PERFORMANCE OF JOINT SEALANTS USED IN 1964-65 MICHIGAN CONSTRUCTION

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This report has been prepared in response to a request from N. E. MacDougall of the Bureau of Public Roads, in a letter to H. E. Hill dated March 15, 1965, that neoprene joint seals be re-evaluated by the Department before the end of the year. This request was repeated in a letter from D. E. Jones to Mr. Hill, dated October 8, 1965, which specified re-evaluation before 1966 lettings.

The assessment of sealant performance reported here, however, originated earlier than Mr. MacDougall's request, when a construction data survey began in November 1964 for determination of current status of 1964 construction projects with regard to completion of sealing, and also such related subjects as slab length, numbers of contraction and expansion joints, and actual sealants installed during the preceding construction season. This data survey was to provide basic information for subsequent comprehensive study of comparative performance of sealant materials.

In a letter of January 18, 1965, concerned with evaluation of joint sealants, Mr. MacDougall stated: "Should you feel that sufficient evidence has been obtained to justify exclusive state-wide use of neoprene, a formal presentation should be submitted to this office in which specific reasons for your proposed use of the material would be cited, based on evaluation of test installations."

When this earlier letter was received, the construction data survey was still in progress, but Research Report No. R-493, dated February 1965, was prepared, summarizing the limitations in performance of both hot-poured and cold-applied liquid sealants. The relatively good performance of a 1963 experimental installation of neoprene on I 96 near Lansing, in joints designed for hot-poured material, was also reported. It was concluded that the neoprene sealer was demonstrably out-performing liquid-type sealants, even though later improvements specified for neoprene sealing were not incorporated in the I 96 experimental installation.

Meanwhile, in February 1965, with the 1964 construction data survey completed, the Research Laboratory outlined a field program of specific measurements and observations for evaluation of subsequent sealer performance. This program, in turn, was completed in early April 1965.

SCOPE OF THE FIELD SURVEYS

The February-April field survey included nine 1964 projects sealed primarily with neoprene or cold-applied materials, with some hot-poured expansion joints. These nine projects subsequently were resurveyed in December 1965 to assess a full year of service. In addition, this December survey included two more 1964 projects, with hot-poured sealer in all joints, and three 1965 projects containing neoprene and cold-applied contraction joints, and cold-applied and hot-poured expansion joints.

For these projects, all transverse joint grooves were formed by use of manually placed, preformed, temporary fillers. For neoprene seals, a vertical joint groove was formed on each slab edge to extend the neoprene material to the bottom of the slab. These vertical grooves were omitted where curbs, curbs and gutters, or additional lanes were to be added to the main roadway slab. Placement of neoprene sealant was preceded by compressed air cleaning of the grooves, and placement of liquid sealants by sandblasting followed by compressed air cleaning. Joint groove spalls were repaired with epoxy mortar before sealant installation.

Standard widths for neoprene seals were 1-1/4 in. for contraction and 1-5/8 in. for expansion joints. The neoprene was installed using hand tools, except for trial of a machine developed by a sealant manufacturer which was not used exclusively on any single project. The liquid-type sealants were installed by specified procedures, including use of a mixing-extrusion machine for cold-applied material.

The 1965 specifications were revised to permit sawed joint grooves on some projects. Two additional 1965 projects, containing sawed grooves, were included in the December survey for evaluation of neoprene installation and performance in this type of construction. These experimental projects are discussed later in this report.

To obtain useful information from the field surveys it was agreed that for each project a representative number of joints would be randomly selected to undergo detailed inspection, rather than cursorily inspecting all joints.

Briefly, the inspection consisted of the following:

1. Recording joint location so that the same joints could be re-inspected later.

2. Estimating length and depth of adhesion and cohesion failures in liquid sealant.

3. Measuring depth below pavement surface for preformed neoprene sealants.

4. Describing general sealant condition, including dirt infiltration in liquid sealants and tears and breaks in neoprene sealants.

5. Measuring joint groove widths.

6. Measuring lengths of repaired spalls, and spalls which had occurred after sealing.

7. Photographing typical joint sealant performance, and unusual conditions noticed during the inspections.

Field data for all regular construction contraction joints surveyed are summarized in Table 1, and for all expansion joints in Table 2. Data for the experimental neoprene joints are given in Table 3.

CONTRACTION JOINTS SEALED IN 1964

Preformed Neoprene

On all projects surveyed in December 1965 after more than a year of service, neoprene showed excellent performance (Fig. 1). The seals were tight against the groove walls, thus preventing infiltration of foreign materials. Sealant tightness, as measured by joint groove widths and given in Table 1, demonstrated the compression remaining in the seals. Because temperatures during both surveys were about the same, there is little variation in the two sealant tightness values given. Measurements of sealant depth below surface (Table 1) indicate little upward or downward creep due to expansion-contraction cycles to which the seals were subjected during the intervals between surveys.

Some difficulties were observed in obtaining proper seal installation (Fig. 2), and in forming joint grooves that have sound walls (Fig. 3). On one project (Oakland Ave., Lansing), several seals were replaced at the contractor's expense because faulty installation resulted in sealant damage. To minimize failures caused by installation techniques, Michigan is contemplating specification of machine installation of neoprene, as soon as such machines become available.

Joint groove quality should improve considerably when sawed joint grooves are required. For example, data on spalling of sawed contraction joint grooves obtained from Michigan's I 96 test pavement containing experimental transverse joints (as reported in Research Report No. R-428, dated January 1964) show 0.6-percent spalls for the total length of joint groove edge after 3-1/2 years, compared to an average of 4.4 percent for the formed contraction joint grooves after about 1-1/2 years on 1964 projects included in Table 1.

Two-Component, Elastomeric Cold-Applied (Type 1)

Performance of this type of sealant on the three projects included in the survey was rated as fair to good early in 1965 after approximately six months of service. Adhesion failures were noted on all three projects during the first survey (Table 1). In percent of total joint length, adhesion failures for the Saginaw, Ypsilanti, and Newaygo projects were 0.5, 2.7, and 6.3, respectively. These percentages of failure increased to 17.3 and 49.2 for the Saginaw and Ypsilanti projects according to data obtained in the December 1965 survey. On the Newaygo project, failures became so extensive during the summer that re-sealing with hot-poured rubber-asphalt was performed in September. Typical performance is shown in Fig. 4.

Hot-Poured Rubber-Asphalt

On one of the two projects surveyed (I 196, Grand Rapids), the sealant had failed extensively in cohesion (Fig. 5). On the other (M 14, Ypsilanti), adhesion and cohesion failures were much less severe. Fig. 5 also shows a typical joint seal on the Ypsilanti project; at the time of survey, this sealant exhibited good resilience and ductility, although some surface wrinkling, overflow, and dirt infiltration were noted. The same conditions have been observed in previous surveys conducted on other projects having this type of sealant. In general, this material performs well during the first few months of service, but failures of either type are common, especially when extrusion has occurred.

CONTRACTION JOINTS SEALED IN 1965

Because sealant installation on projects surveyed was completed in November, both the preformed neoprene and the cold-applied seals still provided effective sealing at time of the December survey. Hot-poured contraction joint seals were not permitted on projects constructed in 1965. Performance data are tabulated in Table 1.

Preformed Neoprene

Less sealer twisting was noted than on the 1964 projects, but sealant depth below the surface continued to vary. No breaks or tears were found in the seals. Spalling of joint walls continued to be a problem, varying in severity among projects. These conditions are shown in Fig. 6.

Two-Component, Elastomeric Cold-Applied (Type 1)

Small lengths of adhesion and cohesion failures were found, indicating that failures originate relatively early for this sealant type. Sealant surface appearance was good. Extensive spalling of joint walls had occurred. Fig. 7 shows typical sealant and groove conditions.

EXPANSION JOINTS SEALED IN 1964

Preformed Neoprene

Neoprene expansion joint seals were performing well after one winter of service. Except for areas where groove walls had spalled, the seals appeared to be effectively preventing joint infiltration. However, during the summer period of pavement expansion, closing of the joints resulted in seal extrusion above the surface at many joints, particularly where heavier-walled, 1-5/8-in. material was used. It appears that formed joint grooves with bottoms narrower than tops cause the seal to move upward when compressed by expanding concrete. The extruded seals are then often torn or nearly pulled out by traffic. This condition was most severe on the Columbia Ave. project in Battle Creek, where damaged seals were replaced with hot-poured rubber-asphalt at the contractor's expense. This problem should be eliminated by requiring sawing of joint grooves for neoprene expansion seals of proper cross-section. Fig. 8 demonstrates the effectiveness of the seals and Fig. 9 the problems arising in installation, pavement expansion, and groove spalling.

Two-Component, Elastomeric Cold-Applied (Type 1)

The earlier 1965 survey showed good performance of cold-applied sealants in expansion joints (Fig. 10). They were pliable and free of embedded material, with only minor adhesion failures noted (Table 2). As in the case of neoprene, pavement expansion forced sealants above the pavement surface. Because this type of sealant remains sufficiently solid in warm weather to resist flow, the extruded seals failed under the action of traffic. This type of failure was so extensive on the M 37-Newaygo project, that the expansion joints were resealed with hot-poured material in August 1965. The December 1965 survey revealed that at the I 75-Saginaw rest area, adhesion failures had occurred along 80 percent of the total joint length surveyed. The sealant was still pliable and generally free of embedded material. Some seals were partially extruded above the surface and damaged by traffic (Fig. 10).

