CONSTRUCTION OF MICHIGAN'S EXPERIMENTAL TRANSVERSE JOINT PROJECT
I 96 from Meridian Road to Wallace Road
(Projects EBI 33084, C5 and C7; EBI 33085, C1)

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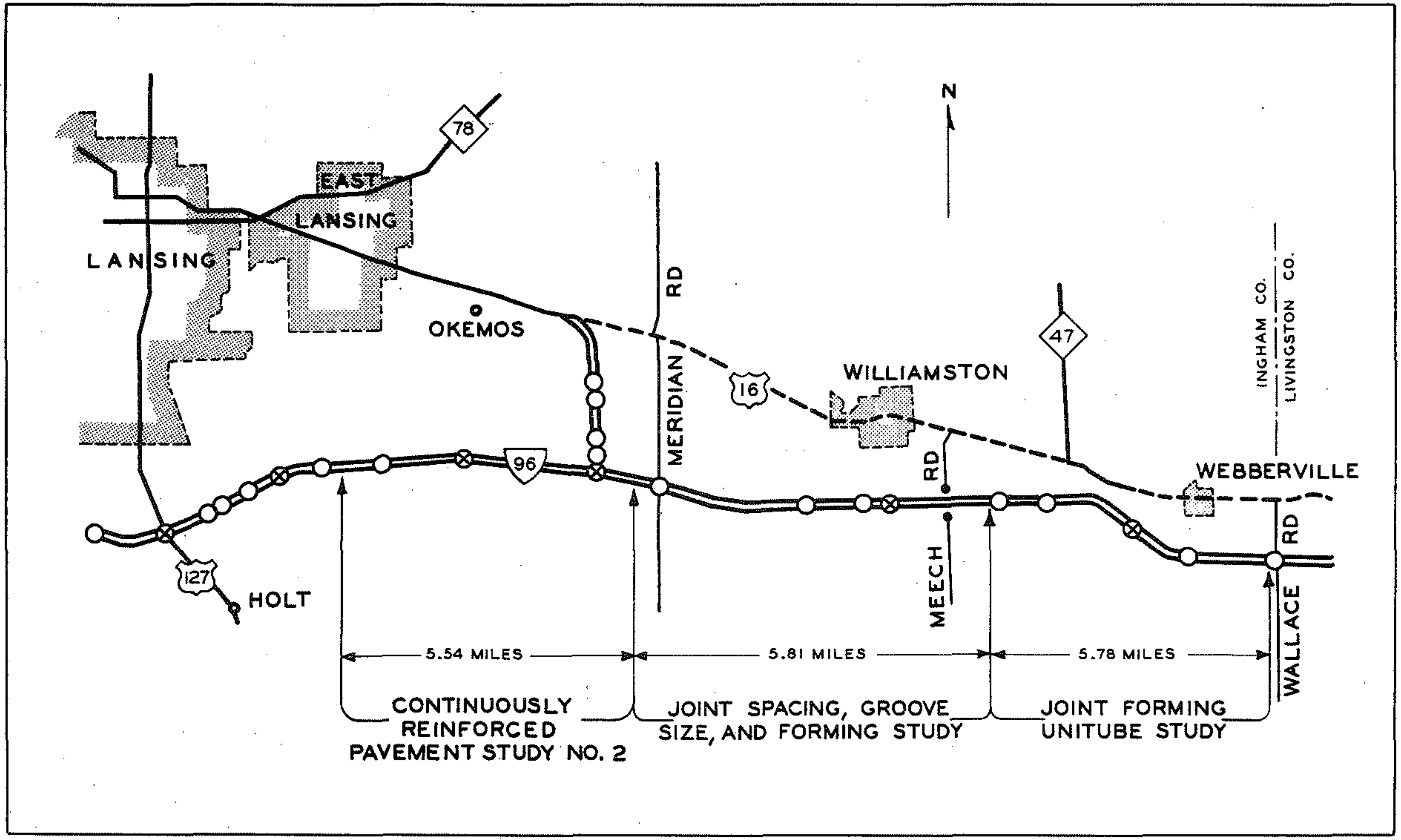

Plan view of I 96 construction southeast of Lansing, showing test road locations.

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Synopsis

A test road has been constructed for comparative performance evaluation of transverse contraction joints, incorporating various joint seal groove sizes (1/2, 3/4, and 1 in. square), various slab lengths (57, 71, and 99 ft), and various methods for establishing a plane of weakness and forming the joint groove. Planes-of-weakness were established during construction a) by embedding metal "Unitube" strips, b) by embedding bituminous fiber filler strips, c) by sawcutting 6 to 24 hr after pouring, or d) by embedding styrofoam strips. In conjunction with these respective techniques, joint grooves were formed after curing a) by crimping the Unitubes, b) by partial removal of the fiber filler with sawcutting, c) by further sawcutting over the initial weakened plane sawcut, or d) by complete removal of the styrofoam. Design details and construction techniques are described for each joint type.

A comprehensive program for performance study through instrumentation and field measurements is outlined, for observation of longitudinal and transverse cracking of individual slabs, spalling and corner cracking at transverse joints, adhesion and cohesion failures of the sealer, magnitude and variation in width of joint opening, and surface roughness changes with time and traffic.

It has been the common practice to provide transverse joints in rigid pavements at predetermined intervals compatible with the steel percentage, if any, in order to prevent random tension cracks. However, a transverse joint is a point of structural weakness in the pavement, the degree of such weakness being related to slab length, joint construction methods, and joint seal quality. In Michigan, a 99-ft slab length with load transfer has been standard since 1946. Construction has generally involved a 1/2- by 2-in. deep joint groove, formed by inserting a premolded styrofoam filler in a manually formed channel in the plastic concrete, with subsequent hand finishing over the filler. In addition to serving as a groove former, the filler also establishes a plane of weakness for controlled cracking. Joint seal quality has steadily improved during the last decade, yet observations of performance of various sealers under service conditions have shown that an adequate sealer, capable of performing satisfactorily for several years for joint width movements as experienced with 99-ft slab lengths, is yet to be developed.

Recent theoretical computations and laboratory experiments have shown that the strain in a sealer subjected to extension and compression is greatly influenced by the shape factor of the joint--that is, the depth-to-width ratio of the sealer reservoir. The lower the value of this ratio, the less the strain in the sealer. However, a shape factor of less than one does not appear feasible in pavement construction, considering the problems involved in forming the joint groove and the environmental conditions to which the sealer is subjected.

As part of the continuing effort to solve joint problems, Michigan has constructed an experimental pavement incorporating various slab lengths, different joint forming methods, and joint seal reservoirs with a shape factor compatible with theoretical values.

LOCATION, DESIGN, AND MATERIALS

The Michigan State Highway Department authorized construction of the experimental pavement in 1960, with the primary purpose of comparing performance of current standard design and construction of transverse joints with performance of joints formed by other methods, having other groove sizes, and spaced at other lineal intervals. The test variables were selected and the supplemental specifications for construction were prepared by the Research Laboratory Division. The detailed design of the project was made by the Road Design Division and construction was under supervision of the Road Construction Division. Instrumentation of the pavement during construction, and the necessary research and evaluation studies after completion, became the responsibility of the Research Laboratory Division.

The Bureau of Public Roads approved the incorporation of the experimental pavement into the plans and specifications of Construction Projects EBI 33084, C5RN and C7RN, and EBI 33085, C1RN, located on I 96 from Meridian Road to Wallace Road in Ingham County (Fig. 1).

The experimental pavement consists of both the eastbound roadway (Sta. 368+15 to 1085+00) and westbound roadway (Sta. 467+90 to 1085+00), each containing two 12-ft lanes with provision for future addition of a third lane on the median side. Therefore, the crown point of the pavement is 6 ft from the median edge of the slab, so that addition of an extra lane will provide a symmetrically crowned pavement. Each roadway has independent vertical alignment, the maximum grade being 1.97 percent on the eastbound and 1.98 percent on the westbound. The center-to-center distance

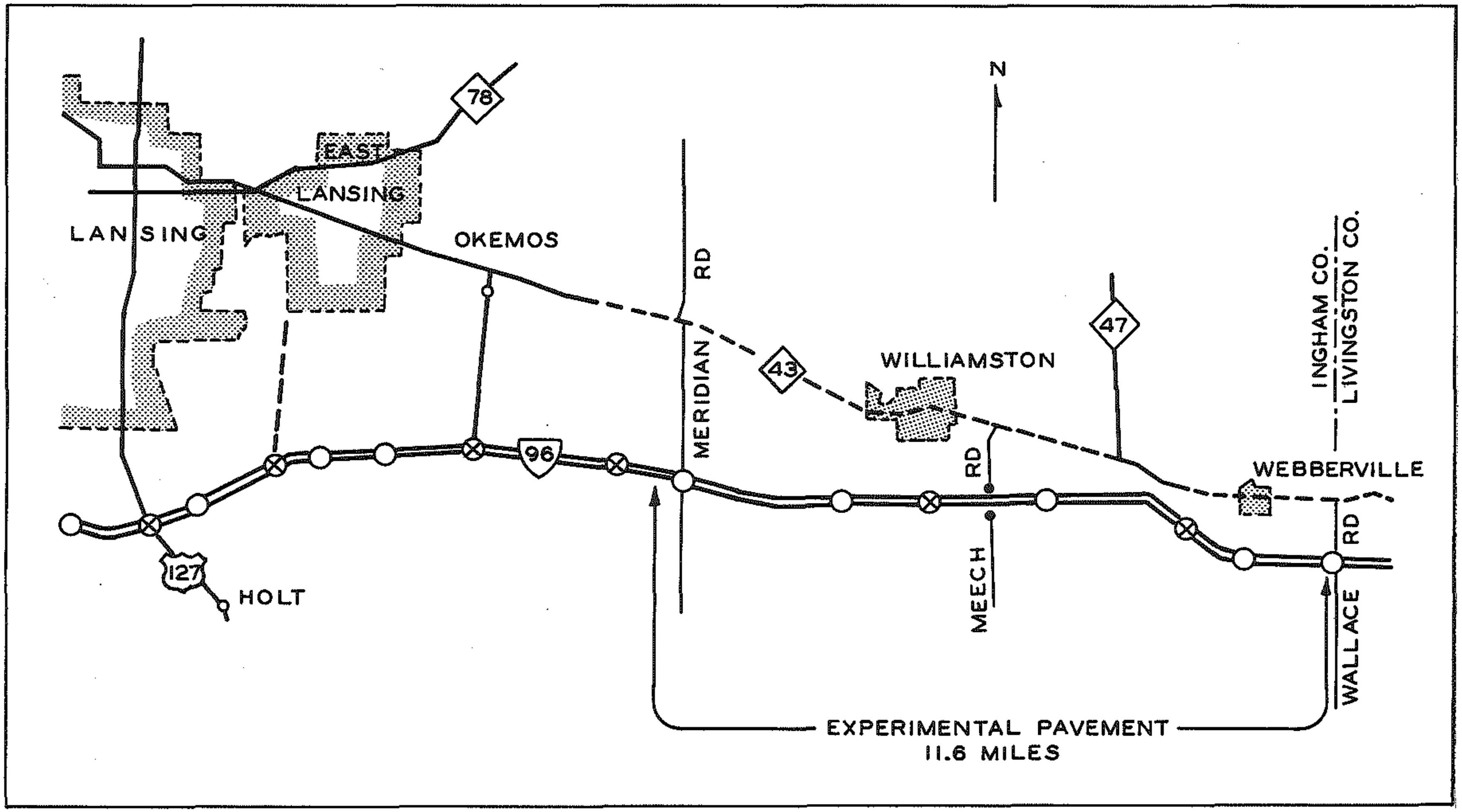


Figure 1. Location of experimental pavement southeast of Lansing.

of the horizontal alignment varies from a maximum of 200 ft to a minimum of 94 ft, and consists of nine straight segments and eight circular curves, the maximum degree of curvature being 1° 00'. The pavement is a 9-in. uniform thickness and was placed on a 14-in. granular subbase. A typical roadway cross-section is shown in Fig. 2.

The concrete was designed by the mortar voids method of proportioning, with a constant cement content of 5.5 sacks of Type 1 cement per cu yd. Air entrainment of the concrete was provided by the addition of Solar AEA to the mix. The concrete had an average air content of 5.7 percent and an average slump of 2 in.

