CONSTRUCTION OF JOINT LOAD TRANSFER TEST ROAD TO EVALUATE ACME LOAD TRANSFER ASSEMBLIES, PLASTIC COATED DOWELS AND END-OF-POUR CONSTRUCTION JOINT ASSEMBLIES

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

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This report gives the location, description, general construction aspects and the experimental features of the subject concrete test pavement. Initial measurements of the various performance factors under study are also included.

Location

The Michigan Department of State Highways with approval of the Bureau of Public Roads incorporated an experimental pavement section into the plans and specifications of Michigan Project S 262(10), State Project SS 76011-009. This project is located on M 52 (former M 47) between Bennington Rd and Morrice Rd in Shiawassee County (Fig. 1).

Description

The test roadway consists of 3.25 miles of 24-ft two-way reinforced concrete pavement beginning at Station 421+00 and ending at 594+09, with 10-ft shoulders primed and double sealed for a width of 9 ft. The horizontal alignment consists of three straight segments and three circular curves, the maximum degree of curvature being 1° 15'. From south to north, the maximum negative grade of the vertical alignment is 1.38 percent and the maximum positive grade 1.63 percent. The pavement is of 9-in. uniform thickness with a 1-3/8-in. crown and was placed on a 14-in. granular subbase. The transverse joint spacing is 71 ft 2 in. and load transfer is provided at all joints. All joint grooves, including the longitudinal centerline plane of weakness joint, are sawed. The transverse joints are sealed with neoprene compression seals whereas the longitudinal joint is sealed with a cold-applied liquid sealant.

The concrete was designed by the mortar voids method of proportioning with a constant cement content of 6 sacks of Type 1A cement per cu yd. Air entrainment of the concrete was provided by the addition of Daravair A. E. additive to the mix. The concrete had an average air content of 6.6 percent

