MICHIGAN'S TEST ROAD FOR TRANSVERSE JOINTS
I 96 from Meridian Road to Wallace Road

L. T. Oehler

Prepared for the Annual Project Engineers Meeting, Lansing, Feb. 1961

Research Laboratory Division
Office of Testing and Research
Research Project 60 F-58
Report No. 368

Michigan State Highway Department
John C. Mackie, Commissioner
Lansing, November 1961

MICHIGAN'S TEST ROAD FOR TRANSVERSE JOINTS
I 96 from Meridian Road to Wallace Road

Michigan has let contracts for two highway projects on I 96 near Lansing (Fig. 1) comprising an 11.6 mile test road for performance experiments in transverse joint design and construction.* Completion is now planned for December 1, 1962.

In connection with planning the new test road, current trends in joint design and construction were examined, revealing several matters of interest. Of the two chief types of rigid pavement now being built in the United States, about 40 percent of the states are constructing plain concrete pavements and 60 percent are constructing reinforced concrete pavements. A few states are building both types.

The plain concrete pavements are commonly built in short slabs to minimize transverse cracking, and load transfer devices are generally omitted at transverse joints. Reinforced pavements have longer slabs, although there is a wide range in lengths throughout the states; load transfer is almost always used. More specifically, these two varieties of construction might be described categorically as follows:

1. Plain concrete slabs, in 15, 20, 25, and 30 ft lengths, without load transfer at joints, are generally more prevalent in southern states;

2. Reinforced concrete slabs, in 40 to 100 ft lengths, with load transfer at joints, are generally more prevalent in the northern states.

---

* Transverse joint test: EBI 33084, C5 (5.811 mi of dual pavement); Unitube joint test: EBI 33084, C7, and EBI 33085, C1 (5.780 mi of dual).