The aggregates consisted of pit gravel, designated as 4A and 10A and conforming to the following grading requirements:

Sieve Size Square Sieve Opening U.S. Standard Sieve Series	Total Percent Passing	
	4A	10A
2-1/2 in.	100	
2 in.	95 to 100	
1-1/2 in.	60 to 90	100
1 in.	10 to 40	95 to 100
1/2 in.	0 to 20	35 to 65
3/8 in.	0 to 5	
No. 4		0 to 8

An analysis was performed on a 5000-g sample of each of the two types of aggregates, obtained by quartering a representative sample from a stockpile and sieving through a 3/8-in. sieve. Visual inspection of material retained on the 3/8-in. sieve showed that the aggregates were composed of the following percentages of the three main geological rock types:

Rock Type	Percent of Sample	
	4A	10A
Igneous	42.0	46.0
Sedimentary	51.6	50.1
Metamorphic	6.4	3.9

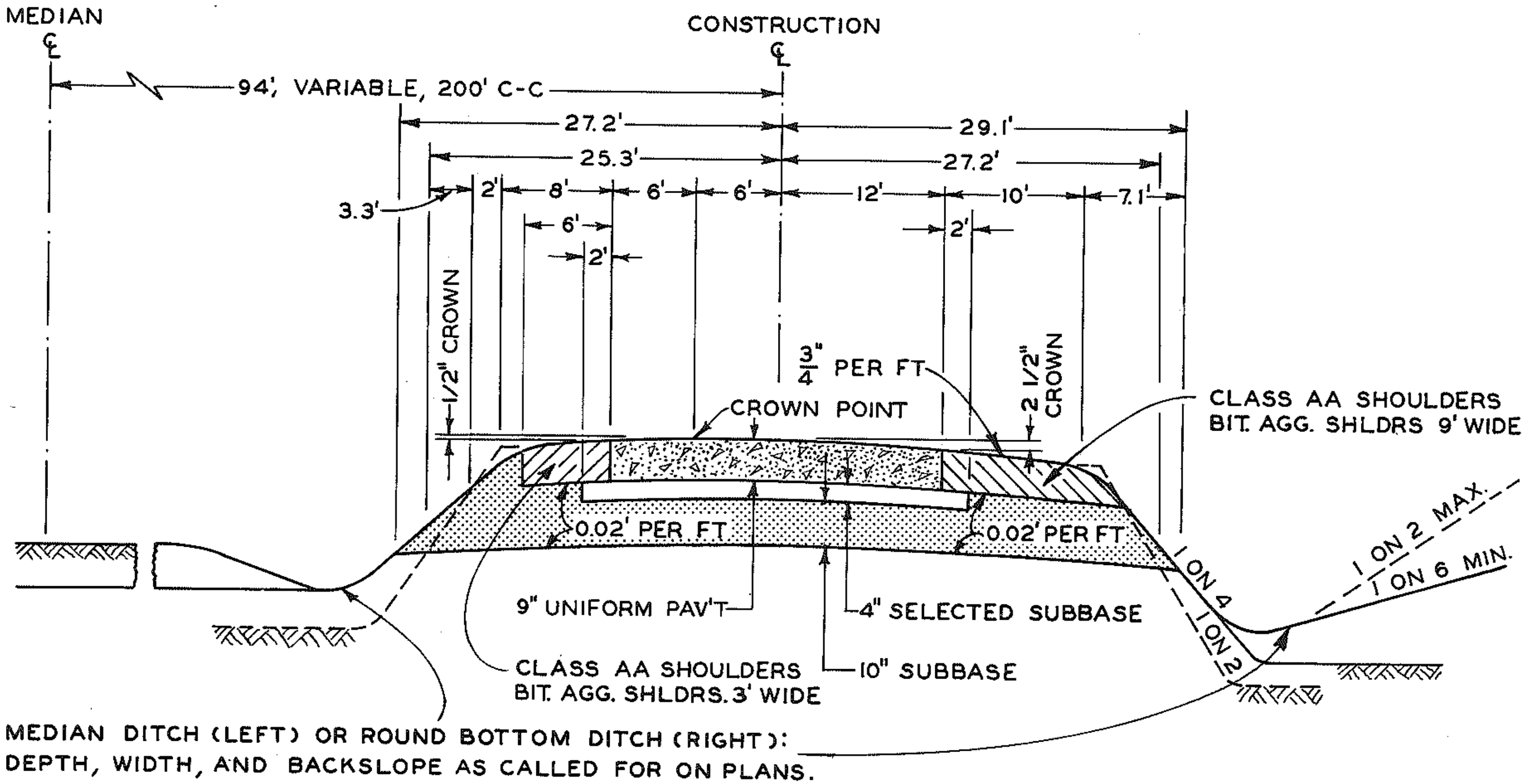


Figure 2. Typical cross-section.

The experimental pavement is composed of 18 test sections. The location; forming method, groove size, and spacing of the transverse joints; and a general plan and instrumentation layout of the test project are given in Table 1 and Fig. 3.

TABLE 1
DESCRIPTION OF FIELD INSTALLATIONS
Sections 1E-9E: Eastbound Roadway
Sections 0W-8W: Westbound Roadway

Section	Stationing	Joint Forming Method	Joint Groove, in.	Joint Spacing
1E	468+15 to 509+68	Sawed (without Filler Strip)*	1 by 1	99 ft 0 in.
2E	509+68 to 552+20	Sawed (without Filler Strip)*	3/4 by 3/4	99 ft 0 in.
3E	552+20 to 594+23	Sawed (without Filler Strip)*	1/2 by 1/2	99 ft 0 in.
4E	594+23 to 634+77	Sawed (without Filler Strip)*	3/4 by 3/4	71 ft 2 in.
5E	634+77 to 676+76	Sawed (without Filler Strip)*	1/2 by 1/2	71 ft 2 in.
6E	677+21 to 720+30	Styrofoam	1/2 by 2	99 ft 0 in.
7E	720+30 to 747+73	Sawed (without Filler Strip)*	3/4 by 3/4	57 ft 3 in.
8E	747+73 to 775+70	Sawed (without Filler Strip)*	1/2 by 1/2	57 ft 3 in.
9E	775+70 to 1085+00	Unitube	3/8 by 1/2	57 ft 3 in.
0W	776+23 to 1085+00	Unitube	3/8 by 1/2	57 ft 3 in.
1W	747+79 to 776+23	Sawed (with Filler Strip)**	1/2 by 1/2	71 ft 2 in.
2W	717+06 to 747+79	Sawed (with Filler Strip)**	3/4 by 3/4	71 ft 2 in.
3W	676+45 to 717+06	Styrofoam	1/2 by 2	99 ft 0 in.
4W	634+92 to 676+01	Sawed (with Filler Strip)**	1 by 1	99 ft 0 in.
5W	594+44 to 634+92	Sawed (with Filler Strip)**	3/4 by 3/4	99 ft 0 in.
6W	552+06 to 595+44	Sawed (with Filler Strip)**	1/2 by 1/2	99 ft 0 in.
7W	510+15 to 552+06	Sawed (with Filler Strip)**	3/4 by 3/4	57 ft 3 in.
8W	467+90 to 510+15	Sawed (with Filler Strip)**	1/2 by 1/2	57 ft 3 in.

* 1/8 by 2 in. plane of weakness sawcut, and sawed joint groove.
** 1/4 by 2 in. filler strip, and sawed joint groove.

The four basic types of contraction joint incorporated in the experimental pavement were as follows:

1. Unitube Joints, where a metal strip was embedded transversely near the pavement surface during construction, and was subsequently treated so as to provide a joint groove for sealing material.

2. Sawed Joints with Filler Strips, where a premolded bituminous fiber filler strip was embedded during construction, with part of the filler removed following curing when the joint groove was cut for sealing.

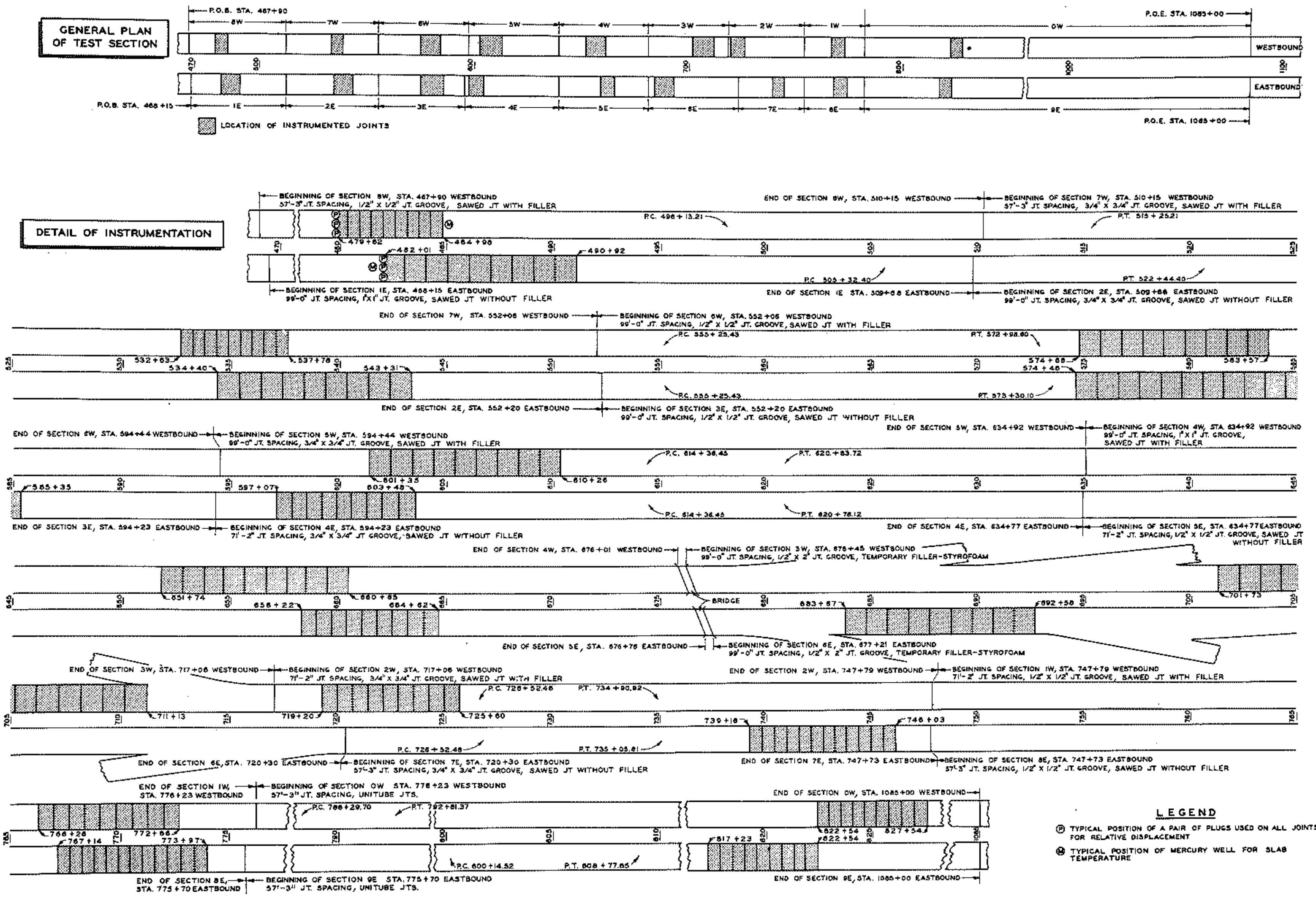


Figure 3. General plan and instrumentation layout.

3. Sawed Joints without Filler Strips, where a plane of weakness was sawcut within 24 hr after pouring, and the joint grooves cut following curing.

4. Styrofoam Joints, where styrofoam strips were embedded during construction and subsequently removed to provide a joint groove, as is currently standard Departmental practice.

At each transverse joint location standard load transfer assemblies were installed, consisting of 1-1/4-in. diam bars, 18-in. long and spaced at 12-in. centers. At structures, 1-in. wide expansion joints were placed in accordance with standard Michigan practice, the number and spacing depending on the length of pavement between structures (in pavement poured after September 19, expansion joints were spaced at approximately 400 ft). A non-metallic base plate 7-1/2 in. wide, approximately 1/4-in. thick, with a 1-in. high trapezoidal parting strip in the center, and of such length as to extend the full width of the pavement and to within 1 in. of the top of the paving forms, was used at all contraction joints. The base plate used with expansion joints was identical, except that the center parting strip was omitted.

Steel reinforcement in the Unitube sections (0W and 9E) consisted of welded wire mesh sheets, 11 ft 6 in. wide and 15 ft long, with 24 No. 2 gage wires in the longitudinal direction and 15 No. 4 gage wires transversely providing a longitudinal steel percentage of 0.10. In the remaining 16 sections, welded wire mesh sheets 11 ft 6 in. wide and 15 ft long, consisting of 24 No. 00 gage wires in the longitudinal direction and 15 No. 4 gage wires transversely, providing a longitudinal steel percentage of 0.16. The two types of reinforcement are shown in Fig. 4.

All transverse joints were sealed with a hot-poured, rubber-asphalt type joint sealing compound meeting Michigan's requirement for conformity with the Federal Specifications for Sealers, SS-S-164.

PAVEMENT CONSTRUCTION

Construction of the pavement began July 24, 1962, and was completed September 26, 1962. Full-width construction was employed, whereby the entire 24-ft width of pavement was placed at one time. The steel reinforcement was placed 3 in. below the surface, and a lap splice length of 13 in. was used with both types of reinforcement. Transverse tie bars, consisting of No. 4 deformed bars, 30-in. long, were spaced at 40 in. across the longitudinal joint between the two 12-ft lanes. The longi-