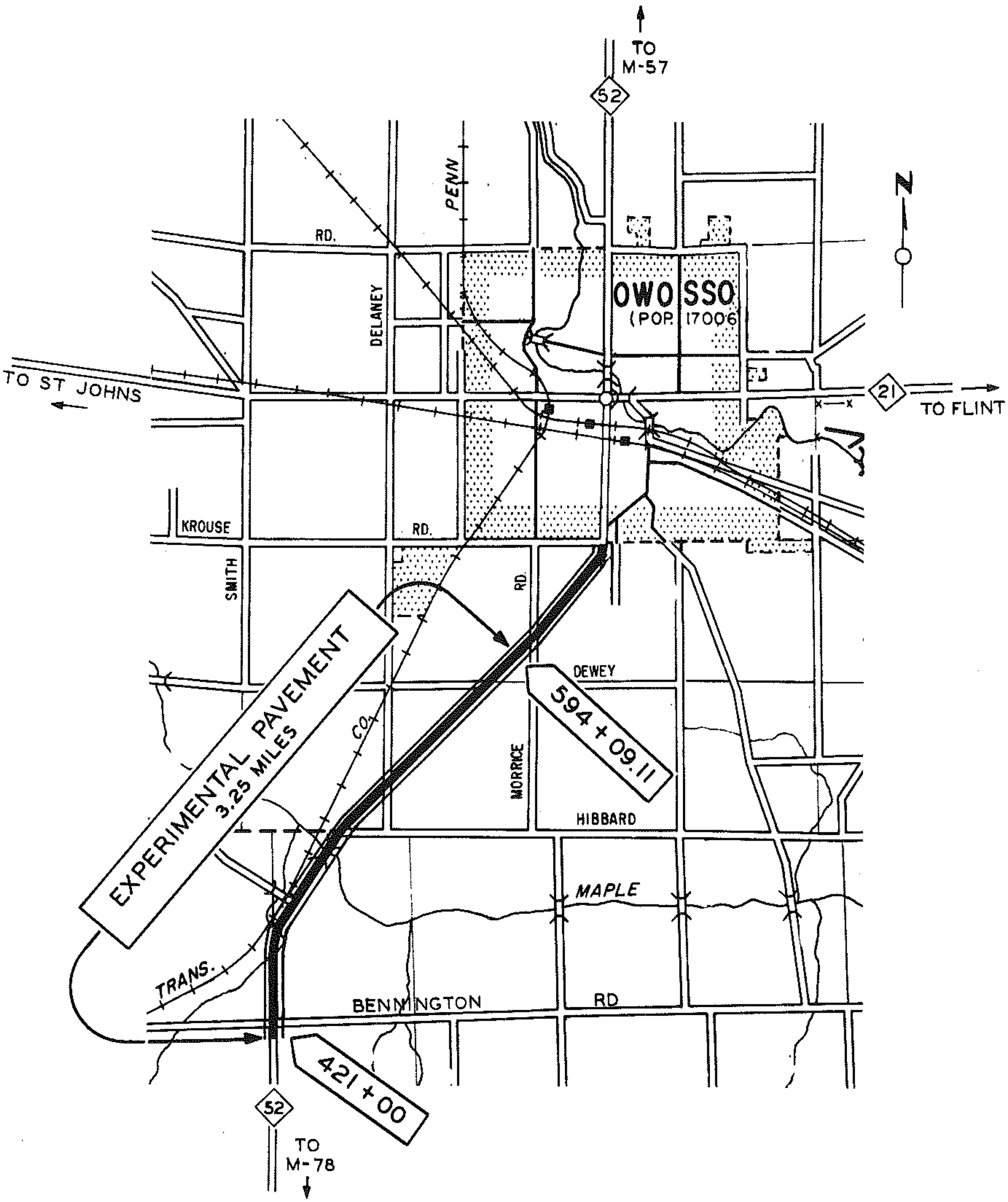

Figure 1. Location of experimental pavement.

and an average slump of 2.5 in. The gradation for coarse and fine aggregates, designated as 6A and 2NS, respectively, were specified as follows:

Sieve Size (in.) Square Sieve Opening US Standard Sieve Series	Total Percent Passing	
	6A	2NS
1-1/2	100	
1	95-100	
1/2	30-60	
3/8		100
No. 4	0-8	95-100
No. 8		65-95
No. 16		35-75
No. 30		20-55
No. 50		10-30
No. 100		0-10
Loss by Washing	0.8 percent, max.	0-3

Experimental Features

The experimental pavement contains three different types of contraction joint load transfer assemblies and a new type of assembly for use in end-of-pour construction joints. Each type is described as follows:

1. Michigan's Standard Assembly - Load transfer is accomplished by use of 1-1/4 in. diameter steel 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 frame. The free dowel ends are sawed to maintain their roundness and thereby reduce restraint of movement. To prevent bonding of the concrete to the free dowel end, a coating of liquid asphalt RC-250 is applied for not less than 2/3 of the length of each dowel.

2. Assembly with Plastic Coated Dowels - This assembly is identical to the standard assembly except the dowels are coated with a plastic material. The coating consists of a 4-mil thick adhesive material overlaid by a 17-mil thick high density polyethylene material. The coating system is applied by an extrusion process before the dowels are sawed and welded into the wire frame. The plastic coating prevents bonding of the concrete to the dowels, thus eliminating application of a bond breaker in the field. In addition to acting as a bond breaker, the plastic coating also minimizes corrosion of the steel bar.

3. Acme Assembly - An assembly of this type utilizes malleable iron castings to accomplish load transfer. Each individual transfer unit within a 12-ft assembly consists of a female and male casting which engage for a distance of 1-1/2 in. at the center of the assembly. The castings are straight in the engagement area but then slant down and outward and are fastened to sheet metal angles designed to support the assembly on the sub-base. Spacing of the individual units at the center of the assembly is maintained by fastening to a metal plate. Assemblies are designed for load transfer at the mid-depth point of the slab. The assembly is held together during handling and installation by crimping the female casting, which is open on one side, onto the male casting. Because the sliding portion of the units is enclosed on three sides and is only 1-1/2 in. long, no bond breaker needs to be applied in the field before installation.