Hot-Poured Rubber-Asphalt

Good performance of this type of sealant in expansion joints was observed in both surveys. On only one project (M 153-Ypsilanti) were adhesion failures visible. As shown in Table 2, 7.2 percent of the total joint length surveyed had failed. The December survey showed this percentage to have decreased to 3.7, with 1.2-percent failure in cohesion. This decrease may be explained by the fact that this type of sealant becomes quite fluid in summer, which in conjunction with closing of the joint, results in obliteration of old failures (Fig. 11). On the M 43-Lansing project, adhesion and cohesion failures were noted in the December survey, but expansion joints on the other two projects showed no failures of either type (Table 2). Typical illustrations of well-sealed expansion joints are shown in Fig. 11.

EXPANSION JOINTS SEALED IN 1965

Again, because seals had been in service only a short time, both hot-poured and cold-applied sealants were in excellent condition. Neither type had failed in adhesion or cohesion. Since the joints had not yet been subjected to compression by expanding pavement slabs, the surface of the cold-applied seal was below the pavement surface and the hot-poured seals had not extruded. Spalling had occurred at some joint edges. Typical seals are shown in Fig. 12.

EXPERIMENTAL NEOPRENE-SEALED JOINTS

As a consequence of extrusion of neoprene expansion joint sealers during the summer of 1965, as previously mentioned (and shown in Fig. 9), the Bureau of Public Roads agreed to experimental installation of sealers of various widths in variously constructed grooves. This comparative evaluation involved two construction projects, at Holt and Holland, as indicated in Table 3. In addition, all contraction joint grooves on both projects were sawed, rather than conventionally formed using temporary filler, in order to evaluate comparative quality of sealer installation and frequency of spalling, as well as effectiveness of seal.

Expansion Joints

At Holland, expansion joint grooves were all initially formed using 1-in. temporary filler. Various joints were then sealed with preformed neoprene expansion joint sealers in three categories:

Group 1. Standard 1-in. grooves were sealed with 1-3/8-in. thin-wall neoprene, with the exception of one groove in which 1-1/2-in. thin-wall neoprene was used. This latter material had been submitted as 1-3/8-in. sealer, but was oversize and was designated as 1-1/2-in. nominal size.

Group 2. Standard 1-in. grooves were sawed to 1-1/4-in. and sealed with 1-5/8 in. thin-wall neoprene.

Group 3. Standard 1-in. grooves were sawed to 1-1/4 in. and sealed with 1-5/8 in. regular-weight neoprene.

At Holt, expansion joints were formed by sawing 1- by 2-1/4-in. grooves before uncontrolled cracking occurred. These were then sealed with 1-5/8-in. thin-wall neoprene.

Upon inspection in early December 1965, shortly after completion of sealer installation, all expansion joints were neat in appearance, but all five different types of installation had isolated spots where sealer was low in the groove. Whether traffic, together with dirt accumulation, is forcing the neoprene down, will be determined by subsequent inspections.

It should be noted that the "Sealer Compression" values in Table 3 were calculated using the sealer's nominal width and the groove's measured width above the sealer. These seal compression figures are conservative, since sealer width specifications have a plus tolerance but no minus tolerance. This is especially true in the case of expansion joints formed with temporary filler, where the joint groove is frequently found to be narrower at the bottom than at the top.

Many more spall patches were found at Holt than at Holland, as illustrated by the typical installations shown in Figs. 13 and 14. This was due to difficulty in determining optimum time for sawing, according to construction personnel.

Contraction Joints

At Holland, contraction joint grooves were constructed using 1/4- by 2-in. temporary filler, and subsequently sawing over the filler to form 1/2- by 2-in. grooves after the concrete had cured. These joints were sealed with standard 1-1/4-in. preformed neoprene contraction joint sealer.

At Holt, contraction joints were formed by sawing 3/8- by 2-in. grooves before uncontrolled cracking occurred. Grooves were sealed with 13/16-in. preformed contraction joint sealer. These sealer and groove sizes were used for study of their feasibility as compared to the standard 1-1/4-in. sealer and 1/2-in. joint groove, in both cases using the 71-ft 2-in. slab length.

The contraction joint installations were inspected at the same time as the expansion joints, in early December. At both locations, the contraction joints were excellent in appearance, were tight, and had very few patched or unpatched spalls (Fig. 15). The most significant observation was that there was considerably less twisting of the seal and greater uniformity of depth below the pavement surface than in installations where joint grooves are not sawed.

SUMMARY

In conclusion, while certain problems remain to be resolved in connection with neoprene sealants, the observations reported here indicate that even at their present stage of development they are doing a better job than either conventional liquid sealant in the basic function of preventing infiltration of foreign material into the joint.

Research now underway in Michigan and elsewhere promises further improvements in two important areas--manufacture and installation. Improvements can be expected from the respective manufacturers in geometry and uniformity of quality of the sealant. Improved installation will result from better joint forming and preparation, and from mechanizing the sealing operation.

TABLE 1
SUMMARY OF CONTRACTION JOINT SEAL PERFORMANCE

Sealed	Sealer Type	Project Number: Michigan	Project Number: Federal	Location	Survey Date	Air Temp. F	Joint Groove Width, in.: Max.	Min.	Avg.	Joint Groove Spalls, % of Total Length: Repaired	Existing	Seal Depth Below Surface, in.: Max.	Min.	Avg.	Computed Seal Compression, %: Max.	Min.	Avg.	Sealant Failure: Adhesion: % of Total Joint Length	Adhesion: Estimated Depth Range, in.	Cohesion: % of Total Joint Length	Cohesion: Depth Range, in.
SEALED 1964	Preformed Neoprene	I 13033D, C8	I 194-7(4)99	Columbia Ave. over I 94BL, Battle Creek	3-11-65	36	0.69	0.60	0.64	0.0	3.6	0.47	0.00	0.17	52	45	49	Not Applicable for this Sealant Type			
					12-14-65	42	0.82	0.62	0.72	---	5.2	0.28	0.03	0.16	50	34	42				
		I 13121E, C2 & 3	U 29 (11)	I 94BL, Battle Creek	3-11-65	41	0.84	0.55	0.76	1.4	3.3	0.41	0.00	0.22	56	33	39				
					12-14-65	40	0.92	0.56	0.82	---	10.9	0.53	0.03	0.23	55	26	34				
		U 33061D, C11 etc.	U 437 (6)	M 43 (Oakland Ave.), Lansing	3-10-65 (a)	28	0.60	0.52	0.58	0.3	4.5	0.50	0.06	0.28	58	52	54				
		I 41027A, C24, etc.	I 96-1(47)72	I 196, Grand Rapids	3-15-65	42	0.83	0.61	0.73	1.2	5.9	0.59	0.00	0.23	51	34	43				
					12-6-65	33	0.90	0.68	0.79	---	6.9	0.50	0.00	0.23	46	28	37				
		F 50092A, C1	F 256 (11)	M 19, New Haven	3-9-65	35	0.82	0.64	0.70	0.6	1.0	0.38	0.06	0.20	49	34	44				
					12-9-65	43	0.77	0.64	0.71	---	2.2	0.38	0.03	0.21	49	38	43				
		EBBF 56044C, C23	BF 182 (19)	US 10 Rest Area, Midland	4-5-65	40	0.61	0.53	0.57	0.0	4.8	0.47	0.06	0.19	58	51	54				
					12-10-65	41	0.69	0.60	0.66	---	10.0	0.41	0.09	0.21	52	45	47				
	Two-Component Elastomeric Cold-Applied (Type 1)	F 62031C, C9	F 268 (9)	M 37, Newaygo	3-8-65 (b)	40	0.82	0.75	0.79	2.3	1.1	Not Applicable for this Sealant Type						6.3	Center to bottom	0.0	0
		BI 73171C, C19	I 75-2(90)133	I 75 Rest Area, Saginaw	2-17-65	35	0.65	0.62	0.64	2.3	0.4							0.5	Top to center	0.0	0
					12-10-65	41	0.75	0.69	0.72	---	5.0							17.3	Center to bottom	0.0	0
		F 81121A, C2	F 250 (15)	M 153, Ypsilanti	2-23-65	18	0.62	0.50	0.57	0.0	1.6							2.7	Center to bottom	0.0	0
					12-8-65	38	0.72	0.54	0.64	---	3.2							49.2	Center to bottom	0.0	0
	Hot-Poured Rubber-Asphalt	I 41029E, C3 etc.	I 96-1(45)70	I 196, Grand Rapids	12-16-65	30	0.97	0.81	0.88	0.0	2.5	Not Applicable for this Sealant Type						0.0	0	53.9	All to bottom
		F 81103B, C7	F 82 (10)	M 14, Ypsilanti	12-8-65	38	0.96	0.82	0.88	0.0	0.2							8.3	Top to center	0.3	Top to center
SEALED 1965	Preformed Neoprene	F 50013A, C2	F 212 (36)	M 53, Utica	12-15-65	35	0.83	0.66	0.77	9.0	4.8	0.56	0.09	0.27	47	34	38	Not Applicable for this Sealant Type			
		BI 81104A, C18	I 94-5(55)178 U 405 (6)	M 14, Ann Arbor	12-13-65	42	0.80	0.68	0.73	0.8	0.7	0.56	0.00	0.26	46	36	42				
	Two-Component Elastometic Cold-Applied (Type 1)	F 50013A, C1	F 212 (35)	M 53, Utica	12-15-65	36	0.94	0.72	0.79	0.1	5.6	Not Applicable for this Sealant Type						1.1	Top to bottom	0.2	Top to bottom

(a) Contraction joints on this project not resurveyed, because a large percentage of the seals were replaced in August and September 1965.
(b) This project not resurveyed, because re-sealing with hot-pour was performed in October 1965.