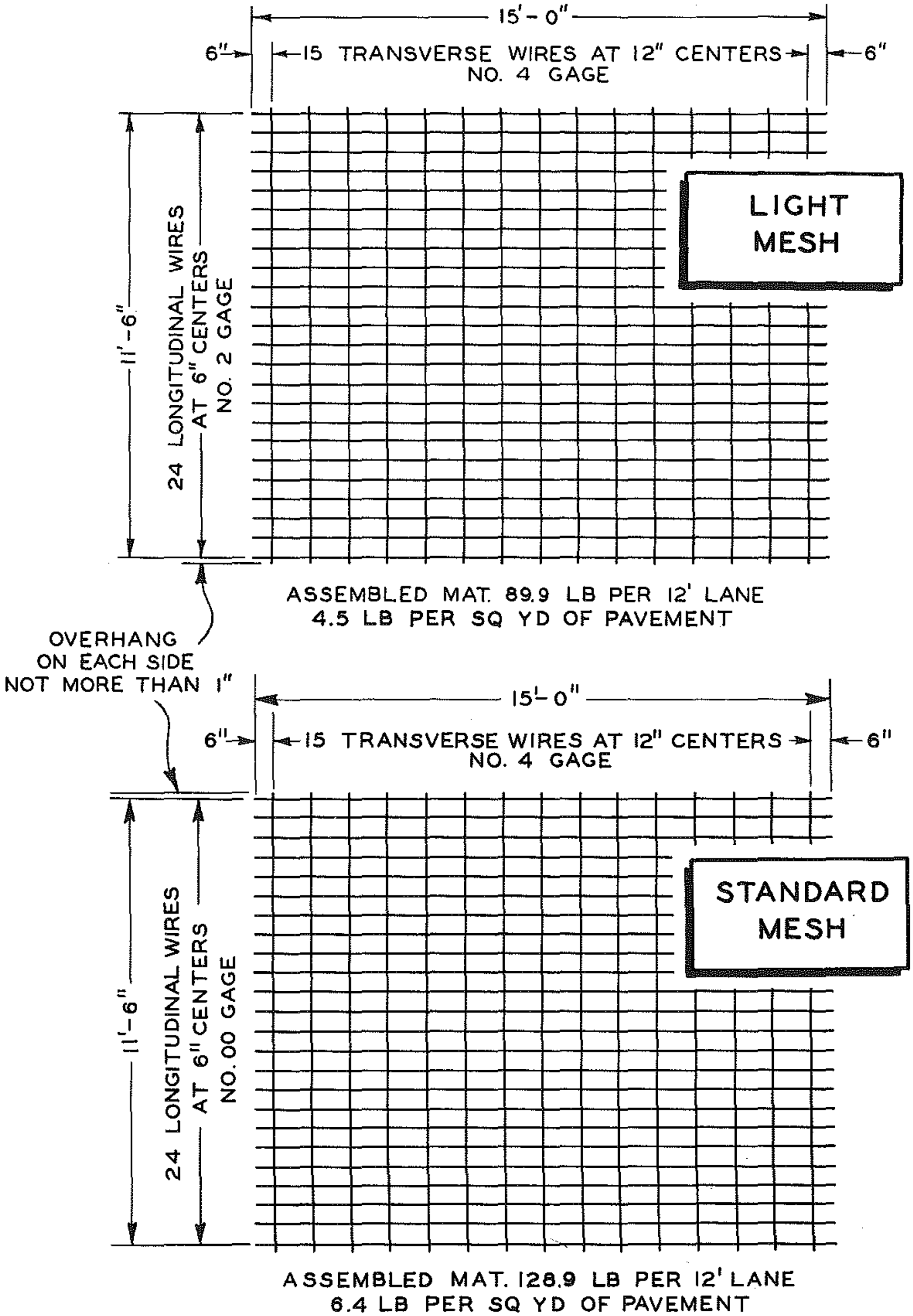


Figure 4. Details of light and standard mesh reinforcement.

tudinal centerline joint was sawed and sealed before traffic was permitted on the slab.

In constructing the pavement slab, the contractor used two 34E dual-drum mixers (one equipped with a side strike-off), a steel carrier, two Jaeger-Lakewood finishing machines, and a Heltzel Flexplane combination finisher-float machine. A self-propelled machine called a "planter," riding the forms directly behind the last mechanical finishing machine, was used to install the Unitube and the 1/4- by 2-in. premolded filler. This machine also vibrated the concrete at locations for the transverse plane-of-weakness sawcut to a depth of 2-1/2 in. to facilitate the sawing. Self-propelled Eveready concrete saws were used in all sawing operations.

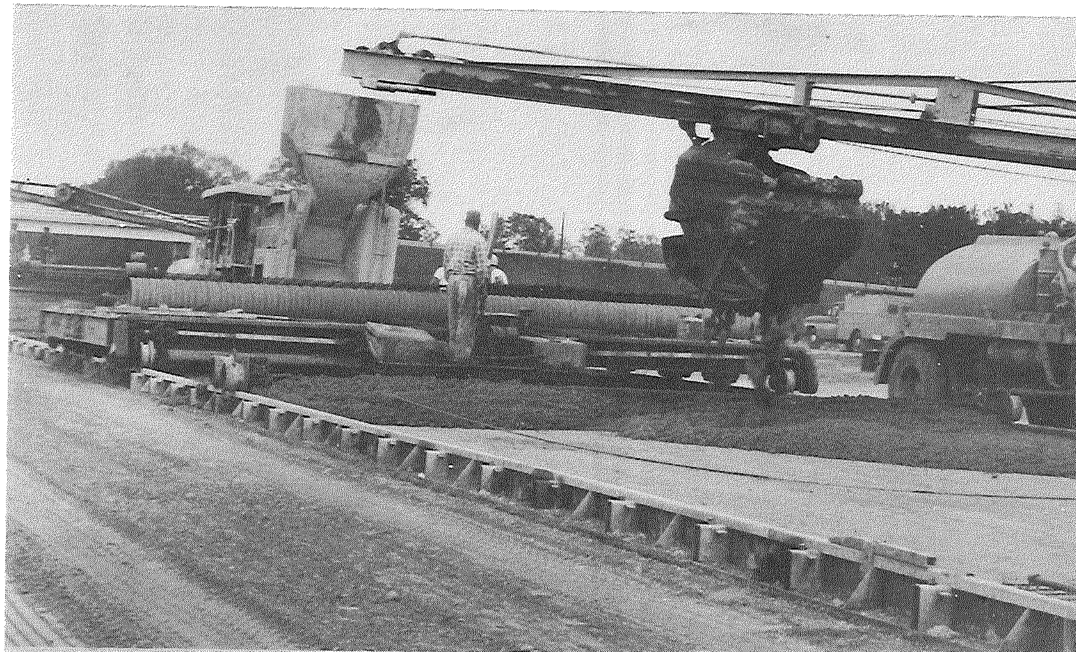
The sequence of construction operations, illustrated in Figs. 5 through 14, was as follows:

1. Placing concrete on subbase from first mixer and striking off concrete 3 in. below surface.
2. Placing transverse tie bars.
3. Placing steel reinforcement from carrier.
4. Placing final layer of concrete from second mixer.
5. Spreading and screeding concrete with Jaeger-Lakewood finishing machine.
6. Initial finishing of concrete surface with second Jaeger-Lakewood machine.
7. Final machine finishing of concrete surface with Heltzel Flexplane.
8. Forming transverse joints (installation of fillers or Unitubes).
9. Final hand finishing of concrete surface.
10. Applying burlap drag finish to concrete surface.
11. Applying white membrane curing compound.

<u>Unitube Joints</u>

This type of joint is formed by installing a metal device, called a "Unitube," a proprietary product of the Middlestadt Corp., of Baltimore, Md., in the fresh concrete at the transverse centerline of the load transfer assembly. The tube (Fig. 15) is 2-in. deep and 13/32-in. wide at the top and each length is formed from a single strip of electro-galvanized, No. 30 gage sheet steel. A built-in crown assures that the tube fits the shape of the top surface of the pavement. The installed tube forms a weakened plane for controlled cracking. The procedure for placing the tube was as follows:

1. The planter was guided into proper location and alignment, as designated by marks on the forms, and securely locked in position.



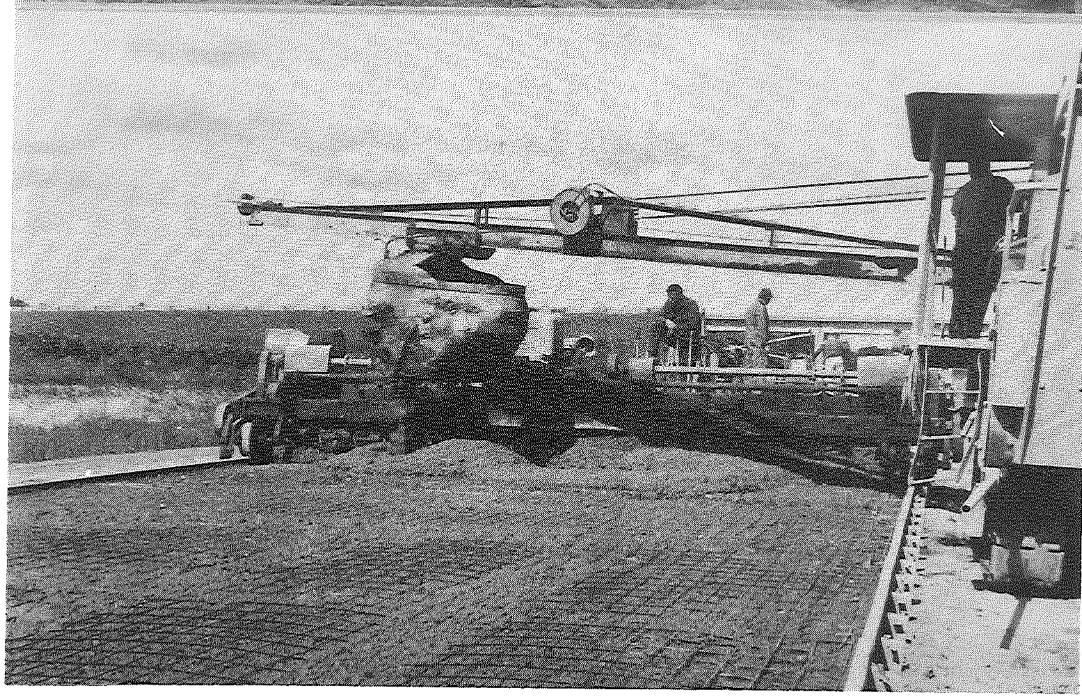


Figure 5. Placing first layer of concrete (upper left).

Figure 6. Placing wire mesh reinforcement (upper right).

Figure 7. Placing and spreading final layer of concrete with Jaeger-Lakewood finishing machine (lower left).

Figure 8. Initial finishing of concrete surface with Jaeger-Lakewood finishing machine.

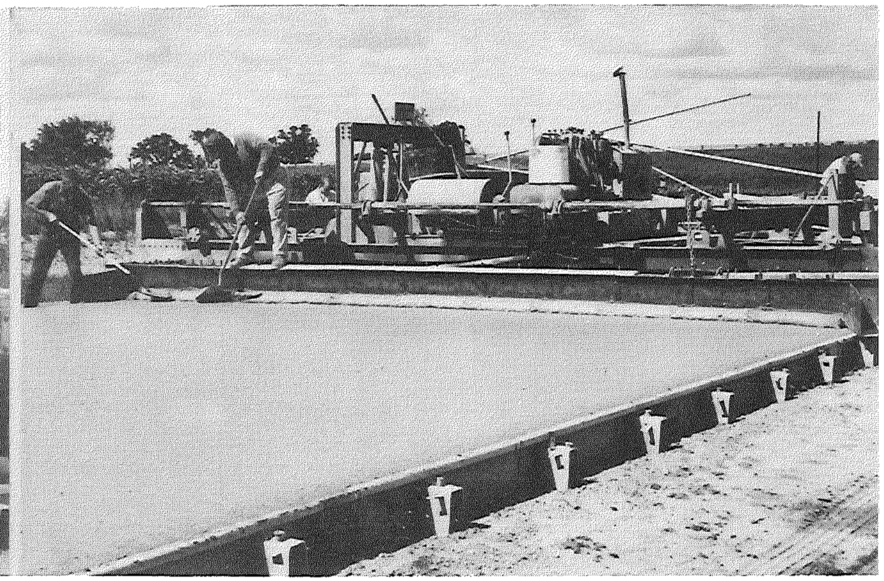


Figure 9. Final machine finishing with Heltzel Flexplane combination finisher-float machine.

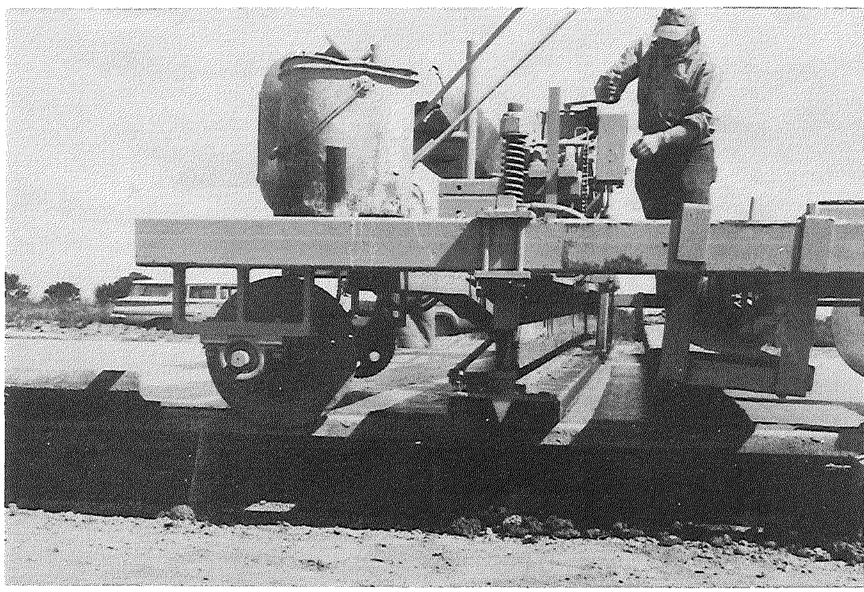


Figure 10. Unitube planter used to install Unitube, 1/4 by 2 in. premolded filler strips, and for vibrating at the locations of sawcut to form plane-of-weakness.