4. End-of-Pour Assembly - This assembly differs from a standard contraction joint assembly in two ways: first, the dowels consist of a 7-1/2 in. length of bar threaded into one end of a 3-in. long sleeve and a 10-1/2 in. bar threaded into the other sleeve end and, secondly, the plain ends of the shorter dowel pieces are welded to one assembly side frame, whereas the other side frame is clipped onto the longer dowel pieces. This design permits the dowels to be supported independently of the bulkhead and allows removal and replacement of the half assembly extending into the second pour area.

Figures 2 through 5 illustrate an assembly of each type. The experimental pavement contains three test sections and eight individual end-of-pour joints. Since the construction was performed in accordance with Standard Specifications the test sections contain expansion joints at intersections of other structures and at the PC's and PT's of curves. Details of the joint layout and location of the test sections are given in Figure 6.

Pavement Construction

Construction of the pavement began July 23, 1969, and was completed August 12, 1969. The pavement was opened to traffic November 10, 1969. Full-width construction was employed, whereby the entire 24-ft width of pavement was placed at one time. The concrete was placed in two layers. The first layer was struck off 3 in. below the pavement surface and the reinforcement placed at that depth. A second layer was then placed and the surface finished with mechanical equipment. The final surface treatment consisted of hand floating followed by burlap dragging. The pavement was protected during the curing period by applying a white membrane curing compound.

Figure 2. Standard dowel bar assembly.

Figure 3. Assembly with plastic coated dowel bars.

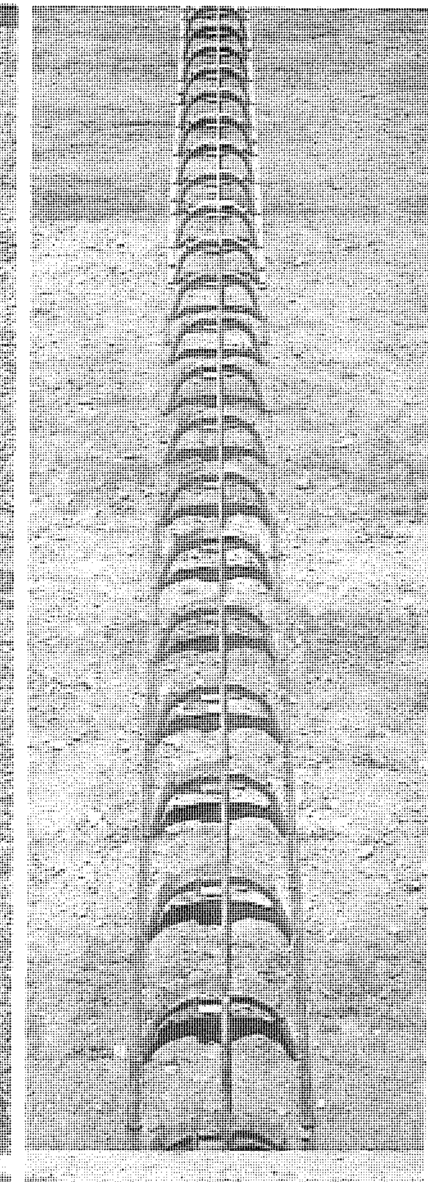

Figure 4. Acme assembly.

Figure 5. End-of-pour assembly.

