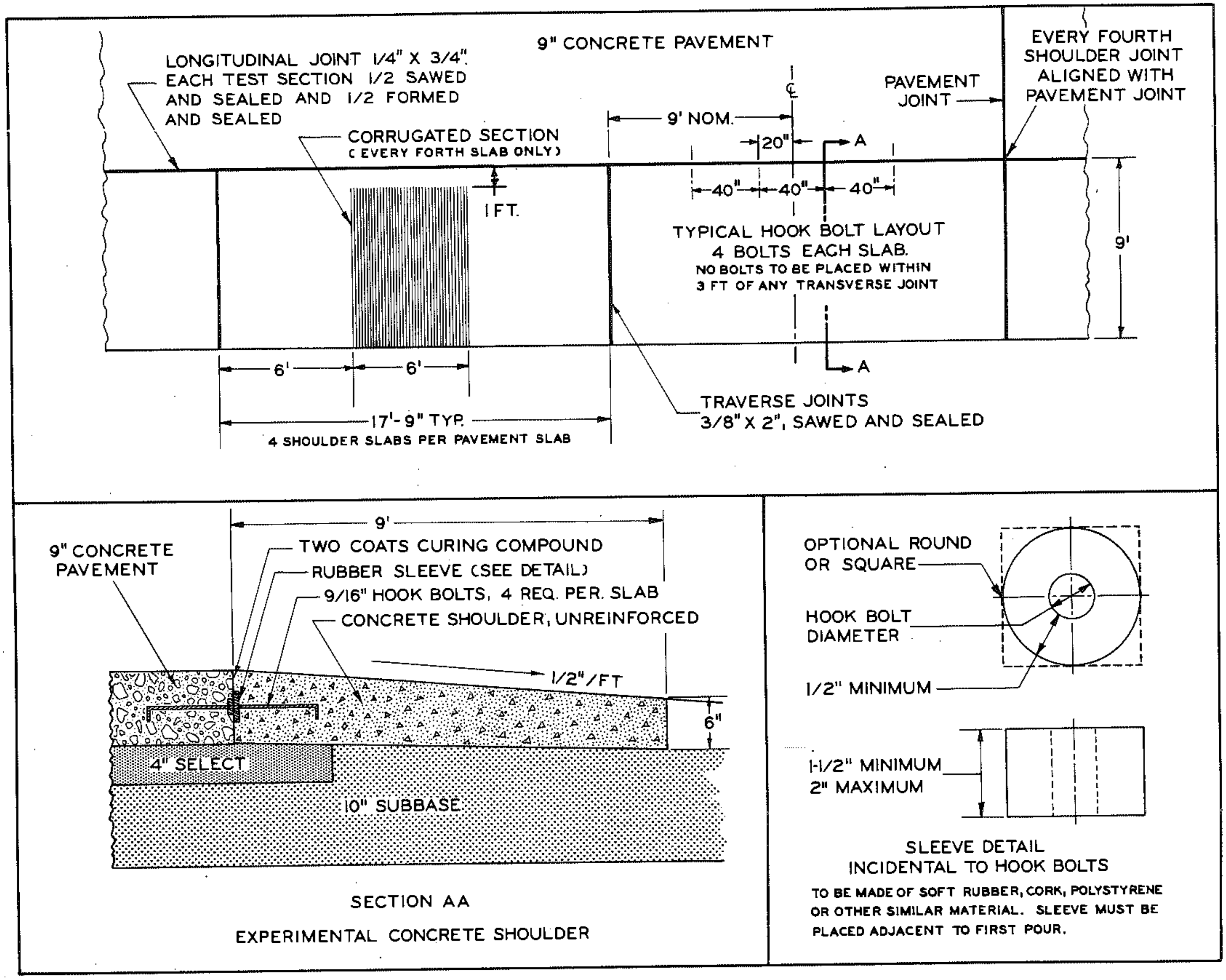


Figure 2. Construction details of experimental portland cement concrete shoulder.