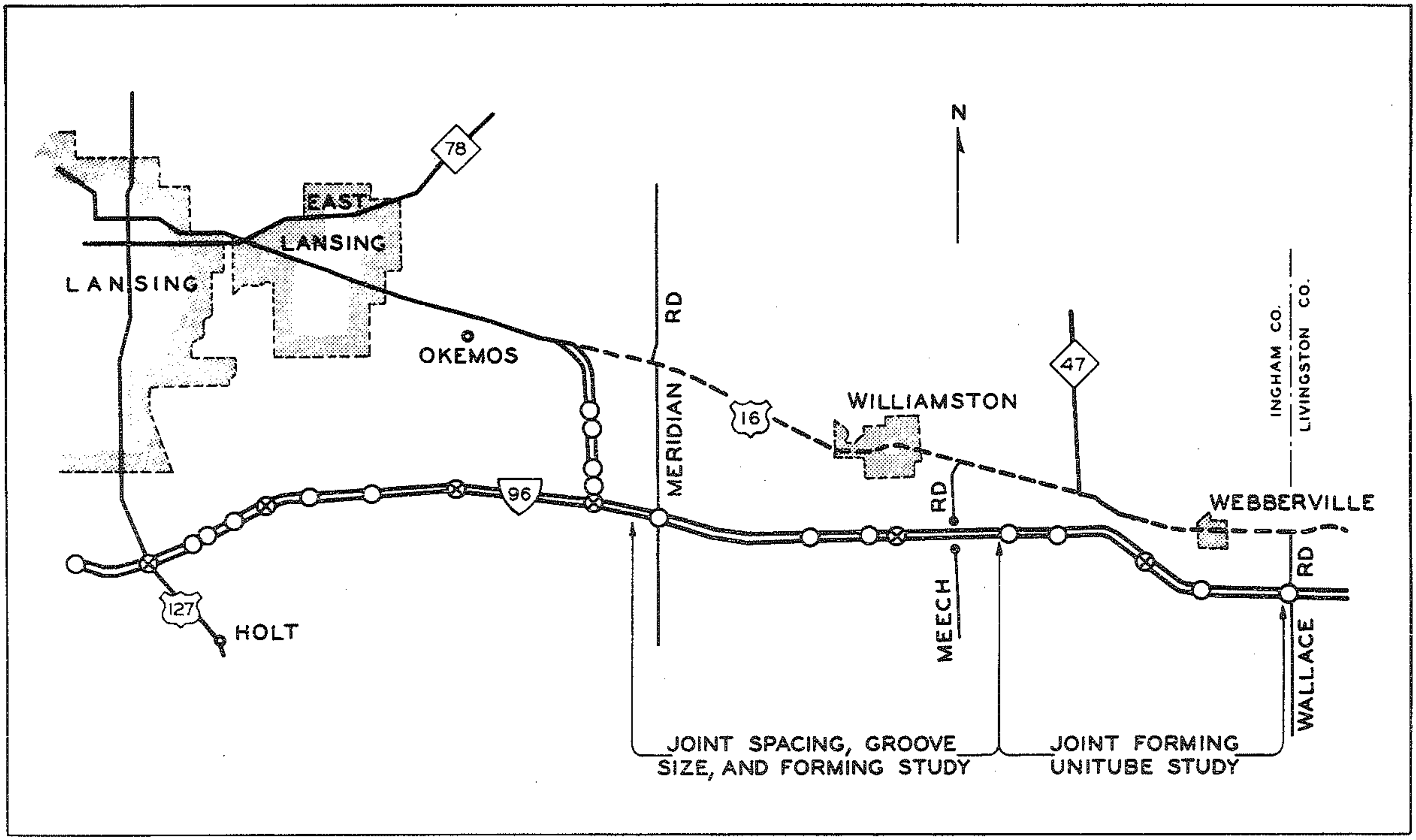


Figure 1. Plan view of I 96 construction southeast of Lansing, showing test road locations.

Of 15 northern states somewhat similar to Michigan in climate, twelve build reinforced concrete, one builds only plain concrete, and two build both types. Joint spacings in the fourteen specifying reinforcement vary considerably--the medium length is about 60 ft and the longest slabs are those in Michigan (99 ft) and Illinois (100 ft).

Longer slab lengths for reinforced concrete pavements have certain advantages. A joint is a point of relative structural weakness in the pavement--the fewer per mile the better. Less hand work and thus greater construction efficiency is achieved when fewer joints are installed. Longer slabs require fewer load transfer assemblies per mile. They also generally produce a pavement surface with better riding quality.

However, certain disadvantages of longer slabs must also be considered. A greater weight of reinforcing steel is required per unit area of pavement, since tensile forces are greater in longer slabs. Fig. 2 shows that the economy of longer slabs through smaller expenditure for load transfer assemblies is offset by increased costs for reinforcement. Longer slabs also involve the very difficult problem of proper sealing of transverse joints, for the opening of contraction joints with temperature variations is proportional to slab length, and the elasticity, adhesion, and cohesion of the sealing material are severely tested.

Although the 99-ft contraction joint spacing has been used in Michigan since 1946, the problems of sealing transverse joints to prevent moisture from reaching the subgrade, and to prevent infiltration of small stones and other foreign material, have not been satisfactorily solved.

