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EFFECTIVENESS OF SAWED-SEALED LONGITUDINAL JOINTS BETWEEN BITUMINOUS SHOULDERS AND RIGID PAVEMENT IN REDUCING LONGITUDINAL SHOULDER CRACKING

First Progress Report

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ABSTRACT: The effectiveness of a sealed joint between bituminous Class AA shoulders and concrete pavement in reducing longitudinal shoulder cracking is being evaluated under varying field conditions. Existing shoulders have been surveyed and performance of five experimental shoulder construction projects is being studied. Observations of these projects include vertical displacement of concrete pavement and shoulders, longitudinal joint width variation, extent and severity of shoulder cracking, durability of the joint sealing material, and photographic records of general appearance. Based on the preliminary data, it is concluded that (a) early longitudinal cracking is not caused by frost heaving of the pavement and shoulders, (b) in cold weather, sealing material will be stretched considerably more than the 50-percent limit usually specified for such materials, and (c) for a realistic evaluation of sealed joint performance, additional experimental data are needed. The experimental projects will be surveyed periodically until definite conclusions can be drawn.

KEY WORDS: joint sealers, joints, longitudinal joints, shoulders, bituminous construction, cracks, sawed joint.

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First Progress Report

For the past five years, the Department has been studying the possibility of reducing longitudinal cracking in bituminous shoulders by constructing a sealed joint between the concrete pavement and the bituminous aggregate shoulder. In 1962, the problem was discussed through correspondence between C. B. Laird, Chief Construction Engineer, and W. A. Wienbrauck, Assistant Road Construction Engineer, in which both the method of joint construction and performance of sealing material were considered. In a memorandum dated September 12, 1962, Mr. Wienbrauck wrote:

> Some failures have been noted on bituminous shoulders in the past. Most of these failures (alligator cracking) seem to occur about 6 to 9 in. from the edge of the pavement. It seems that the open joint between the pavement and the surfaced shoulder, caused by differential heaving, allows water to infiltrate into the gravel beneath the surfaced shoulder, thereby contributing to some failure of the shoulder surface.

The need for more information on shoulder performance led the Department, in 1962, to authorize construction of an initial project including a sealed joint between rigid pavement and bituminous aggregate shoulders. The test site was 4.9 mi of four-lane divided highway on US 10 about 10 mi west of Sanford in Midland County. Later, three additional experimental shoulder joint projects were constructed between 1962 and 1964. Pertinent information from these projects including crack formation data, are listed under Phase I of Table 1.

Characteristics of the experimental joint tested in these projects are shown in Figure 1. Joints as constructed were not less than 1/8-in. nor more than 1/4-in. wide and 1-1/4- to 1-3/4-in. deep. Joint grooves were filled with cold-applied sealer of the solvent-mastic type.

After inspecting and comparing these experimental sites with others of conventional construction, engineers involved in the study agreed that bituminous shoulder failures might result from many factors, but longitudinal cracks were apparently caused by differential heaving due to frost

TABLE 1
SUMMARY OF LONGITUDINAL CRACKING OF BITUMINOUS SHOULDER

	Test Project	Construction Project and Construction Year	Project Location and Length	Stationing	Traffic Direction	Joint Type	Shoulder Length, lin ft	Longitudinal Cracking*: Length of Shoulder, lin ft	Longitudinal Cracking*: Length of Shoulder, percent	Longitudinal Cracking*: Total Length of Cracks, lin ft
Phase I Survey of Existing Projects	1	EBBF 56044, C16 (1962)	US 10 west of Sanford (4.924 mi)	1060+00 to 1192+35	WB	1/8- to 1/4-in. wide, sawed and sealed	13,235	958	7.2	958
					EB	conventional, without sawing	13,235	626	4.7	643
	2	EBI 69013, C1 (1962)	I 75 north of Waters (7.655 mi)	2125+73 to 2256+00	NB	1/8- to 1/4-in. wide, sawed and sealed	13,027	155	0.8	155
					SB	1/8- to 1/4-in. wide, sawed and sealed	13,027	10	less than 0.1	10
	3	FI 34044C, C18 FI 19022C, C9 I 34044C, C19 I 19022C, C10 (1964)	I 96 east of M 100 to Portland (8.987 mi)	1348+00 to 1533+27.22 (1533+27.22 Back = 33+27.22 Ahead) 33+27.22 to 319+35	EB	1/8-in. wide, sawed and sealed	46,785	514	1.1	732
					WB	1/8-in. wide, wheel-cut and sealed	46,785	63	0.1	66
	4	I 81062C, C14, C15 (1964)	I 94 from Ann Arbor to junction with US 23 (7.934 mi)	934+90 to 458+38 458+00 to 89+85	EB	1/8-in. wide, wheel-cut and sealed	38,028	3,402	8.9	3,884
					WB	1/8-in. wide, wheel-cut and sealed	36,815	3,572	9.7	4,051
Phase II New Project	5	F 33035A, C6 (1966)	US 127 in Mason (3.309 mi)	568+10 to 399+17 SB and 397+51 to 564+72 NB	SB NB	1/8-in. wide, sawed and sealed	15,840	77	0.5	77
					NB SB	conventional, without sawing	15,840	901	5.7	904

*Survey data of December 1966

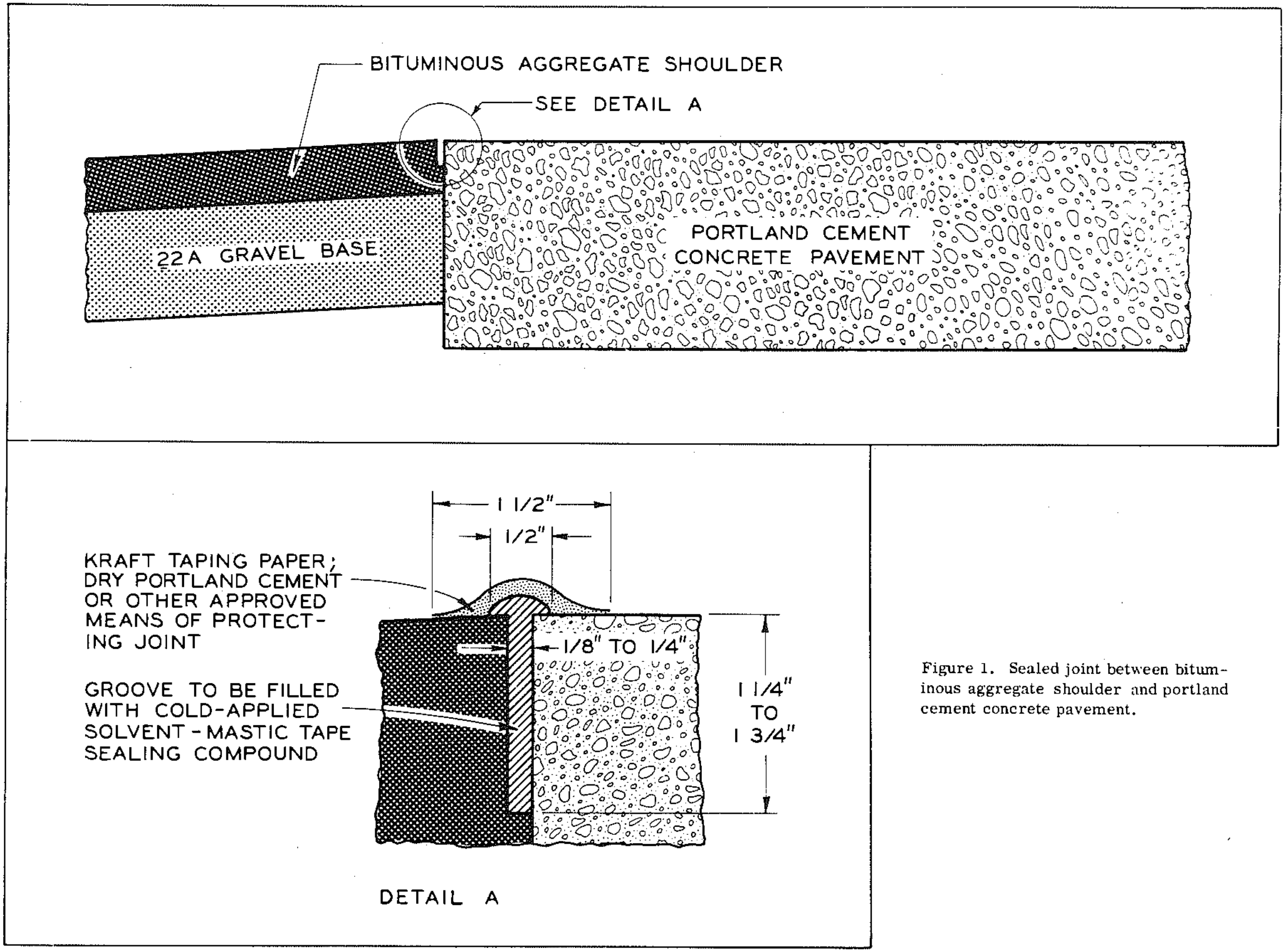


Figure 1. Sealed joint between bituminous aggregate shoulder and portland cement concrete pavement.

Sta. 1064+00
Project 1: EB Roadway
Age: 11 months

Sta. 2357+00
Project 2: NB Roadway
Age: 6 months

Figure 2. Typical longitudinal shoulder cracks 6 to 8 ft in length, located 6 to 9 in. from unsealed conventional longitudinal joints. Cracks were open less than 1/4 in. when photographed (May 1963).

action. Other factors that might promote shoulder cracking were water and salt infiltration at the joints, excessive subgrade moisture, subbase instability or displacement, insufficient thickness of the shoulder course, faulty bituminous mixture, and excessive loads.

During the fall of 1962 and winter and spring of 1963, Test Project 1 (Table 1) was studied for differential heaving due to frost action. Pavement edge-shoulder edge level measurements at 25-ft intervals (a total of 530 readings) were recorded along about 2.5 mi of the sealed westbound traffic lane joint and 2.5 mi of unsealed eastbound traffic lane joint. A partial analysis of these data indicated that elevation changes due to frost heaving were greater in the conventional shoulders with unsealed joints than shoulders having sawed-sealed joints. Vertical movements or elevation changes of conventional shoulders were reported as 1/4 to 1/2 in. above the pavement edge. In March 1963, elevation changes were reported for Test Project 2. Results of these measurements coupled with other observations supported the suspicion that frost heave of the conventionally jointed shoulder caused two types of failure:

1. Longitudinal cracks 3 to 9 in. from the conventional joint (Fig. 2).
2. Bituminous shoulders splitting away from the concrete pavement and leaving opened joints, wide enough for salt and water infiltration (Fig. 3).

It was agreed that sealed joints between concrete pavement and bituminous aggregate shoulders, as illustrated in Figure 1, might be a possible solution to the problem of longitudinal shoulder cracking. Typical sawed-sealed joints that are performing well are shown in Figure 4.