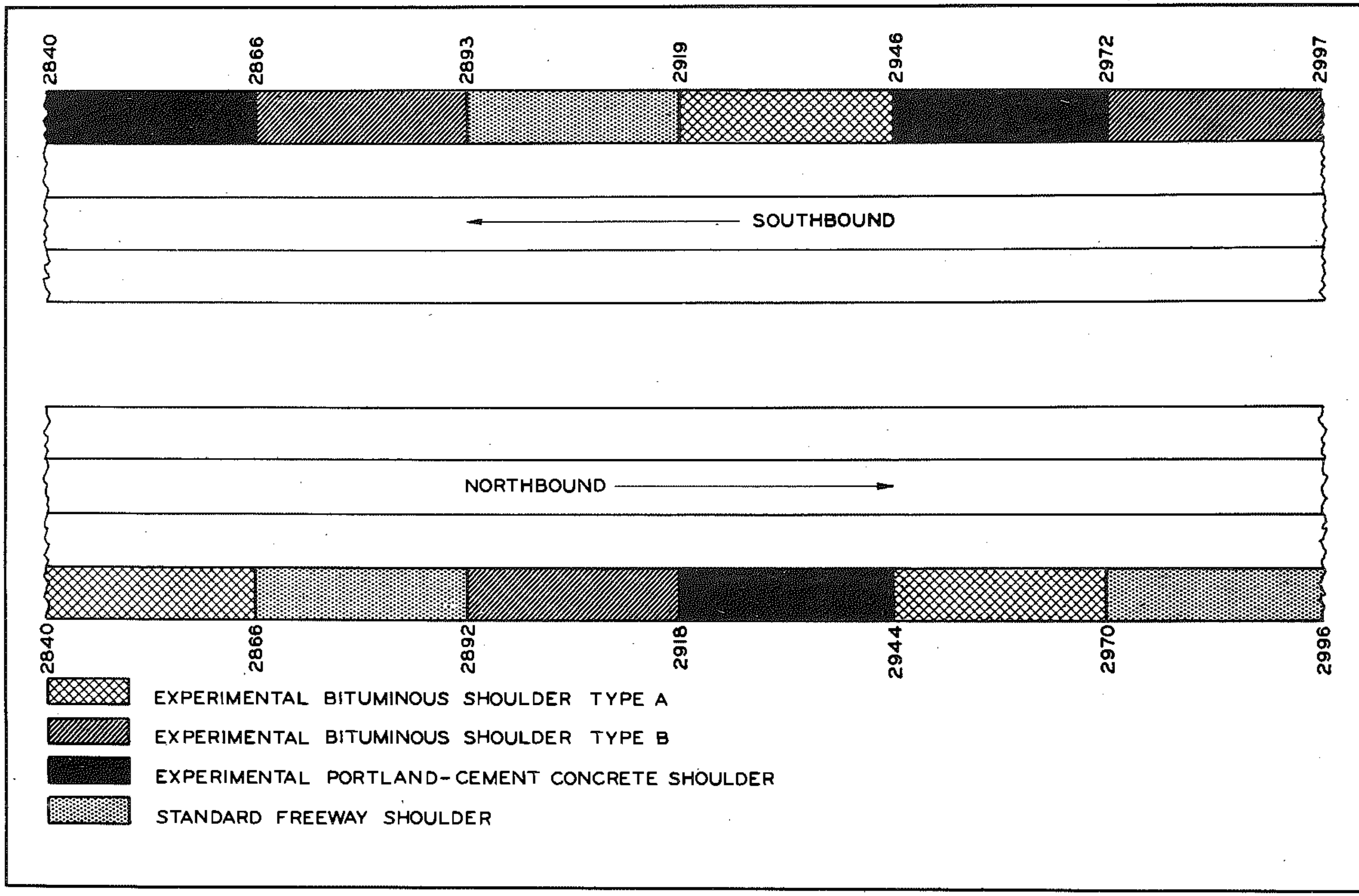


Figure 3. Test section locations for experimental shoulders I 69 Stine Rd to Five Point Hwy.

central mix. General specifications for the concrete shoulders were as per Standard Specifications for concrete pavements, except that surface tolerance was increased from 1/8-in. in ten feet to 1/4-in. The section of I 69 containing the experimental shoulders was opened to traffic during November of 1972.