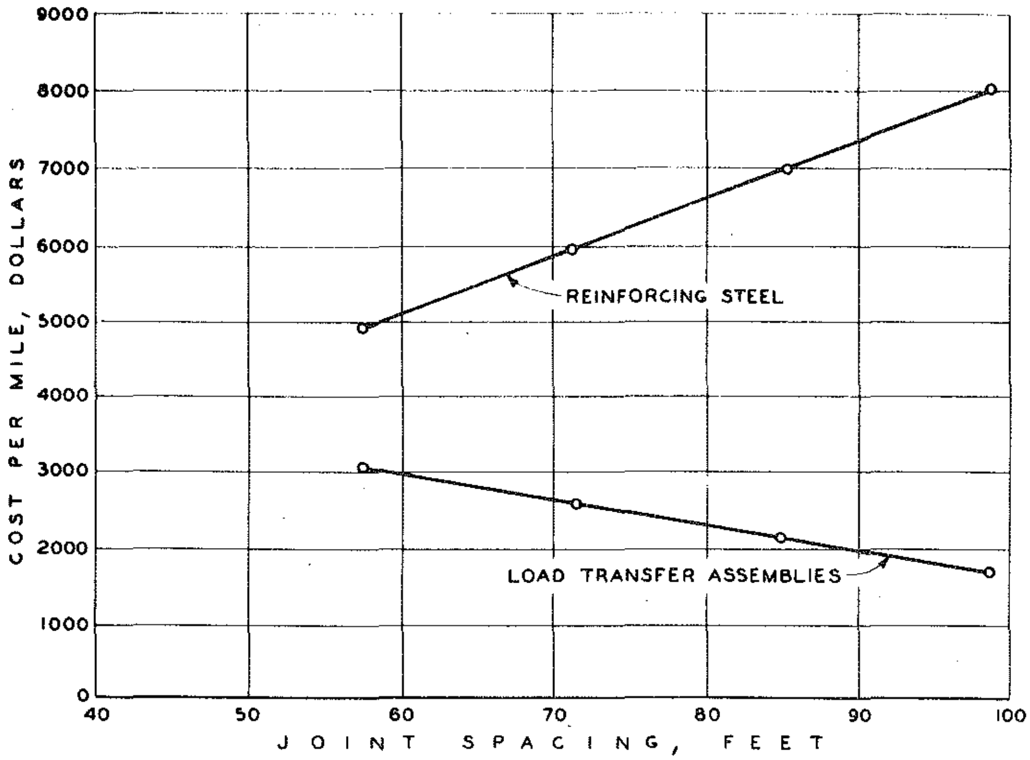


Figure 2. Cost per mile in relation to joint spacing; longer slabs require fewer load transfer assemblies but more reinforcement.

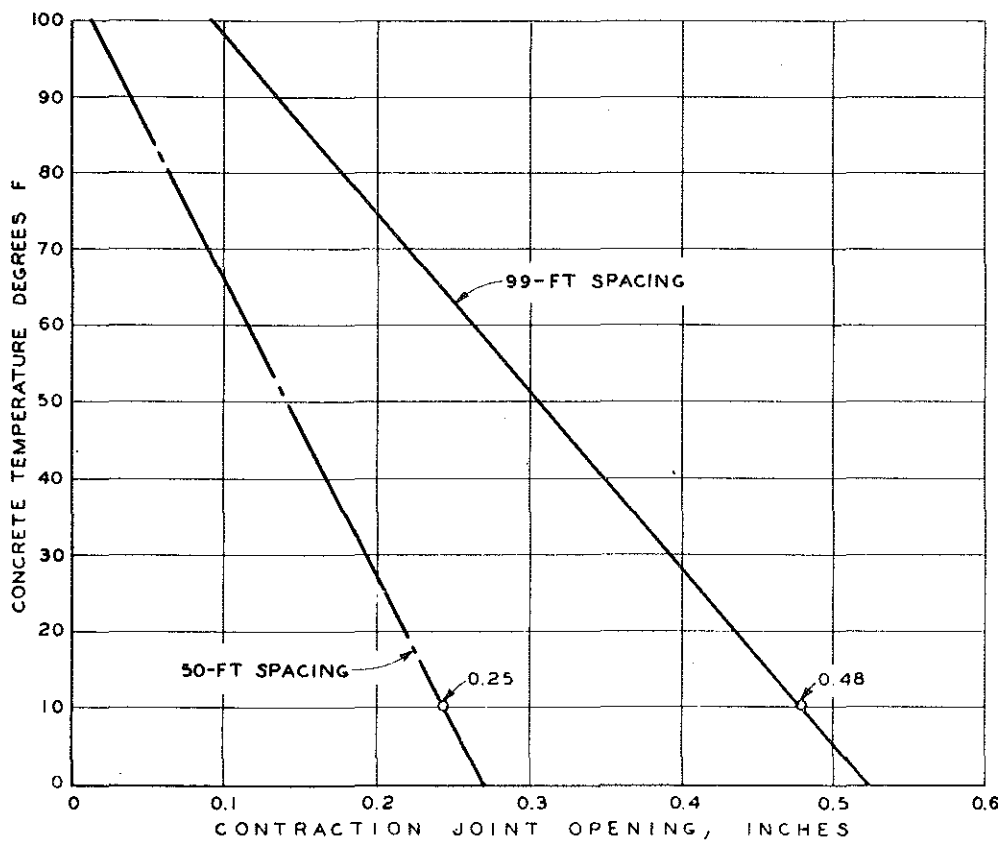


Figure 3. Average openings of contraction joints spaced at 50 and 99 feet.

Experiments conducted with a cooperating group of joint seal manufacturers, and other installations of new and better joint seal materials have been tried on Michigan experimental projects. However, a material has not been found to meet these severe conditions, which will perform satisfactorily over a period of years.

Objectives of the Michigan Study

The main objective of the new Michigan study is to determine methods of obtaining better performance of pavement joints, eliminating or minimizing such problems as longitudinal cracking at joints, joint blowups, concrete spalling at joints, and joint seal failure. By obtaining better sealed joints, some of these other joint problems may also be solved.

On the new project, three major research comparisons will be made:

1. Comparison of contraction joint spacings

   a. 57 ft 3 in. (four 15-ft reinforcing mats per slab)
   b. 71 ft 2 in. (five 15-ft mats)
   c. 99 ft (seven 15-ft mats)

2. Comparison of joint groove sizes for sealing material

   a. 1/2 in. wide by 1/2 in. deep
   b. 3/4 by 3/4 in.
   c. 1 by 1 in.
   d. 1/2 by 2 in.

