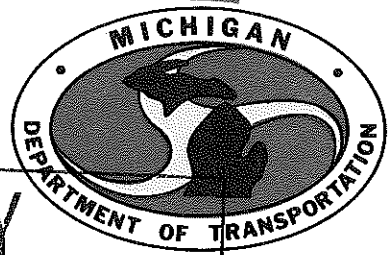


EXPERIMENTAL SHORT SLAB PAVEMENTS
Construction Report



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**TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION**

EXPERIMENTAL SHORT SLAB PAVEMENTS
Construction Report

M. A. Chiunti

Research Laboratory Section
Testing and Research Division
Research Project 73 F-136
(Work Plan No. 34)
Research Report No. R-1016

Michigan State Highway Commission
Peter B. Fletcher, Chairman; Carl V. Pellonpaa,
Vice-Chairman, Hannes Meyers, Jr., Weston E. Vivian
John P. Woodford, Director
Lansing, August 1976

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Introduction

This report describes the pavement construction on an experimental portion of freeway on relocated US 10 northwest of Clare, Michigan. Foundation materials investigations, bituminous base and asphalt treated permeable material design criteria, and evaluation of subsurface drains will be covered in a separate report.

The project was constructed to evaluate the performance of short slab, unreinforced pavement placed on conventional base, on a porous bituminous drainage blanket, and on a bituminous stabilized base. The work is being done by the Michigan Department of State Highways and Transportation as a "Category 2" project, in cooperation with the Federal Highway Administration.

During the past few years, the costs of jointed reinforced and continuously reinforced concrete pavements in Michigan have increased considerably. There have been some difficulties in constructing continuously reinforced pavements with slipform equipment, and there are indications of rebar corrosion in this type of pavement built with slag aggregate. Although existing pavements of this type have performed quite well, the above mentioned problems—coupled with the recurrent shortages and high price of steel—have led to reconsideration of rigid pavement design for areas of relatively light commercial traffic. Concrete pavements that require less steel and/or those that can be built at lower costs, are to be evaluated.

Design changes must be placed in service on an experimental basis in order to allow evaluation over a period of time. The purpose of this study is to obtain relative performance information on several alternate pavement designs.

Background Information

The status of known research on short slab unreinforced pavements, with and without load transfer at the joints, was extensively documented in the research proposal for this project. Quoting from the summary included in the proposal:

'Experience in Michigan, and in many other states, indicates that short slab pavements without load transfer, placed on the usual granular or stabilized subbases and subjected to significant amounts of commercial traffic at highway speeds, will provide poor rideability within a few years. This has occurred even on projects with cement or bituminous stabilized

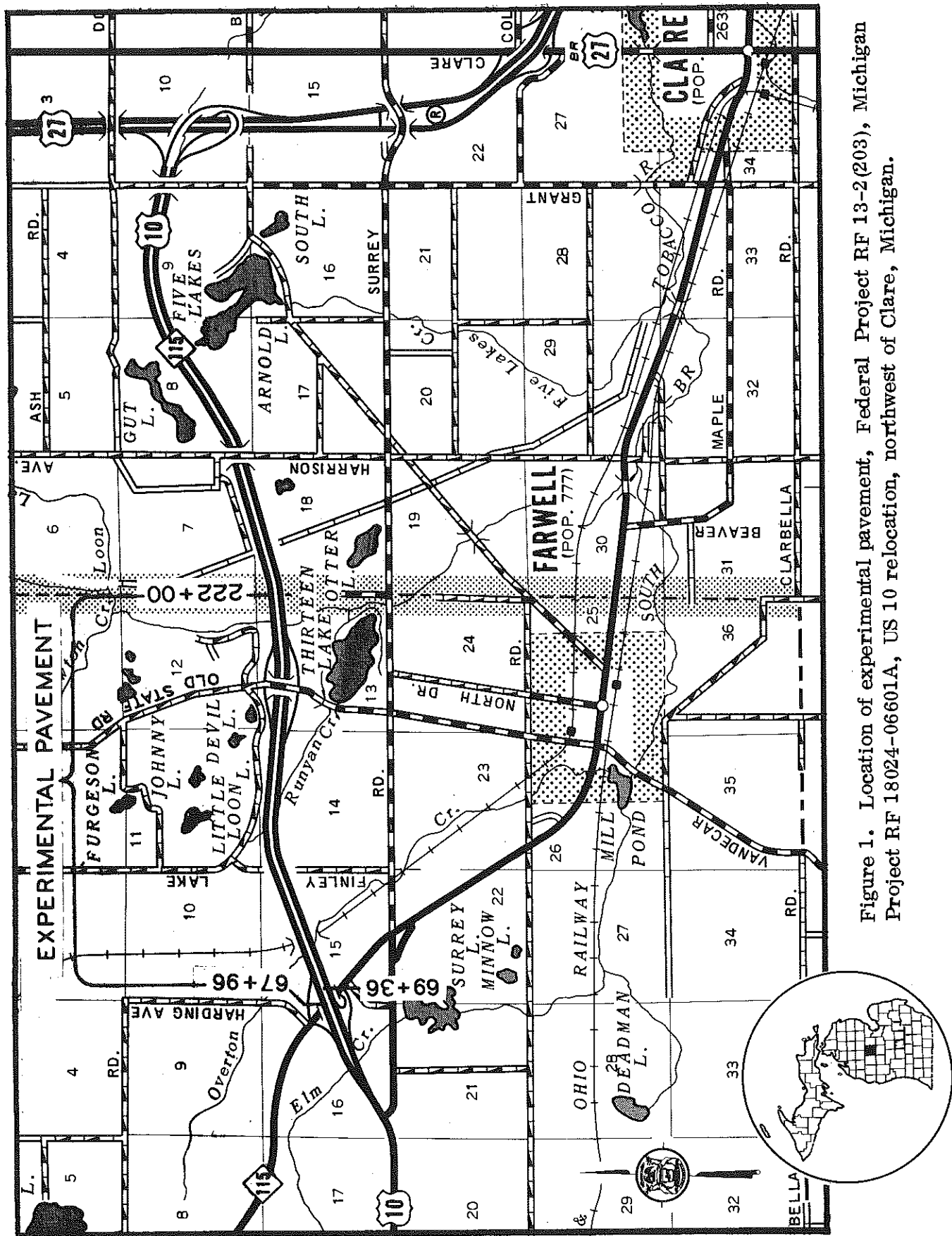


Figure 1. Location of experimental pavement, Federal Project RF 13-2(203), Michigan Project RF 18024-06601A, US 10 relocation, northwest of Clare, Michigan.

bases, and using skewed joints. California research has identified the cause of faulting on such pavements. Free water under the slab causes movement of finer aggregate particles from under the "leave" slab and/or the shoulder, to new positions under the approach slab.

"Corrosion-resistant dowel bars are required where load transfer is used. Compression type seals are necessary, even for short slab, non-reinforced pavements.

"Full-depth stabilized shoulders are required adjacent to the edges of pavements without load transfer.

"Evidence indicates that if commercial traffic exceeds approximately 250 to 300 vehicles per day, then load transfer or some special, highly permeable base is required to prevent faulting. Permeable asphalt base materials are in the experimental stage of development. It is obvious that even small amounts of commercial traffic will cause faulting of pavements without load transfer, if erodible materials are present in the shoulder or the base.