In March 1964, the Department approved a supplemental specification providing for a sealed longitudinal joint between concrete pavement and bituminous shoulders. In February 1965, the Department learned that the Bureau of Public Roads was interested in test results for sealed longitudinal joints. About the same time, the Department requested retroactive approval for Federal funding of the existing sealed joint projects.

In August 1965, the Bureau of Public Roads delayed retroactive approval for Federal aid pending review of further experience with both unsealed and sealed joints, as well as cost trends for this work. Thus, at the request of W. W. McLaughlin, Testing and Research Engineer, and with the approval of the Bureau of Public Roads, in September 1966, the Research Laboratory Division established a research project divided into two major phases: I--survey and evaluation of existing experimental and conventional bituminous shoulders, and II--construction and evaluation of new experimental shoulders.

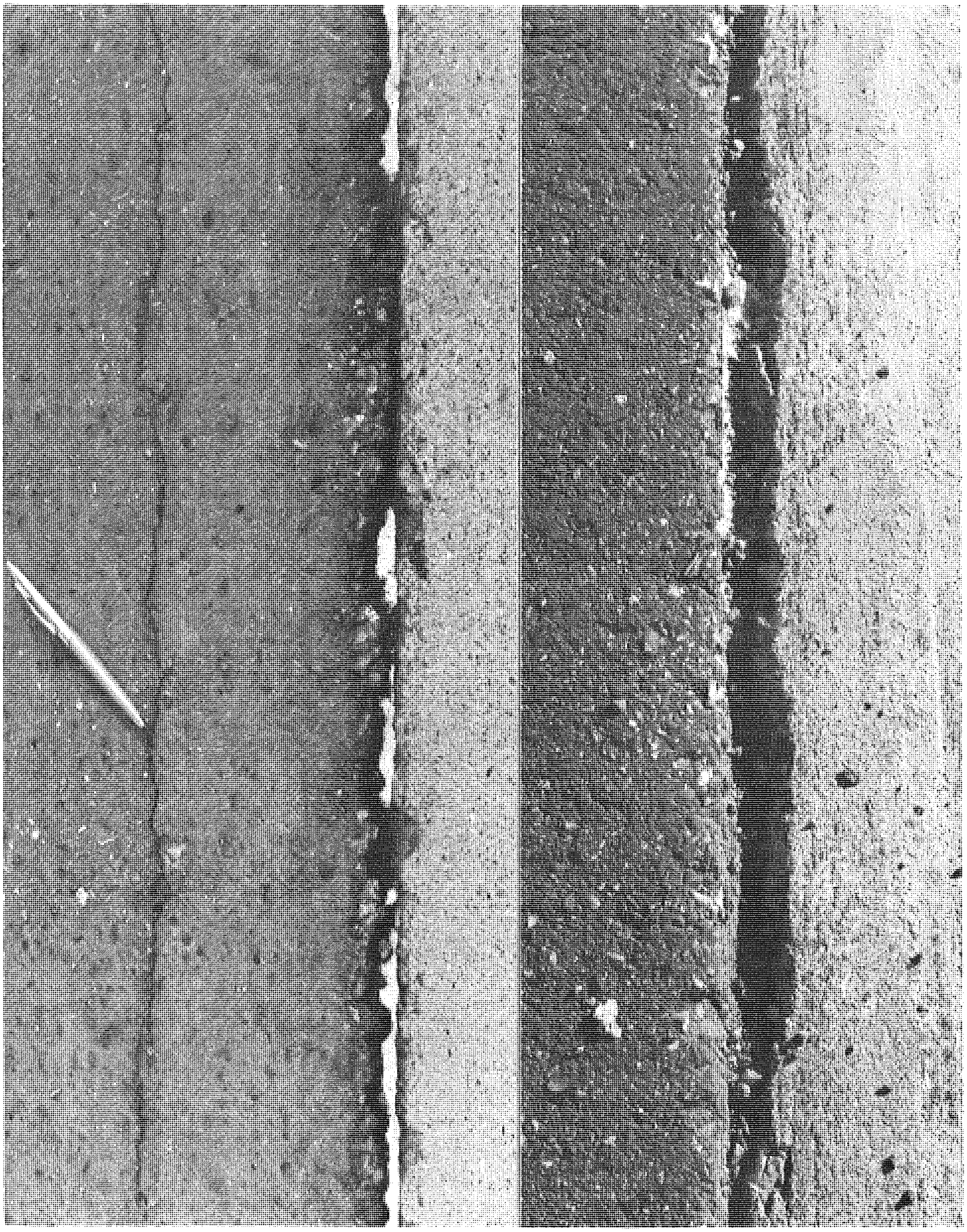
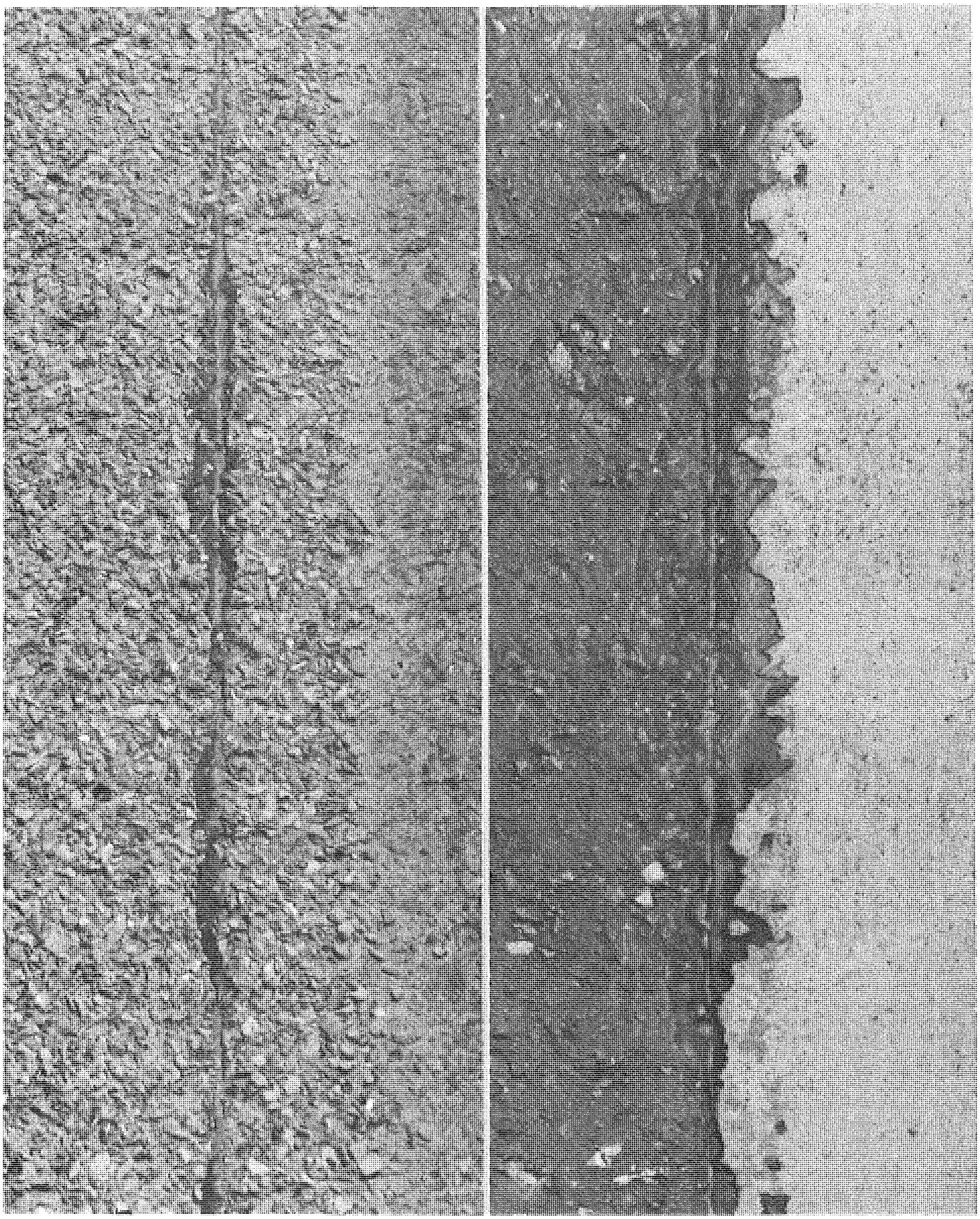


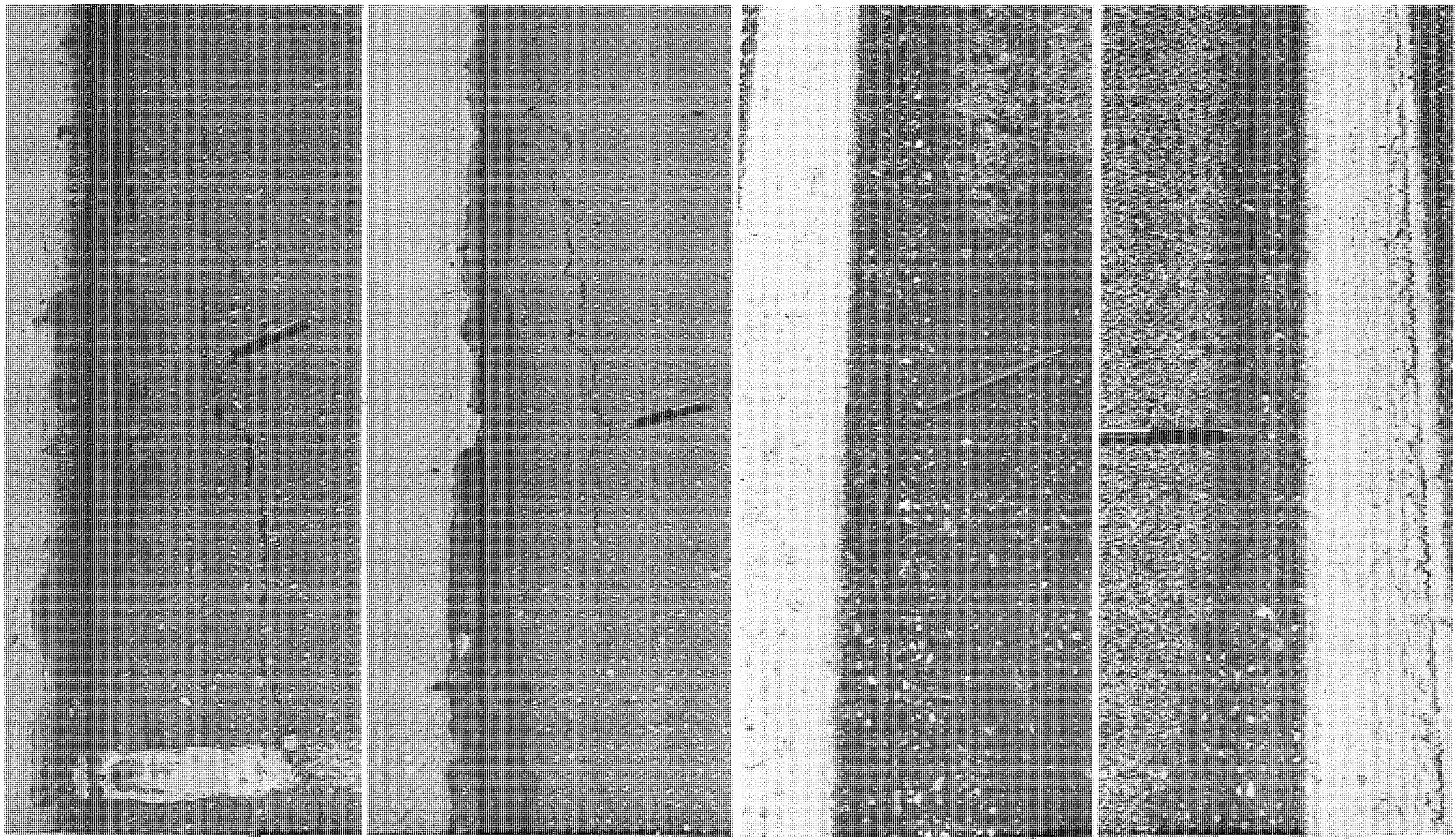
Figure 3. Typical splitting away of conventionally constructed bituminous shoulders from concrete pavement at two Project 2 locations, leaving opened joints wide enough for infiltration of water, sand, gravel, salt, or other incompressible material resisting normal joint movement. At left, typical longitudinal crack has developed parallel to open joint. Photographed 4 months after construction (May 1963).