3. Comparison of crack control obtained by joint forming methods

   a. temporary styrofoam filler
   b. premolded fiber filler
   c. sawing to a 2-in. depth

The variations in contraction joint spacing were selected for specific examination of joint sealer performance between slabs of different lengths.

Joint movement where slabs are 99 ft long, during contraction due to temperature, is about twice as great as where they are only 50 ft long (Fig. 3). For example, at a colder temperature such as 10 F, average contraction joint opening is 0.25 in. for 50 ft slabs while the opening is 0.48 in. for 99 ft slabs. This larger opening produces much greater strain in the sealing material.

In 1959, Professor Egon Tons of M.I.T. attacked the problem of joint seal performance on the basis of theoretical strains induced in joint seal material by various changes in joint opening, and by the width and depth of the joint groove.[1] After determining these strains theoretically, he verified them by laboratory experiments.

The accepted relationships between strain and joint opening, and between strain and groove width, were verified by Tons as follows:

1. Fig. 4 shows that in a joint seal groove 1/2 in. wide and 1/2 in. deep, filled flush with joint seal, as joint opening increases strain is maximum along the parabolic "curve-in" line formed by the upper or lower surface of the sealer. With an opening of 1/4 in., the strain is 60 percent. But, when the opening is 1/2 in.--close to the average opening at 10 F for 99-ft slabs--strain is about twice as great, or 120 percent.

2. In Fig. 5, groove width varies and the accompanying joint seal strain is shown for a joint groove of 1/2 in. depth, as the joint width is increased by 3/4 in. This indicates that the narrower the groove is, the greater is the strain in the seal material.

---

(1) Tons, Egon. "A Theoretical Approach to Design of a Road Joint Seal." HRB Bull. 229 (1959) pp. 20-53.

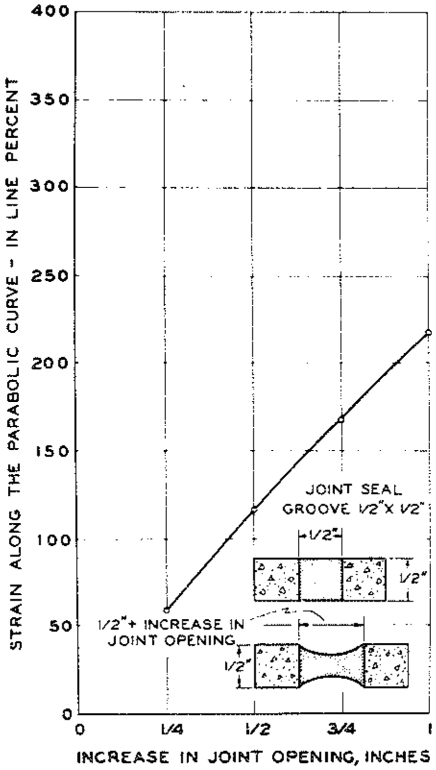


Figure 4. Relationship of strain in joint seal and increased joint opening.

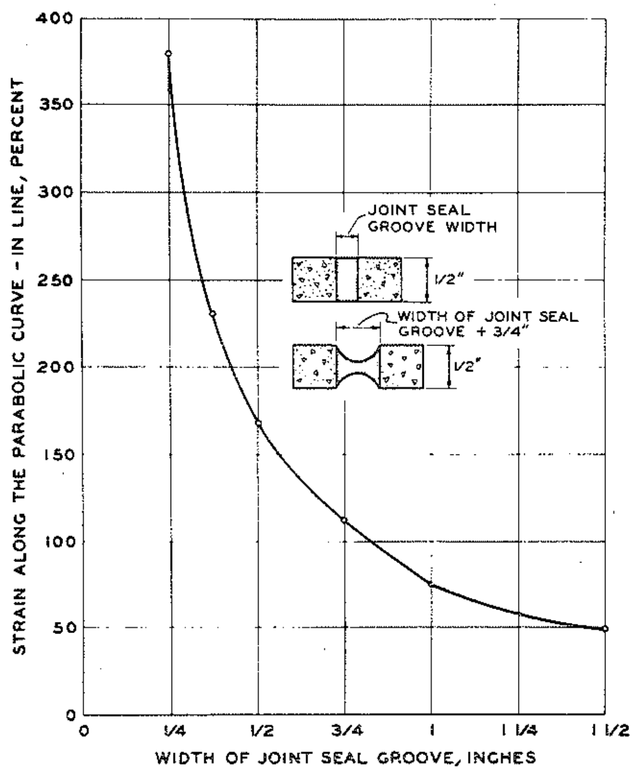


Figure 5. Relationship of strain in joint seal and width of joint seal groove.