"Since trunkline installations that warrant rigid pavements can be expected to encounter more than 300 commercial vehicles per day, and long range rideability is an important consideration, experimental plain pavements included in this project will have either load transfer, asphalt stabilized base, or porous asphalt base." The latter is called Asphalt Treated Permeable Material, (abbreviated ATPM).

Location

The experimental features were incorporated into the plans and specifications of Federal Project RF 13-2(203), Michigan Project RF 18024-06601A, US 10 relocation, northwest of Clare. The experimental portion of the project begins at M 115 and proceeds east to a point approximately one-half mile east of Old State Rd in Clare County (Fig. 1).

Description

The experimental roadway consists of three miles of dual 24-ft concrete pavement. The limits of the eastbound roadway are from Station 69+36 to 222+00, the westbound limits are Station 67+96 to Station 222+00. The pavement is 9-in. uniform thickness with 0.015 ft/ft slope for drainage. All shoulders are full-depth bituminous. The outside and inside shoulders are 9 and 5 ft wide, respectively.

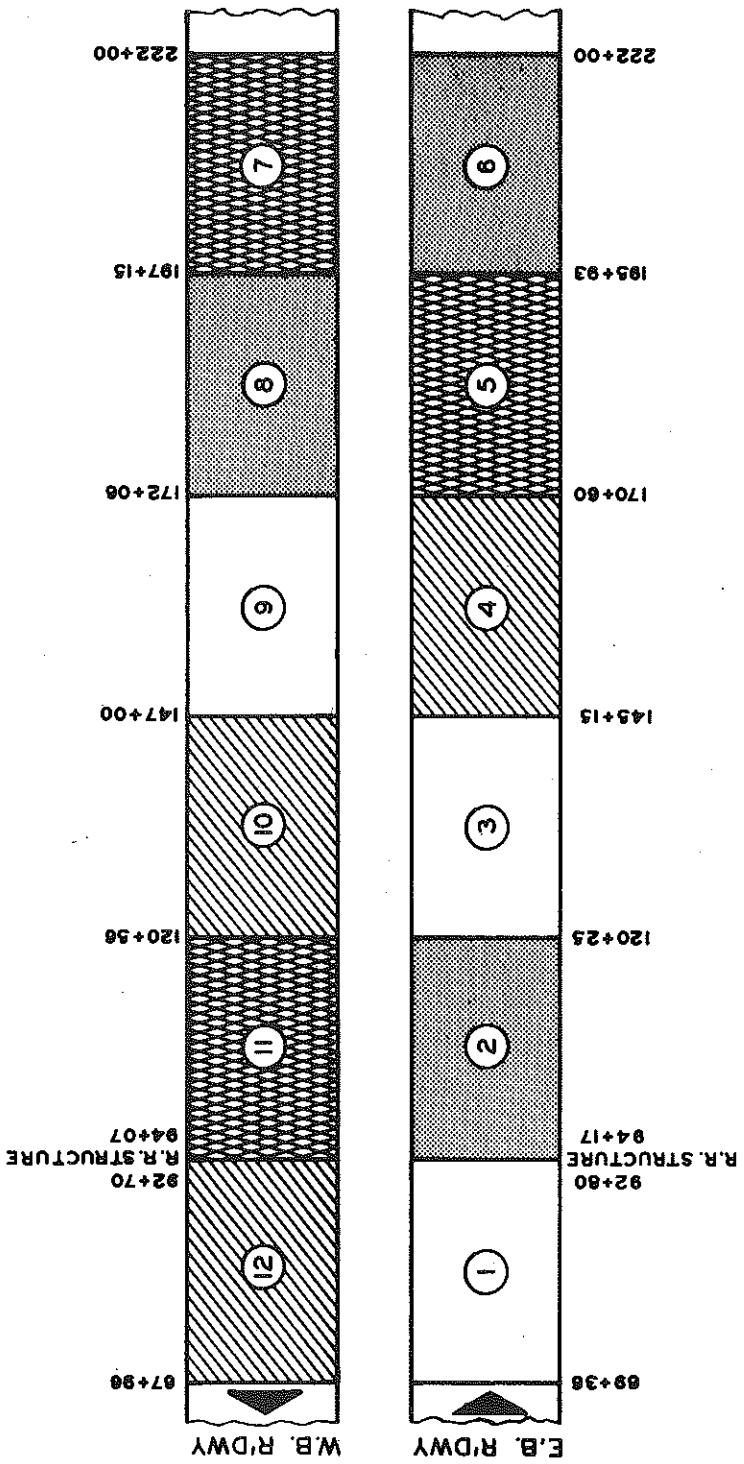


Figure 2. Experimental test section layout, as constructed. (US 10 relocation).

Expansion joints were used at all ramp spring points. All except 10 joints contain neoprene joint seals. Those 10 joints were sealed with a hot-poured polyvinylchloride (PVC) joint sealant and are located between Stations 120+88 and 122+25 in the eastbound roadway. Sections of standard pavement are included for comparison of performance. Figure 2 shows the layout of the experimental test sections, as constructed.

Experimental Features

Experimental features included in this project are Types B, C, and D pavement designs. Michigan standard reinforced pavement (Type A) was included to provide a basis for comparison (Figs. 3 through 6).

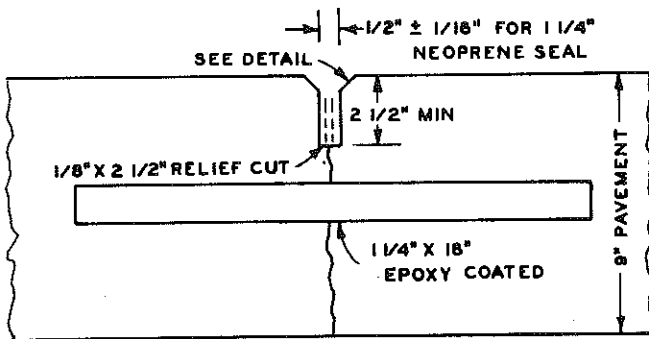
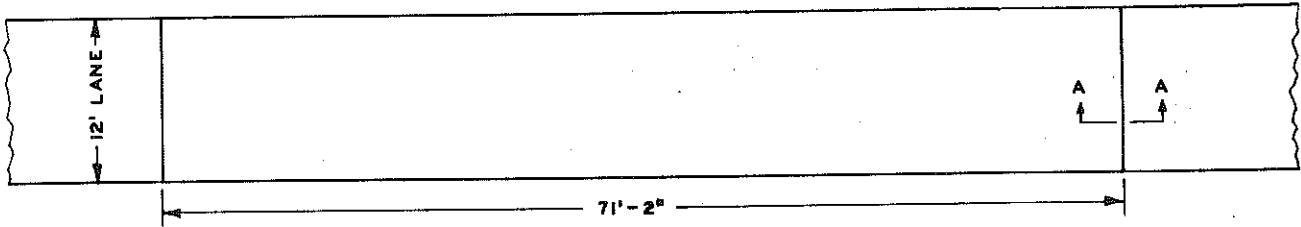
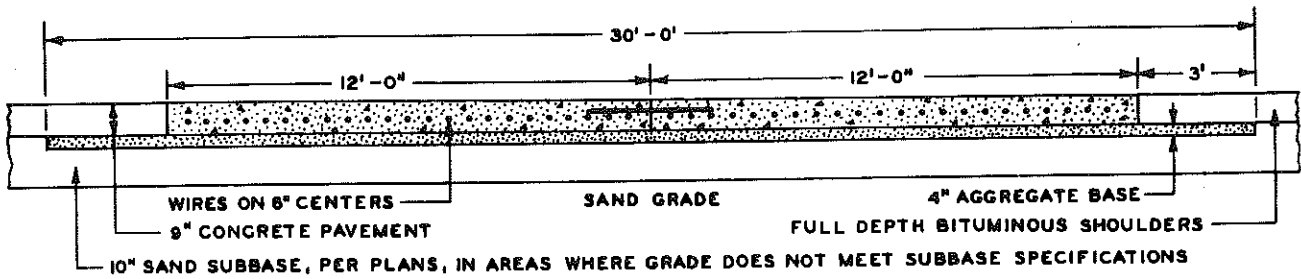
Michigan's standard pavement design (Type A) consists of 9-in. reinforced concrete placed over 10 in. of sand subbase and 4 in. of aggregate base. The standard joint spacing is 71 ft - 2 in. The reinforcing steel mats used are made up of 15, W-4 transverse wires (nominal diameter, 0.225 in.) spaced 1 ft apart and 24, W-8.6 longitudinal wires (nominal diameter, 0.331 in.) on 6-in. centers. The mat sizes are generally 15 ft long by 11 ft - 6 in. wide.