TABLE 2
SUMMARY OF EXPANSION JOINT SEAL PERFORMANCE

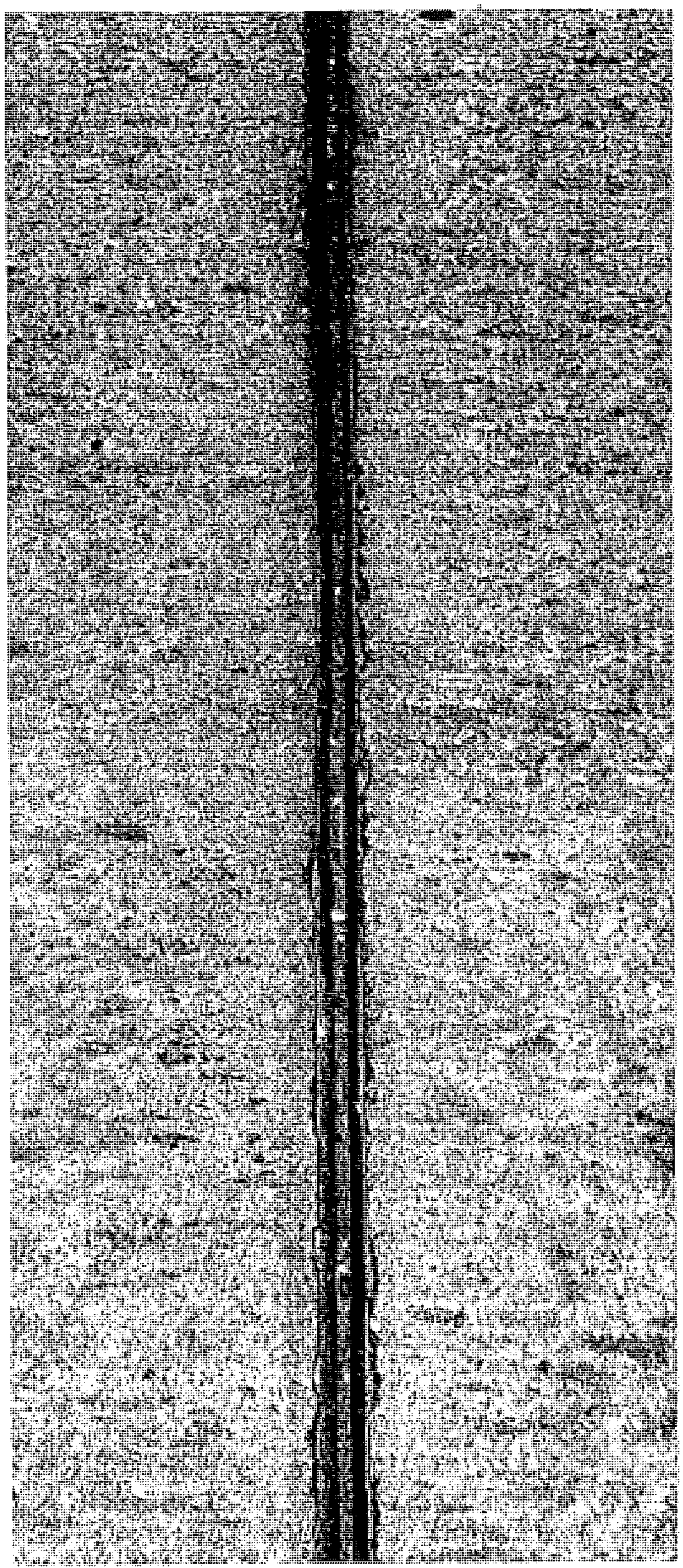
Sealed	Sealer Type	Project Number		Location	Survey Date	Air Temp, F	Joint Groove Width, in.			Joint Groove Spalls, % of Total Length		Seal Depth Below Surface, in.			Computed Seal Compression, %			Sealant Failure			
																		Adhesion		Cohesion	
		Michigan	Federal				Max.	Min.	Avg.	Repaired	Existing	Max.	Min.	Avg.	Max.	Min.	Avg.	% of Total Joint Length	Estimated Depth Range, in.	% of Total Joint Length	Depth Range, in.
1964	Preformed Neoprene	I 13033D, C8	I 194-7(4)99	Columbia Ave. over I 94BL, Battle Creek	3-11-65 (a)	36	1.34	1.05	1.18	0.0	4.5	0.45	0.29	0.36	36	20	28	Not Applicable for this Sealant Type			
		I 13121E, C2, C3	U 29 (11)	I 94BL, Battle Creek	3-11-65	41	1.51	1.39	1.43	0.4	1.4	1.25	0.37	0.55	15	7	12				
					12-14-65	40	1.60	1.31	1.49	0.0	4.0	1.78	0.22	0.38	19	0	8				
		I 41027A, C24 etc.	I 96-1(47)72	I 196, Grand Rapids	3-15-65	42	1.39	1.00	1.13	0.5	3.6	1.09	0.16	0.41	39	14	30				
					12-6-65	33	1.10	0.83	1.03	0.0	4.4	0.72	0.00	0.16	49	32	36				
		F 50092A, C1	F 256 (11)	M 19, New Haven	3-9-65	35	1.40	1.30	1.35	0.0	7.3	0.19	0.06	0.15	20	14	17				
					12-9-65	43	1.26	1.14	1.20	0.0	11.4	0.31	0.12	0.23	30	22	26				
		EBBF 56044C, C23	BF 182 (19)	US 10 Rest Area, Midland	4-5-65	40	1.18	1.11	1.16	5.0	13.8	0.47	0.16	0.25	32	28	29				
					12-10-65	41	1.20	1.00	1.12	0.0	21.0	0.41	0.12	0.28	38	26	31				
	Two-Component Elastomeric Cold-Applied (Type 1)	F 62031C, C9	F 268 (9)	M 37, Newaygo	3-8-65 (b)	40	1.72	1.39	1.59	0.4	0.7	Not Applicable for this Sealant Type						2.4	Center to bottom	0.0	0
		BI 73171C, C19	I 75-2(90)133	I 75 Rest Area, Saginaw	2-17-65	35	1.67	1.45	1.58	2.5	0.7							0.0	0	0.0	0
					12-10-65	41	1.61	1.43	1.52	0.0	4.3							7.9	Top to bottom	0.0	0
	Hot-Poured Rubber Asphalt	U 33061D, C11 etc.	U 437 (6)	M 43 (Oakland Ave.), Lansing	3-10-65	28	1.52	1.32	1.39	0.0	0.0	Not Applicable for this Sealant Type						0.0	0	0.0	0
					12-17-65	30	1.22	1.01	1.11	0.0	0.2							3.5	Top to center	0.1	Top to center
		F 81121A, C2	F 250 (15)	M 153, Ypsilanti	2-23-65	18	1.48	1.10	1.37	0.3	1.0							7.2	Center to bottom	0.0	0
					12-8-65	38	1.40	0.98	1.25	0.0	1.0							3.7	Center to bottom	1.2	Center to bottom
		I 41029E, C3	I 96-1(45)70	I 196, Grand Rapids	12-16-65	30	0.97	0.81	0.88	0.0	2.5							0.0	0	0.0	0
		F 81103B, C7	F 82 (10)	M 14, Ypsilanti	12-8-65	38	1.57	1.38	1.50	0.0	0.0							0.0	0	0.0	0
1965	Two-Component Elastomeric Cold-Applied (Type 1)	F 50013A, C1	F 212 (35)	M 53, Utica	12-15-65	36	1.58	1.30	1.38	0.0	5.3	Not Applicable for this Sealant Type						0.0	0	0.0	0
	Hot-Poured Rubber-Asphalt	F 50013A, C2	F 212 (36)	M 53, Utica	12-15-65	35	1.58	1.27	1.46	1.0	0.0	Not Applicable for this Sealant Type						0.0	0	0.0	0
		BI 61104A, C18	I 94-5(55)178 U 408 (6)	M 14, Ann Arbor	12-13-65	42	1.49	1.16	1.36	0.0	0.1							0.0	0	0.0	0

(a) Expansion joints on this project not resurveyed, because the neoprene seals were replaced with hot-pour in the late summer 1965.
(b) Expansion joints on this project not resurveyed, because the cold-applied seals were replaced with hot-pour in August 1965.