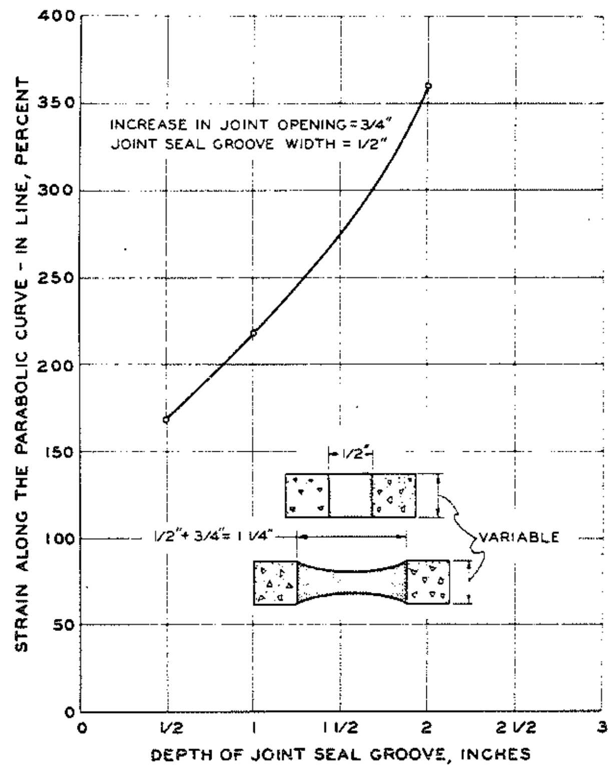


Figure 6. Relationship of strain in joint seal and depth of joint seal groove.

There was, however, a third relationship investigated by Tons, with a resulting reversal rather than a verification of a common assumption. It had been generally assumed that other things being equal, the deeper the joint groove and the greater the volume of joint sealing material, the smaller would be the strain in the seal for a given increase in joint opening. Tons showed this assumption to be incorrect both in theory and in laboratory experiments, and that actually the reverse was true:

3. Fig. 6 shows that for a joint seal groove width of 1/2 in. and an increase in joint opening of 3/4 in., joint seal strain increased with groove depth.

Therefore, in the Michigan experimental project, the shapes of the joint seal grooves are being varied in an attempt to improve joint seal performance.

Joint Spacing, Groove Size, and Forming Test Sections

In the transverse joint construction project, eight test sections will be placed in each roadway (Fig. 7), as follows:

1. One section in each roadway will have 99-ft slabs, with joints formed and sealed according to current Michigan practice--1/2 by 2-in. temporary fillers of styrofoam for crack control, replaced later with joint sealing compound.

2. In the eastbound roadway (Fig. 8), initial crack control in the other seven sections of variable slab lengths will be obtained by sawing thin, 2-in. deep transverse joints as soon as possible after concrete is so hardened that the sawcut can be made without raveling, and then sawing to widen and deepen the groove later just prior to sealing.