Sta. 2230+00
Project 2: NB Roadway
Age: 7 months

Sta. 1123+50
Project 1: WB Roadway
Age: 11 months

Figure 4. Sawed and sealed 1/8-in. longitudinal joints between shoulder and concrete pavement (with and without bituminous overlay), show good adhesion without evidence of parallel longitudinal cracking of the shoulder (photographed May 1963).



Sta. 1071+85
Project 1: WB Roadway
Age: 4 years 2 months

Sta. 2141+70
Project 2: NB Roadway
Age: 3 years 10 months

Sta. 2194+37
Project 2: NB Roadway
Age: 3 years 10 months

Figure 5. Good performance of sealer in 1/8-in. wide sawed longitudinal joints. At left, in two views at adjacent locations, joint and sealer remain in good condition although 10-ft crack, opened 1/4 in., has formed 6 in. from joint. At right, two views of bituminous shoulder adjacent to concrete pavement with bituminous overlay show good adhesion of sealer. At far right, crack 30 to 40 ft long has opened 3 to 6 in. from sound joint.

PHASE I - Survey of Existing Shoulders

Test Procedure

The test procedure under Phase 1 is as follows:

1. Inspection, photography, and measurement of longitudinal cracks on experimental projects.

2. Mapping progress of crack formation and conditions of the bituminous shoulders, including the joints and sealing material.

3. Tabulation and analysis of the extent and severity of the types of distress recorded.

4. Comparison of results from the three preceding procedures with results obtained for a sample of about 50 mi of conventional Class AA shoulders.

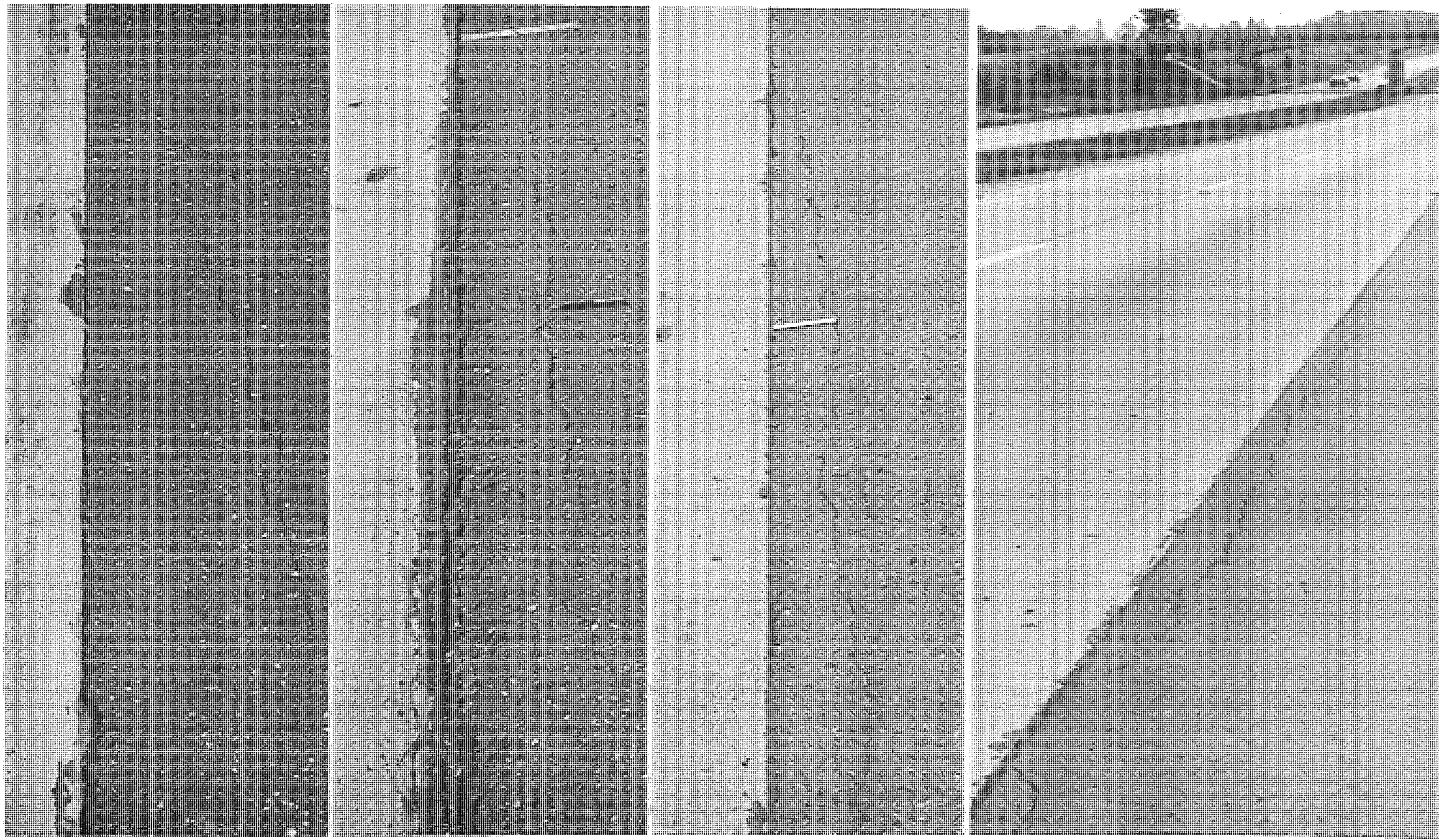
Test Results

After a detailed review of each project's background, the test areas were inspected with special attention to conditions of the bituminous shoulders, joints, and sealing compound. Figure 5 shows good sealer performance, while Figure 6 illustrates typical cases of sealer deterioration. In general, performance of the sealing material appeared to be affected by several factors, which may be grouped as follows:

1. Those reflecting the quality of the sealing material. These include ability to maintain tight joints by elastically absorbing changes in joint width.

2. Those related to the physical problem of binding together two different materials. These include important variables such as joint width, times of sawing and sealing, type of sealant, and method of sealing.

Results of shoulder condition surveys are summarized in Table 1, which includes two measured quantities: (a) the length of shoulder in linear feet which contains longitudinal cracking, and (b) the total linear feet of cracks (single and multiple) found in the shoulder section. Additional surveys of conventional shoulders must be conducted before any conclusions can be drawn from Phase I.



Sta. 1084+10
Project 1: WB Roadway
Age: 4 years 2 months

Sta. 1084+20
Project 1: WB Roadway
Age: 4 years 2 months

Sta. 253+00
Project 3: EB Roadway
Age: 1 year 11 months

Sta. 188+00
Project 4: EB Roadway
Age: 3 years 9 months

Figure 6. Minor deterioration or failure of sealer in 1/8-in. wide sawed longitudinal joints. At left, a 3-ft long crack has opened 3 to 9 in. from the joint; sealing material is gone but joint remains closed. At left center, an 8-ft crack runs 6-in. from the joint, with sealer showing inadequate adhesion and structural strength. At right center, sealer has disintegrated and 25-ft crack runs 3 to 9 in. from the joint. At right, with some sealer deterioration, a 30-ft crack up to 1/2 in. wide has opened about 3 in. from the joint.

Based on preliminary data, no valid conclusion can be stated. However, further surveys should provide a basis for a realistic evaluation of sealed joint performance.

PHASE II - Construction and Evaluation of Additional Experimental Shoulders

Under Phase II, test projects are to be constructed and carefully controlled so that the effect of a sealed joint in reducing shoulder cracking may be precisely evaluated. Operations for Phase II include the following considerations:

1. Size and Location of Experimental Sections. It has been proposed that a minimum of 25 lin mi of shoulders be built on four different construction projects, with about one-half of this length having sawed-sealed joints and the other half conventional uncut joints for comparison. Each project will be divided into 24 test sections and each section will be about 1/4-mi long. The first of these (Project 5) has been completed. Each 1/4-mi test section will be divided into 26 sample units approximately 51-ft long. Within each test section three of the 51-ft sample units will be selected at random and identified by paint markings for detailed elevation and joint width measurements.

2. Controlled Variables. Those factors which must be known and controlled within acceptable limits include the width and depth of cut joints, proper time for joint cutting or sawing, amount and rate of cold sealant applied, construction equipment and materials, and other construction variables. Aside from these controlled factors, variations in background conditions may affect results of the experiment. By dividing each test project into several sections, the influence of these variations will be somewhat equally distributed between both sealed and conventional joints. This will provide greater assurance that differences in environmental and construction variables will be spread equally within the total experimental area.

3. Type of Measurements. These will include extent and severity of longitudinal, transverse, and diagonal cracking; alligator cracking and patching; durability of the sealing material; and the severity of other types of distress that may occur. Vertical movements of the concrete pavement and the shoulders, and horizontal movements of the joints will also be measured. Photographic records will be maintained. Regular condition surveys and field inspections will be continued over the entire length of each project in fall, winter, and spring until sufficient measurable results can be recorded.