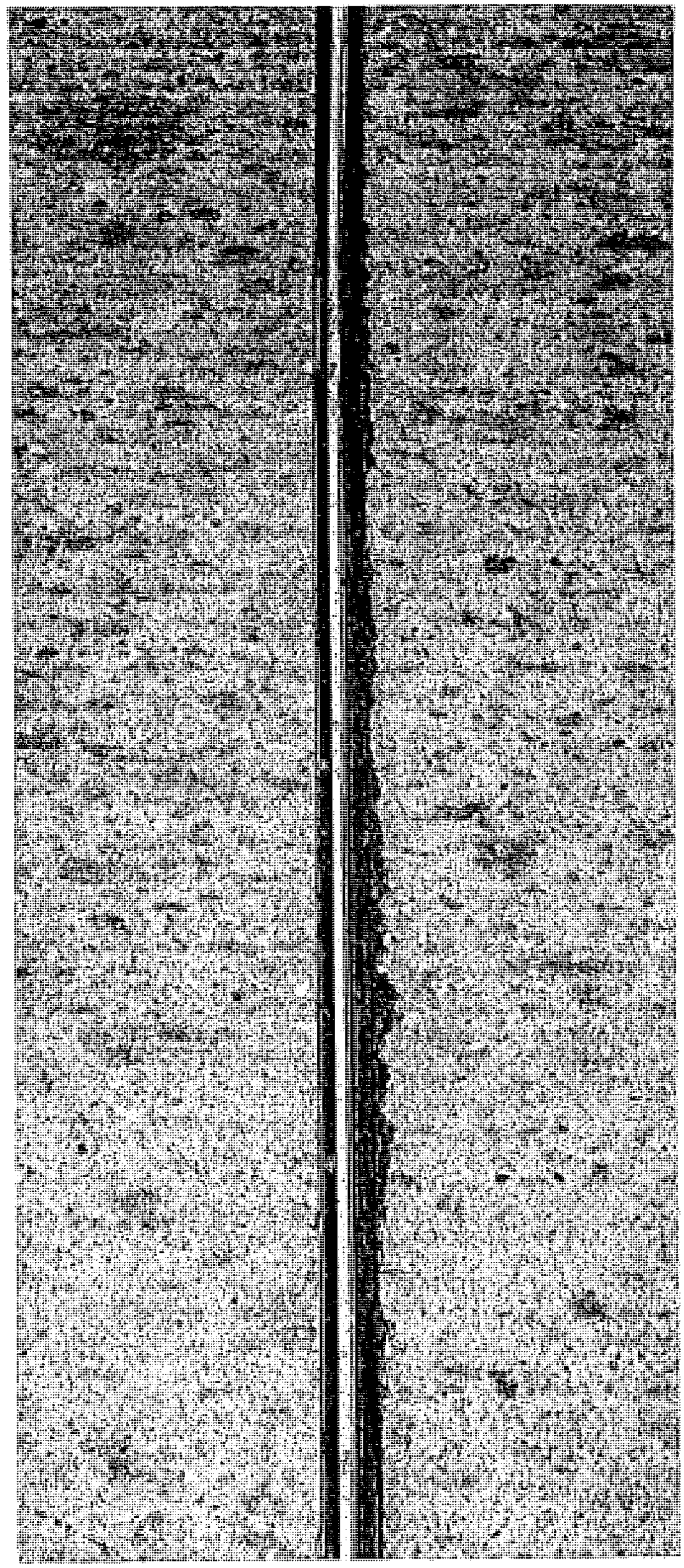
TABLE 3
SUMMARY OF DATA ON 1965 EXPERIMENTAL NEOPRENE-SEALED PROJECTS

Joint Type	Project Number		Location	Specified Sawed Joint Groove Dimensions, in.		Specified Seal Width, in.	Survey Date	Air Temp. F	Joint Groove Width, in.			Joint Groove Spalls, % of Total Length		Seal Depth Below Surface, in.			Computed Seal Compression, %		
	Michigan	Federal		Width	Depth				Max.	Min.	Avg.	Repaired	Existing	Max.	Min.	Avg.	Max.	Min.	Avg.
Contraction	BI 33035B, C1	F 146 (17) I 96-3(35)150	Holt Rd. over I 496, Holt	3/8	2	13/16	12-17-65	30	0.50	0.43	0.46	1.0	0.3	0.50	0.06	0.28	47	38	43
	U 70012B. C2 etc.	U 210 (20)	US 31BR, Holland	1/2	2	1-1/4	12-16-65	30	0.85	0.64	0.72	2.9	1.4	0.53	0.06	0.25	49	32	42
Expansion	BI 33035B, C1	F 146 (17) I 96-3(35)150	Holt Rd. over I 496, Holt	1	2-1/4	1-5/8 Thin wall	12-17-65	30	1.28	1.09	1.18	9.6	1.1	0.66	0.12	0.33	33	21	27
	U 70012B, C2 etc.	U 210 (20)	US 31BR, Holland	1-1/4	2-1/4	1-5/8 Regular	12-16-65	30	1.46	1.12	1.37	0.8	1.1	0.88	0.12	0.40	31	10	15
				1-1/4	2-1/4	1-5/8 Thin wall	12-16-65	30	1.53	1.41	1.47	0.9	1.8	0.53	0.16	0.35	13	6	9
				1*	2-1/4	1-3/8 Thin wall	12-16-65	30	1.58	1.32	1.44	2.1	2.0	0.88	0.12	0.32	4	0	0
				1*	2-1/4	1-1/2 Thin wall	12-16-65	30	--	--	1.48**	0.0	0.0	--	--	0.34	--	--	1.3

* Formed joint grooves (others sawed).
** Only one joint sealed with material of this size.

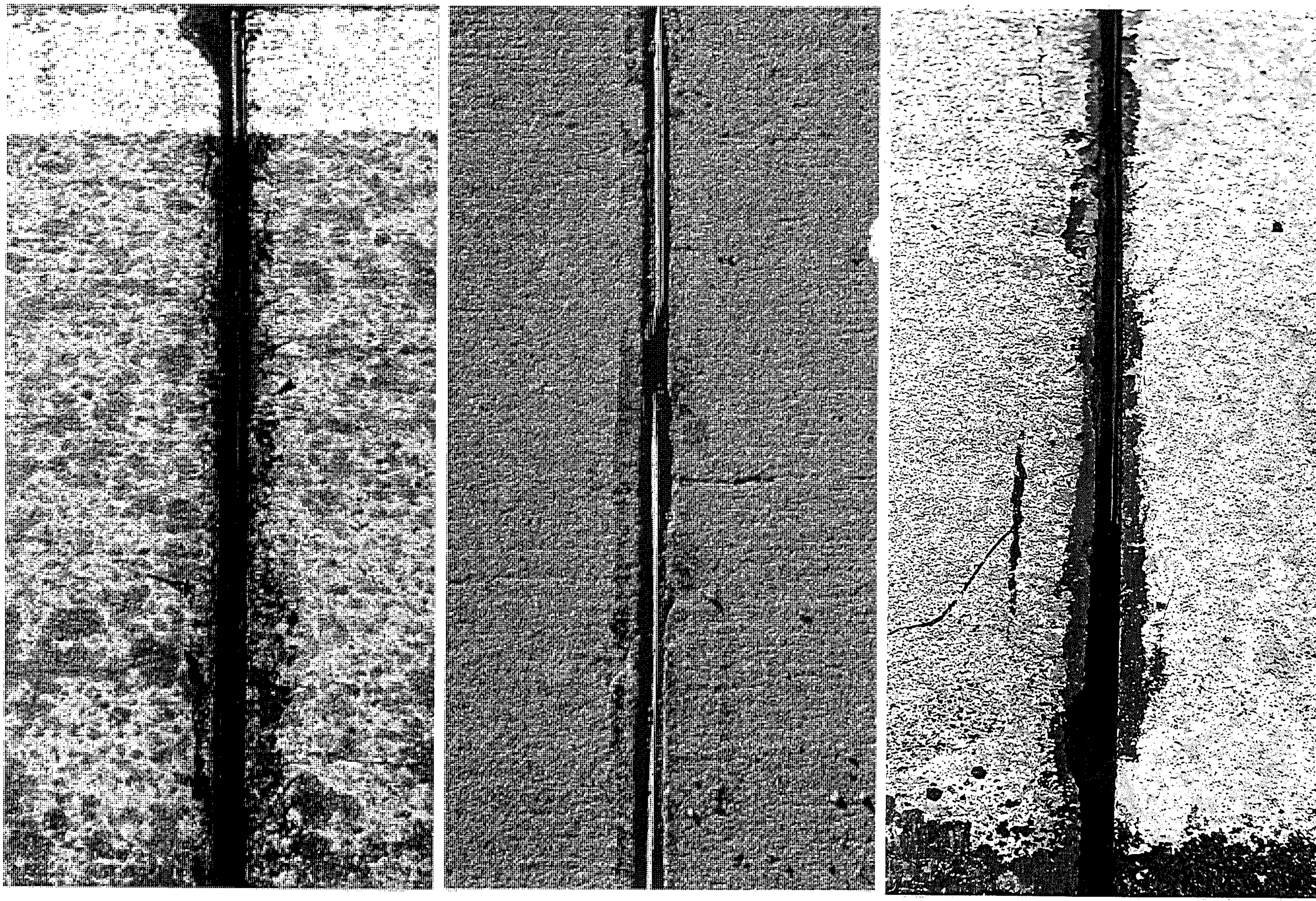


Sta. 872+24 (EB)
I 196, Grand Rapids
(Photo: 12-6-65)



Sta. 444+30 (EB)
I 196, Grand Rapids
(Photo: 12-6-65)

Figure 1. Typical excellent performance of neoprene contraction joint sealants in different locations after more than a year of service.