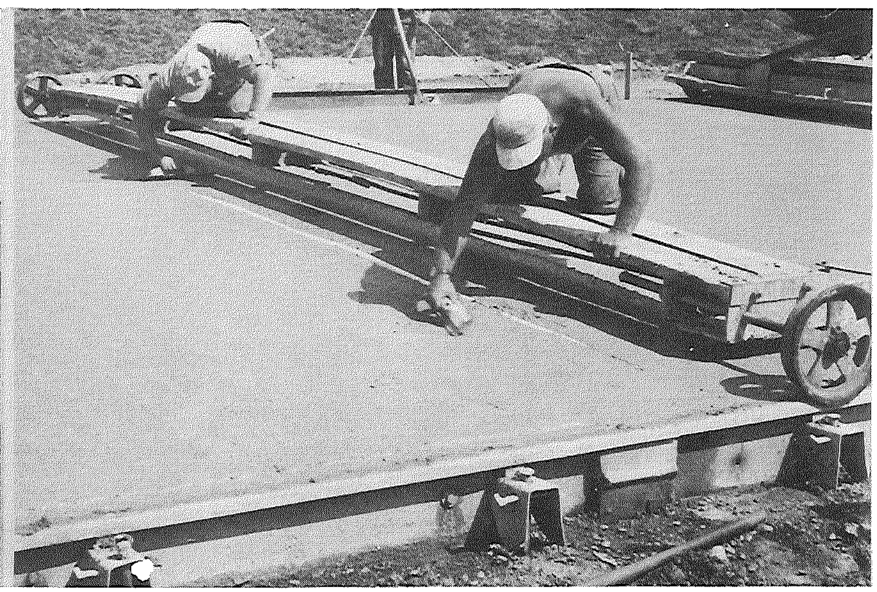
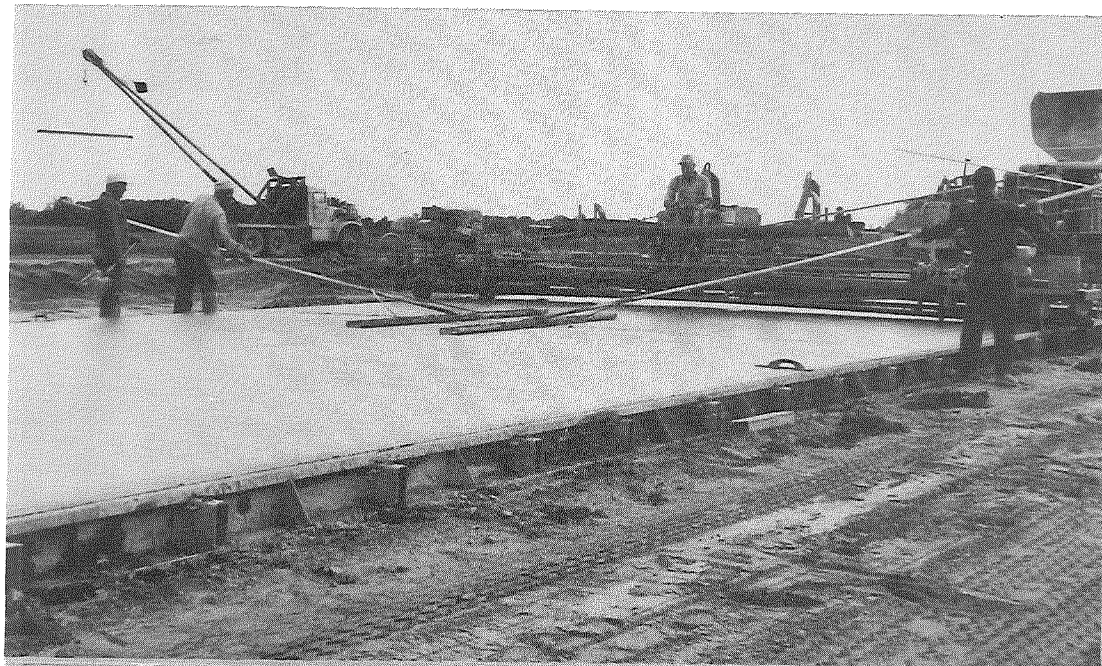
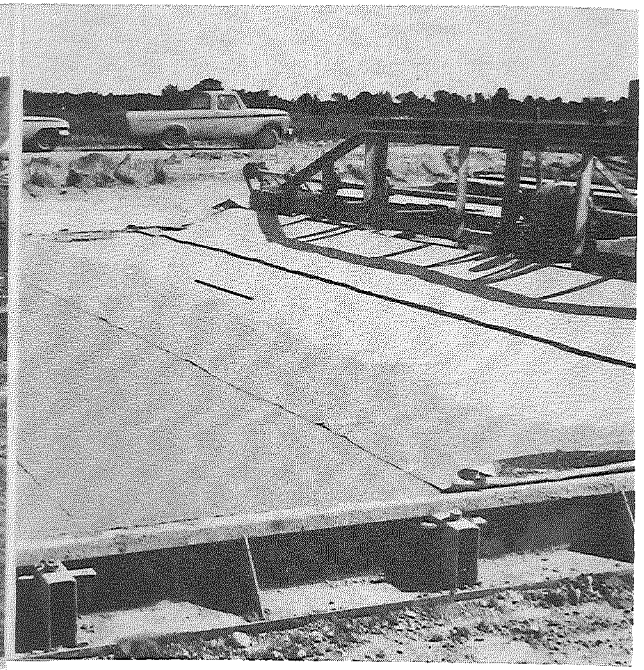


Figure 11. Installing styrofoam filler.





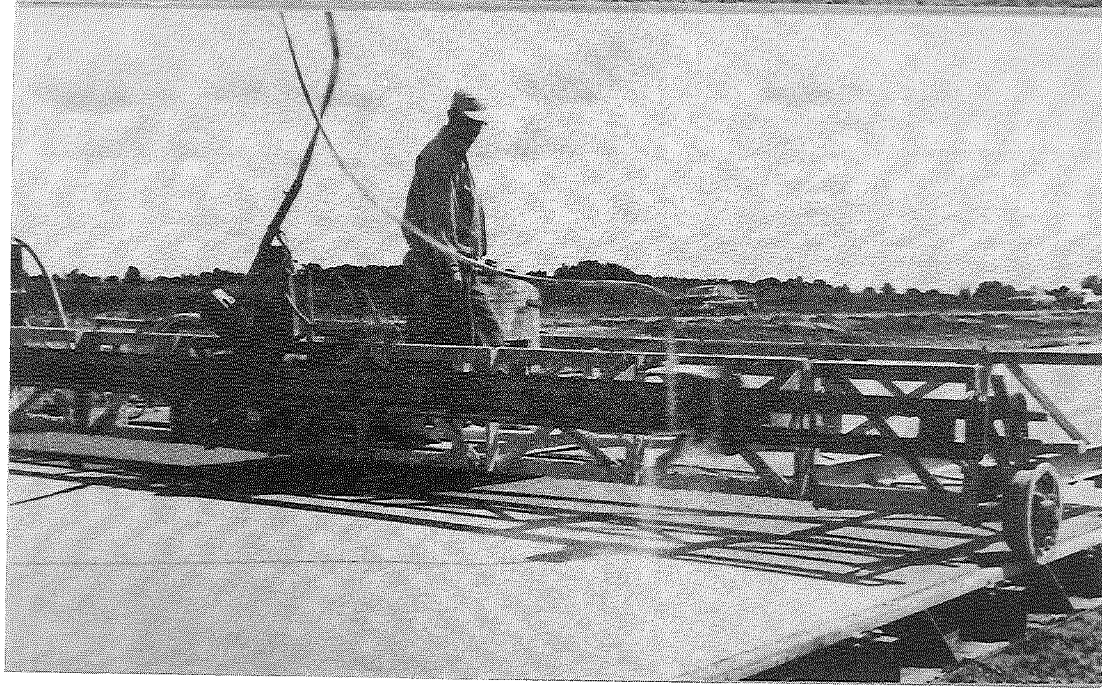


Figure 12. Final hand finishing of concrete surface (upper left).

Figure 13. Applying burlap drag finish to concrete surface (upper right).

Figure 14. Applying white membrane curing compound (lower left).

2. Two 2- by 4-in. tubular guide members, with just enough space between them for the Unitube to pass through, were lowered to the pavement surface.

3. A 5/16-in. mechanically vibrated steel T-bar was lowered between the guide members into the concrete to a depth of 2-1/2 in. to form a groove into which the tube would be inserted.

4. Upon retraction of the T-bar, two lengths of tube with open ends at the forms plugged with styrofoam to prevent mortar from entering, and spliced at the center, were placed between the guide members and slightly depressed by hand to assure proper placement.

5. The tube was then pressed into the formed groove in the concrete by lowering the T-bar to a predetermined depth so that the tube was flush to 1/8 in. below the pavement surface. The T-bar was then vibrated sufficiently to consolidate the concrete against the sides of the tube.

6. The installation was completed by final hand finishing over the tube.

After the pavement had cured for seven days, the Unitube was crimped or folded down into itself, exposing from 3/8 to 1/2 in. of joint side wall above the crimped tubing. Fig. 16 shows cross-sectional views of the tube before and after crimping. The crimping machine consists of a circular vibrating disk mounted in a movable frame. Tube crimping consists of lowering the vibrating disk into the tube to the pre-set depth, and then as the machine is pushed forward the tube is crimped. This process is shown in Figs. 17 and 18. The disk penetrates the thin layer of hardened mortar deposited over the tube during final hand finishing operations of the pavement surface, and is deposited along the joint groove as shown in Fig. 19.

At first, some difficulty was experienced in installing the Unitube to the correct depth, primarily because the machine was designed for pavements with symmetrical crown, whereas this project was constructed with the crown point offset to coincide with the center of the median lane. Thus, the tube generally was set too deep in the center portion of the median lane, creating some difficulty in crimping. However, after the operator became experienced with the installation process, and the tube was manually adjusted as to depth when required, no further serious difficulties were encountered. It is understood that the manufacturer is now designing an installing machine that can be adjusted to fit various crown designs so that difficulties of the type encountered here may be eliminated in the future.

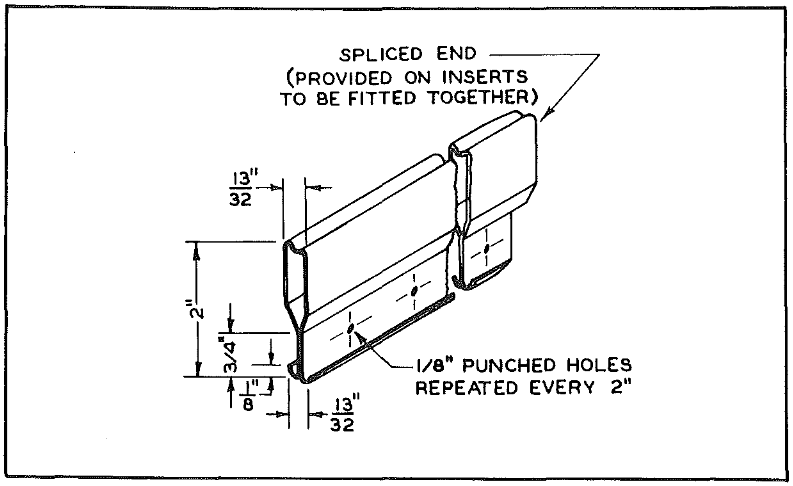


Figure 15. Unitube device.

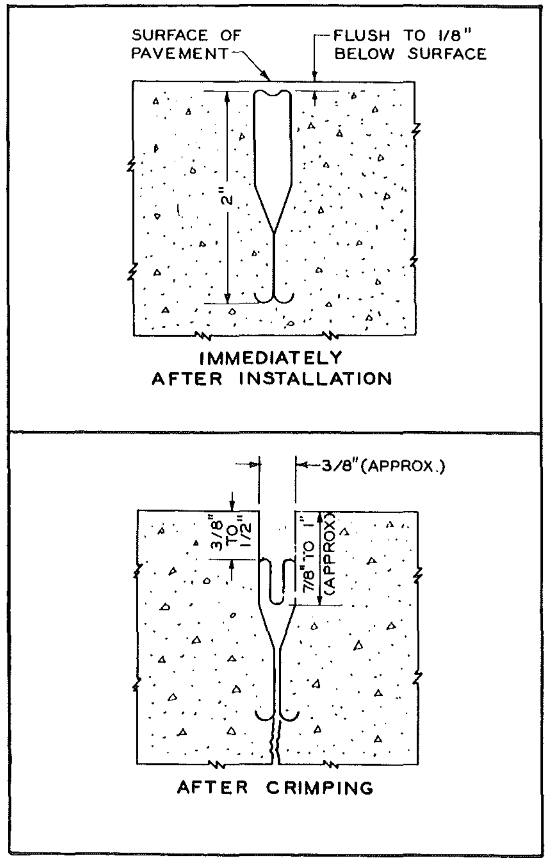


Figure 16. Cross-sections of Unitube joint.

Figure 17. Crimping the Unitube.

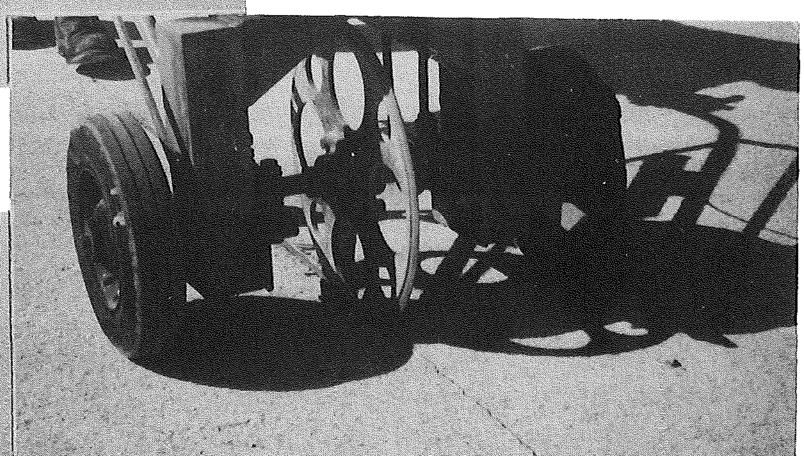


Figure 18. Vibrating crimping disk.

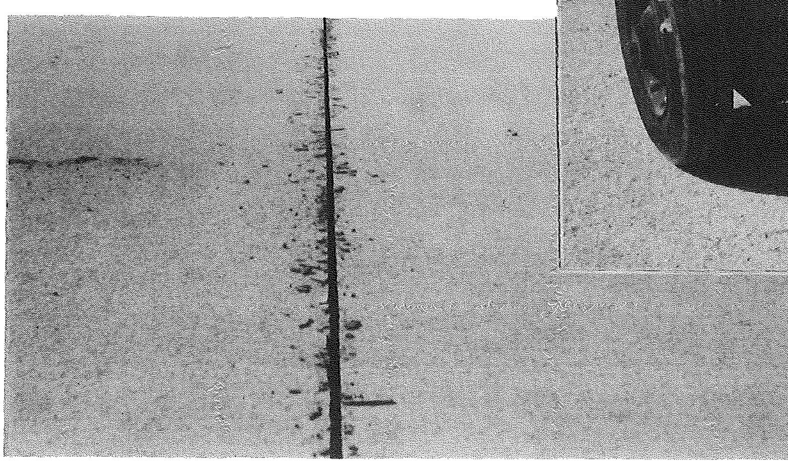


Figure 19. Condition of newly crimped joint.