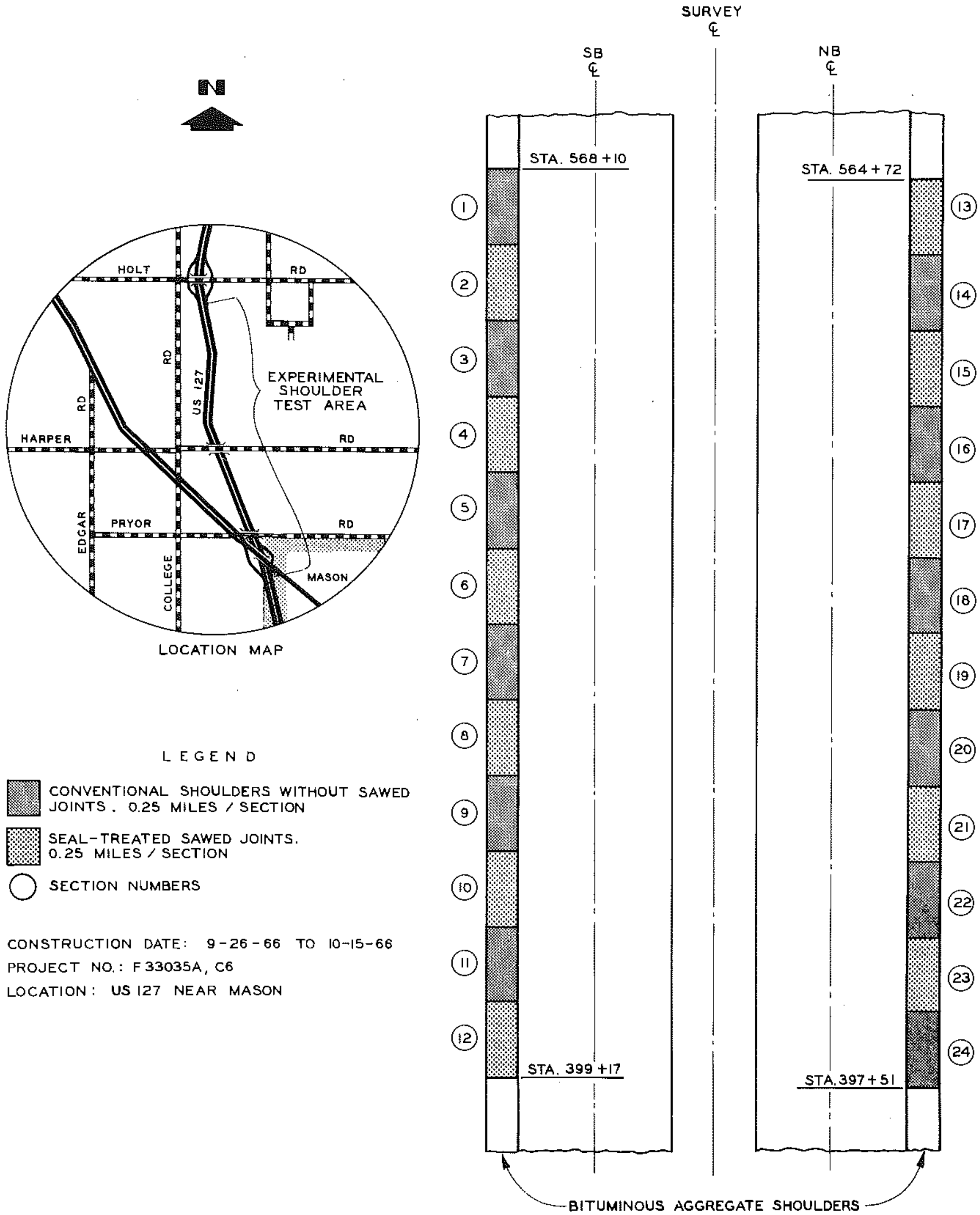


Figure 7. Schematic drawing showing 3 mi of experimental shoulders on four-lane divided highway. The outside shoulders of both roadways are divided into a total of 24 test sections.

CONSTRUCTION AND EVALUATION OF PROJECT 5

The Project 5 test site consists of 3.3 mi of four-lane divided highway on US 127 about 1 mi northwest of Mason in Ingham County (Fig. 7), in Construction Project F 33035A, C6. U. S. Weather Bureau climatological data procured from the Capital City Airport, about 15 mi from the test area, are shown in Figure 8. The charts include monthly averages for temperature and precipitation, and maximum and minimum monthly temperatures. During the 1964-65 winter, a maximum frost penetration of 45.5 in. was recorded for an area near the test site, with alternate thawing and freezing of the surface totaling about 70 cycles (based on surface temperature measurements). Soil surveys indicated that approximately 98 percent of the length of the project was underlaid by subgrade materials with poor or imperfect drainage characteristics.

The rigid pavement was poured between June 20 and September 19, 1966, and the bituminous shoulders were constructed between September 26 and October 15, 1966. The entire construction operation was carried out according to 1965 Michigan Department of State Highways Standard Specifications for Road and Bridge Construction.

Construction of Bituminous Shoulders

Only the outside or traffic lane shoulders are being investigated at the existing five sites and those to be constructed at a later date. The Class AA shoulders were designed and constructed to meet Departmental requirements for four-lane divided highways as shown in Figure 9. Moisture content and density values for the subbase and base course on outside shoulders were as follows: (a) for moisture content, 529 tests averaged 4.6 percent and varied from this average with a standard deviation of $\pm$ 2.6 percent, and (b) for compaction, 529 tests averaged 99.8 percent and varied from the average with a standard deviation of $\pm$ 2.3 percent. The 22A aggregate base course gradation data, summarized in Table 2 and plotted in Figure 10, were obtained from 254 tests on accepted samples of the stockpiled material. Bituminous mixture materials were proportioned by weight in 3,750-lb batches containing 50-percent 20A gravel, 41-percent sand, 3-percent mineral filler, and 6-percent bitumen. The asphalt cement, of 200-250 penetration grade, was used as obtained from a single producer located about 1 mi west of the project. Mixing times for the materials in the pugmill were 15 sec of dry mixing and 35 sec of wet mixing. Mixing temperature was maintained between 330 and 335 F. The bituminous plant analyses are summarized in Table 3.

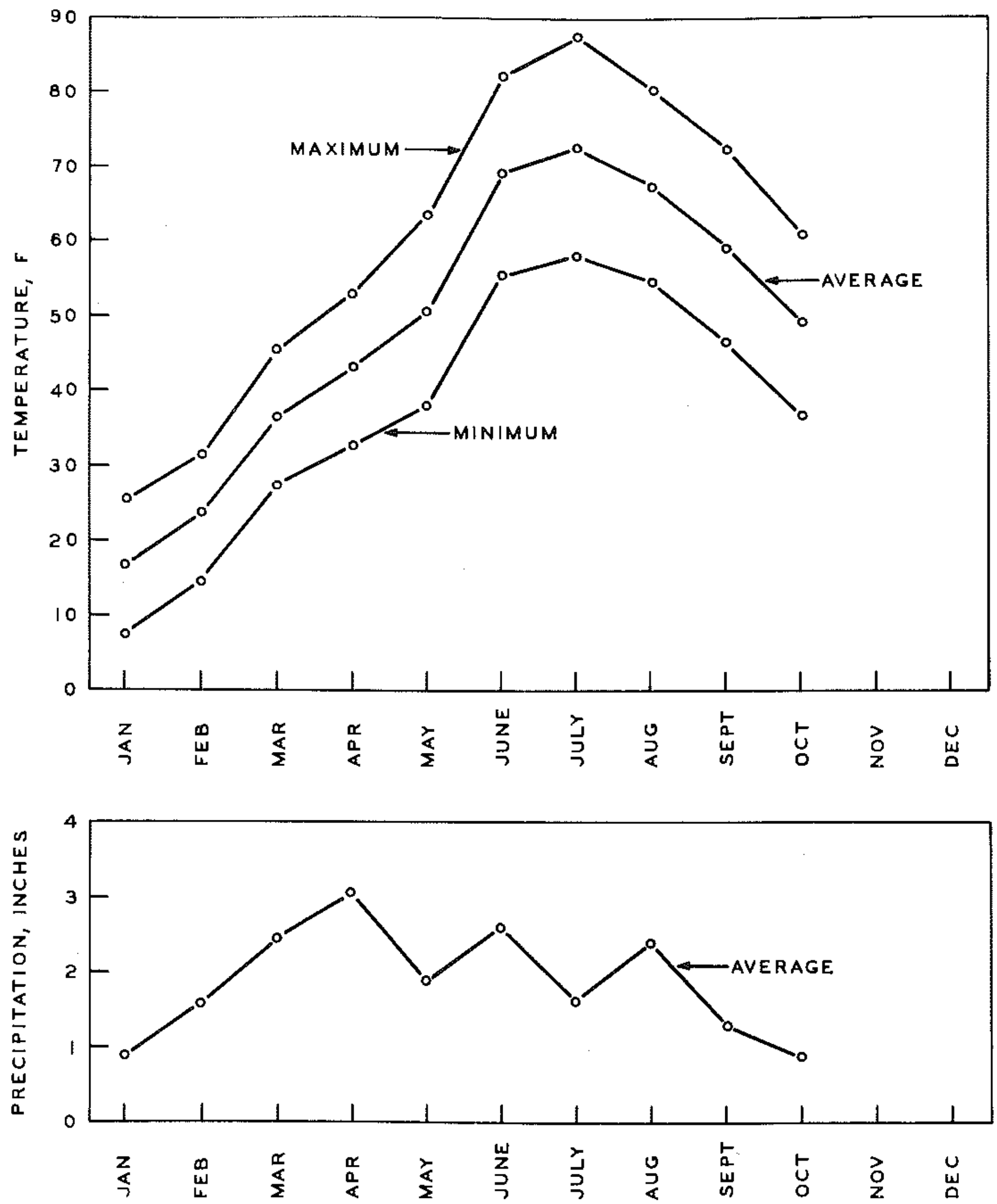


Figure 8. 1966 climatological data from Lansing's Capital City Airport weather station.