Load transfer assemblies used in Type A and Type C pavements were the same. Load transfer is accomplished by 1-1/4-in. diameter dowels 18 in. long. The dowels are held in a wire frame on 12-in. centers and at mid-depth of the slab. Alternate ends of the dowels are welded to the wire frame. Specifications require that the free ends of the dowel be sawed instead of sheared to maintain roundness. The free ends of the dowels used on this project were deformed more than desirable, therefore, caps were installed on the free ends of all dowels in the assemblies, to minimize resistance to movement.

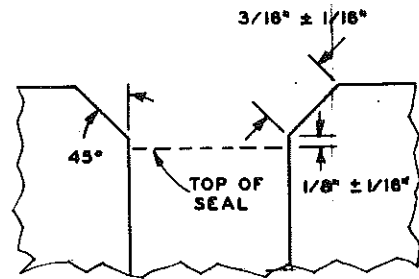
All baskets used on the project contained epoxy coated dowels for corrosion resistance. In addition, the dowels were coated with liquid asphalt which acts as a bond breaker. Figure 7 shows the load transfer devices set on the grade in a Type C section. The beveled joint groove also is a special feature included in all sections.

Type B pavement design consists of 9-in. unreinforced concrete. The joint spacing is a repeating pattern of 13, 19, 18, and 12-ft slabs. The variable spacing was developed in California to prevent resonant vibrations in automobiles when traveling over faulted joints.

TYPICAL CROSS SECTION



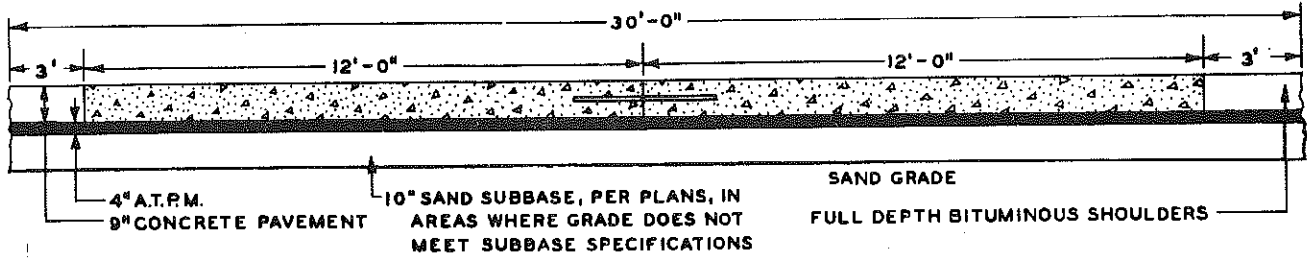
SECTION A - A



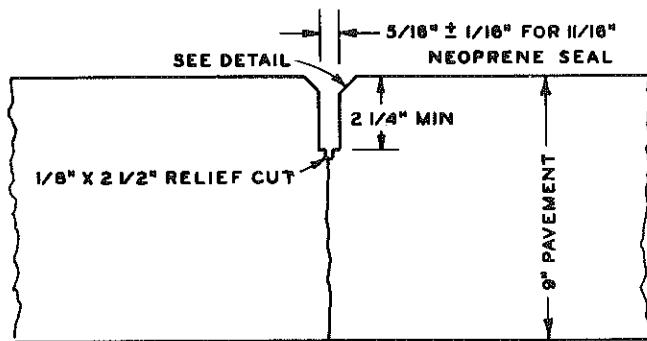
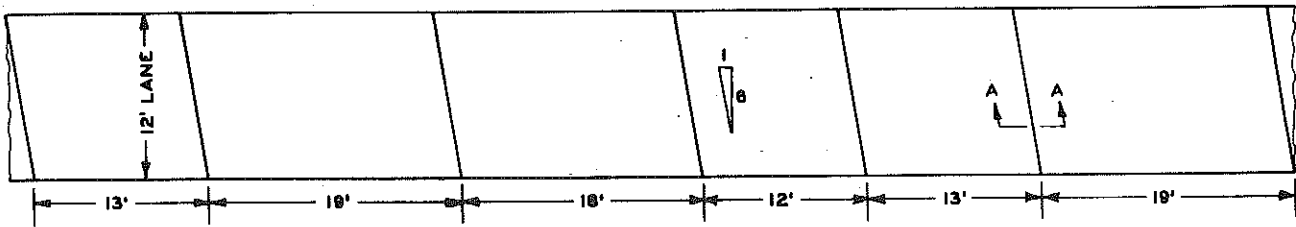
JOINT GROOVE CHAMFER
DETAIL

Figure 3. Type A, control section. Nine-inch standard pavement, 71 ft - 2 in. slabs, reinforced, 90-degree, equal spacing with load transfer and neoprene seals.

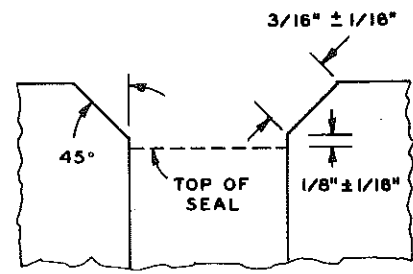
TYPICAL CROSS SECTION



Note: Asphalt for bituminous base to be 200-250 penetration grade.