Sawed Joints with Filler Strips

Premolded bituminous filler strips 1/4-in. thick, 2-in. deep, and 6-ft long, were used to form the plane-of-weakness for controlled cracking. The flexibility of the filler strips made it difficult to obtain proper vertical and transverse alignment of the filler when installed manually. Therefore, the Unitube planting machine was used to place the filler strips in the fresh concrete, using the same installation procedure. Considerably better horizontal and vertical alignment was obtained using the planter.

The required joint grooves, specified for the various sections, were sawed after the seven-day curing period. To facilitate removal of the top portion of the filler, it was scored on each 2-in. face to a depth of 1/16 in., at 1/2, 3/4, and 1 in. from the top edge to meet the required joint groove depths of the various sections. Table 2 shows the number and type of blades, sawing speed, and depth variations for the joint grooves.

TABLE 2
SUMMARY OF TRANSVERSE JOINT SAWCUTTING

	Section	Specified Joint Groove Size, in.	No. of Blades on Saw Arbor*	Blade Type	Sawing Speed, ft per min	Depth Variation, in.
With filler strip	1W, 6W, 8W	1/2 by 1/2	1	Carborundum	11.0	+1/8
With filler strip	2W, 5W, 7W	3/4 by 3/4	7	Diamond	4.8	±1/8
With filler strip	4W	1 by 1	10	Diamond**	4.0	-1/4+1/8
Without filler strip	1E	1 by 1	10	Diamond	3.5	±1/4
Without filler strip	2E, 4E, 7E	3/4 by 3/4	7	Diamond	7.4	±1/8
Without filler strip	3E, 5E, 8E	1/2 by 1/2	5	Diamond	18.0	+1/8

* Contractor used blades already worn from cutting centerline joint.
** Temporary filler sawed out by carborundum blade before sawing joint groove.

Sawed Joints without Filler Strips

In six of the seven test road sections where this type of contraction joint was constructed, the contractor used the Unitube planter to displace larger aggregate particles by vibrating the plastic concrete at all joint locations to a depth of 2-1/2 in. This facilitated sawing of the initial 1/8- by 2-in. deep plane of weakness cut for controlled cracking.

Vibration at the joint locations occurred immediately after the final machine finish had been applied to the pavement surface. Surface roughness remaining after the T-bar was retracted was smoothed away during hand finishing operations. After the burlap drag finishing, the vibrated locations were marked by holding a string across the centerline of the load transfer assembly and snapping it to form a line in the fresh concrete. This line then served as a guide for the initial sawcut, which occurred from 6 to 24 hr after pouring.

A wet diamond saw was used in sawing the planes-of-weakness in the first two days' pours. However, sawing the green concrete caused excessive blade wear because of loose sand particles acting as an abrasive on the blade. Therefore, carborundum blades were tried and used with success for the remaining joints in these six sections.

In Section 5E, the seventh test section of this type, for comparison purposes, vibration prior to the initial sawcut was omitted at 15 contraction joints from Sta. 666+02 to Sta. 675+98. These 15 joints, due to the presence of the larger aggregates at the sawcut location, were cut approximately 24 hr after pouring and required the use of diamond blades. In the contractor's opinion, earlier sawing of these non-vibrated joints would have risked dislodging rather than cutting of the aggregate.

Weather conditions during the sawing were very favorable for this type of operation. In most cases, the days were partly cloudy and humid, with moderate-velocity winds and an average recorded daily temperature variation of 22 deg. Under these conditions, the earliest time the vibrated concrete could be sawed without excessive raveling of the edges was 6 hr after pour. Generally, the morning pour was sawed in the late afternoon or early evening of the same day, and the afternoon pour in the early morning hours of the following day. No random cracking was experienced ahead of the saw during sawing or at locations between joints.

The average sawing speed with either type of blade was 6.8 ft per min at joints where a groove had been vibrated, while a sawing speed of 4.4 ft per min was obtained at the 15 joints where the vibration had been omitted. Range in concrete age when the plane-of-weakness was established by sawing in each day's pour, type of blade used, air temperature and average daily weather conditions, are shown in Table 3. Figs. 20 and 21 show the equipment used and typical sawcuts made with both types of blades in concrete at various ages.

The required joint grooves, as specified for the various sections, were sawed after the pavement had cured for seven days or more. Blade number, type, and sawing speed, and variation in groove depth are given in Table 2.

Styrofoam Joints

Two sections (3W and 6E) were constructed with contraction joints in accordance with current Departmental standard practice. Styrofoam strips 1/2-in. wide and 2-in. deep were installed in manually formed channels in the fresh concrete, and the surface in the joint area was finished by hand troweling. These filler strips formed the plane-of-weakness for crack control and also formed the joint groove. After initial curing of the slab, the styrofoam was removed completely, leaving a joint groove of 1/2 by 2 in.

Joint Sealing

Fig. 22 illustrates the condition of a typical joint of each of the four types of joint forming utilized, prior to sandblasting. Joint sealing was preceded by sandblasting of the joint groove and the immediately adjacent pavement surface as shown in Fig. 23. Just prior to sealing with a hot-poured rubber-asphalt type compound, the joint groove was cleaned by a jet of compressed air (Fig. 24). The sealer was heated in a double-boiler, thermostatically controlled kettle and applied to the joint through a conical hand-poured pot. Some joints were sealed using a mechanical pouring pot of the double-boiler type. The sealing process is illustrated in Figs. 25 through 27. Under provisions in the supplemental specifications, no traffic was allowed on the pavement until transverse joints were sealed.

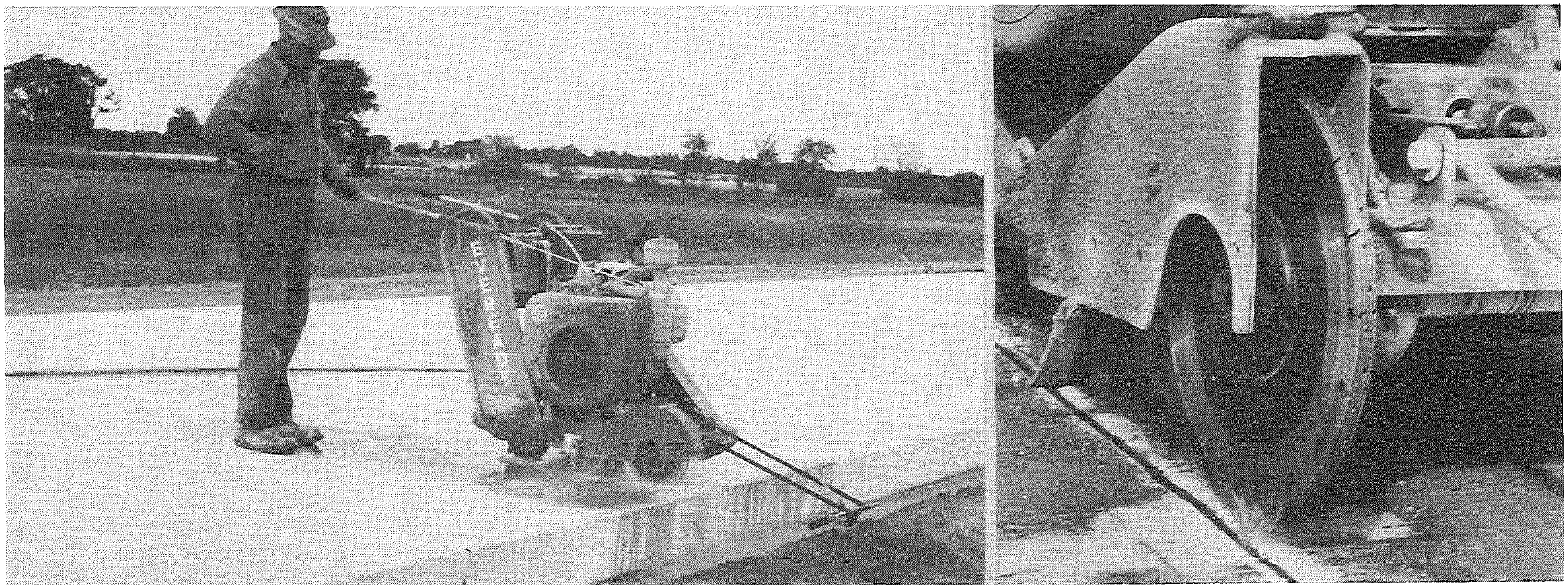
INSTRUMENTATION AND MEASUREMENTS

This experimental pavement was constructed to evaluate field performance of transverse joints in relation to slab length, joint groove configuration, and joint forming methods. In evaluating field performance,

TABLE 10
PLANE-OF-WEAKNESS SAWCUT DATA

Date Poured	Date Sawed	Range in Concrete Age at time of sawing, hr	Number of Joints Sawed	Saw Blade Type	Construction Site Air Temperature			Sky Cover, in tenths*	Relative Humidity, percent*	Wind Velocity, mph*
					High	Mean	Low			
9-11-62	9-12-62	17 to 23	29	Diamond	72	59	50	6	67	16
9-12-62	9-12-62	6 to 9	17	Diamond	84	68	50	2	69	14
	9-12-62	7 to 10	11	Diamond						
	9-13-62	14 to 15	4	Diamond						
9-13-62	9-13-62	6 to 7	4	Carborundum	82	68	60	6	86	15
	9-13-62	6 to 9	10	Carborundum						
	9-14-62	16 to 18	11	Carborundum						
9-14-62	9-14-62	6 to 10	15	Carborundum	74	63	55	3	64	10
	9-15-62	17 to 18	12	Carborundum						
9-17-62	9-17-62	7 to 10	9	Carborundum	67	58	48	7	73	16
	9-18-62	17 to 20	25	Carborundum						
9-18-62	9-18-62	8 to 10	12	Carborundum	66	55	45	5	64	16
	9-19-62	17 to 20	32	Carborundum						
9-19-62	9-19-62	9 to 11	8	Carborundum	57	48	40	5	73	12
	9-20-62	18 to 22	22	Carborundum						
	9-20-62	25 to 26	13**	Diamond						
9-20-62	9-21-62	24	2**	Diamond	51	41	31	5	65	9
9-21-62	9-22-62	17 to 20	11	Carborundum	60	47	32	5	67	8
9-24-62	9-24-62	7 to 8	8	Carborundum	70	57	47	5	71	10
	9-25-62	18 to 22	36***	Diamond						
9-25-62	9-26-62	17 to 23	24	Carborundum	55	53	49	10	83	13

* Obtained from nearby weather station (24 hr averages).
** No vibration before sawing.
*** Carborundum blades not available.



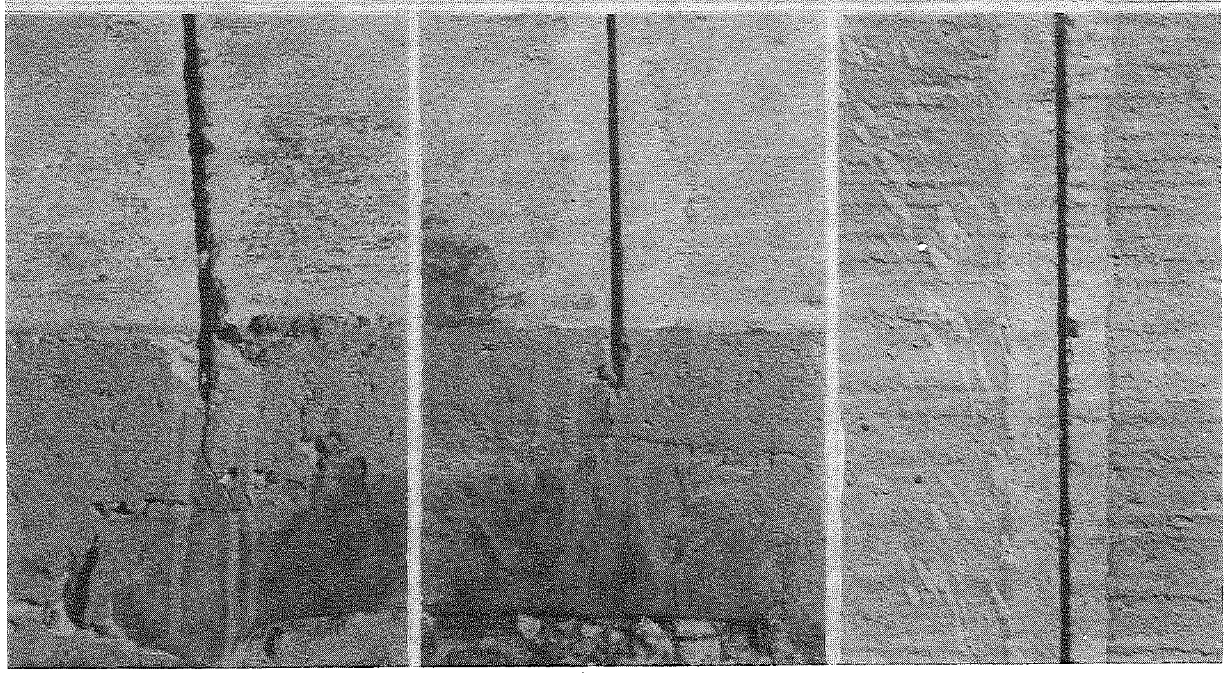


Figure 20. Sawcutting transverse joint grooves with diamond blades is shown above. Typical plane-of-weakness cuts include one at a vibrated joint 6 to 7 hr after pour (lower left), at a vibrated joint 15 to 18 hr after pour (lower center), and at a non-vibrated joint 24 to 25 hr after pour (lower right).