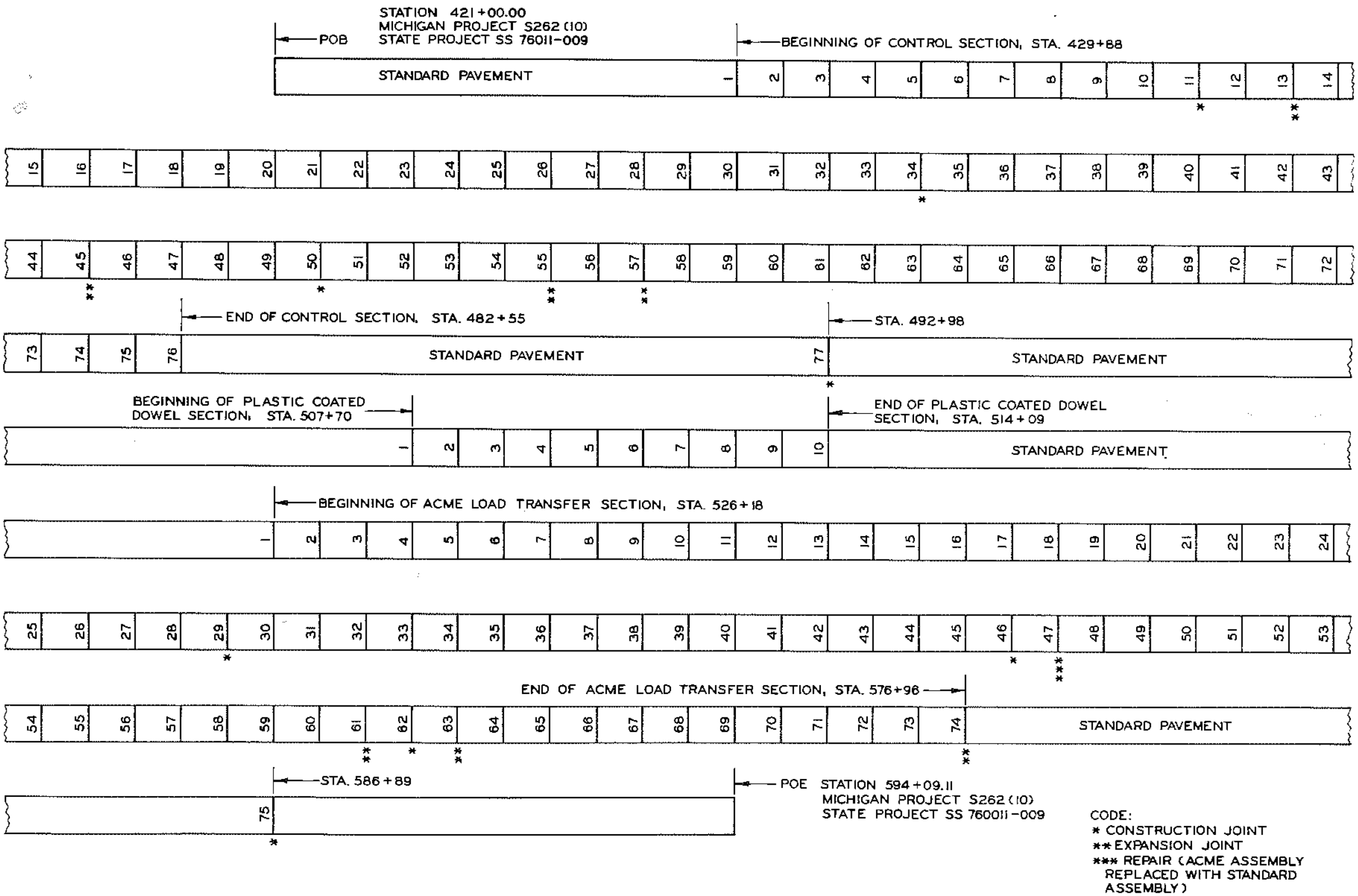

Figure 6. Test section locations and joint layout.

The installation procedure for the three types of contraction joint assemblies was identical. The assemblies were staked to the grade at the required locations and in the case of the standard assembly the free ends of the dowels were coated with asphalt. The bottom layer of concrete was poured over and through the assembly. To avoid hitting the assemblies while striking off the bottom concrete layer the spreader blade was lifted at each assembly location. The concrete in the immediate area of the assemblies was consolidated by use of hand vibrators. The edge joint groove for the Acme assemblies was formed by clipping a steel plate to the assembly's center plate (Fig. 7). The center of the joint was marked by inserting a nail in the edge groove former after concrete pouring, (Fig. 8). At the joints containing dowel assemblies the groove was formed by inserting a preformed groove template in the plastic concrete (Fig. 9).

The 1/8- by 2-in. plane of weakness saw cut was made from 6 to 10 hours after the concrete was poured. At joint No. 47 in the Acme section, a crack formed parallel to and about 2 in. away from the saw cut. This apparently was caused by the assembly being hit by the paving equipment. A standard contraction joint assembly was installed later at this location.