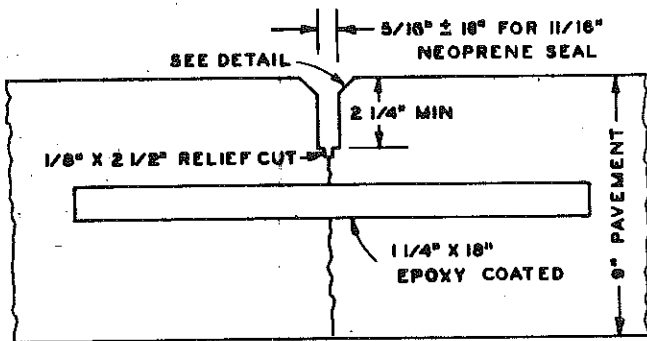
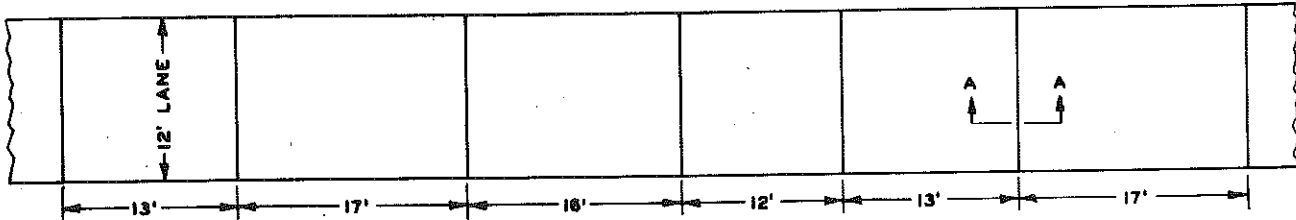
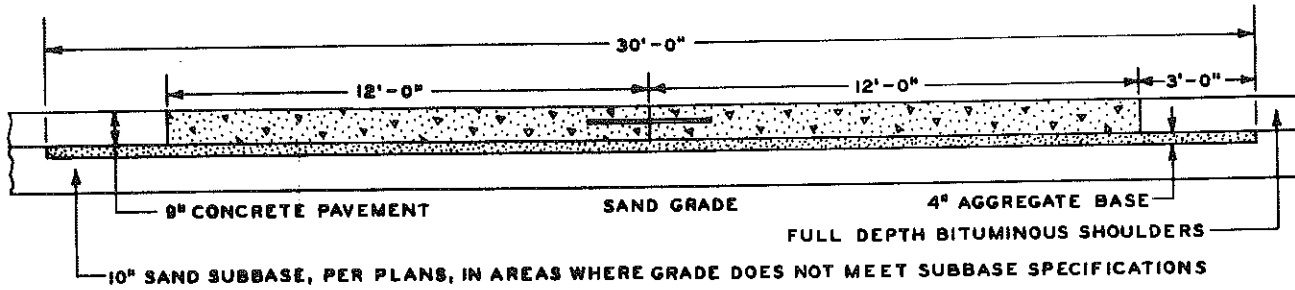
SECTION A-A



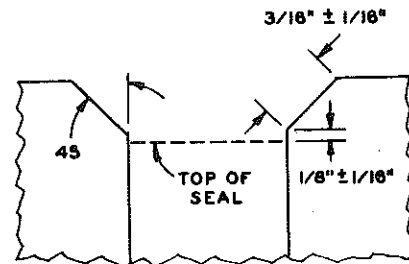
JOINT GROOVE CHAMFER DETAIL

Figure 4. Type B, short slab, plain concrete, skewed joints, variable spacing, no load transfer, porous base, neoprene seal.

TYPICAL CROSS SECTION



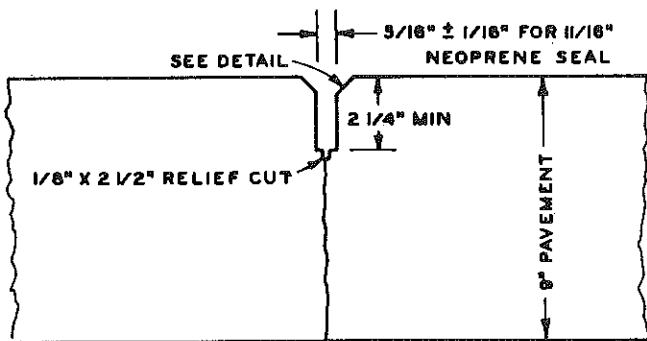
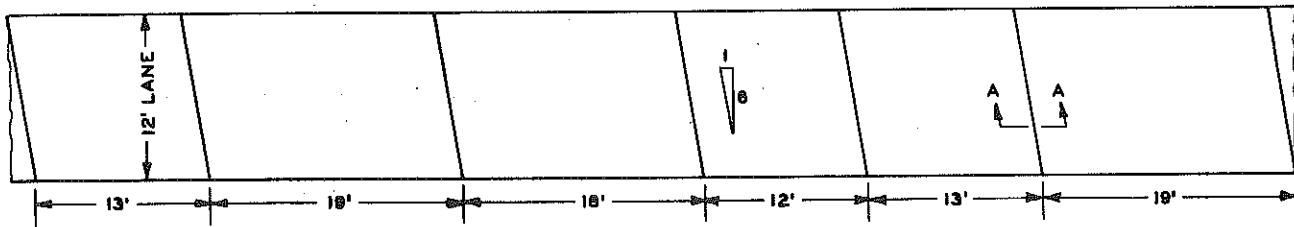
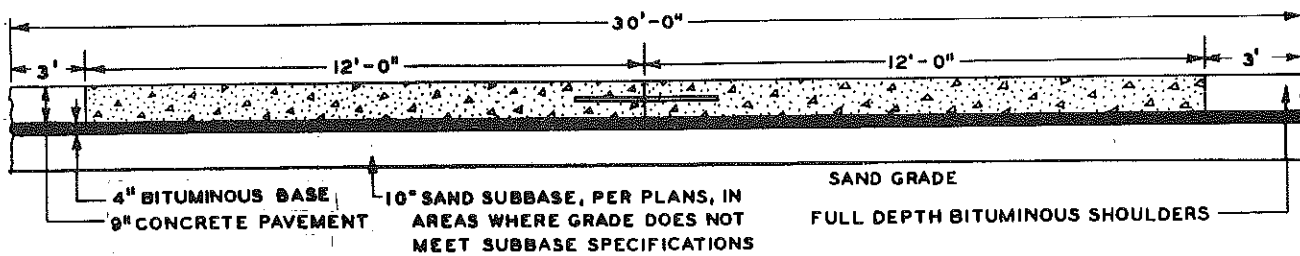
SECTION A - A



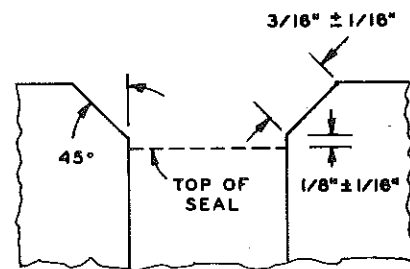
JOINT GROOVE CHAMFER DETAIL

Figure 5. Type C, short slab, plain concrete, 90-degree joints, variable spacing, with load transfer and neoprene seals.

TYPICAL CROSS SECTION



SECTION A-A



JOINT GROOVE CHAMFER
DETAIL

Figure 6. Type D, short slab, plain concrete, skewed joints, variable spacing, no load transfer, bituminous base and neoprene seals.