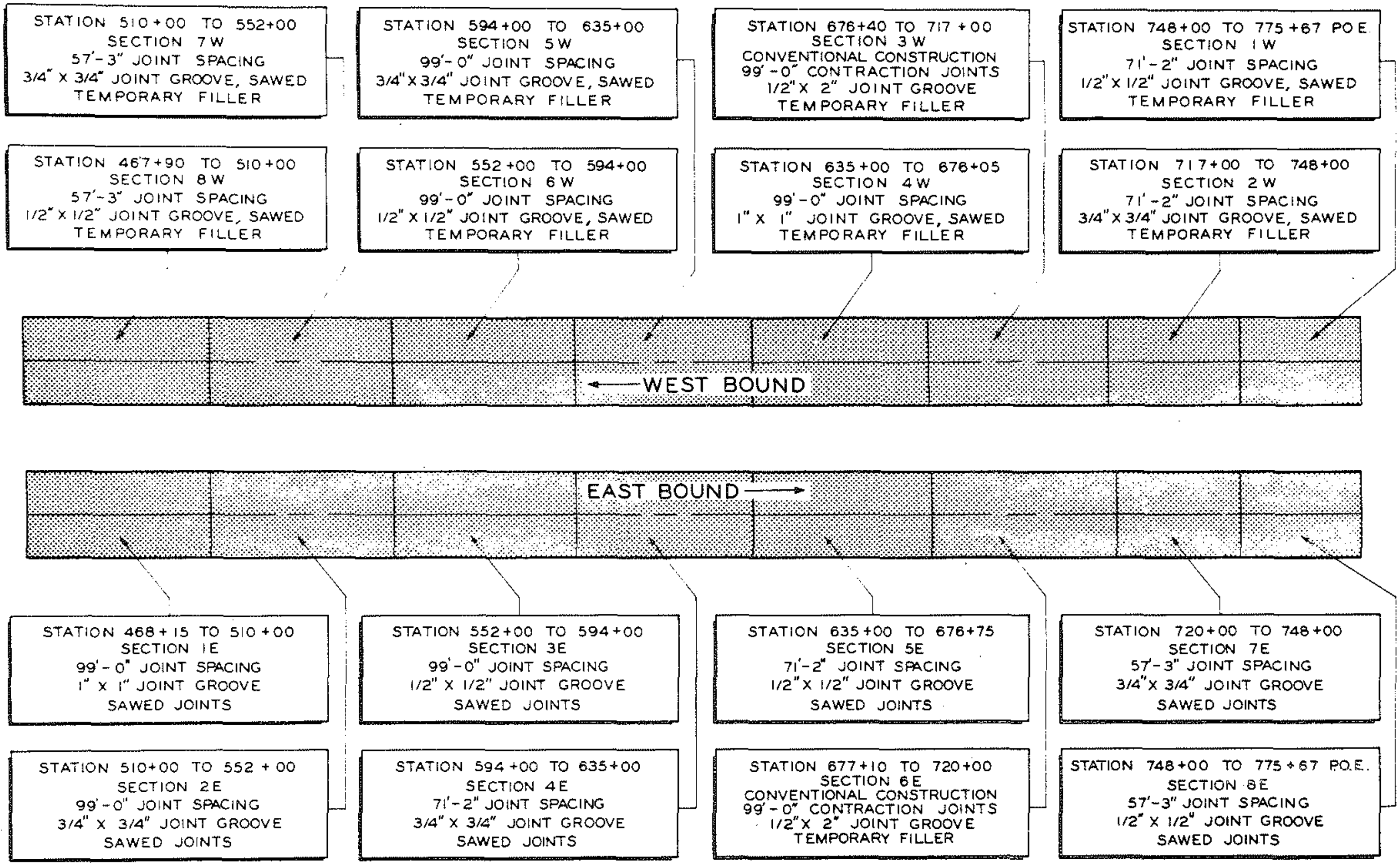
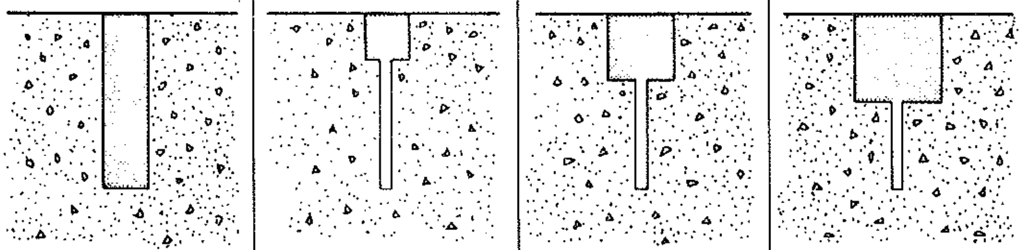
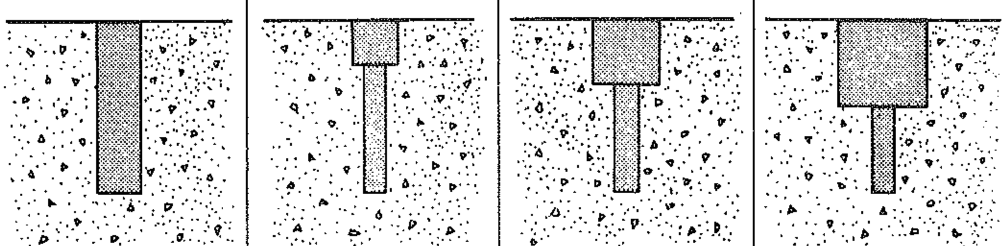


Figure 7. Test sections for transverse joint construction (EBI 33084, C5).