Construction

Davco Inc., concrete paving contractor for the project, elected to use a 12-ft CMI slip-form paver to place the shoulders. Since the paver was equipped for 9-in. pavement thickness, and the outside edge of the shoulder was to be only 6-in. thick, the base was trimmed in an unusual fashion to allow retention of the full depth side form. A CMI Autograder was used to trim the subbase and the concrete was placed directly from trucks running on the slab (Fig. 4). The paver was run as shown in Figure 5, to place and consolidate the 9-ft wide shoulder. This operation is not easily accomplished, since steering control is not as positive as it should be. Moreover, coarse aggregate from the mix tends to collect between the oscillating screeds and the existing slab, raising the effective height of the screeds. The job was successfully completed by using additional workmen before and behind the paver to check constantly on the operation, remove excess mix from the vicinity of the edge of slab, and promptly correct any malfunction of the steering mechanism. Special shoulder paving gear was not developed for this project because of the relatively small quantities involved. If future projects, with large quantities of concrete shoulders, are planned, they probably would be done with special equipment, or further adaptation of the slip-form paver, to accomplish the task more easily.

The surface of the shoulders was hand floated, textured with a burlap drag and cured with white membrane applied by spraying. Rumble strips were formed in the surface by a corrugated metal float, as shown in Figure 6. A board held against the outside edge of the shoulder reduced edge slump during formation of the corrugations.

Mainline pavement on this project contained expansion joints at every fifth slab as required by specification for paving in the late fall. Therefore, matching expansion joints were required in the concrete shoulder. Premolded expansion fillers without any load transfer devices were placed on the subbase, secured by stakes, and cast into the concrete to form the necessary expansion space in the shoulders.

Transverse joints in the shoulder were sawed and sealed at the locations shown in Figure 2. The longitudinal joints between shoulders and mainline slabs, were constructed by two different methods; approximately