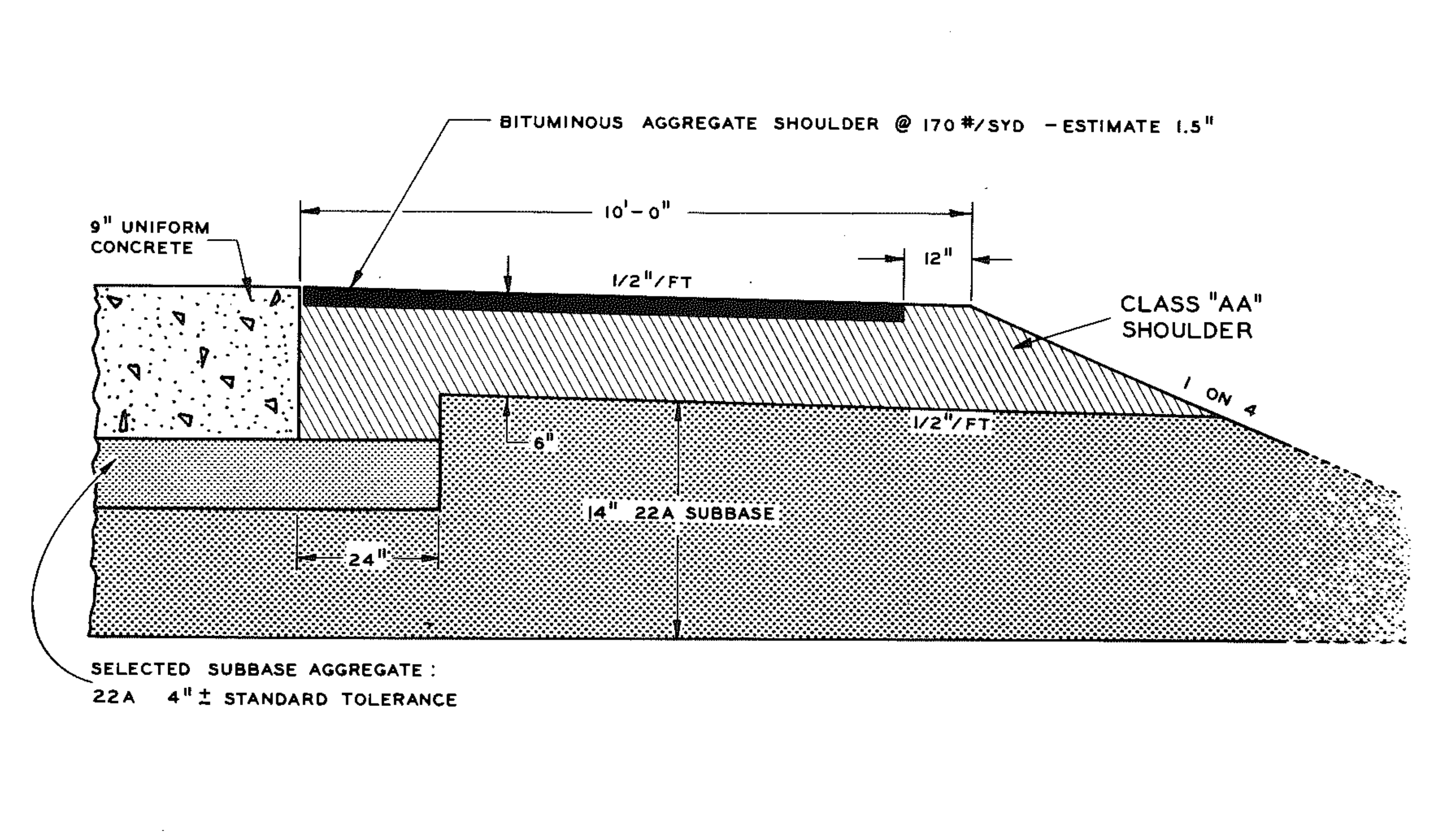


Figure 9. Typical cross-section of an outside Class AA shoulder.

TABLE 2
GRADATION TEST RESULTS FOR STOCKPILED 22A AGGREGATE

Sieve	Specification Limits, percent passing	Mean Value, percent passing	Standard Deviation, percent passing	Percent of Tests		
				Within Specifications	Above Specifications	Below Specifications
1 in.	100	100.0	--	100.0	--	--
3/4 in.	90-100	97.6	1.6	100.0	--	--
3/8 in.	65-85	73.7	4.4	98.0	--	2.0
No. 8	30-50	40.6	5.1	99.2	0.4	0.4
No. 10	30-45	38.2	5.0	93.7	5.0	1.3
No. 200	3-7	5.9	0.9	93.2	6.8	--
Crushed Material	25 min.	30.9	6.0	88.6	--	11.4

TABLE 3
SUMMARY OF BITUMINOUS PLANT ANALYSES

Sieve	Sand Bin (Based on 15 tests)		Stone Bin (Based on 14 tests)		Sampled from Mix Trucks (Based on 10 tests)		Sampled from Extracted Aggregate (Based on 10 tests)	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
3/4 in., percent passing	--	--	--	--	--	--	100.0	--
3/8 in., percent passing	--	--	--	--	--	--	83.9	1.7
No. 8, percent passing	3.4	1.8	95.0	0.8	46.8	1.1	50.1	1.2
No. 30, percent passing	--	--	--	--	--	--	27.1	0.9
No. 200, percent passing	2.2	0.7	1.1	0.7	6.4	1.9	6.8	0.3
No. 200, percent retained	94.4	1.4	3.9	0.9	10.8	1.2	--	--
Bitumen	--	--	--	--	6.0	0.2	--	--
	100.0		100.0		100.0			

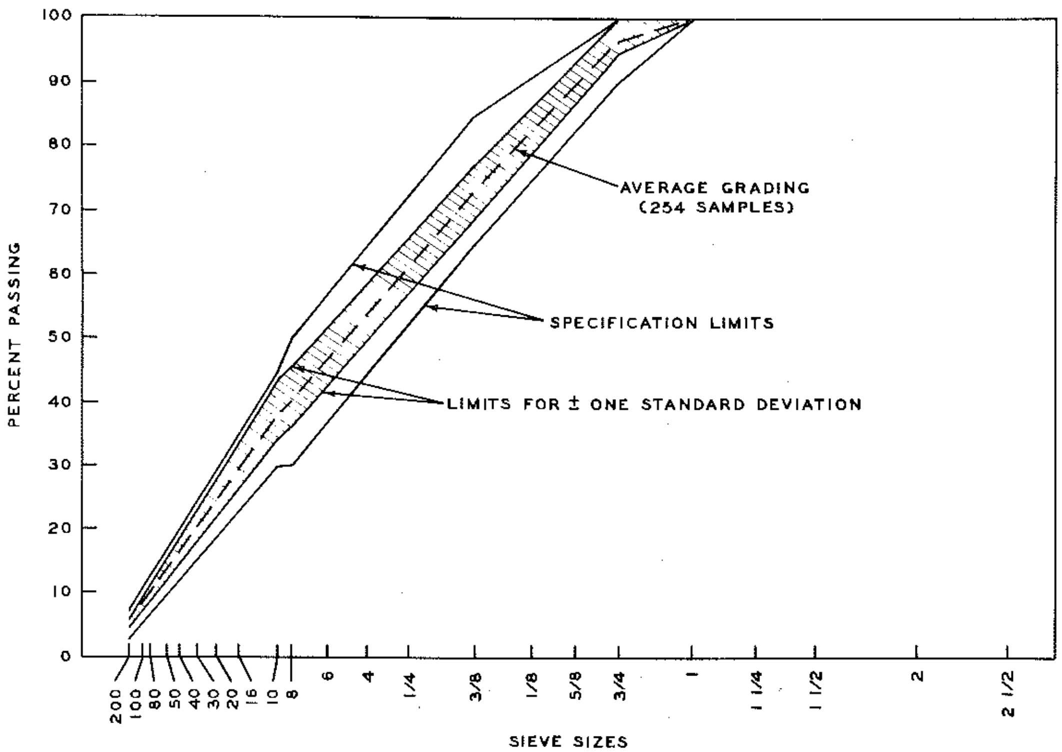


Figure 10. Gradation curve for 22A aggregate shoulders.

Construction of Sealed Longitudinal Joints

Outside shoulders of the Project 5 roadway were divided into 24 test sections as shown in Figure 7. Each section was 0.25 mi long and separated from adjacent sections by painted marks on the bituminous surface. Twelve of these sections had shoulders with sawed-sealed joints between the bituminous shoulders and rigid pavement, and the remaining 12 conventional shoulder sections were constructed as control sections, without sawed-sealed joints. Layout of the shoulder test sections (alternate sections on each roadway) was selected to provide the same environmental conditions for both types of joints under study.

Longitudinal joints were sawed in 12 selected test sections and filled with a cold solvent-type mastic sealer as specified for concrete construction (Section 7.16.03-d of 1965 Standard Specifications). Width and depth of the joints were measured at random locations in each sawed section. Based on 60 random measurements, average joint width was 9/64 in. with a standard deviation of 2/64 in. from the average, and average depth was 1-1/4 in. with a standard deviation of 1/16 in. from the average (Fig. 11). Width was measured to the nearest 1/64 in. with a pocket slide caliper and depth with a standard ruler graduated in 1/16-in. increments.

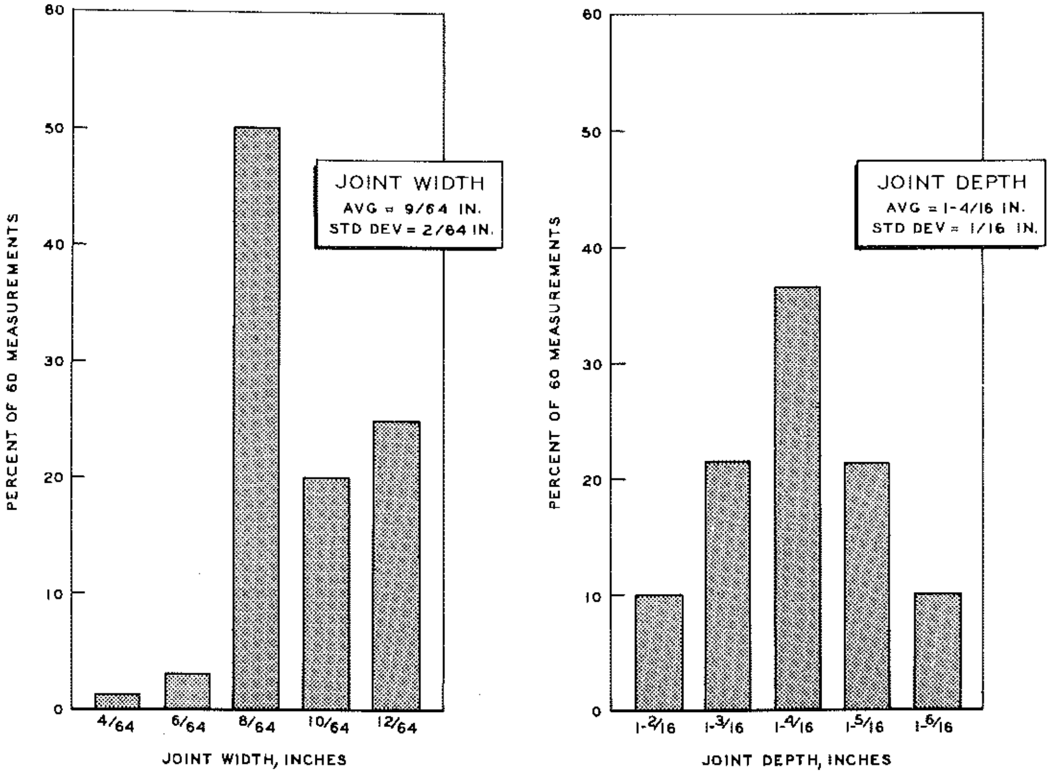


Figure 11. Dimensions of sawed Project 5 joints prior to sealing.