The end-of-pour load transfer assembly is intended to be used only when the second pour is placed more than seven days after the first pour. However, to gain experience with the use of the assemblies the contractor was required to install an end-of-pour assembly at each of eight transverse construction joints. Since the second pour generally was placed the following day, the clipped-on side frame and protruding dowels were left in place. The procedure used in constructing this type of joint was as follows:

1. The assembly was placed at the desired location and aligned to proper position.

2. A slotted steel bulkhead was inserted through the assembly and staked to the grade. The top elevation of the bulkhead was about 2 in. below the surface of the finished pavement to allow the paving equipment to pass over it.

3. After the concrete was poured and finished by the mechanical equipment the bulkhead was raised manually to within about 1 in. of the pavement surface. Pieces of 1/4 x 2 in. premolded filler were inserted behind the bulkhead and the joint edge finished to the required shape and elevation by hand.

4. Before placing the second pour the bulkhead and filler strips were removed and the protruding dowels were coated with asphalt.

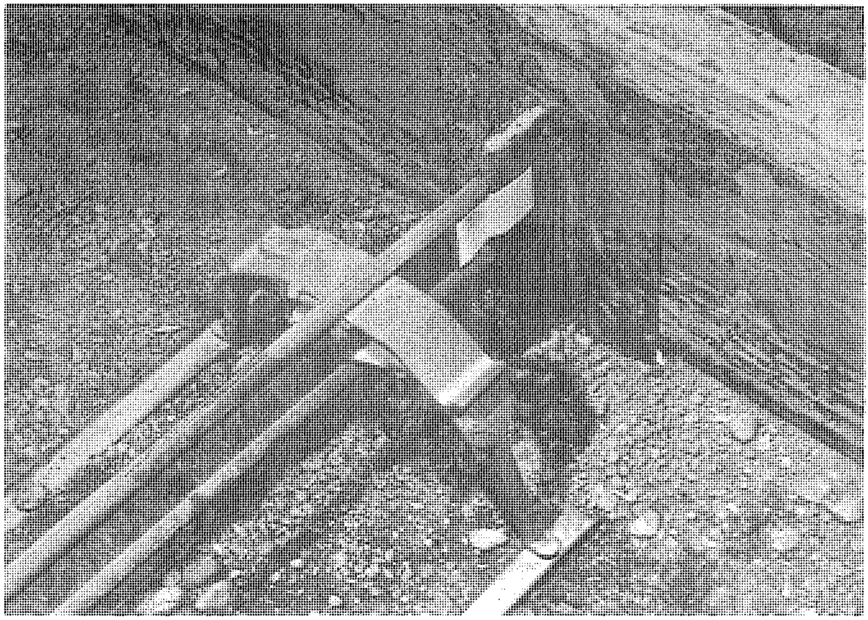

Figure 7. Steel plate for forming edge groove attached to Acme assembly center plate.

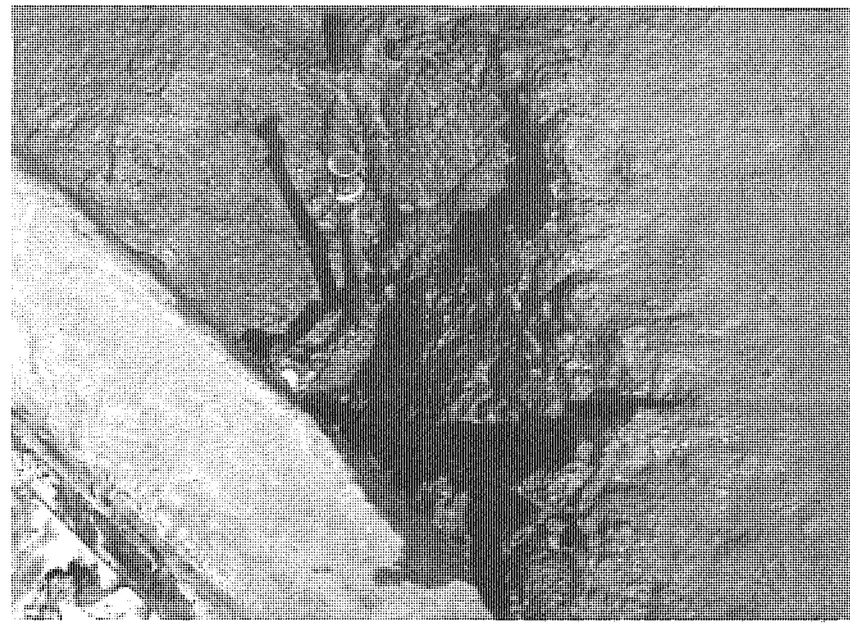

Figure 8. Centerline of Acme assembly marked by inserting nail in top of edge groove forming plate.