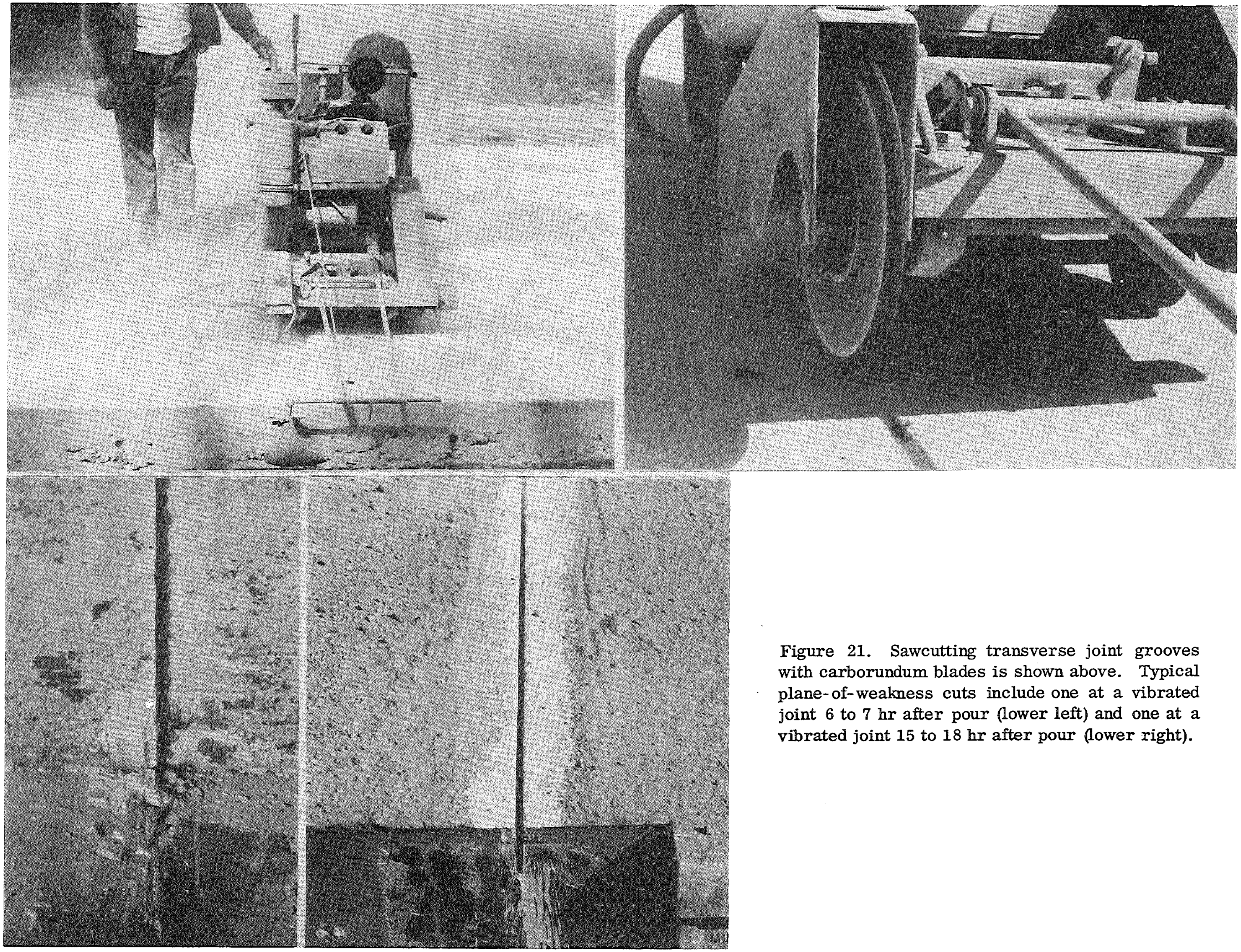


Figure 21. Sawcutting transverse joint grooves with carborundum blades is shown above. Typical plane-of-weakness cuts include one at a vibrated joint 6 to 7 hr after pour (lower left) and one at a vibrated joint 15 to 18 hr after pour (lower right).

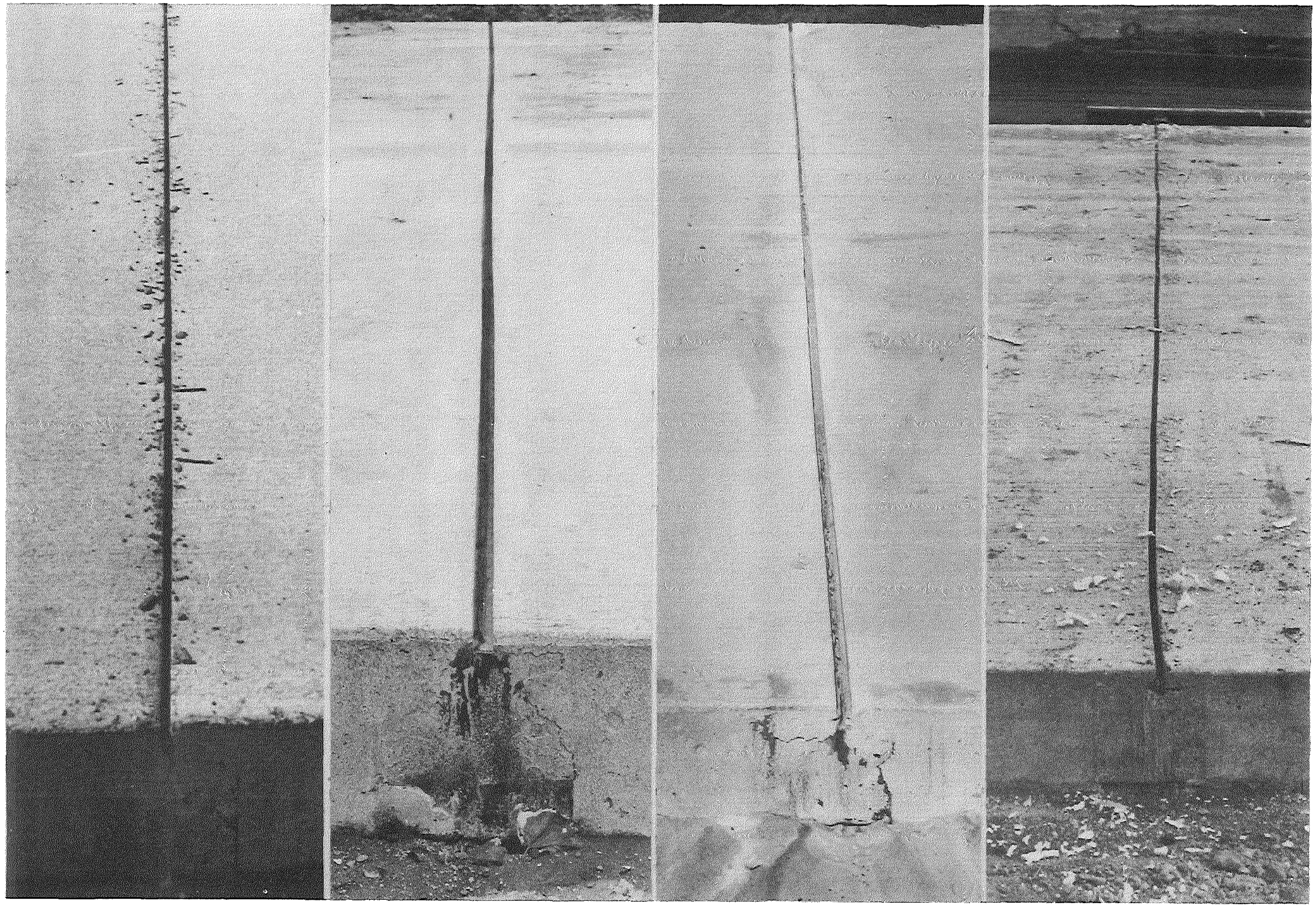


Figure 22. Typical joints before sandblasting: from left, Unitube, sawed with filler strip, sawed without filler strip, and styrofoam.

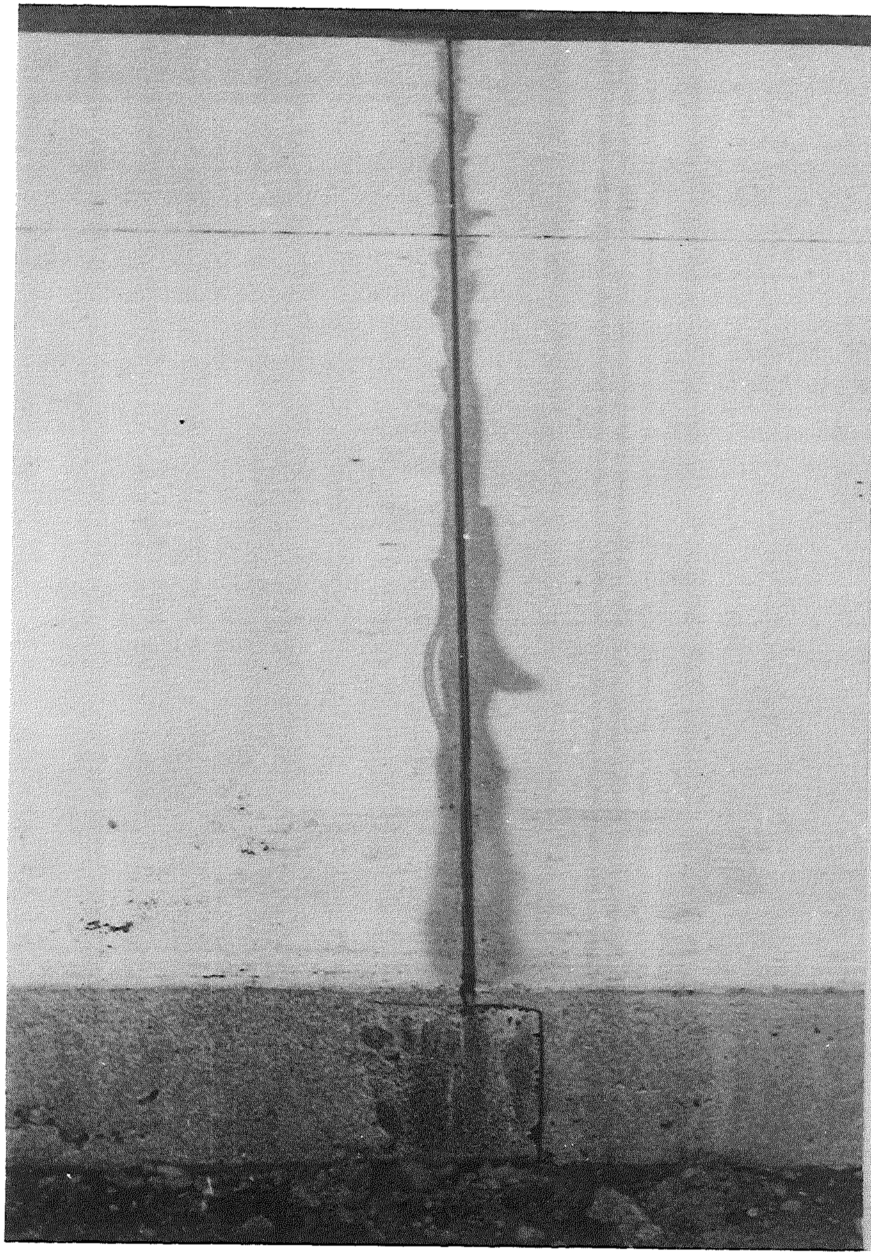


Figure 23. Condition of typical joint after sandblasting.