The sawing equipment used was a self-propelled saw with a water-cooled diamond blade adjusted to cut to the required depth of the compacted bituminous shoulders at an average rate of 1,300 lin ft per hr (Fig. 12). The sawing operation started October 19, 1966, four days after the bituminous shoulders had been constructed. The 12 test sections were sawed in 12 hr. The joint groove followed the side face of the concrete pavement and was uniform and free of spalls throughout the project (Fig. 13). Immediately following sawing, the joint was cleaned out by flushing with a jet of water under pressure (Fig. 13). The remaining dirt, water, and other debris were removed from the groove and surrounding area by using a jet of compressed air. The joint groove was clean and dry at the time of sealing.

Pressure equipment fitted with a narrow nozzle applied 2,000 lb of sealing material at an average rate of 4 lb per min. The nozzle was extended into the groove to fill the joint until the sealing material overlapped both the surface of the pavement and the shoulder as shown in Figure 1.

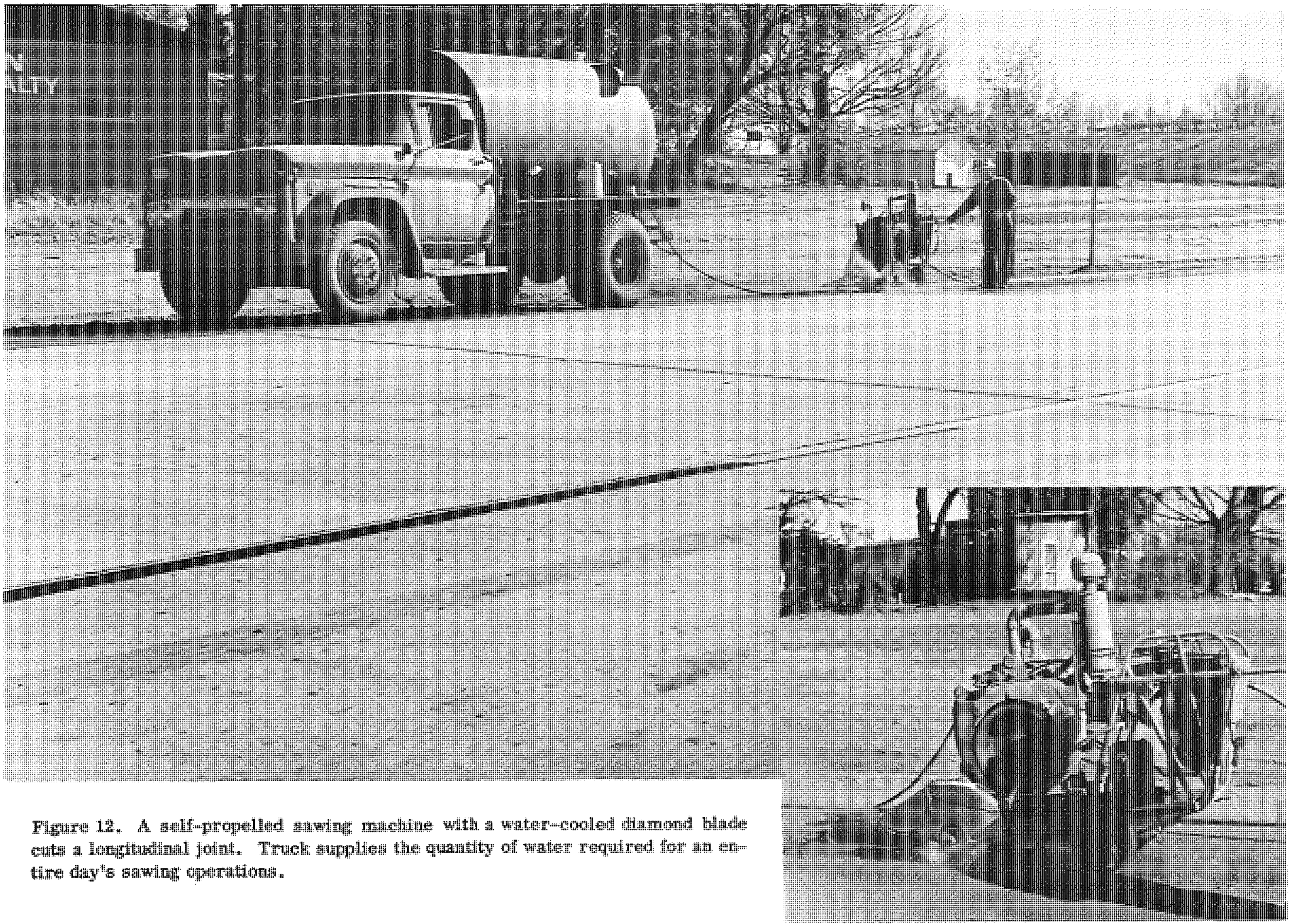


Figure 12. A self-propelled sawing machine with a water-cooled diamond blade cuts a longitudinal joint. Truck supplies the quantity of water required for an entire day's sawing operations.

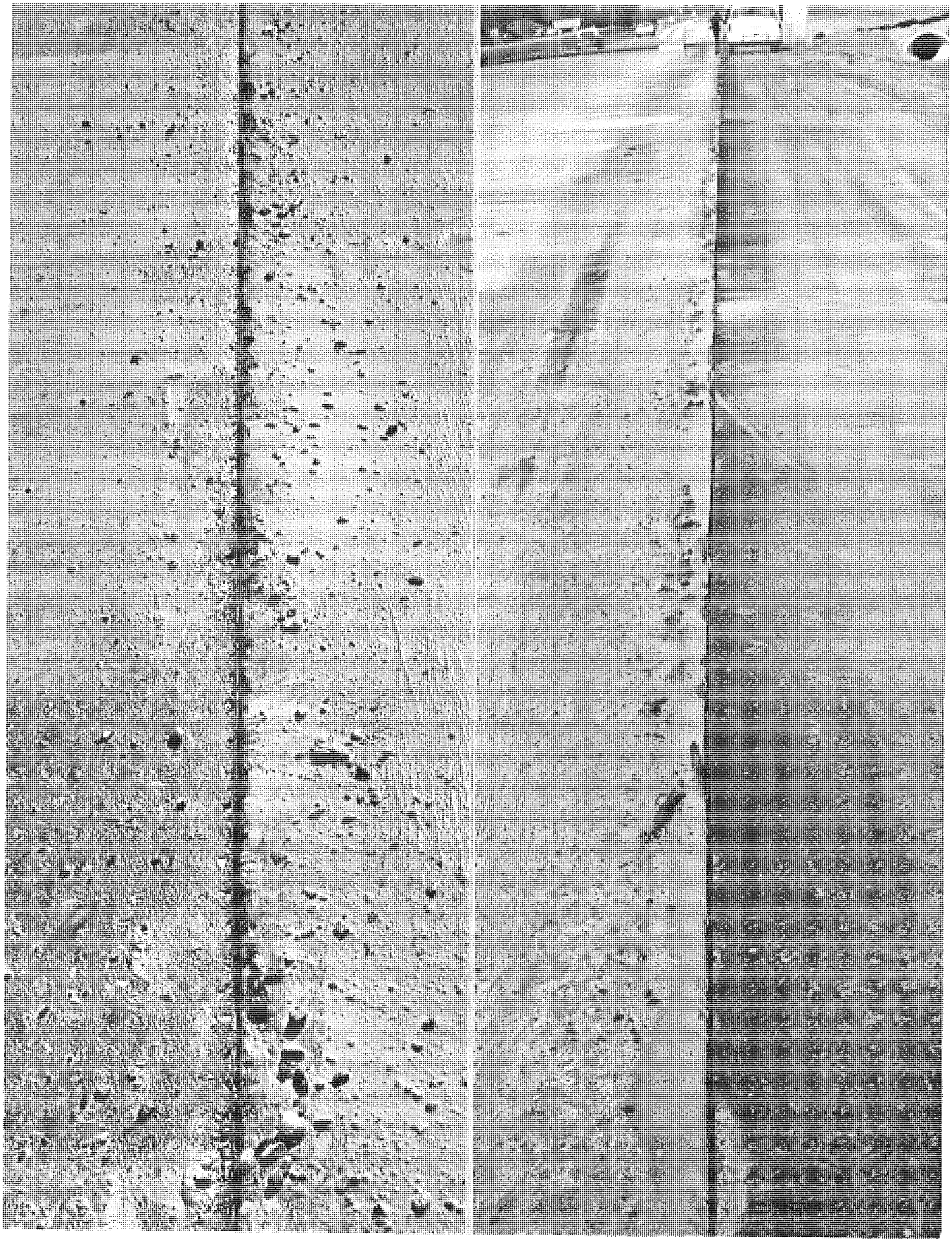


Figure 13. After sawing (left), the longitudinal joint is flushed with water, then cleaned and dried with compressed air.

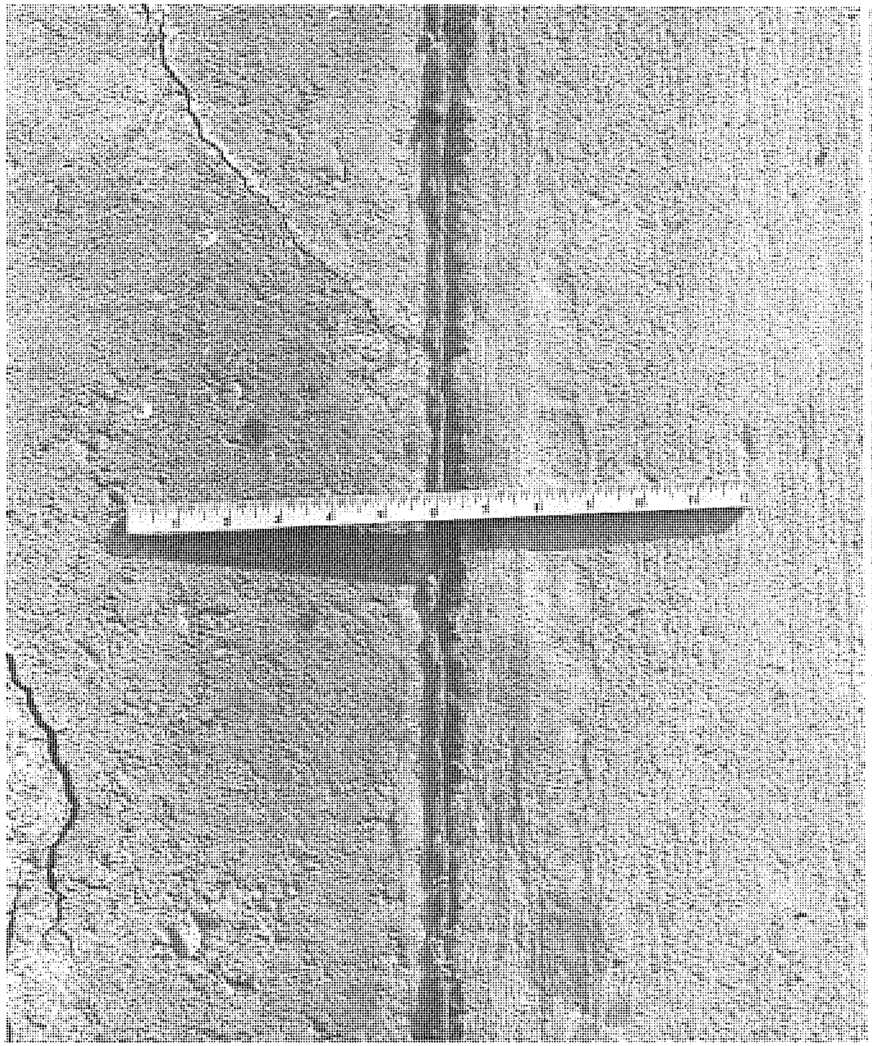
In Project 5, neither kraft paper nor other protection was used to cover the treated joints following the application of the sealer. Thirty samples of the sealing material were taken at random from the nozzle for possible future laboratory testing. If it is decided that the physical properties of the sealer merit laboratory verification, the tests will include penetration, flow, and bonding, conducted in accordance with standard specifications. The sealing operation started October 24, 1966 and the 12 test sections were sealed in 9 hr.