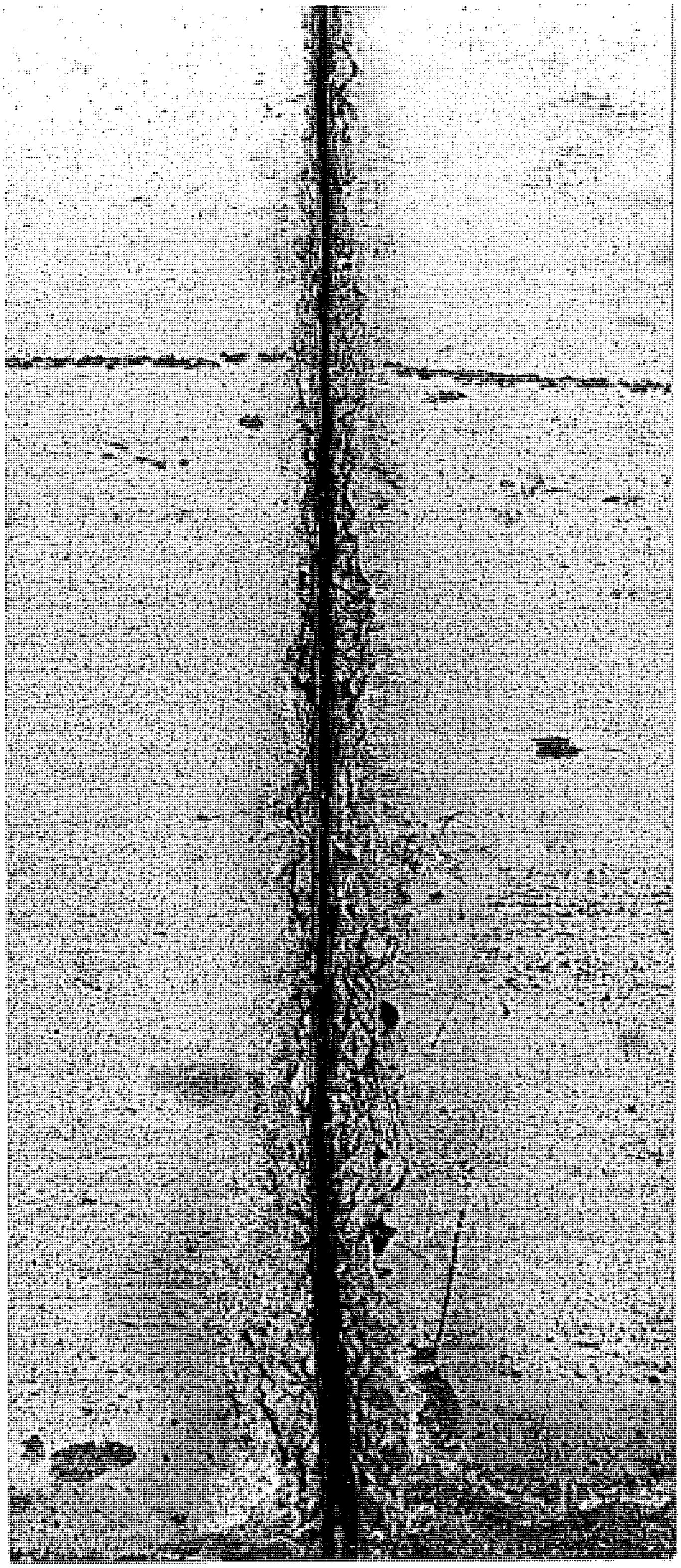


Sta. 67+21 (EB)
M 19, New Haven
(Photo: 3-9-65)

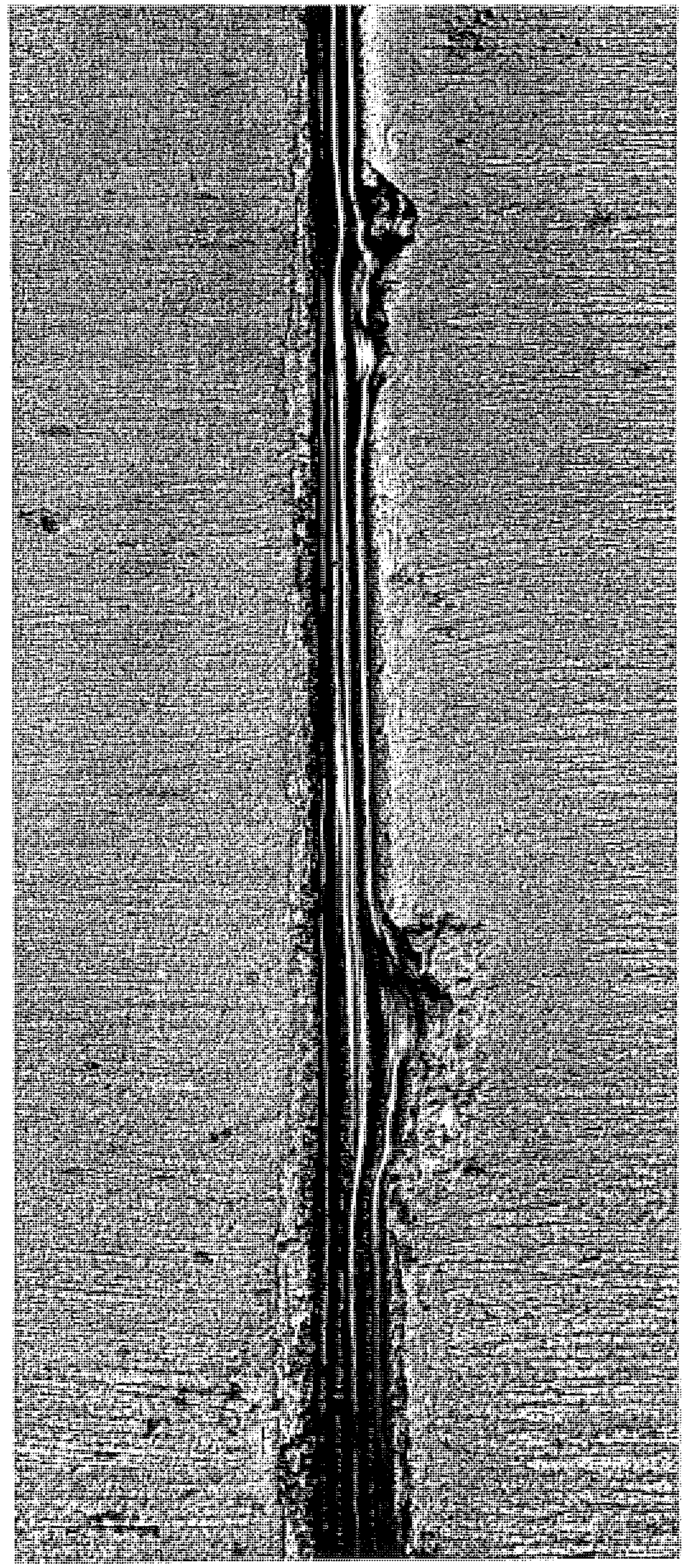
Sta. 113+30 (WB)
M 19, New Haven
(Photo: 12-9-65)

Sta. 72+45 (WB)
M 19, New Haven
(Photo: 3-9-65)

Figure 2. Imperfections in contraction joint seal material or its installation result in twisting so that one side is higher than the other (left), breaks and pulling apart of sealer due to stretching during installation (center), and pulling away from shoulder edge also due to stretching (right).