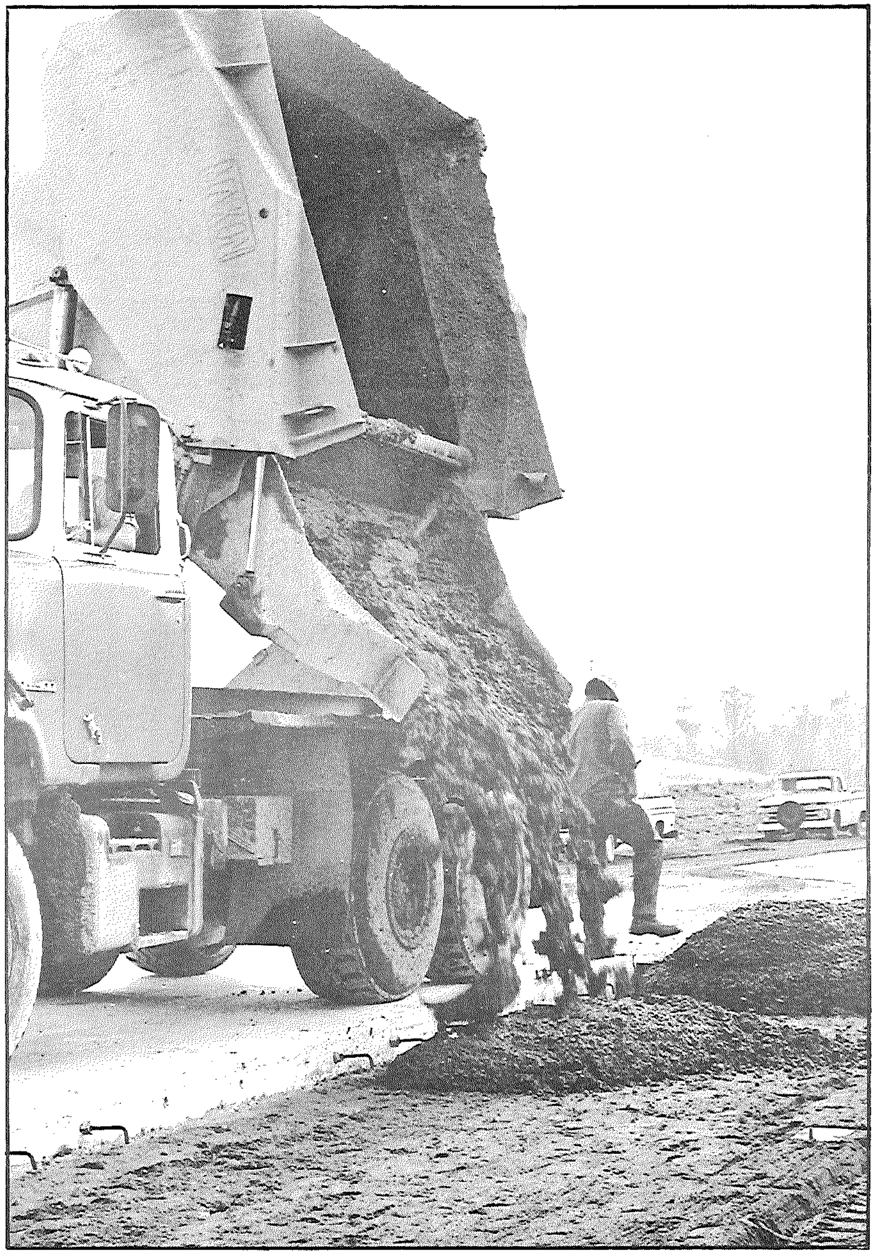
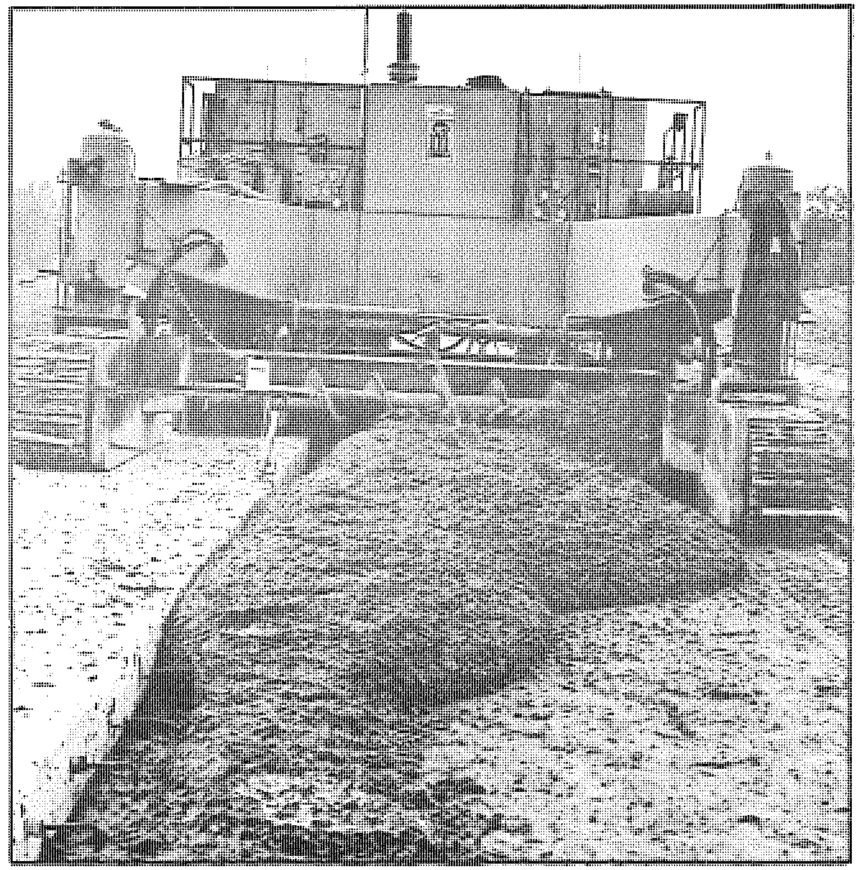


Figure 4. Concrete placed on subbase ahead of paver. Note shape of subbase trim in foreground that allowed use of full 9-in. slip-form on the outside of the paver to place slab that varied from 9-in. at pavement edge to 6-in. near track line. Also note hookbolts in slab edge.