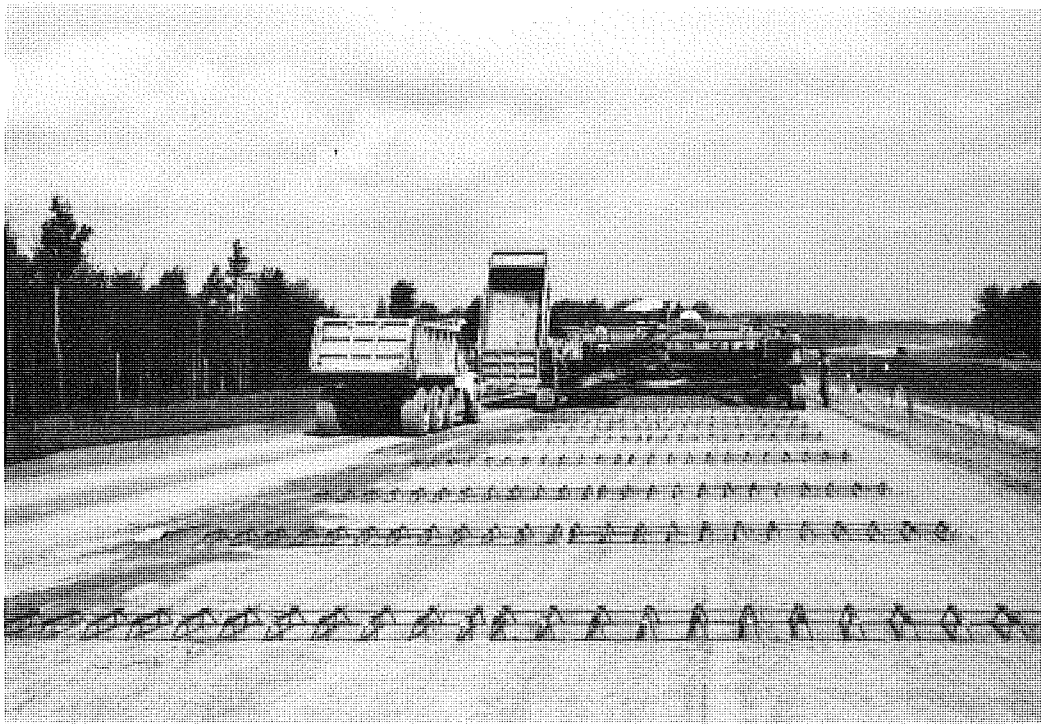


Figure 7. Load transfer assemblies set on grade in Type C section.

The concrete wearing surface of Type B pavement was placed over 4 in. of ATPM (Asphalt Treated Permeable Material) and 10-in. of sand sub-base. Originally the pavement was designed to include a 4-in. filter base between the sand subbase and the ATPM. However, existing conditions on the project were such that the subbase material closely approximated the gradation required for filter material, so no special filter layer was hauled to the site.

All joints in the Type B sections were skewed, 1-ft in 6-ft across the 24-ft width of the pavement and sealed with neoprene joint seals.

Type C pavement design is a short slab, unreinforced, with load transfer at the joints. The load transfer devices contain corrosion resistant dowels. The joints are perpendicular to the roadway and spaced with a repeating pattern of 13, 17, 16, and 12 ft. The maximum slab length was slightly less than for Types B and D because the restraint provided by the load-transfer devices would tend to promote mid-slab cracking.

The concrete wearing course was placed over 4 in. of aggregate base and 10 in. of sand subbase. Joint grooves contain neoprene joint seals.

Type D pavement design is a short slab pavement without reinforcement or load transfer at the joints. The joint spacing is a repeating pattern of 13, 19, 18, and 12-ft slabs. The joints are skewed 1-ft in 6-ft across the 24-ft pavement width.

The concrete wearing course was placed over 4 in. of bituminous base and 10 in. of sand subbase. All except 10 joints in the eastbound section were sealed with neoprene joint seals. These 10 special joints were sealed with a hot-poured PVC sealant. The joint grooves were modified by sawing them 5/8 in. wide by 1-1/2 in. deep instead of 5/16 in. by 2-1/4 in. as used for neoprene seals.

As was previously stated, the cause of slab faulting is the presence of free water under the pavement joints. This experiment was designed to investigate methods by which faulting can be prevented. Specifically, the pavements contain load transfer, a porous bituminous drainage base designed to remove free water, and a relatively soft and impermeable bituminous base which was included to determine its performance when used along with full-depth stabilized shoulders and subjected to relatively light commercial traffic. Cracking of the impermeable bituminous base at the contraction joints could lead to pumping and faulting failures beneath the base; therefore, the bituminous mix was designed to minimize this occurrence.

Job specifications for the two types of bituminous base course materials are shown below.

Bituminous Base Course Mixture for Type D Pavement Structures - Asphalt cement used for bituminous base course mixtures shall be penetration grade 250-300. The amount of asphalt cement used shall be between 5 and 9 percent of the mixture, by weight, as determined by the Engineer. Air voids in the mix will range between 2 and 6 percent. Dense graded 24A aggregate was used.

ATPM Base Course Mixtures for Type B Pavement Structures - Coarse aggregate 9A shall be used. Between 2 and 6 percent, by weight, of mineral filler shall be added to the mixture, as determined by the Engineer. Asphalt cement, penetration grade 85-100, shall be used in the mixture. The residual asphalt in the mixture shall be between 2 and 3 percent.

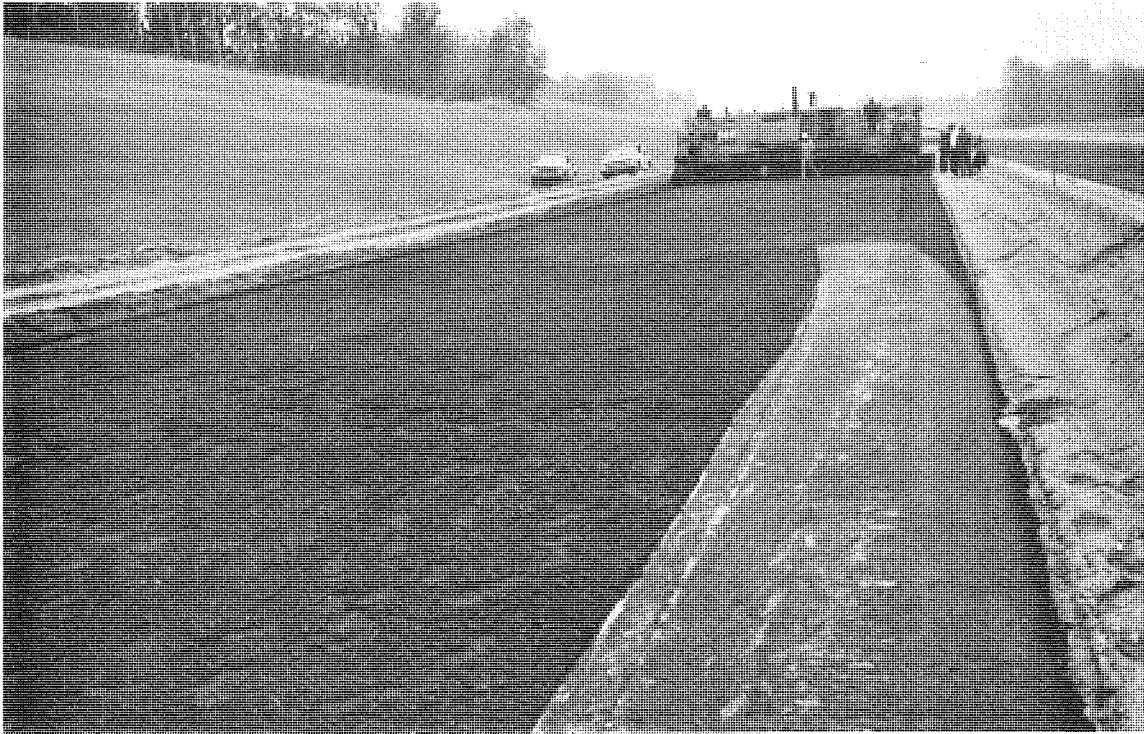


Figure 8. Placing bituminous base. Roller pass shown along right edge.