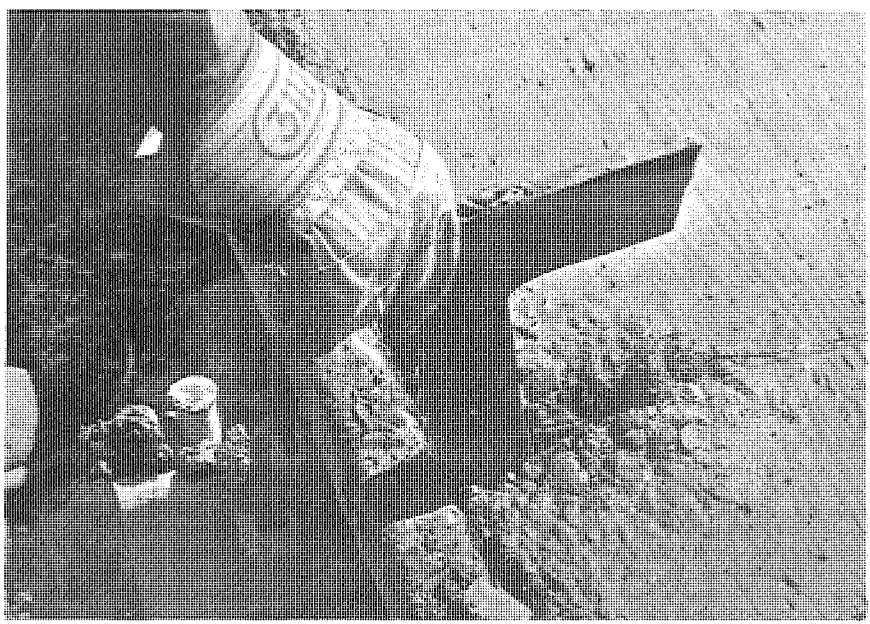

Figure 9. Installing preformed template to form edge groove of standard assembly.

5. The joint groove was sawed and sealed in the same manner as the regular joints.

Cost

The contract unit price per lineal ft was $6.00 for contraction joints and $10.00 for end-of-pour joints. Thus the total additional cost for the eight end-of-pour joints was $768.00

Since the contractor was not required to furnish separate price information for contraction joints containing Acme assemblies, the actual cost for these joints is not available. On the basis of list prices, the Acme assembly is about 32 cents more per lineal ft than a standard joint assembly. Not all of this extra cost is passed on to the contractor, since he realizes a savings in labor and material costs incurred by the necessity of coating the bars in the standard installation.

The plastic coated dowels were furnished through the courtesy of Republic Steel Corporation. The plastic coating is estimated by the manufacturer to add about 12 cents to the cost of each dowel. As in the case of the Acme assembly some of this added cost would be regained in savings realized by the elimination of the de-bonding application.

Evaluation

As outlined in the project work plan, evaluation will consist of comparing the performance of the experimental load transfer assemblies to that of the standard assemblies. The performance will be based on data obtained by measuring or inspecting the following factors:

1. Installation problems during pavement construction.

2. Uniformity of joint movement.

3. Relative deflection of the slabs during load transfer across the joint.

4. Formation and number of transverse slab cracks.

5. Amount and degree of joint groove spalling.

6. Roughness of the pavement surface.

7. Corrosion and pull-out resistance of load transfer units.

Installation - On the basis of observations made during paving operations the installation of the Acme assembly was just as easily accomplished as that of assemblies with dowel bars. Sawing of the plane of weakness over the Acme assembly's center plate did not appear to present any problems, when the assembly's centerline was marked with nails as previously discussed.