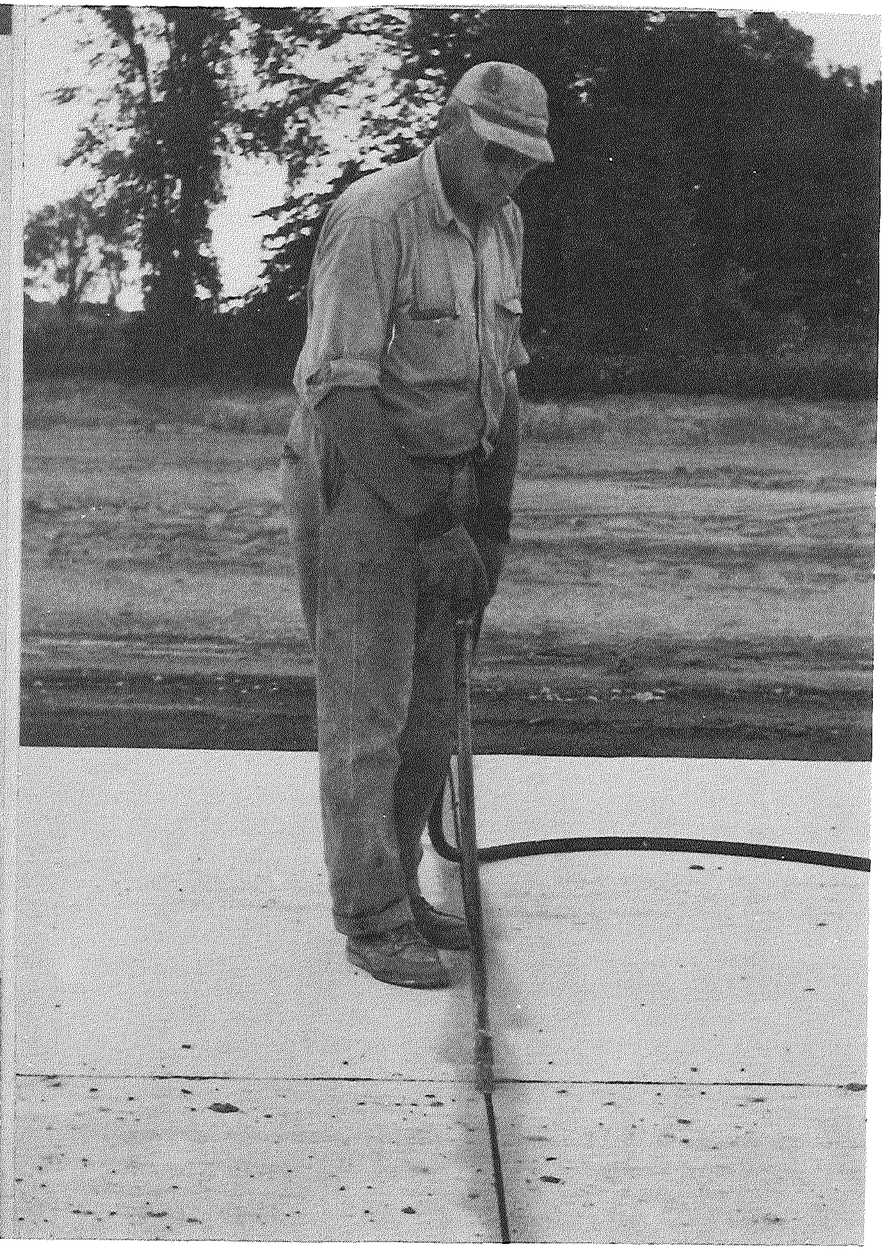
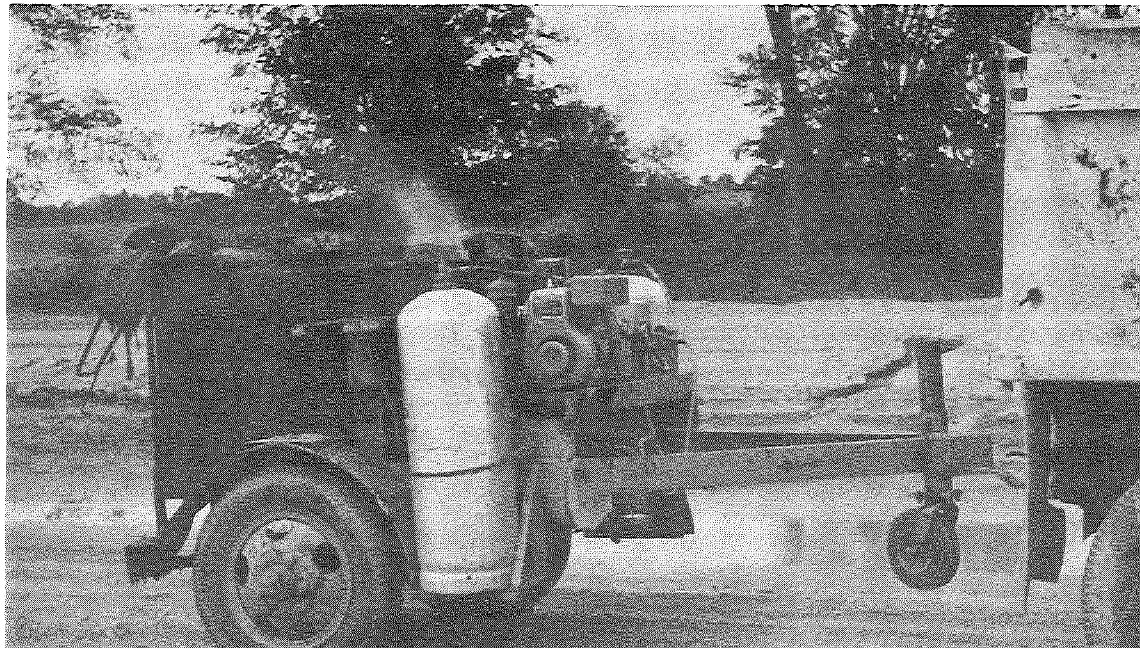


Figure 24. Cleaning joint with compressed air just before sealing.



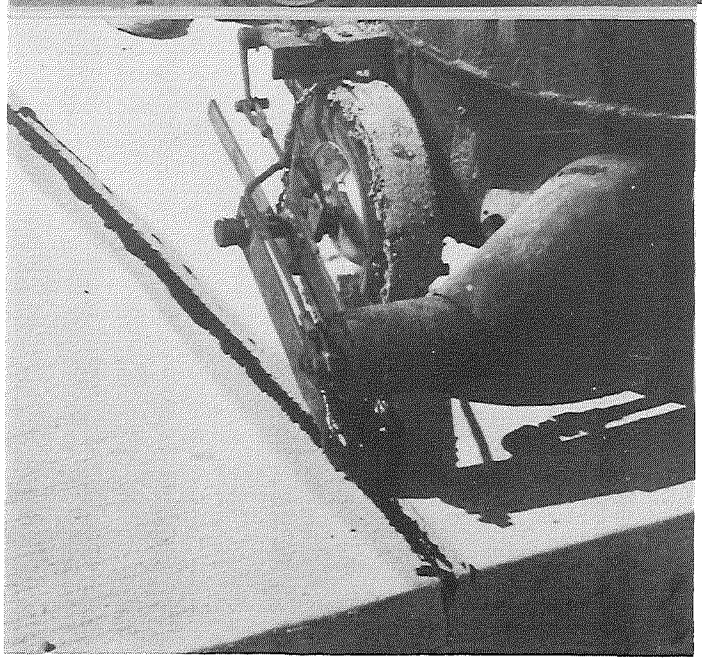


Figure 25. Double-boiler, thermostatically controlled kettle (upper left).

Figure 26. Sealing joint with hand-poured pot (right).

Figure 27. Sealing joint with mechanical pouring pot of the double-boiler type (lower left).

the following factors are being studied:

1. Longitudinal and transverse cracking of individual slabs.
2. Spalling and corner cracking at transverse joints.
3. Adhesion and cohesion failures of the sealer.
4. Magnitude and variation in width of joint opening.
5. Initial surface roughness and roughness changes with time and traffic.

In addition to instrumentation installed during construction and initial records involving climate and materials, further observations will continue over a period of years, until sufficient data have been obtained to warrant conclusions.

Air Temperature

A record of daily air temperatures throughout the construction period was obtained by means of a Taylor seven-day temperature recorder. Table 4 shows high, mean, and low temperatures for each 24-hr day throughout construction. Average monthly air temperature in the vicinity of the experimental project will be obtained throughout the test period from a local station of the United States Weather Bureau.

Concrete Properties

In the Unitube sections, four beams were taken for modulus of rupture testing at the usual intervals as required during construction. In each of the other sections, a set of four beams was taken at the instrumented location. Two of every four specimens were tested at 7 days and two at 14 days. Modulus of rupture values, along with daily construction progress and air temperature readings, are given in Table 5.

Joint Width Changes

In each of the 18 test sections, ten consecutive joints were instrumented with gage plugs for joint width readings. The gage plugs are 2-in. long by 1/4-in. diam stainless steel countersunk-head rivets, with appropriately machined conical holes in the rivet head. Three sets of gage plugs were placed in the concrete at each joint just after burlap drag finishing, 12 in. from the pavement edge in the traffic and passing lanes, and 12 in. from the longitudinal joint centerline in the traffic lane. Each set was placed symmetrically about the transverse joint centerline 8-in. apart. Initial

TABLE 4
DAILY AIR TEMPERATURE VARIATION

Date	Degrees F			Date	Degrees F		
	High	Mean	Low		High	Mean	Low
7-24-62	Not recorded			8-26-62	68	63	60
7-25	77	67	56	8-27	75	64	53
7-26	67	59	47	8-28	84	69	56
7-27	78	61	44	8-29	86	71	58
7-28	68	61	51	8-30	86	72	58
7-29	76	66	58	8-31	79	70	64
7-30	79	67	60	9-1	74	67	55
7-31	74	64	55	9-2	81	65	48
8-1	75	63	52	9-3	79	67	55
8-2	78	63	46	9-4	77	67	57
8-3	81	68	55	9-5	61	51	41
8-4	86	72	62	9-6	68	50	34
8-5	80	69	59	9-7	73	56	37
8-6	69	64	60	9-8	74	61	48
8-7	82	67	58	9-9	72	68	61
8-8	78	64	57	9-10	70	65	56
8-9	71	61	51	9-11	72	59	50
8-10	74	62	48	9-12	84	68	50
8-11	77	64	48	9-13	82	68	60
8-12	74	67	59	9-14	74	63	55
8-13	64	59	54	9-15	72	60	51
8-14	70	60	51	9-16	79	63	51
8-15	75	60	43	9-17	67	58	48
8-16	76	65	57	9-18	66	55	45
8-17	70	58	47	9-19	57	48	40
8-18	76	60	44	9-20	51	41	31
8-19	86	72	58	9-21	60	47	32
8-20	78	69	61	9-22	57	49	44
8-21	80	67	57	9-23	66	51	40
8-22	80	64	50	9-24	70	57	47
8-23	85	70	54	9-25	55	53	49
8-24	88	75	60	9-26	60	50	44
8-25	76	70	64				

TABLE 5
CONSTRUCTION DATA

	Pour Date	Length, ft	Stationing	Modulus of Rupture, psi(1)		Air Temp., deg F		
				7 day	14 day	High	Mean	Low
Eastbound	7-24-62	1366	795+00 to 808+66			Not recorded		
	7-25-62	2974	808+66 to 838+40	616*	800*	77	71	62
	7-26-62	3376	838+40 to 872+16			67	62	50
	7-27-62	2922	872+16 to 901+38	696	956	78	69	50
	7-30-62	2791	901+38 to 929+29			79	71	60
	7-31-62	2917	930+97 to 960+14	667	1083	74	66	57
	8-1-62	3603	960+14 to 996+17			75	69	58
	8-2-62	3434	996+17 to 1030+51			78	71	54
	8-3-62	3380	1030+51 to 1064+31	679	1025	81	75	63
	8-6-62	1588	1069+12 to 1085+00			69	66	64
Westbound	8-7-62	2858	1085+00 to 1051+54			82	74	65
	8-8-62	2461	1051+54 to 1026+93			78	69	60
	8-9-62	2975	1026+93 to 997+18	783	1075	71	67	56
	8-10-62	3090	997+18 to 965+47	812	1118	74	69	58
	8-13-62	2979	965+47 to 935+68	721	1137	64	59	55
	8-14-62	2392	935+68 to 910+09			70	65	54
	8-15-62	3140	910+09 to 879+55	800	1029	75	67	48
	8-16-62	3372	879+55 to 845+83			76	70	60
	8-17-62	3448	845+83 to 811+35	779	1154	70	64	50
	8-20-62	613	811+35 to 805+33			78	70	66
	8-21-62	2850	805+33 to 776+23			80	73	61
	8-22-62	1494	776+23 to 761+29	816	1175	80	70	55
	8-27-62	2132	761+29 to 739+97	687	1154	75	69	62
	8-28-62	3263	739+97 to 707+16	608	1142	84	76	60
	8-29-62	3071	707+16 to 676+45	787	1129	86	78	61
	8-30-62	3119	676+01 to 644+83	696	1132	86	79	60
	8-31-62	2864	644+83 to 616+19	729	1117	79	72	66
	9-4-62	3163	616+19 to 584+56	829	1165	77	71	64
	9-5-62	2969	584+56 to 554+03	784	1157	61	55	43
	9-6-62	3226	554+03 to 521+55	771	1230	68	58	36
	9-7-62	3158	521+55 to 489+97			73	63	39
	9-10-62	2207	489+97 to 467+90	762	1154	70	67	61
Eastbound	9-11-62	3065	468+15 to 498+80	821	1152	72	64	55
	9-12-62	3263	498+80 to 531+43	783	1169	84	76	57
	9-13-62	2473	531+43 to 556+16	842	1200	82	72	60
	9-14-62	2679	556+16 to 583+48	754	1179	74	67	55
	9-17-63	2712	583+48 to 610+60	758	1217	67	61	56
	9-18-62	3127	610+60 to 641+87			66	61	49
	9-19-62	3268	641+87 to 674+55	725	1196	57	51	46
	9-20-62	2452	674+55 to 699+52	812	----**	51	46	31
	9-21-62	2931	699+52 to 728+83			60	52	34
	9-24-62	3032	728+83 to 759+15	687	1012	70	63	47
	9-25-62	3257	759+15 to 791+72	608	996	55	54	53
	9-26-62	268	791+72 to 794+40			60	53	45

(1) Average of two specimens.
* Only one specimen available.
** Specimen broken in transit.

readings were taken just after the initial set of the concrete with a Starrett 0.001-in. vernier caliper and a second set of readings was taken again just before installing the joint seal. Figs. 28 through 30 illustrate the sequence of operations. The widths of the 180 instrumented joints will be measured in January and July of each year throughout the test period.

Concrete Temperature

A temperature well for the mid-depth slab temperature was placed in the center of the traffic lane and 3 ft ahead of the first instrumented joint in each of the 18 sections. This well was formed by inserting a template (Fig. 31) consisting essentially of a 5-1/4-in. long by 1-in. diam bar reduced to 3/8-in. diam at a point 2 in. from the top, into and flush with the concrete surface, just after the burlap drag finishing operation. After initial set of the concrete, the template was removed and a hollow, 1-1/2-in. long, brass plug, with appropriate cap screw (Fig. 32), was placed in the formed hole and cemented with hot sulphur. Liquid mercury was poured into the well to a depth of 1 in. Slab temperature readings were recorded at the time of joint width measurements, and will be measured at the 18 locations in January and July in conjunction with the joint width readings. In addition, the concrete temperature was measured at each of the joints at the time of plug installation (Fig. 33).