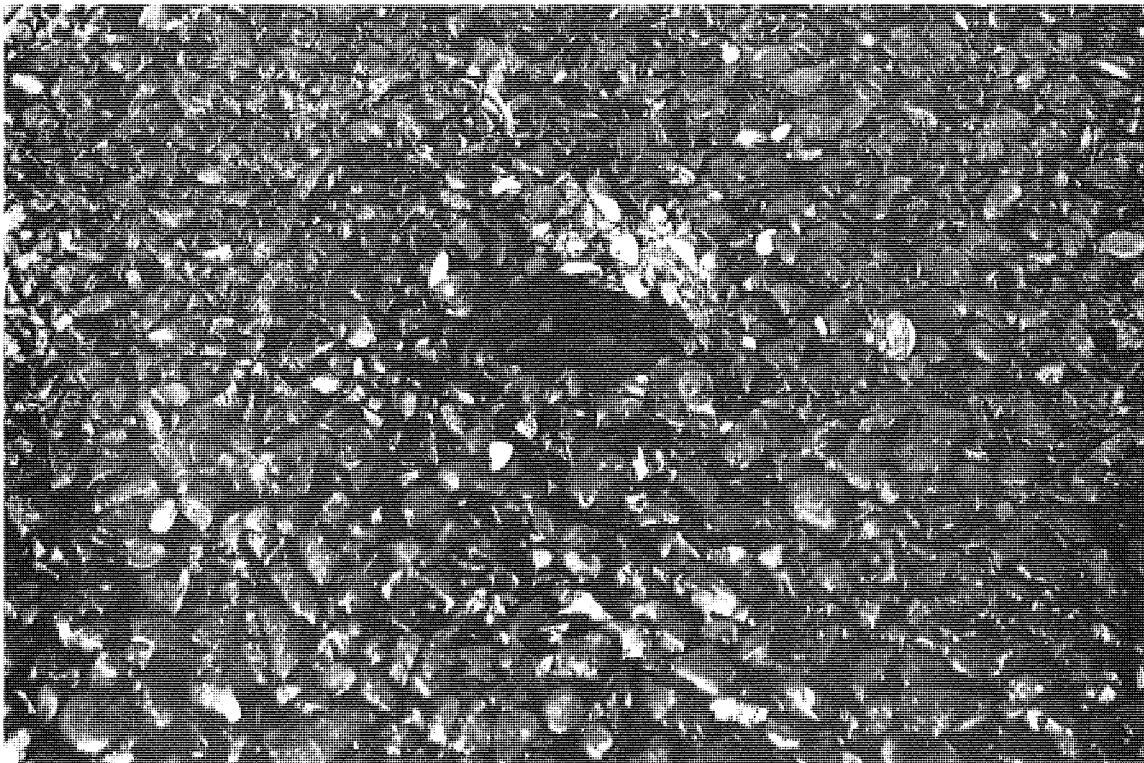


Figure 9. Appearance of ATPM. Cross-section of material can be seen on walls of core hole.

Construction

Earthwork was begun during the 1974 construction season. Final grading and placement of the bases was done during July 1975. The aggregate bases, ATPM and bituminous bases were all placed prior to beginning paving operations. Placement of the ATPM and bituminous base presented no unusual or serious problems.

The bituminous materials were central mixed and transported to the construction site in dump trucks. The mix was placed on the subbase by a CMI spreader which was modified to place 30 ft of material in one pass. The modification consisted of adding "wings" to each side of the spreader. The 30-ft width was required to provide a base for the tracks of the paving equipment when the 24-ft concrete slab was placed. Figure 8 shows the bituminous base being placed, ATPM was placed in the same manner. Figure 9 shows the appearance of ATPM.

The CMI spreader was controlled by a single stringline on the median side of the roadway. Both alignment and elevation were controlled by the stringline on that side, and the elevation of the other side was set from grade. After spreading the bituminous materials, a single pass was made with a lightweight (3 ton) roller to smooth the surface.

It was found that both the ATPM and bituminous base could be readily trimmed with a CMI Autograder. This was done on some of the sections where thickness variations of the base existed or elevation was not as required.

Pouring of the concrete pavement experimental sections was started August 4, 1975 and completed August 14, 1975. The roadway was opened to traffic during November 1975.

There was some concern regarding the use of the ATPM and bituminous bases for hauling purposes. It was feared that the ATPM would lose its permeability due to contamination with materials carried on the tires, and any of the bases could become rutted if they were traveled on by the contractors machinery during construction operations. Therefore, it was decided that a 10-ft by 6-in. gravel base would be provided at each roadway to facilitate construction hauling operations and to protect the experimental base, the adjacent slopes, and the ditches from damage. This gravel base was placed on the outside shoulder and left in place as a base for the full-depth bituminous shoulders.

The concrete wearing course was constructed by conventional methods using CMI slipform paving equipment. The mainline roadway was poured in one pass, 24 ft wide. The longitudinal centerline was sawed and sealed with cold-poured sealant and contained tie bars between lanes. The tie bars are No. 5 deformed bars, 30 in. long and spaced on 40-in. centers.

The concrete was central mixed, transported to the construction site in rear-dump trucks and placed on the prepared base by a CMI spreader. In the Type A sections, the reinforcing steel was placed on top of the concrete and mechanically depressed to the correct depth. Consolidation and mechanical finishing were done by the CMI paver. The final surface treatment consisted of floating with a mechanical tube float, hand straightedging, and texturizing with a machine-operated transverse wire comb. The concrete was protected during the curing period by white membrane curing compound. Figure 10 shows the paving train used on the project, working in a "Type C" pavement section.

Joint seal grooves were sawed by a two-step method. First, a plane-of-weakness cut 1/8 in. wide by 2-1/2 in. deep was made at the location of the transverse joints as soon as the concrete had hardened enough to prevent excessive ravelling. When the concrete had gained sufficient strength and hardness, the joint grooves were sawed to the widths and depths required.

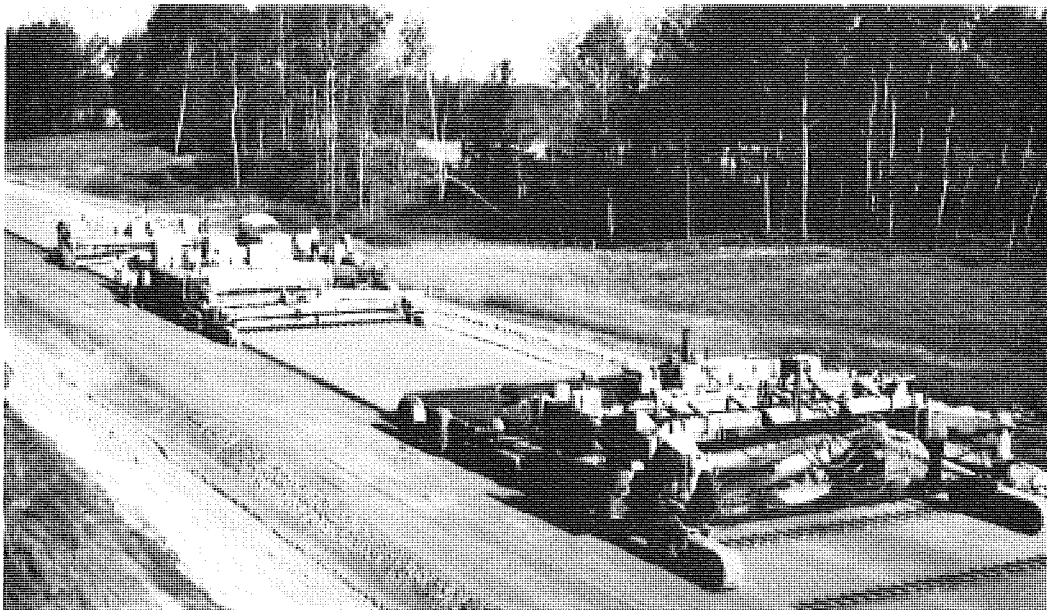


Figure 10. Paving train used on project.