	1/2"X 2" STYROFOAM, REPLACED BY JOINT SEAL	SAWED TO 2" DEPTH 1/2"X 1/2" JT. GROOVE FOR SEALER	SAWED TO 2" DEPTH 3/4"X 3/4" JT. GROOVE FOR SEALER	SAWED TO 2" DEPTH 1"X 1" JT. GROOVE FOR SEALER
JOINT SPACING	99'-0"	57'-3" 71'-2" 99'-0"	57'-3" 71'-2" 99'-0"	99'-0"

EASTBOUND ROADWAY



	1/2"X 2" STYROFOAM, REPLACED BY JOINT SEAL	1/4"X 2" PREMOLDED FIBER FILLER 1/2"X 1/2" JT. GROOVE FOR SEALER	1/4"X 2" PREMOLDED FIBER FILLER 3/4"X 3/4" JT. GROOVE FOR SEALER	1/4"X 2" PREMOLDED FIBER FILLER 1"X 1" JT. GROOVE FOR SEALER
JOINT SPACING	99'-0"	57'-3" 71'-2" 99'-0"	57'-3" 71'-2" 99'-0"	99'-0"

WESTBOUND ROADWAY

Figure 8. Cross-section views for joint forming methods.

3. In the westbound roadway (Fig. 8), 1/4 by 2-in. premolded fiber filler will be placed in the other seven sections during construction at various spacings to form weakened planes, with grooves sawed later to varying depths and widths, and the upper portion of the fillers removed for insertion of sealing compound.

Joint Forming--Unitube Test Sections

The second experimental project, between Meech Road and the county line, will consist of transverse contraction joints on both roadways formed by a metal tube called a "Unitube." This is a proprietary produce of the Middlestadt Corporation. The Unitube is placed in the fresh concrete by a power-driven mechanical device called a "planter." The planter rides on the paving forms directly behind the last mechanical finishing machine. The Unitube is 13/16-in. wide, forms a weakened plane for crack control similar to styrofoam, and transverse floating and the burlap drag finishing can be done after it is placed.

After the concrete has cured seven days the Unitube is depressed as shown in Fig. 9 by the use of power-driven vibratory equipment called a "crimper." Subsequently the joint groove remaining above the Unitube will be sand blasted, cleaned, and sealed with hot-pour rubber-asphalt joint sealer.

Joint spacing throughout the project will be 57 ft 3 in. In 1960, three states--Maine, South Dakota, and South Carolina--were using this method exclusively for forming transverse contraction joints. However, ten states reportedly have used Unitube contraction joints on some projects.

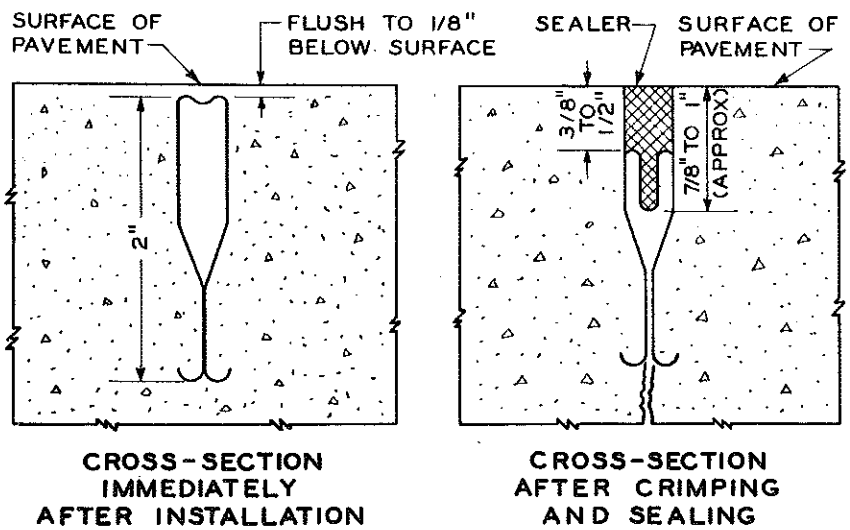


Figure 9. Cross-section views for a Unitube joint.