Joint and Sealer Condition

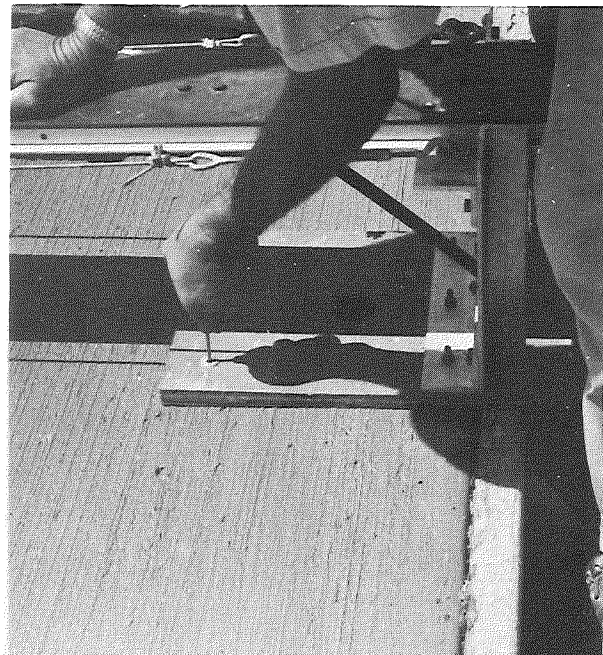
An initial condition survey of the 180 instrumented joints was made November 27, 1962. In conjunction with this survey, joint width movement and slab temperature were measured, and joint spalling and corner breaks were recorded. First photographs were taken for a continuous pictorial record of performance. Similar condition surveys of joint and sealer performance will be made in January and July of each year throughout the test period.

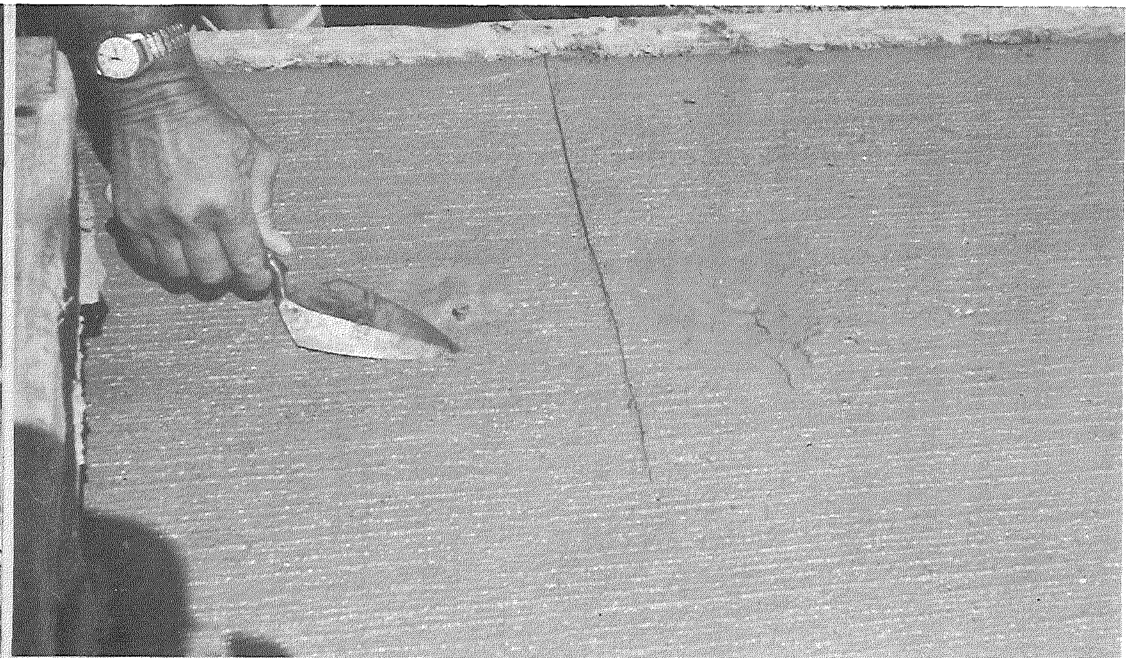
Pavement Condition

A general pavement condition survey will be made once each year throughout the test period.

Surface Roughness

The initial surface roughness index was obtained November 30, 1962, twelve days before opening of the project to traffic. Roughness will be measured once each year throughout the life of the project.





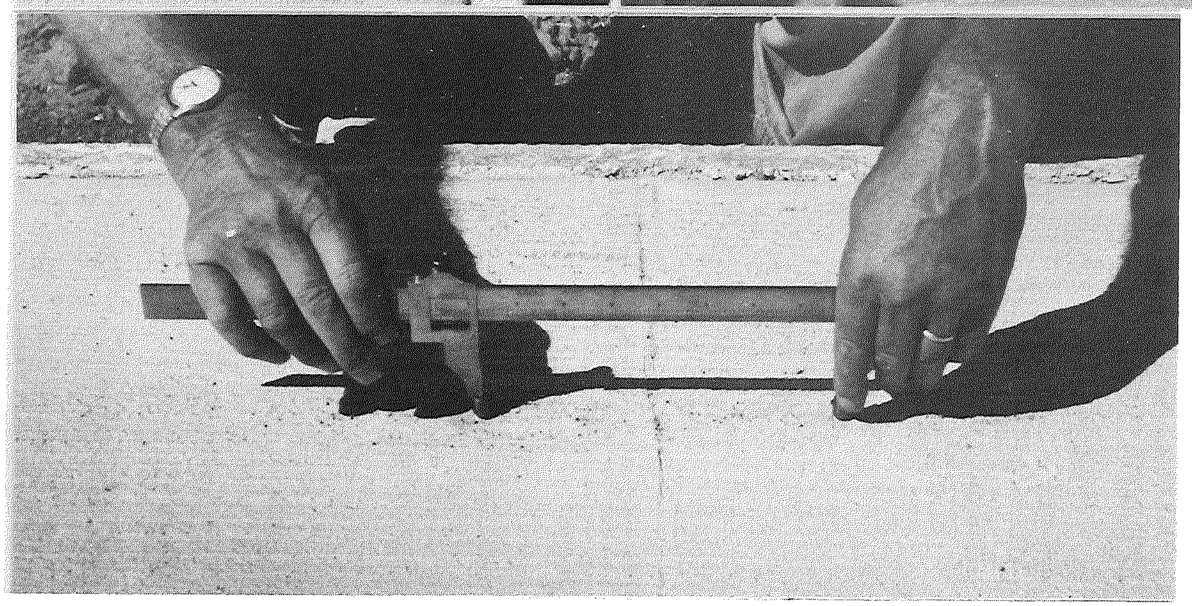


Figure 28. Setting plugs for measurement of relative joint displacement (upper left).

Figure 29. Finishing concrete surface after setting plugs (upper right).

Figure 30. Measuring relative joint displacement (lower left).

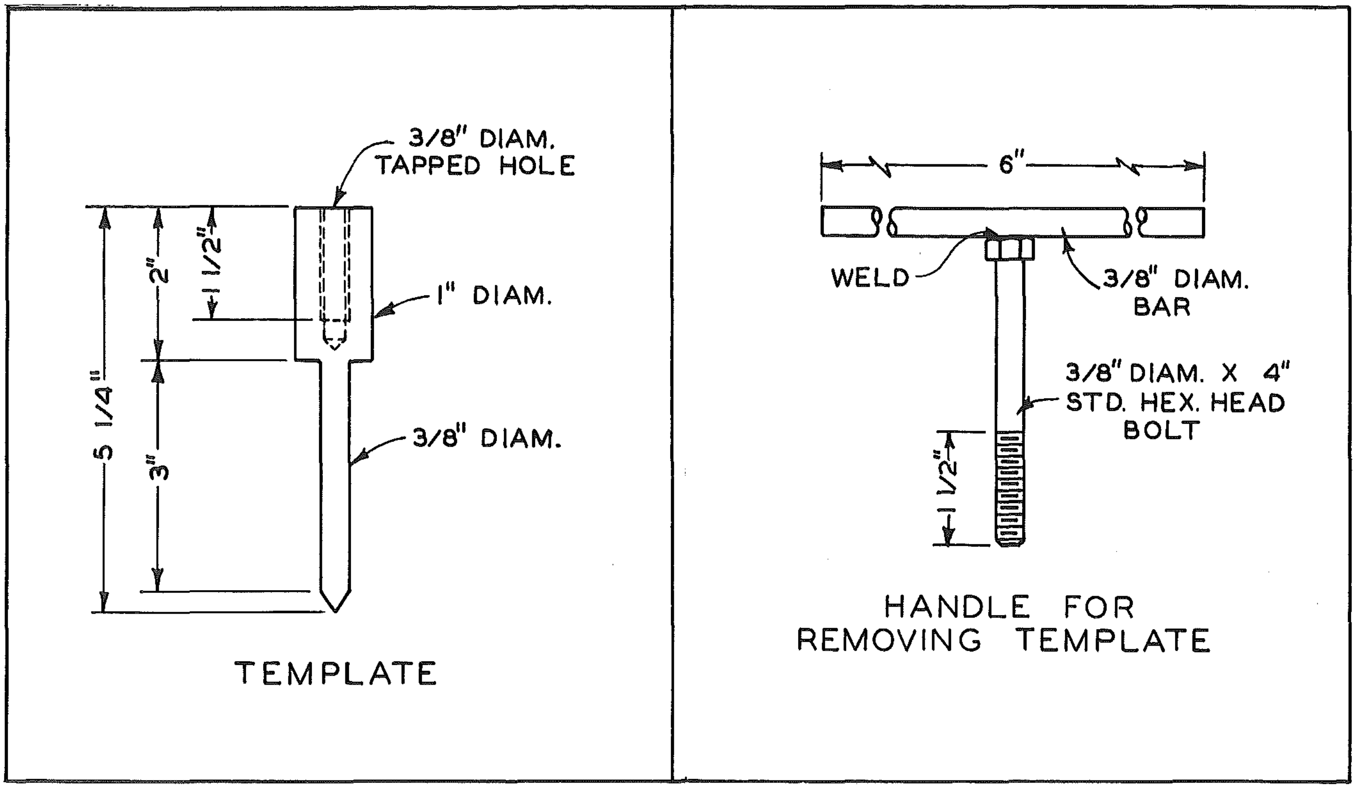
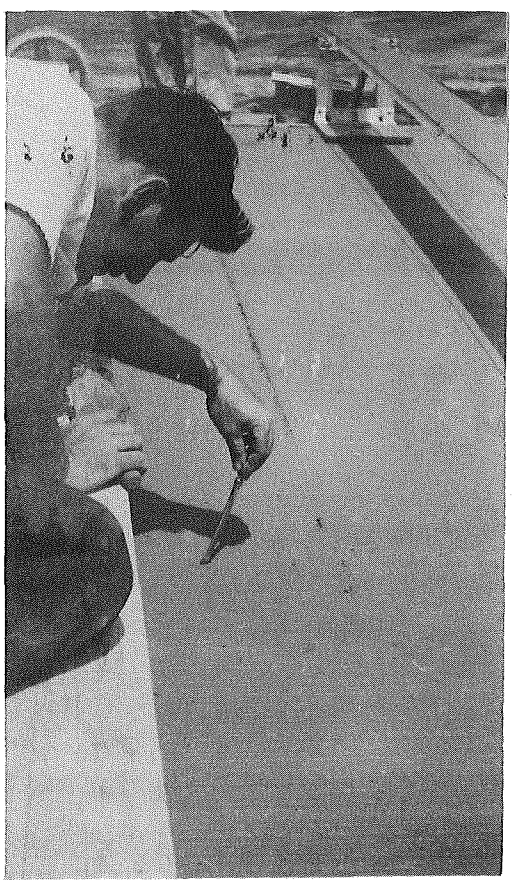


Figure 31. Template for forming temperature well.



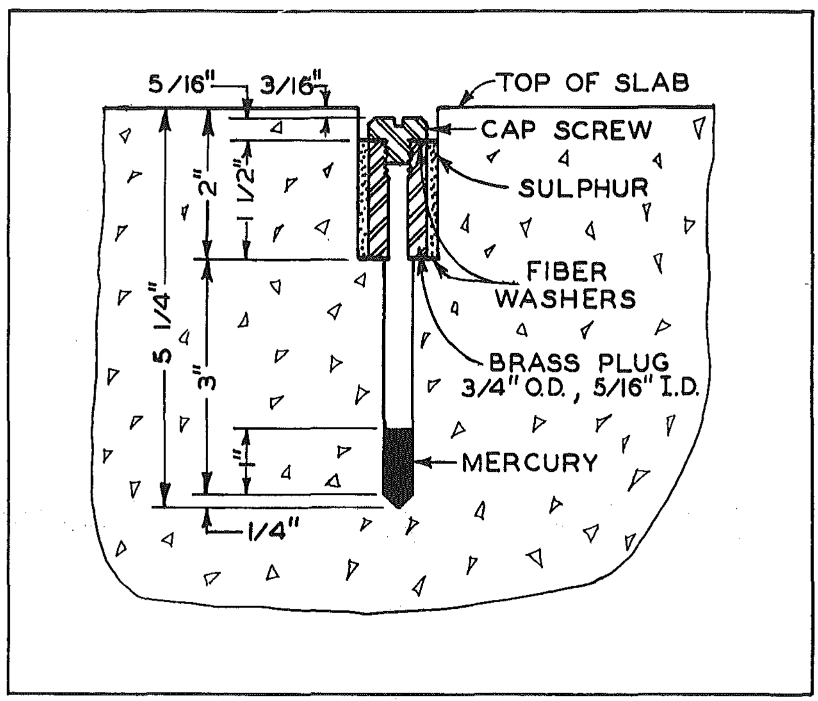


Figure 32. Cross-section of temperature well (above).

Figure 33. Taking slab temperatures (left).

Traffic Surveys

As supplementary information, traffic surveys will be made each year to determine axle weights and frequencies and average daily traffic.

Schedule of Performance Studies

In summary, the continuing performance observations will include the following:

1. Monthly reports of average air temperature.

2. Semi-annual readings of width changes at 180 instrumented joints, and slab temperature at 18 temperature wells, with a semi-annual survey of joint and sealer condition.

3. Annual surveys of general pavement condition, surface roughness, and prevailing traffic conditions.

REFERENCE

Oehler, L. T. "Michigan's Test Road for Transverse Joints: I 96 from Meridian Road to Wallace Road." MSHD Research Report No. 368 (Nov. 1961).