The feasibility of using an assembly in end-of-pour joints instead of loose dowels was reported in Research Report R-718. This report states that by aligning and supporting the dowels independently of the bulkhead it appears that the overall quality of this type of joint will be improved, and recommends that the end-of-pour assembly be approved for use in transverse end-of-pour joints.

Joint Movements - All joints in the control section and the experimental sections were instrumented with gage plugs. An initial or zero joint opening reading was taken before any movements occurred at the joints. A second measurement was made in February and the movement recorded at each joint is shown in Figure 10. The plotted joint openings resulted from an average temperature change of 63 F since the pavement was poured.

Since there are many variables that influence the amount of movement occurring at joints, variation in movement is to be expected. Joints containing Acme assemblies and those with plastic coated dowels show somewhat less variation in movement than joints with standard assemblies. The large movement recorded at joint No. 48 in the Acme section apparently is caused by restraint of the standard assembly installed during repair of joint No. 47. In the standard contraction joints, Nos. 30, 36, and 40 have opened only about half of the average opening. This is probably due to restraint of the load transfer assembly, and may be caused by misalignment.

Load Transfer - Load-deflection tests were conducted at three contraction joints in each of the experimental sections, during the early morning hours of December 4, 1969. A single axle load of 18,000 lb was moved across the joints at creep speed, 12 in. from the pavement edge. Deflection was measured by linear variable differential transformers, and recorded on a Sanborn Oscillograph. Deflection measurements were made 2 in. each side of the joint centerline, 1 in. from the pavement edge. Three trials were