Results of Preliminary Surveys

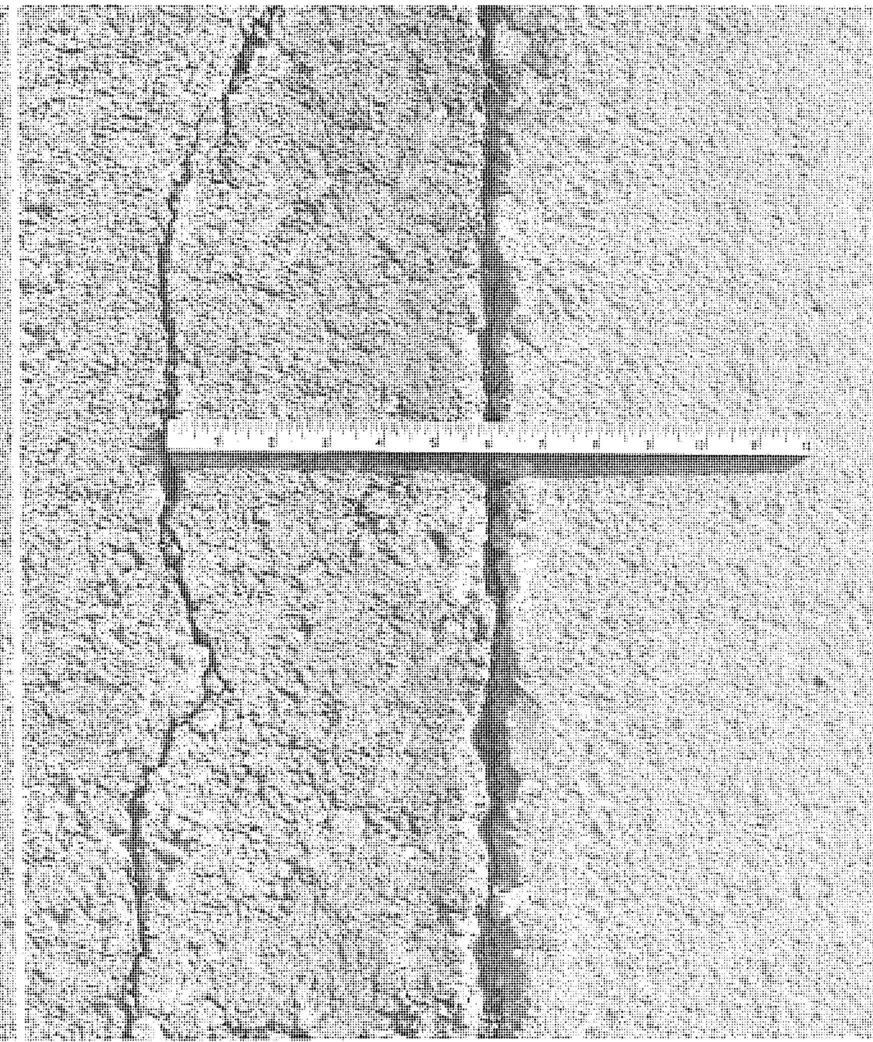
In November and December, field surveys at the test site included random measurements of elevation change, lateral joint displacement, and extent of cracking. Figure 14 illustrates diagonal and longitudinal cracking after only two months of service. The extent of longitudinal cracks in linear feet and percent of shoulder length surveyed in 1966 is listed under the Phase II portion in Table 1.

Because it was considered possible that frost heaving had some effect on formation of longitudinal cracking, and since field experience has shown that greater heaving occurs at the extreme edges of the pavement than in the interior portions, elevations were obtained at both edges of the experimental joint. These elevations, at three random locations per test section, ranged from 880.22 to 914.35 ft and were recorded to the nearest 0.01 ft. From these measurements, elevation differentials were obtained between the bituminous shoulder and concrete pavement. Figure 15 summarizes results of these measurements and illustrates the distribution of the elevation differentials. The data show that on the average the pavement was higher than the shoulder by 0.01 ft. This elevation differential was constant for both survey periods and was considered insignificant because it fell within the variability expected from instrument error and the normal variation in vertical displacement. Therefore, it is extremely unlikely that the early longitudinal cracking listed in Table 1 for Project 5 was caused by differential frost heaving.

Since concrete pavement and bituminous shoulders expand and contract from the effects of daily and seasonal changes in temperature and humidity, sealing materials used in the experimental joints are subject to extreme tensile stresses. The seriousness of these stresses depends upon type of sealing material, joint shape, and environment. Lateral movements of the joints were recorded to the nearest 1/64 in. and measured at three random locations per test section. Figures 15 and 16 show that on the average, joint opening remained constant between November and December 1966. However, when this opening of 13/64 in. is compared with the initial



Sta. 502+20
NB Roadway



Sta. 461+40
NB Roadway

Figure 14. Typical Project 5 sealed and unsealed longitudinal joints after two months of service. The seal exhibits good adhesion (left), with minor diagonal cracks on the shoulder. Pavement and shoulder edges have spalled at the unsealed joint (right), and a 30-ft crack, 1/4 in. wide, has developed 6 in. from the joint (December 1966).

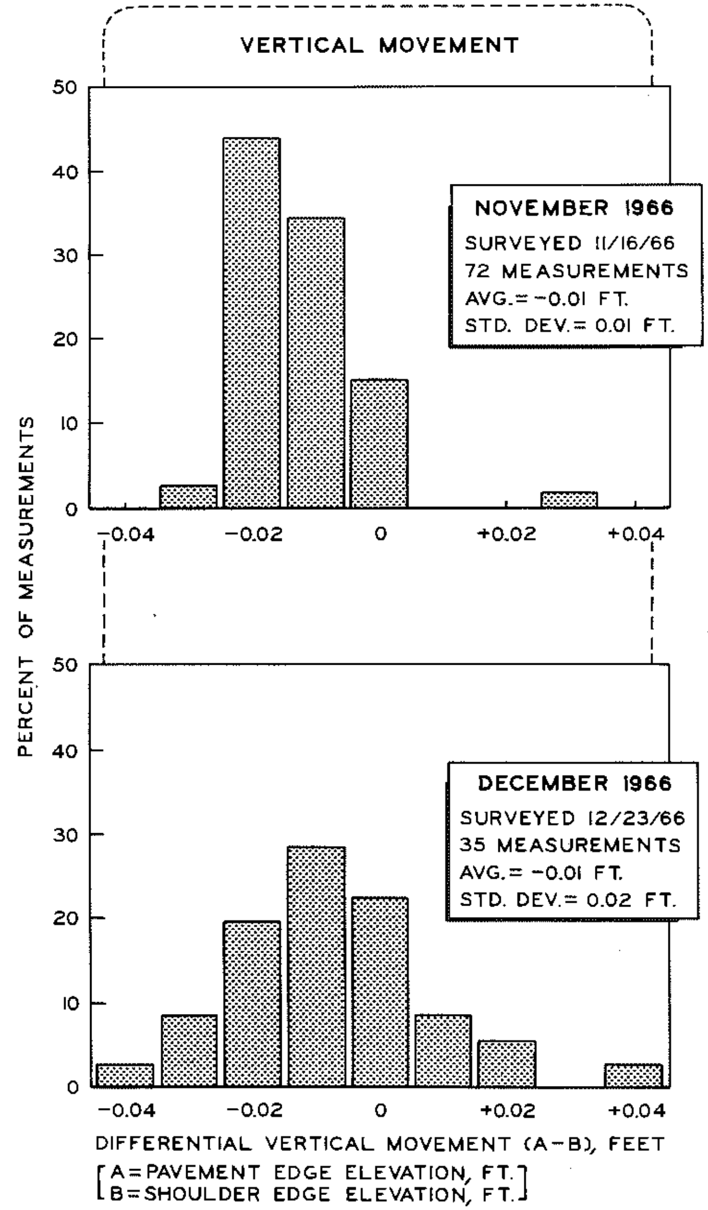


Figure 15. Differential vertical movement between bituminous shoulders and concrete pavement.