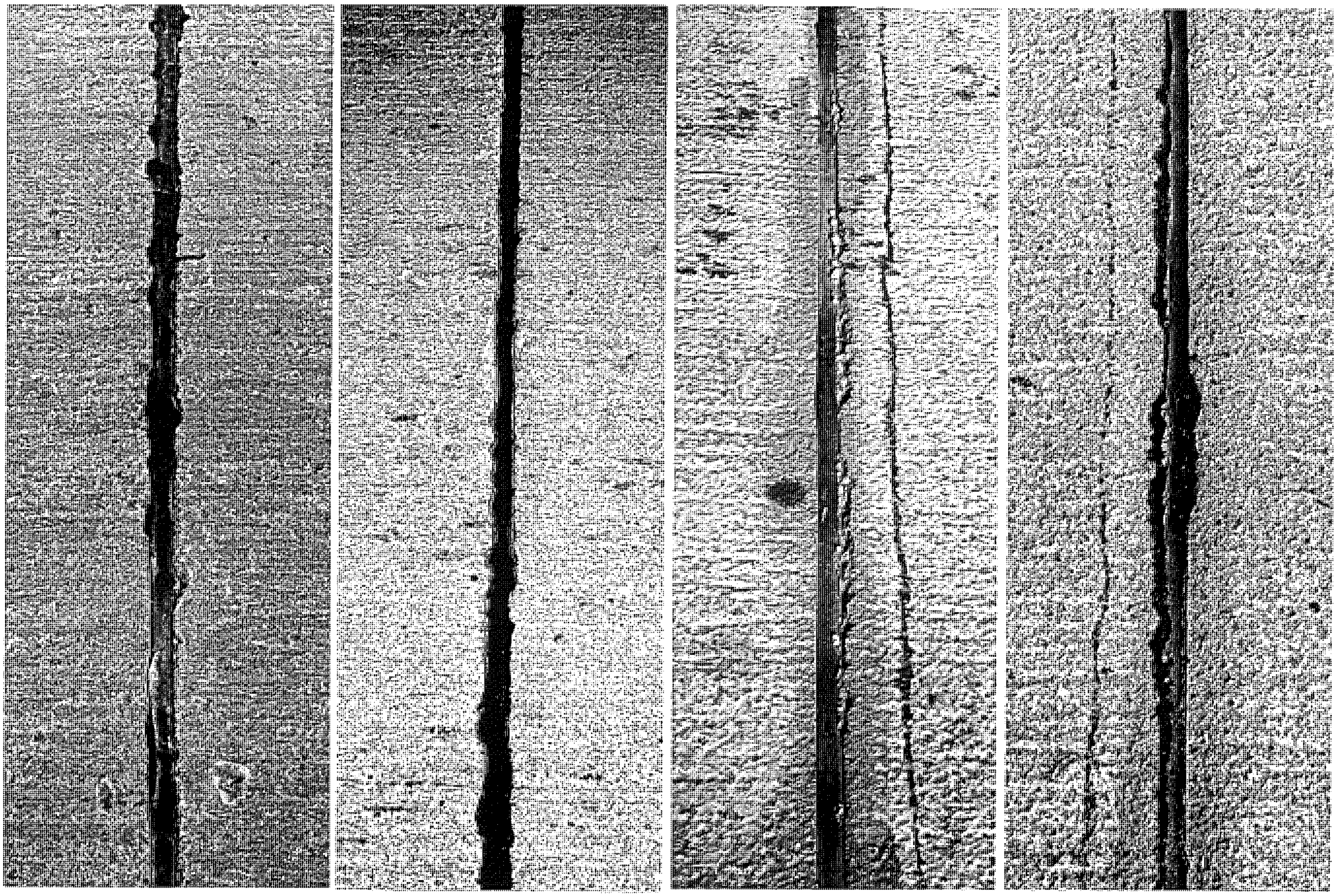


US 10 Rest Area, Midland
(Photo: 4-5-65)



Sta. 655+50
Columbia Ave. over I 94BL
(Photo: 3-11-65)

Figure 3. Deterioration of formed joint grooves, affecting contraction joint neoprene sealer performance, includes severe crumbling of groove walls (left) and spalling (right).



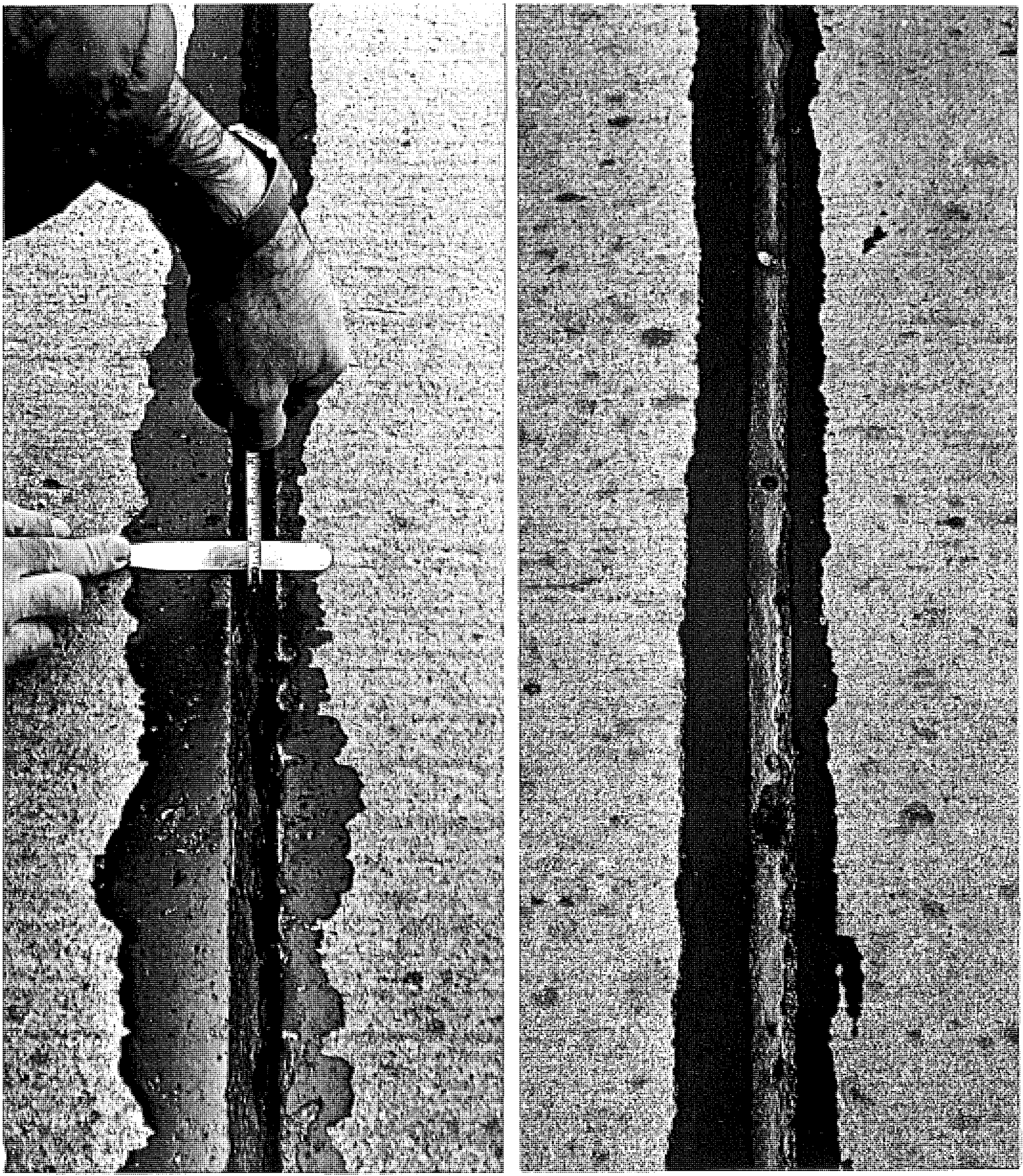
(Photo: 2-23-65) (Photo: 12-8-65)

Sta. 589+85 (EB)
M 153, Ypsilanti

(Photo 2-17-65) (Photo: 12-10-65)

I 75 Rest Area, Saginaw

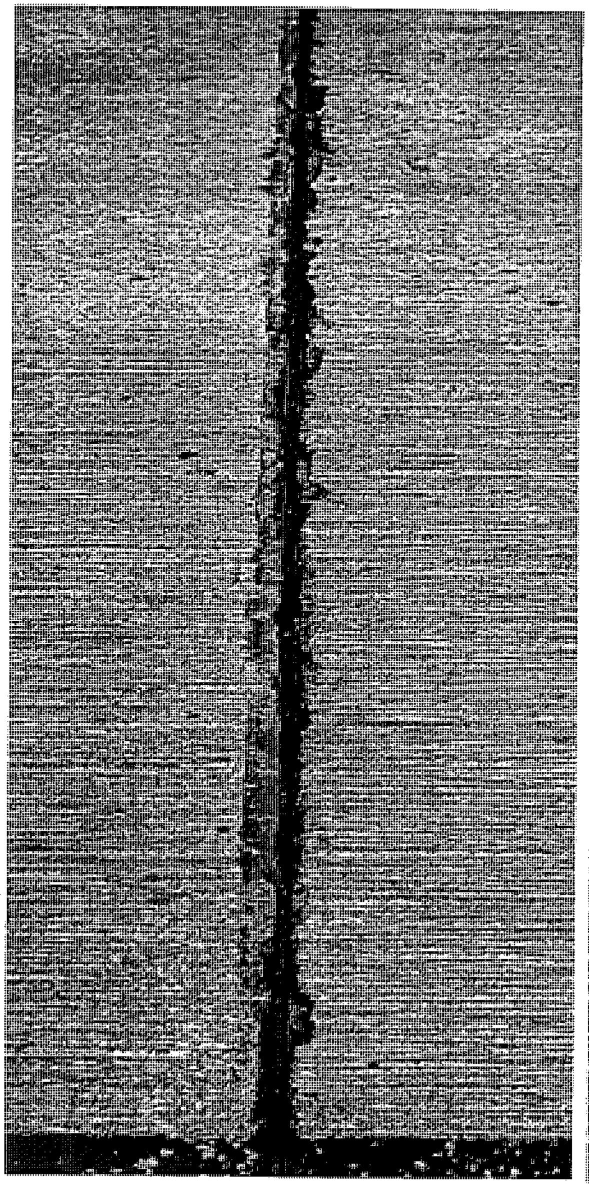
Figure 4. Cold-applied contraction joint sealers performed satisfactorily in some joints (left), but frequently underwent progressive adhesion failure (right).