Figure 5. Twelve-ft CMI slip-form paver used to place 9-ft concrete shoulder on I 69 near Charlotte, Michigan.



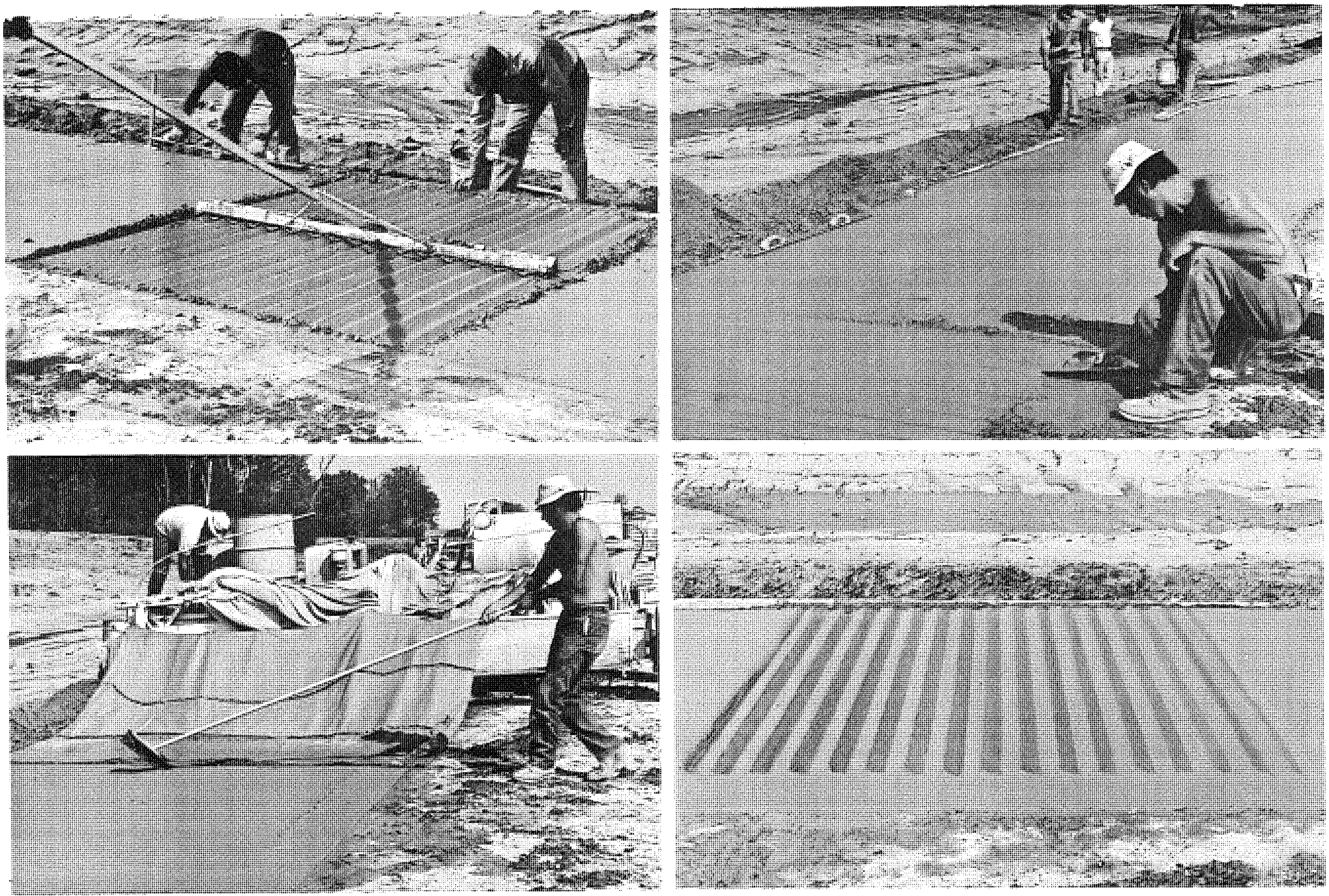


Figure 6. Series of operations used in forming rumble strips. Initial removal of some concrete from the area prevents corrugations from protruding upward where they would be struck by scraper blades.

one half of the longitudinal joint in each test section was formed with styrofoam, and the remainder was sawed. All of the shoulder joints, both longitudinal and transverse, were filled with hot-poured rubber sealant, Interim Fed. Spec. SS-S-001401. Future evaluations will compare the formed and sawed joints for relative performance.