Future Plan of Study

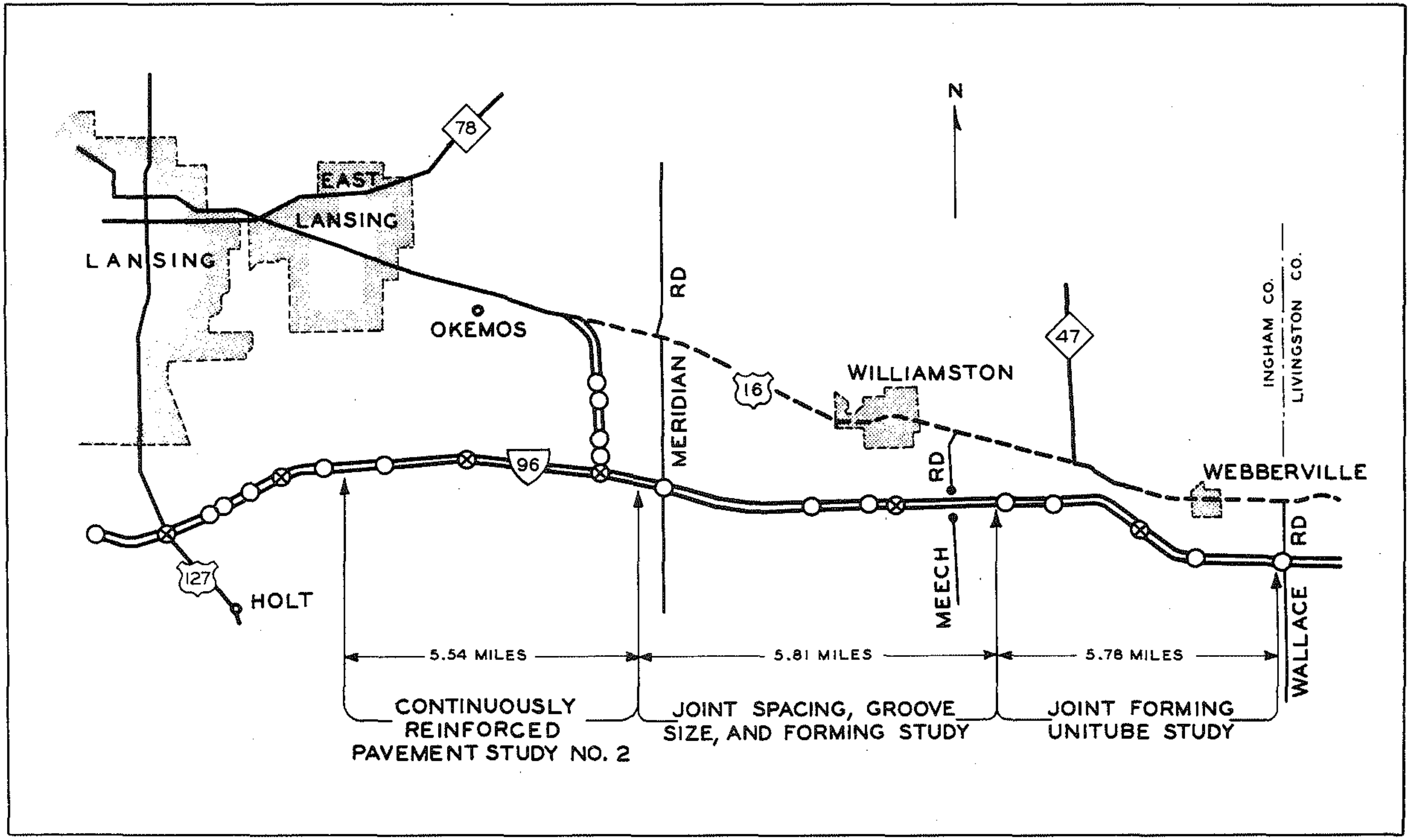
Observations will be made during construction to determine the feasibility of the various experimental features and procedures which have been incorporated into this project.

In addition, observations on pavement performance will be made annually. These observations will include recording pavement conditions including longitudinal and transverse cracking and spalling, and also observations of the performance of the joint sealers including their adhesion and cohesion and the extent of infiltration of foreign material in joints.

Measurements of the opening of certain joints in each experimental section will be made semi-annually (July 30 and January 30) at joint plugs placed in the fresh concrete during construction.

Riding quality will be measured immediately after completion of construction, and semi-annually thereafter (also July 30 and January 30). These measurements will be used to determine the effect of joint spacing on riding quality as constructed, and how time and traffic affect the riding quality of the various sections.

In conclusion, it is worth mentioning that a great deal of present pavement design practice has developed on the basis of pavement performance observations of conventionally constructed pavements and experimentally constructed pavements. Joint construction practice through the years and throughout the various states has been an endless series of experiments seeking the ultimate goal of a method of preventing or controlling concrete cracking, and yet minimizing other undesirable features of joint construction. It is hoped that these two experimental projects will contribute to this long-range goal.



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