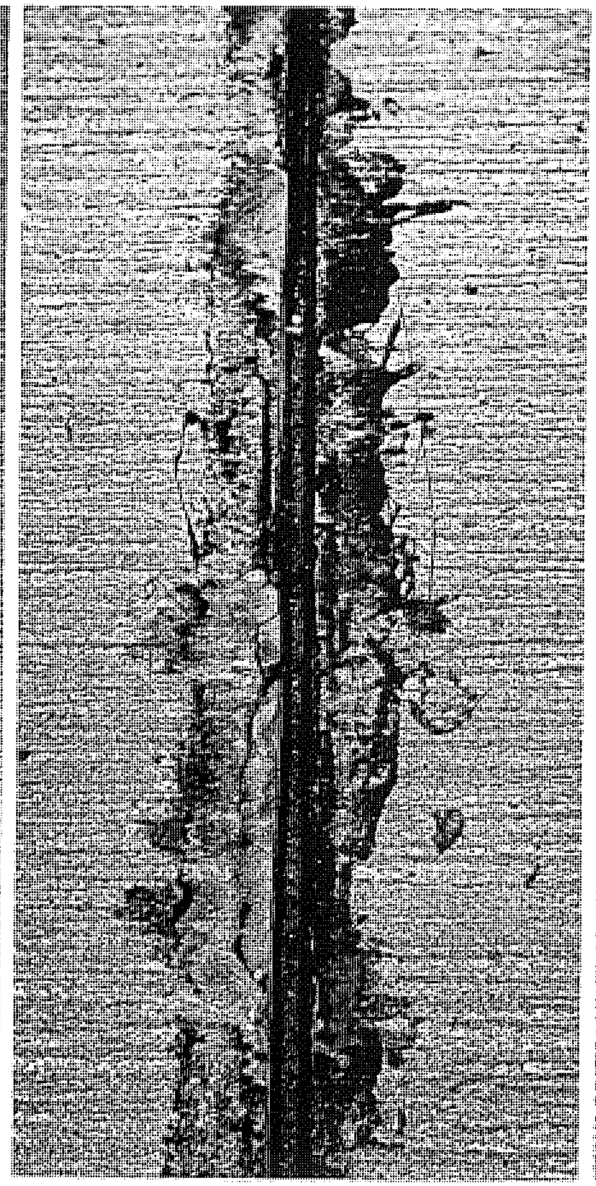
Sta. 368+45 (WB)
I 196, Grand Rapids
(Photo: 12-16-65)

Sta. 563+12 (WB)
M 14, Ypsilanti
(Photo: 12-8-65)

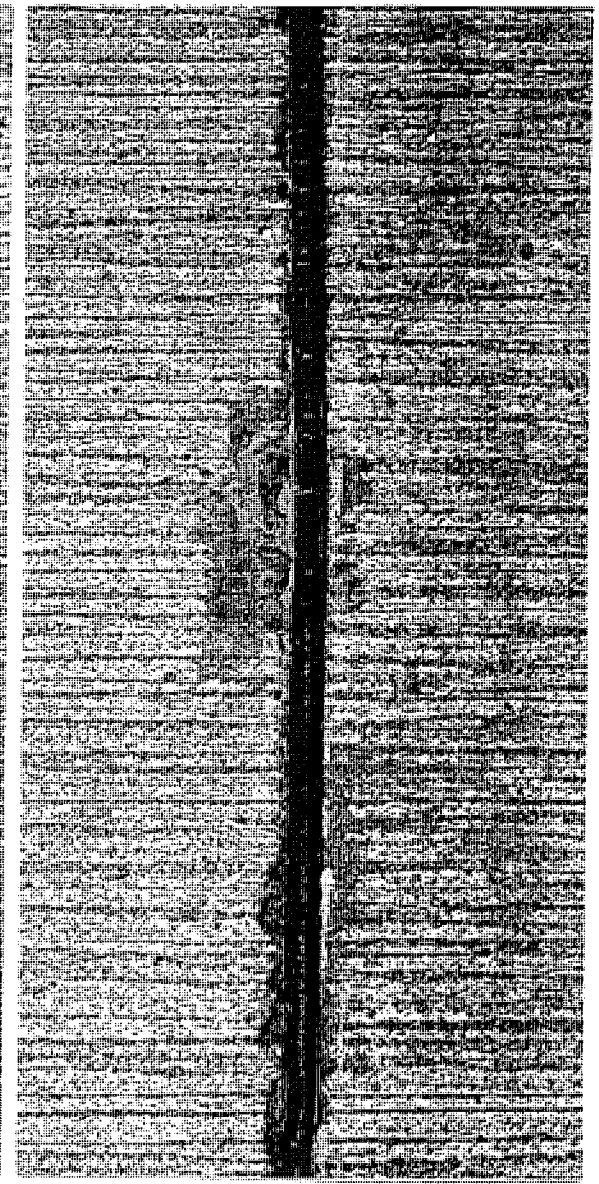
Figure 5. Hot-poured sealants in contraction joints exhibit typical cohesion failure (left) with extrusion of sealer resulting in depression of its upper surface, and typical adhesion failure (right, at right edge of sealer).



Sta. 917+94 (NB)
M 53, Utica
(Photo: 12-15-65)

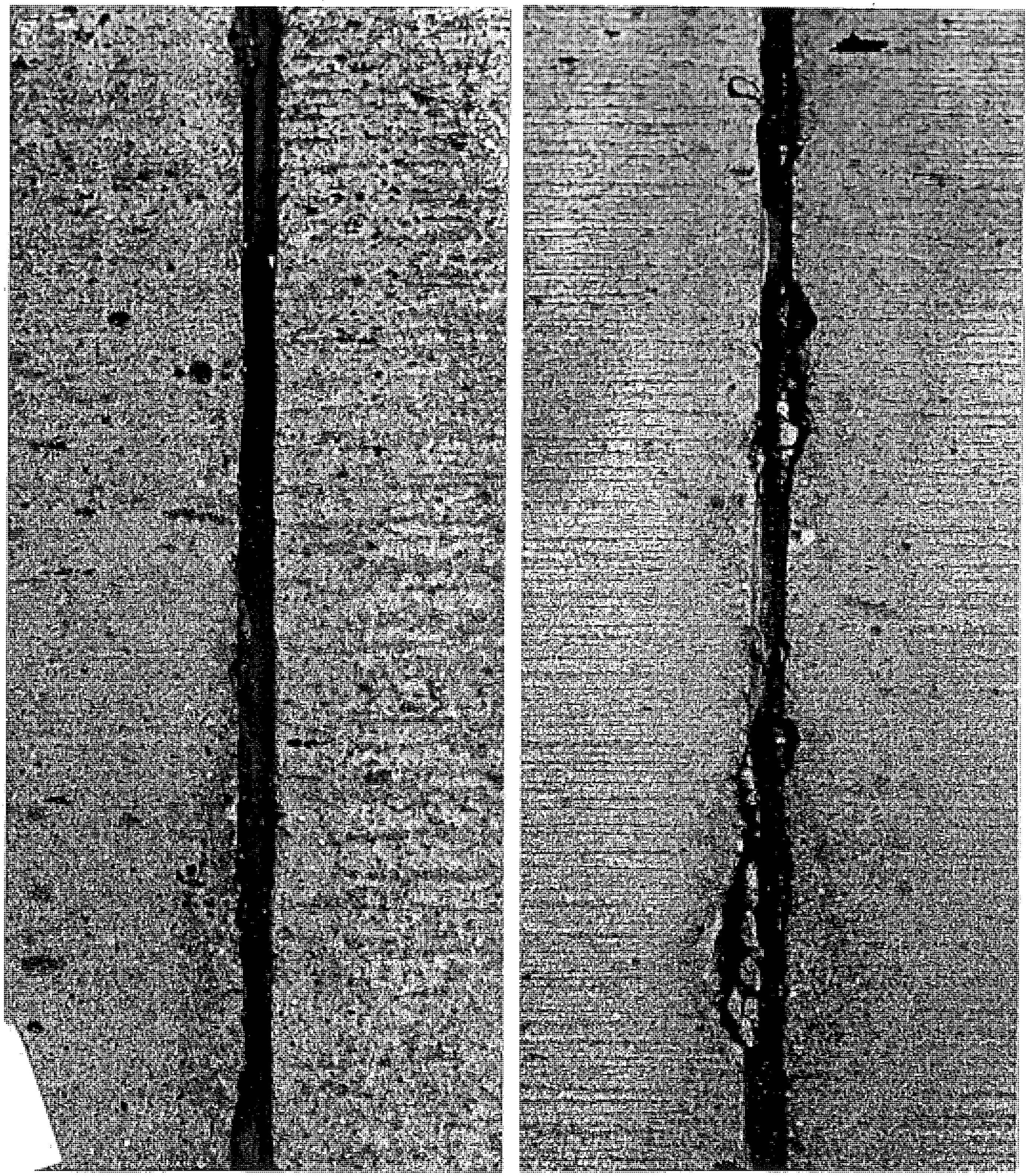


Sta. 917+94 (NB)
M 53, Utica
(Photo: 12-15-65)