Bituminous shoulders were placed during October of 1972. Experimental Type A and B sections were placed in two courses by using a spreader for the first course and a paver for the top course. The early onset of bad weather prevented the placement of the seal coat on Type A, and those sections will lie through the winter with the asphalt stabilized soil aggregate exposed. Application of the seal coat will be done in the spring of 1973.

Instrumentation and Observations

Forty-eight concrete shoulder slabs (16 in each 1/2-mile test section) were instrumented with stainless steel rivets as shown in Figure 7. Fifteen additional shoulder slabs in each test section were randomly selected and instrumented with only two rivets at mid-length, across the longitudinal joint.

Measurements for joint opening and faulting are made across the joints both longitudinally and transversely. Joint opening measurements are made with a vernier caliper, and fault measurements with the special fixture (Fig. 8). The two foreward legs of the instrument are set in the rivets, and the rear leg is used to level the device. A reading then is taken from the scale attached to the right side of the instrument. Changes in reading from one time to another indicate a shift in the relative vertical positions of the slabs.

All instrumentation was installed in the concrete shoulders in the fall of 1971, and two sets of readings have been made. Only very minor changes were recorded, except that expansion joints have closed considerably. This is due to the fact that the paving was done very late in the fall when temperatures were quite low. Heating of the slab caused the expansion joints to close when warmer weather occurred the following year. Future readings on the concrete sections will be made in the spring and fall of each year.

Performance of the bituminous sections will be checked by condition surveys, noting the amount of cracking and other observable deterioration. The initial condition survey has been made, and subsequent surveys will coincide with the joint readings noted above. These surveys also will be made in the concrete areas to record any cracking, spalling, or other defects that develop.