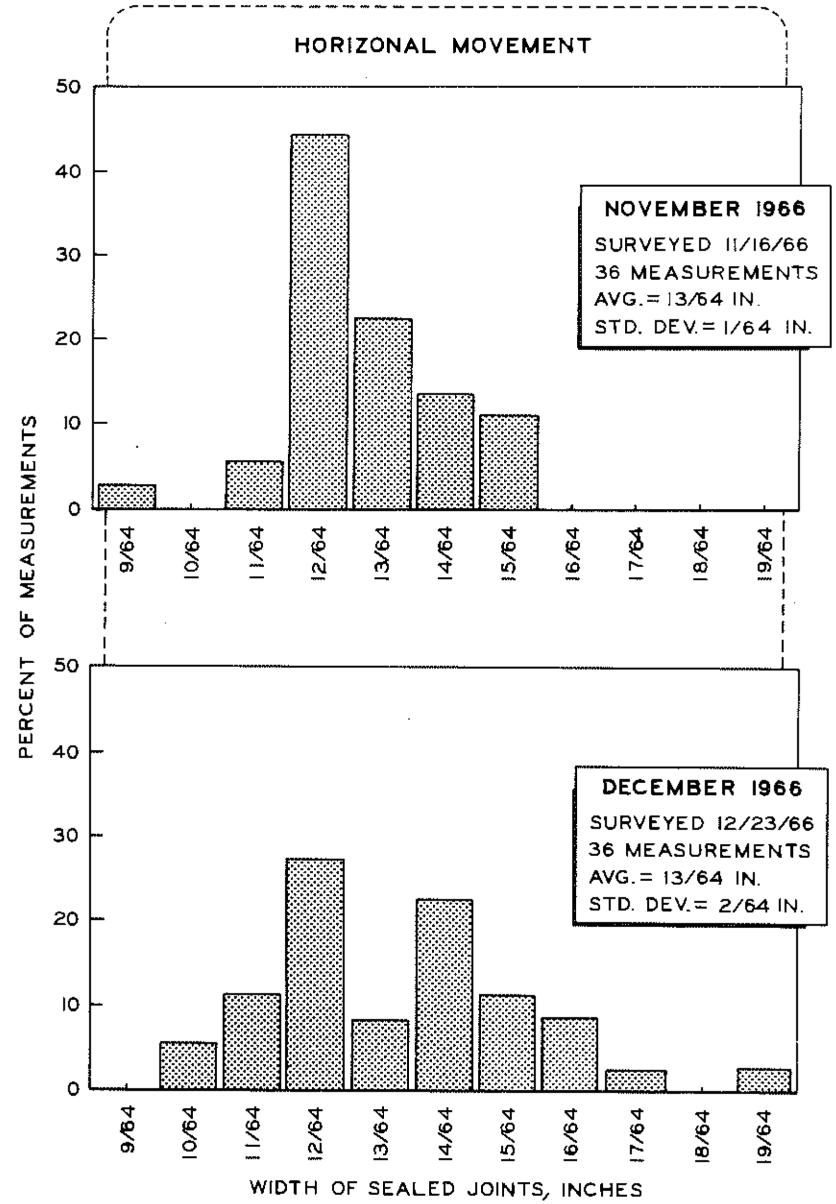


Figure 16. Horizontal movement of sealed joint.

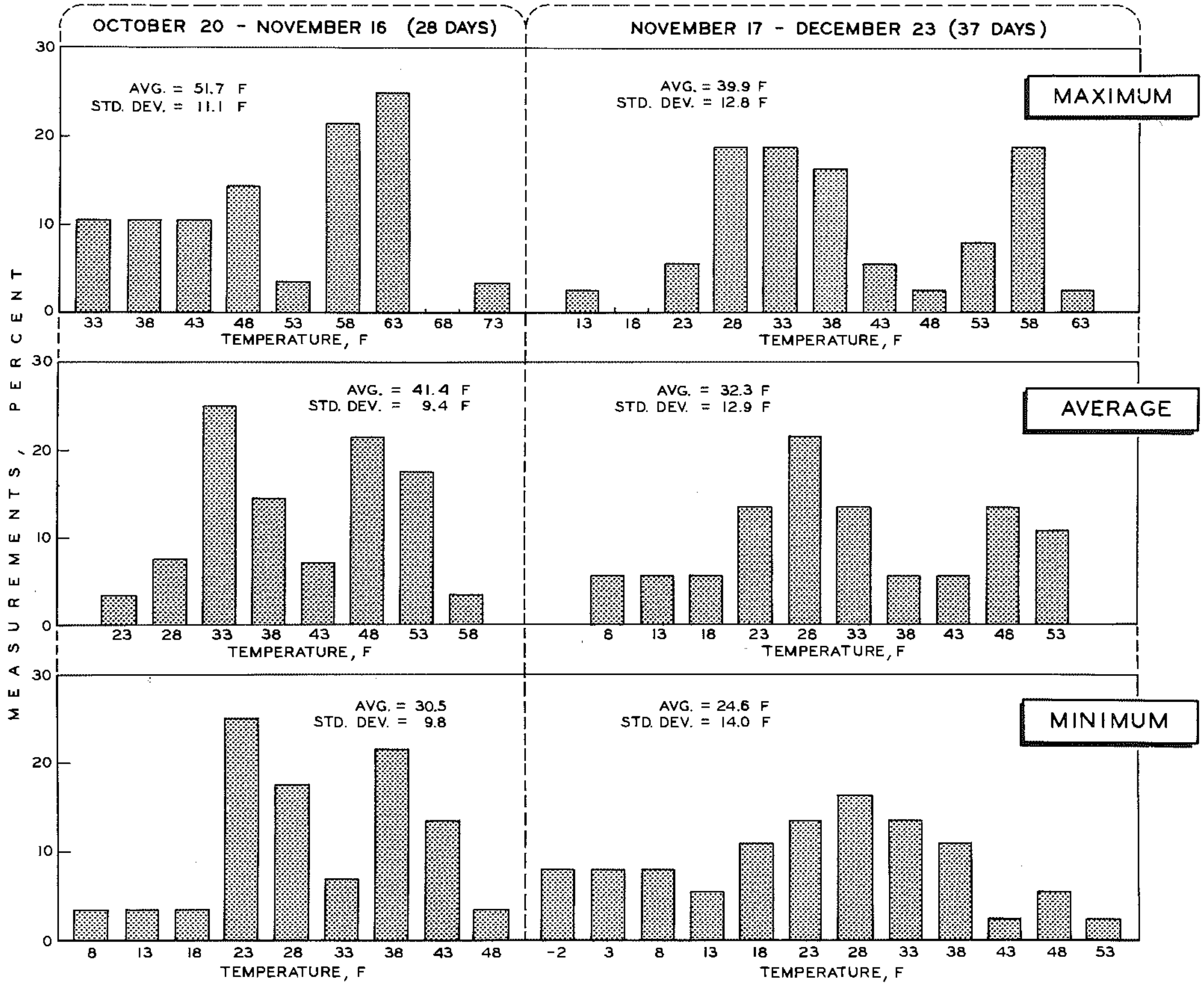


Figure 17. Daily 1966 temperature data from Capital City Airport, about 15 mi from the test site.

sawed joint width of 9/64 in. (Fig. 11), a lateral movement is indicated which caused a 44-percent stretch in the sealing material. Since wider opening of the joint is expected during periods of colder weather, the sealing compound will be stretched considerably more than the 50-percent limit specified for such materials. After only two months of service life, the sealing material showed good adhesion and consistent structural strength throughout Project 5.

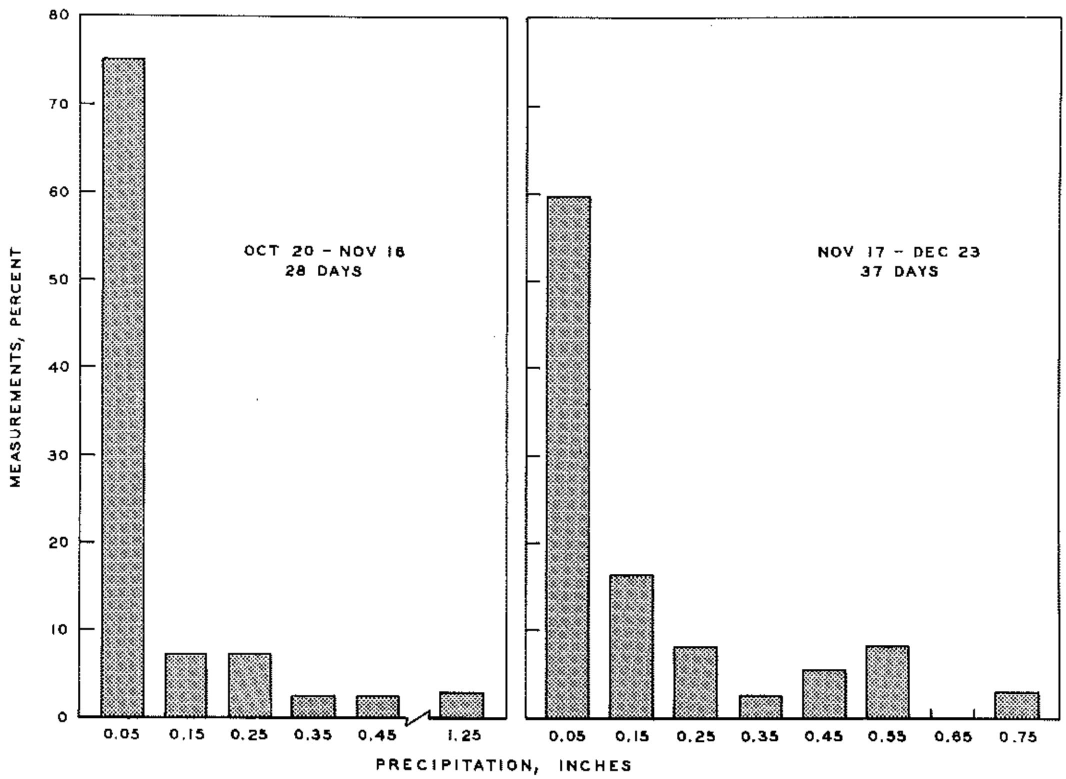


Figure 18. Precipitation data from Capital City Airport, about 15 mi from the test site.

Distributions of temperature and precipitation data for the period between construction and field surveys of the experimental joints are shown in Figures 17 and 18. Figure 17 shows that relative changes in temperature were up to 25-percent greater in December than in November 1966. Consequently, the experimental site was subjected to a greater range of tensile stresses in December than in November. This increase in temperature variation was also accompanied by 15-percent higher precipitation during the same period (Fig. 18).

Table 1 shows that the length of shoulder exhibiting longitudinal cracks was 958 ft for the sealed joint shoulder and 626 ft for the conventional shoulders in Project 1. On the other hand, in Project 5, early longitudinal cracks appeared more frequently on conventional shoulders than on sealed ones. To this extent, the data collected thus far are insufficient to establish the merit of the sealed joints in controlling the cracking problem.

CONCLUSIONS

1. It is very unlikely that frost heave caused early longitudinal cracking observed within two months after shoulder construction in Project 5.

2. During the first two months of service, the sawed joint between shoulder and pavement opened about 44-percent more than the original width. Michigan specifies a 50-percent stretch limit (bond test) for solvent-type mastic compound.

3. Further observations are necessary for conclusive evaluation of the merit of sawed-sealed longitudinal shoulder joints.

FUTURE WORK

Future surveys will continue until sufficient results are obtained to draw reliable conclusions. If data from seasonal surveys indicate that additional variables such as different joint widths or other types of shoulder asphalt should be included in the investigation, such variables may be tested in the remaining three projects to be constructed. During seasonal inspections, survey diagrams or maps will be prepared showing locations, extent, and degree of cracking and other types of distress for both experimental and convention construction. From these records, a serviceability index for sealed joint performance will be computed. Photographic records will be maintained and core samples through the shoulder cracks will be taken to measure crack depth variance.