Beveling of the joint groove edges was performed at the same time the grooves were cut. Beveling plates with a 45 degree cutting edge containing diamond chips were installed on both sides of the groove cutting blades. A bogie wheel added to the front of the concrete saw maintained the correct depth of cut. Figure 11 shows the joint groove cutting and beveling operation. Neoprene joint seals were installed by conventional methods.

Instrumentation

To determine the amount of joint movement and to check for the occurrence of joint faulting, selected groups of joints were instrumented in the short slab sections. All joints in the standard sections were instrumented. Instrumentation was placed near the outside edge of the roadway and consisted of stainless steel rivets embedded in the fresh concrete on each side of the joint location as shown in Figure 12.

The joints selected for instrumentation in the short slab sections were located in areas where foundation materials studies are also being conducted. It is hoped that in this manner data can be obtained that may assist in developing the relationship between subsurface drainability and pavement performance.

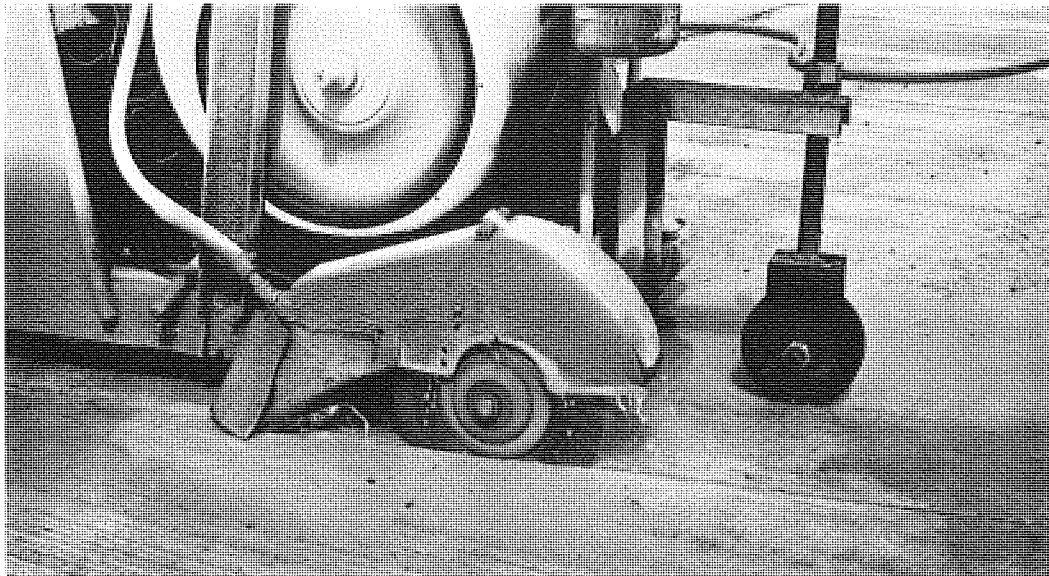


Figure 11. Joint groove cutting and beveling.

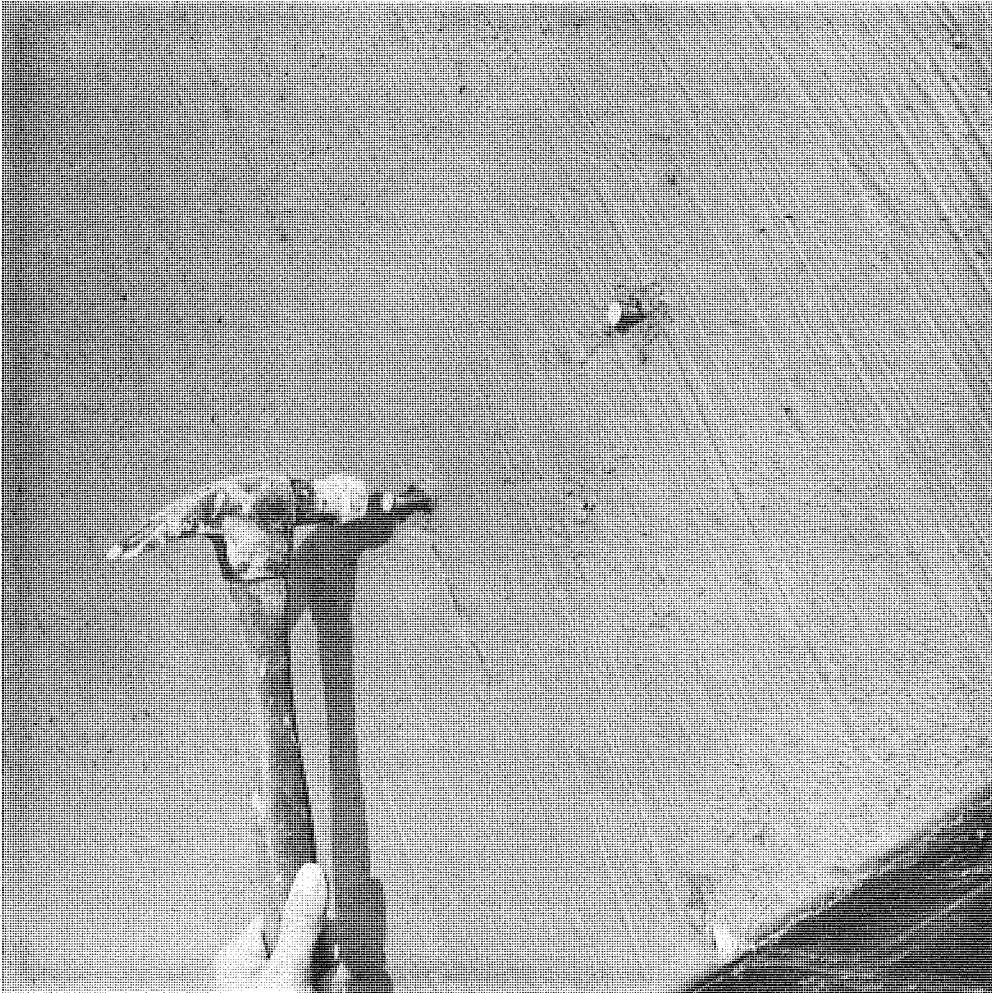
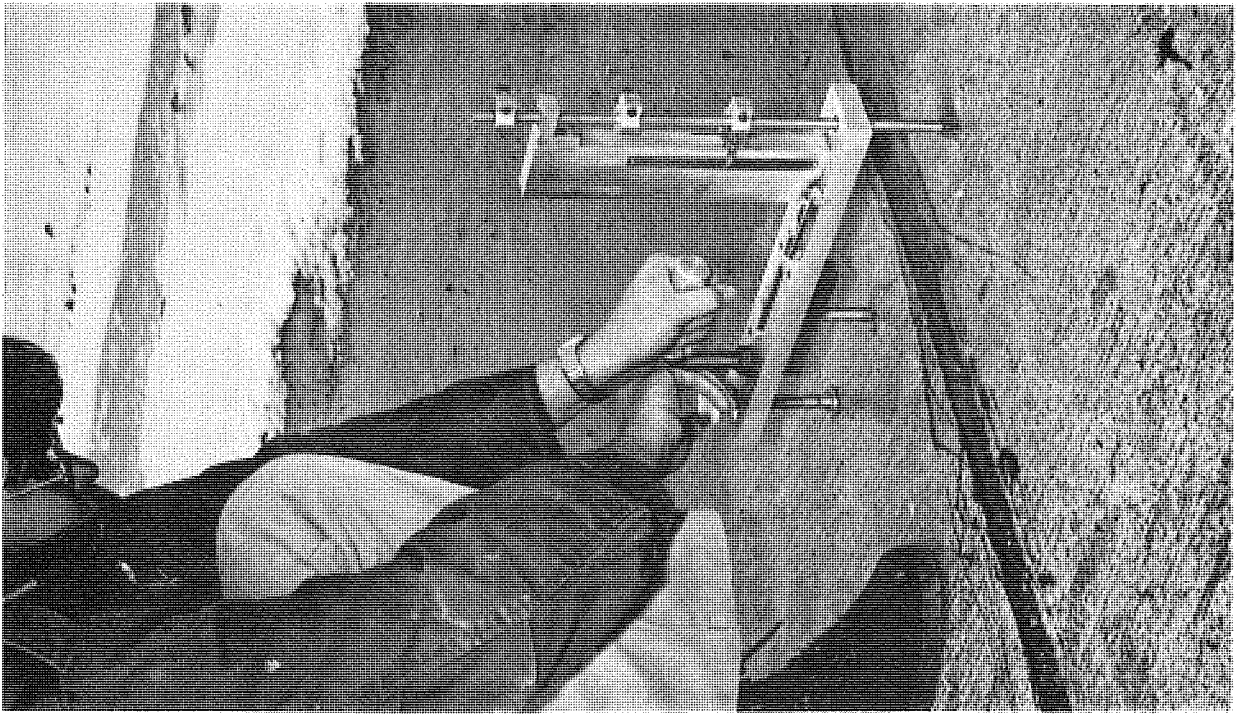