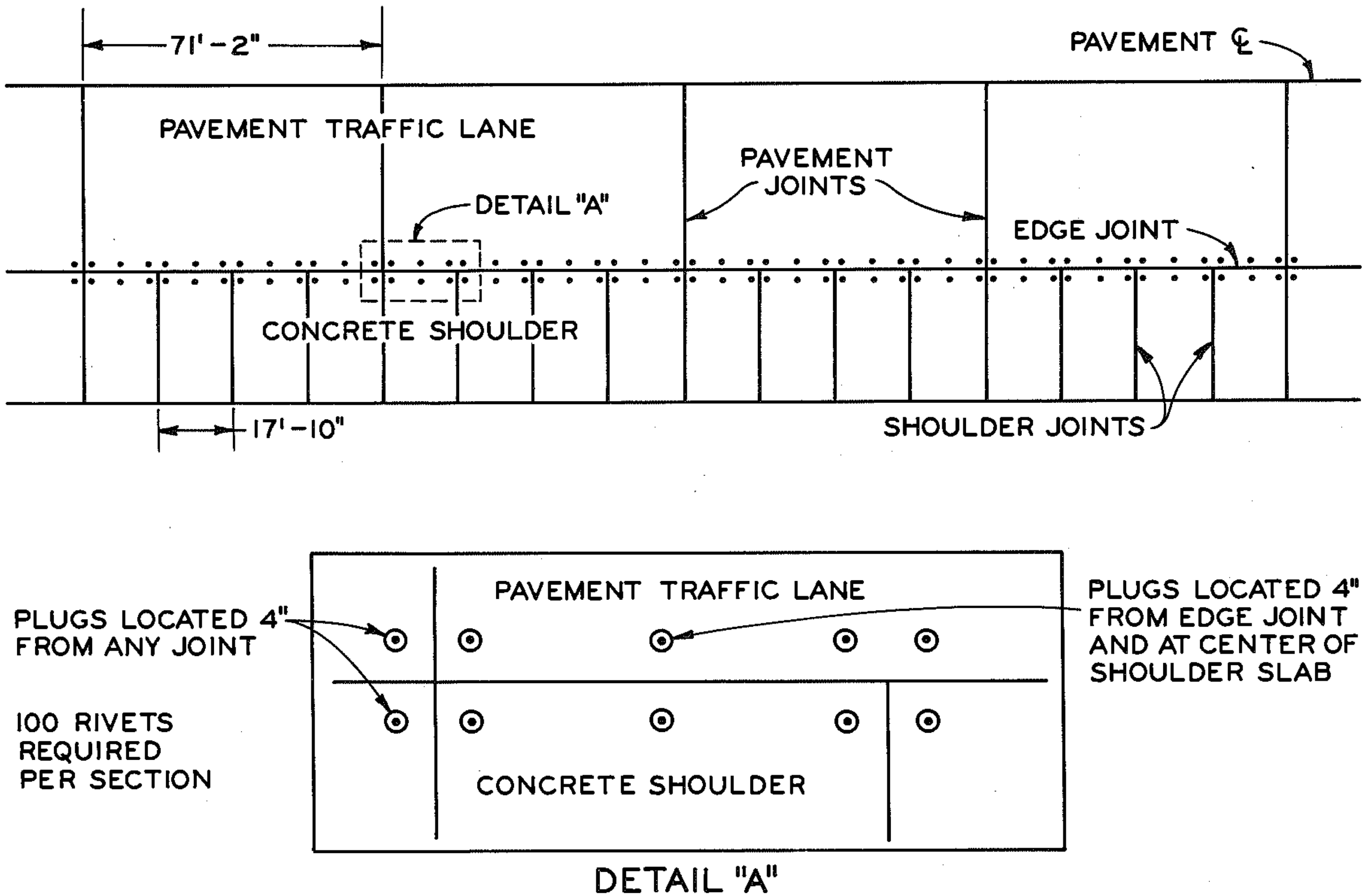


Figure 7. Rivet locations for instrumented sections of concrete shoulder project. One section of 16 shoulder slabs was instrumented as shown in each of 3 half mile test sections. One contains an expansion joint at center of instrumented section, and the other two have an expansion joint at one end.