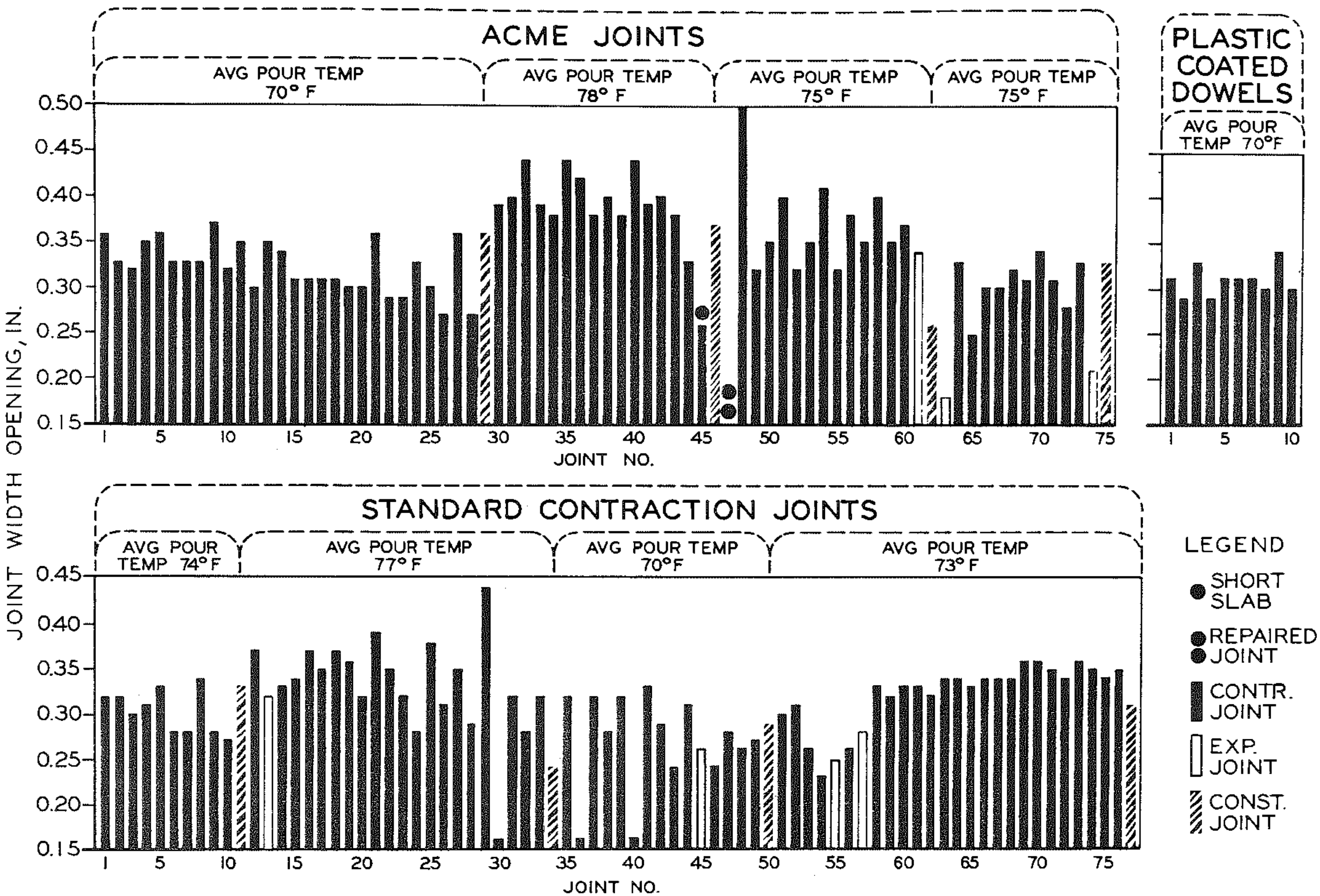

Figure 10. Joint openings recorded in February, 1970. (Average temperature drop since pour equals 63^{o} F).

made at each joint. The range and average deflection in inches of each load transfer type were as follows:

Load Transfer Type	Joint Station	Joint No.	Deflection		
			Low	High	Average
Standard Assembly	442+67	19	0.012	0.014	0.013
	447+65	26	0.010	0.012	0.011
	450+49	30	0.012	0.013	0.013
Assembly With Plastic Coated Dowels	509+12	3	0.013	0.014	0.013
	510+55	5	0.010	0.012	0.011
	511+95	7	0.018	0.010	0.009
Acme Assembly	530+40	7	0.007	0.009	0.008
	535+37	14	0.008	0.009	0.008
	538+18	18	0.008	0.009	0.008

These figures show little difference in the deflections measured at the standard contraction joints and those at the joints with plastic coated dowels or joints with Acme assemblies. This is to be expected since the deflections are primarily a function of the load carrying capacity of the roadway foundation. Therefore, to compare the performance of the three load transfer units, their effectiveness in transferring load was computed. The load transfer effectiveness is defined as the ratio of the deflections of the unloaded side of the joint to the loaded side.

The average load transfer effectiveness of the standard dowel assemblies and the Acme assemblies was found to be 90 percent and that of assemblies with plastic coated dowels to be 75 percent. Thus it appears that the assemblies with plastic coated dowels are 15 percent less effective in transferring load compared to the standard and Acme assemblies. However, it should be pointed out that because of the relatively small deflections measured, a very small amount of difference in deflection from the unloaded to loaded side, when given in percent, will show what appears to be poor load transfer effectiveness. For example, the 15 percent difference between the standard and plastic coated dowels actually results from the unloaded side of the assembly with plastic coated dowels, deflecting on the average only 0.002 in. more than the unloaded side of the standard assembly.

Transverse Cracks - The condition of the pavement surface was surveyed one month after the pavement was opened to traffic. No transverse cracks were found in any slabs of the three experimental sections.

Joint Groove Spalls - An inspection of the joint grooves four months after the pavement was opened revealed that the average spall length per joint was 3.7 in. in the standard control section, 3.6 in. in the plastic coated dowel section, and 3.0 in. in the Acme assembly section. The average length, width, and depth of each spall was found to be 2, 1/2, and 1/2 in. respectively.

Surface Roughness - The initial surface roughness in inches per mile was measured to be 131 for the standard control section, 141 for the Acme assembly section, and 147 for the plastic coated dowel section. On the basis of the Department's criterion for riding quality all three sections would be classified as having "average" surface roughness.

Corrosion and Pull-Out Resistance - After five years of service an attempt will be made to remove samples of each type of load transfer unit to determine their pull-out resistance and inspect for corrosion of the dowels or castings.