Figure 12. Instrumenting pavement with stainless steel rivets placed on each side of joint. Rivets were set flush or slightly below pavement surface.

Figure 13. Special fixture for measuring faulting of joint.

An initial reading or zero reference was obtained as soon as the concrete had set up enough to allow taking of the readings and before any joint movement had occurred.

Measurements

After construction, an initial condition survey was performed. The survey included measurements of joint movements, transverse cracking, joint groove spalling, and pavement roughness.

Measurements of horizontal joint movements and faulting are made across the transverse joints. Joint movement measurements are made with a vernier caliper, and fault measurements with the special fixture shown in Figure 13.

Amounts of transverse cracking and joint groove spalling are obtained by visual observations. Pavement roughness is recorded by the Department's Rapid Travel Profilometer.

Table 1 shows the results of the initial survey.

TABLE 1
RESULTS OF INITIAL SURVEY

Pavement Type	Average Joint Movement, in.	Transverse Cracking, lin ft	Ride Quality Index*	
			Traffic Lane	Passing Lane
A	0.343	36	57	48
B	0.085	0	39	35
C	0.081	0	49	41
D	0.082	0	46	41

* Ride Quality Index: 0 to 30 Excellent; 31 to 70 Good-Fair; 71 to 100 Poor.

At the time of the initial survey, there was no spalling of the beveled joints.

TABLE 2
 EXPERIMENTAL PAVEMENT COSTS
 Construction Project RF 18024, Job No. 06601A

Type A. Control Section - Standard pavement, 9 in.

9 in. reinforced, 71 ft-2 in. slabs (reinforcement included in price)	\$ 9.50 sq yd
Jointed, with plastic coated dowels and neoprene seals	0.78 sq yd
Aggregate base, 4 in.	1.00 sq yd
Sand subbase	0.56 sq yd
	\$11.84 sq yd

Type B. Short slab, plain concrete, skewed joints, variable spacing, no load transfer, asphalt treated porous base (ATPM), neoprene seal, (average joint spacing 15.5 ft).

9 in. non-reinforced concrete pavement	\$ 7.80 sq yd
ATPM	3.40 sq yd
Joints, with neoprene seals	1.44 sq yd
Sand subbase	0.56 sq yd
	\$13.20 sq yd*
*ATPM Drains - 6 in. diameter (shallow)	\$ 1.68 sq yd
ATPM Drains - 6 in. diameter (deep)	\$ 2.24 sq yd
Total cost w/shallow drains	\$14.88 sq yd
Total cost w/deep drains	\$15.44 sq yd

Type C. Short slab, plain concrete, 90 degree joints, variable spacing with load transfer and neoprene seals (average joint spacing 14.5 ft).

9 in. non-reinforced concrete pavement	\$ 7.80 sq yd
Aggregate base, 4 in.	1.00 sq yd
Joints, with plastic coated dowels and neoprene seals	3.44 sq yd
Sand subbase	0.56 sq yd
	\$12.80 sq yd

Type D. Short slab, plain concrete, skewed joints, variable spacing, no load transfer, bituminous base, neoprene seals (average joint spacing 15.5 ft).

9 in. non-reinforced concrete pavement	\$ 7.80 sq yd
Bituminous base	3.08 sq yd
Joints with neoprene seals	1.44 sq yd
Sand subbase	0.56 sq yd
Total cost w/neoprene seal	\$12.88 sq yd
Special (hot pour joint seal)	2.02 sq yd
Total cost w/hot poured seal	\$13.46 sq yd

The average joint movements reflect the difference in slab lengths of the various types of pavement. The joint movements are fairly uniform throughout each section, except for Section 12. This section only shows movement at approximately every other joint. The exact cause of this behavior is not known; however, it is suspected that perhaps all the joints had not cracked at the time the measurements were taken. Subsequent readings should verify this assumption.

The measurements of Ride Quality Index show that the short slab sections exhibit better riding quality than the standard sections. Also, the passing lane is better riding than the traffic lane and there is less decrease in riding quality from passing lane to traffic lane in the ATPM and bituminous sections as compared to the sections containing aggregate base.

These differences in riding quality can be partly attributed to the methods by which the pavement was constructed. The fact that the paving equipment was controlled from the median side of the roadway would tend to produce a more uniform riding surface in the passing lane.

The ATPM and bituminous bases were retrimmed to remove surface irregularities whereas the aggregate bases were only trimmed at the time they were placed. The original smoothness of the base reflects the better riding quality of the wearing course placed on these types of bases. It has been determined that the action of the paver on the concrete and the steel reinforcement in slipformed standard sections sometimes produces a depression of the concrete over the lapped areas of the mats. These depressions of the concrete account for loss of riding quality in the standard sections as compared to the non-reinforced sections.

Costs

Bid prices for each type of pavement are shown in Table 2.

For ease of comparison, all units were converted to a cost per sq yd amount. Obviously, the relatively small quantities involved, along with the fact that some construction procedures were being tried in Michigan for the first time, tend to increase the price of the experimental sections. It is expected that as quantities increase, and experience in placing these types of pavements is gained, the prices would decline.

Remarks

It was found that the experimental bases could be placed and trimmed with relative ease using conventional paving equipment, under typical Michigan summer conditions. Placing of the concrete wearing course was simplified by elimination of the steel reinforcement and/or joint load-transfer devices. Greater production could be obtained by eliminating stops of the paving train required to load the steel. The greater care required to pave over the baskets and problems associated with placement of the reinforcement were also eliminated. Paving of the experimental sections required four men less than paving the standard sections.

As was previously stated, results of foundation materials investigations will be reported separately.

Performance data will continue to be gathered and compiled by the Research Laboratory. Additional information concerning this project may be obtained upon request.