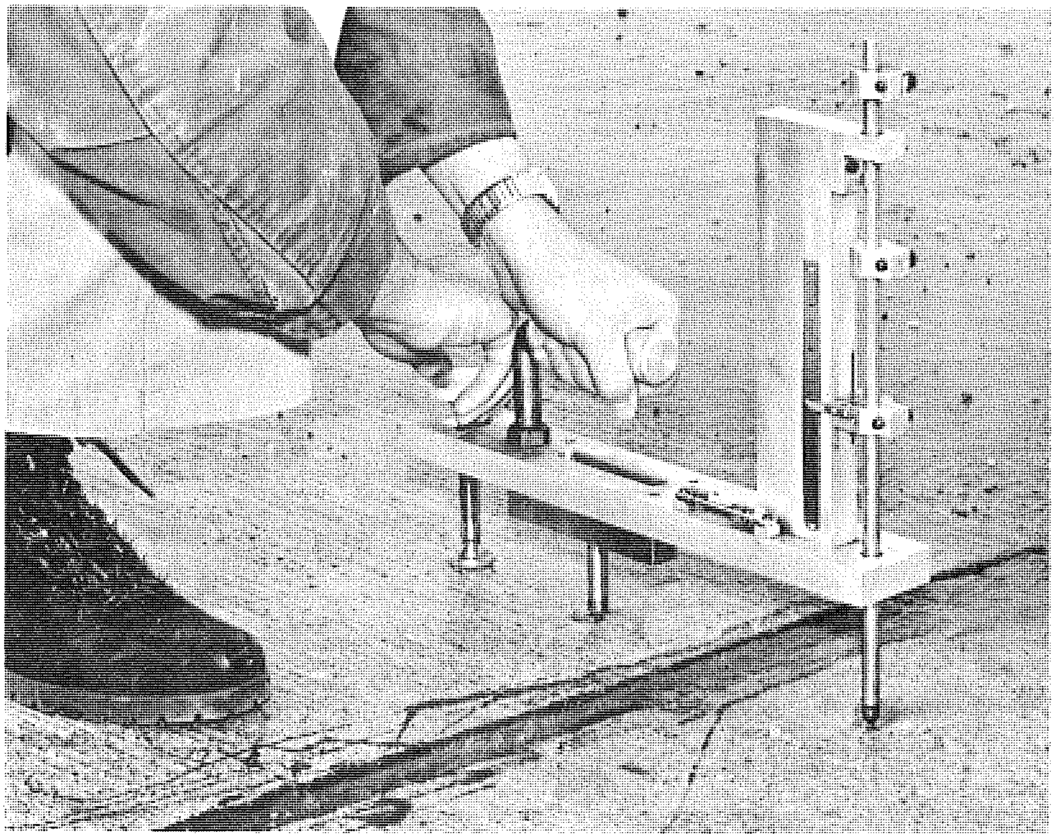


Figure 8. Special fixture for measuring faulting of joints.

Costs

Unit costs for this project, like any other, are affected greatly by quantities involved. The surface course for the Type B experimental bituminous shoulder was used in large quantities on the remainder of the project, thereby reducing the relative cost for that item. Conversely, the seal coat surface on the Type A shoulder was not used anywhere else on the job, making quantities low and price relatively high. Therefore, the following costs are presented more for information than as representative values.

Concrete shoulders cost $6.00 per sq yd including hook bolts and the longitudinal joint. The transverse joints for the concrete shoulders inadvertently were not included as a bid item and presently are in dispute by the contractor and the Department. However, similar joints in unreinforced ramp slabs on an adjacent project, were bid at $1.00 per ft by the same contractor. This would add about $.50 per sq yd to the cost of the concrete shoulders, making the total amount $6.50 per sq yd.

Bid prices for bituminous shoulders are listed by the ton, so the necessary conversions were made to give a sq yd cost for comparison.

Bituminous shoulder Type A cost approximately $4.40 per sq yd, while Type B was about $3.50 per sq yd.

Quantities for each of the above three shoulder types were less than 8,000 sq yds.

The standard freeway shoulder was bid at approximately $1.70 in large quantity.

Remarks

The rumble strips on the concrete shoulder were terminated about a foot from the longitudinal joint to eliminate jointing and sealing in the corrugated area. Construction workers were able to form the rumble strips without unusual difficulty. These strips cause a loud sound when driven upon and should be a valuable safety device for warning drowsy drivers that they have wandered onto the shoulder. No adverse effects on vehicle control were noted by staff members who drove over the completed sections.

Hook bolts were used to tie the rigid shoulders to the pavement, because previous experience has shown that rigid slabs tend to separate in time if not secured, due to thermal expansion and contraction and expansion of freezing water in the joint.

The pavement edge was coated with two layers of curing compound prior to casting the shoulders in order to prevent strong bond between the longer and shorter slabs possibly inducing cracks in the pavement slabs adjacent to joints in the shoulder. This type of cracking had been noted in continuously reinforced pavements with concrete shoulders in a neighboring state. Such cracking has not yet developed on the I 69 project, but it is one of the related performance factors that will be observed in the future to see if the preventive measures used were sufficient, or whether stress concentration due to the shoulder joints still may initiate such cracking in the pavement. Prevention of bond between the shoulder and pavement also should allow some relative longitudinal movement as the shorter slabs tend to expand and contract independently with cycles of temperature and moisture.

Hookbolts were specified to be more than 3 ft from transverse joints, and compressible washers were placed around the bolts in order to allow relative motion between the slabs without initiating corner breaks in the unreinforced slabs. Recent inspections of the installation revealed no visible cracking in the concrete shoulders.

Eight cores were taken from the concrete shoulders for determination of thickness and strength. Variance from specified thickness ranged from approximately -0.1 in. to +0.9 in. and averaged about +0.3 in. Compressive strength varied from about 3,600 to 5,200 psi, averaging nearly 4,500 psi.

Bituminous shoulders are in new condition at present, due to the one year difference in construction schedule. The initial condition survey disclosed no obvious defects.

Performance data will be collected and maintained by the Research Laboratory until such time as further reporting is warranted by the information gathered. Information concerning the project may be obtained by request, during the interim period.