Sta. 897+67 (EB)
M 14, Ann Arbor
(Photo 12-15-65)

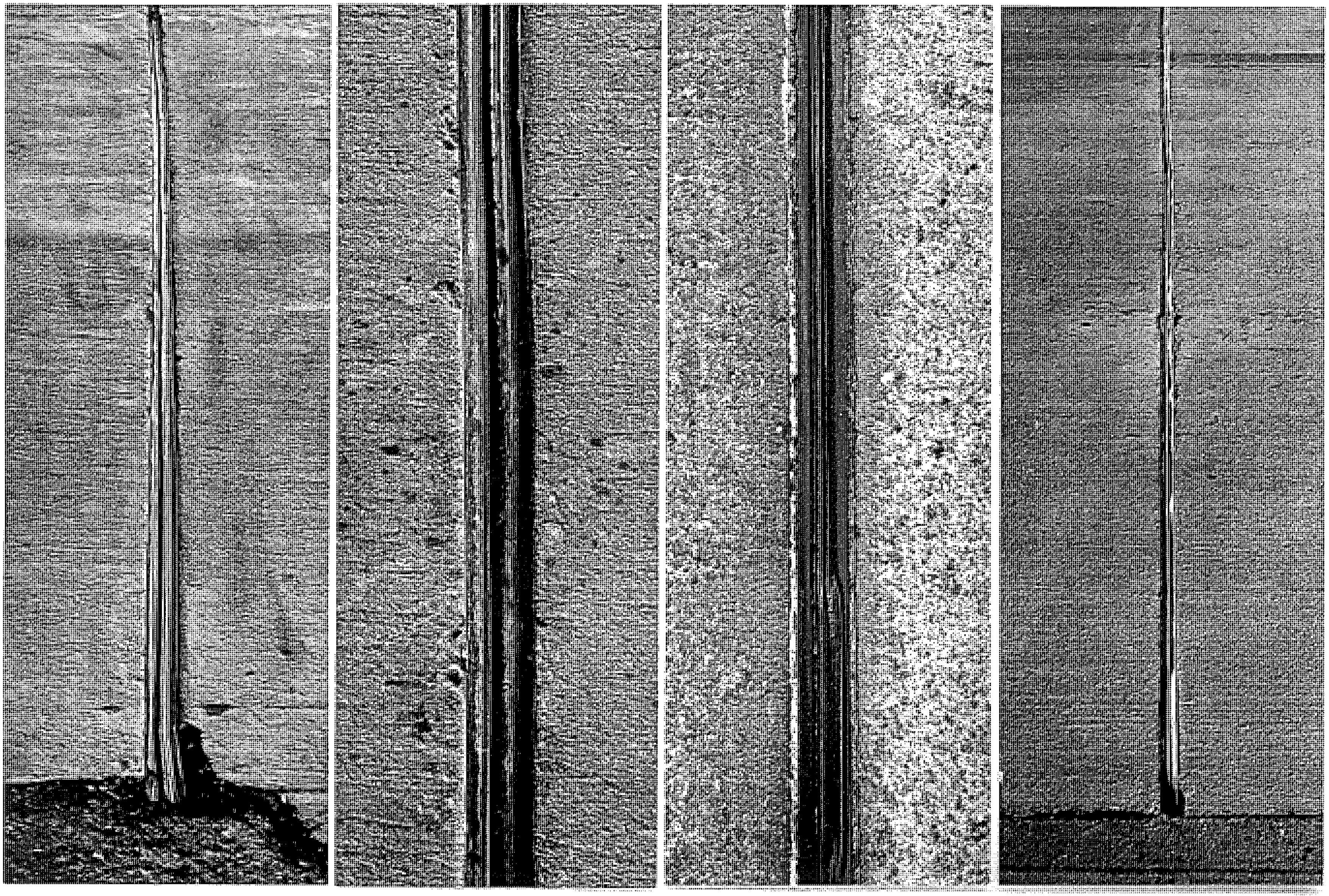
Figure 6. Conditions encountered in inspection of 1965 contraction joints sealed with neoprene included smearing of lubricant resulting in an unsightly slab edge (left), a repaired spall now losing adhesion to slab concrete (center foreground), and a sound repair of spalling (right).



Sta. 755+50 (NB)
M 53, Utica
(Photo: 12-15-65)

Sta. 757+90 (NB)
M 53, Utica
(Photo: 12-15-65)

Figure 7. Conditions noted during inspection of 1965 contraction joints sealed with cold-applied material included some adhesion failures (left, at left edge of joint), and extensive spalling of groove walls (right).



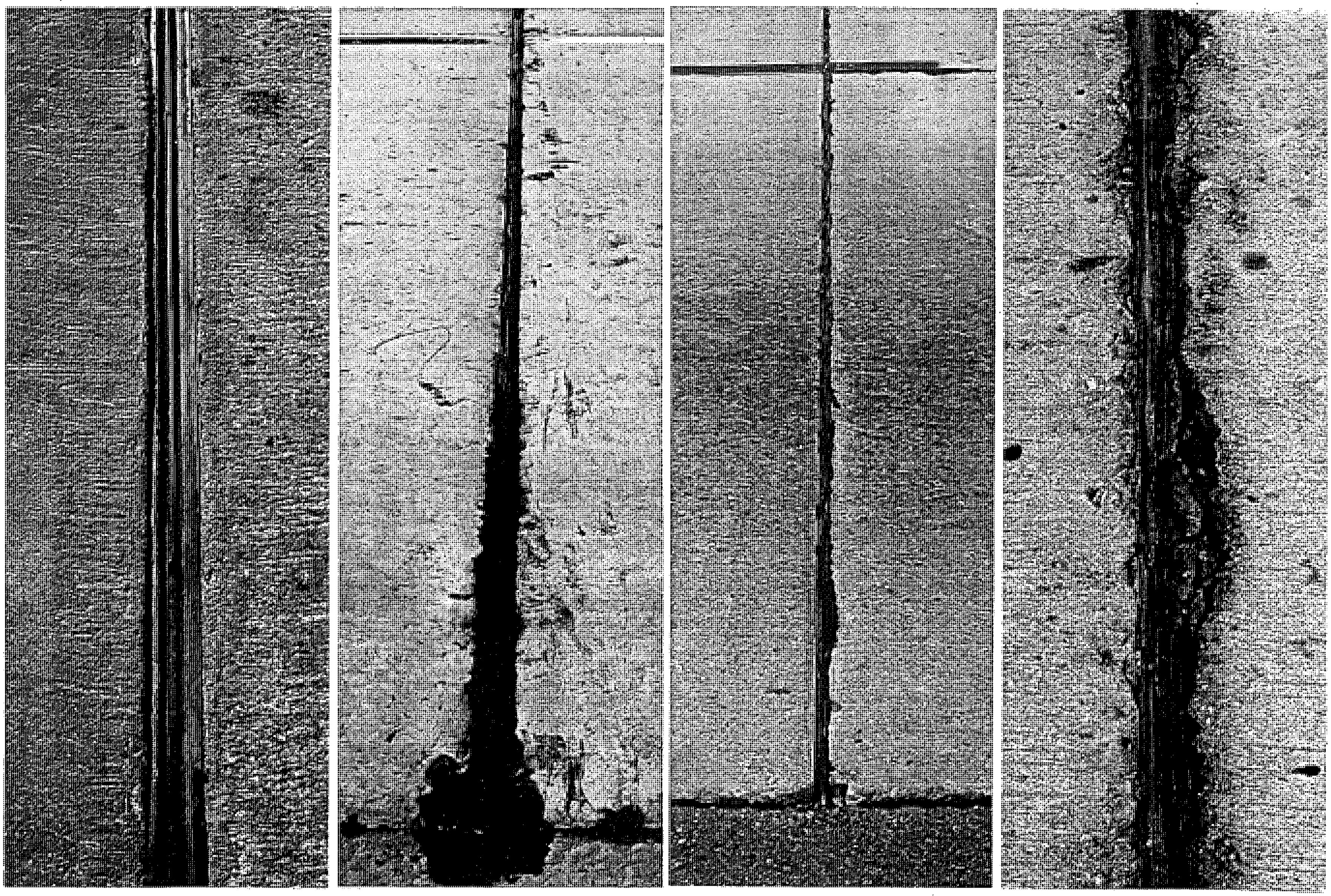
Sta. 387+12 (EB)
I 94BL, Battle Creek
(Photo: 3-11-65)

Sta. 387+12 (EB)
I 94BL, Battle Creek
(Photo: 3-11-65)

Sta. 446+26 (EB)
I 196, Grand Rapids
(Photo: 3-16-65)

Sta. 112+18 (WB)
M 19, New Haven
(Photo: 12-9-65)

Figure 8. Typical good performance of neoprene sealer in expansion joints after the first winter of service (left and center), and after more than a year (right).



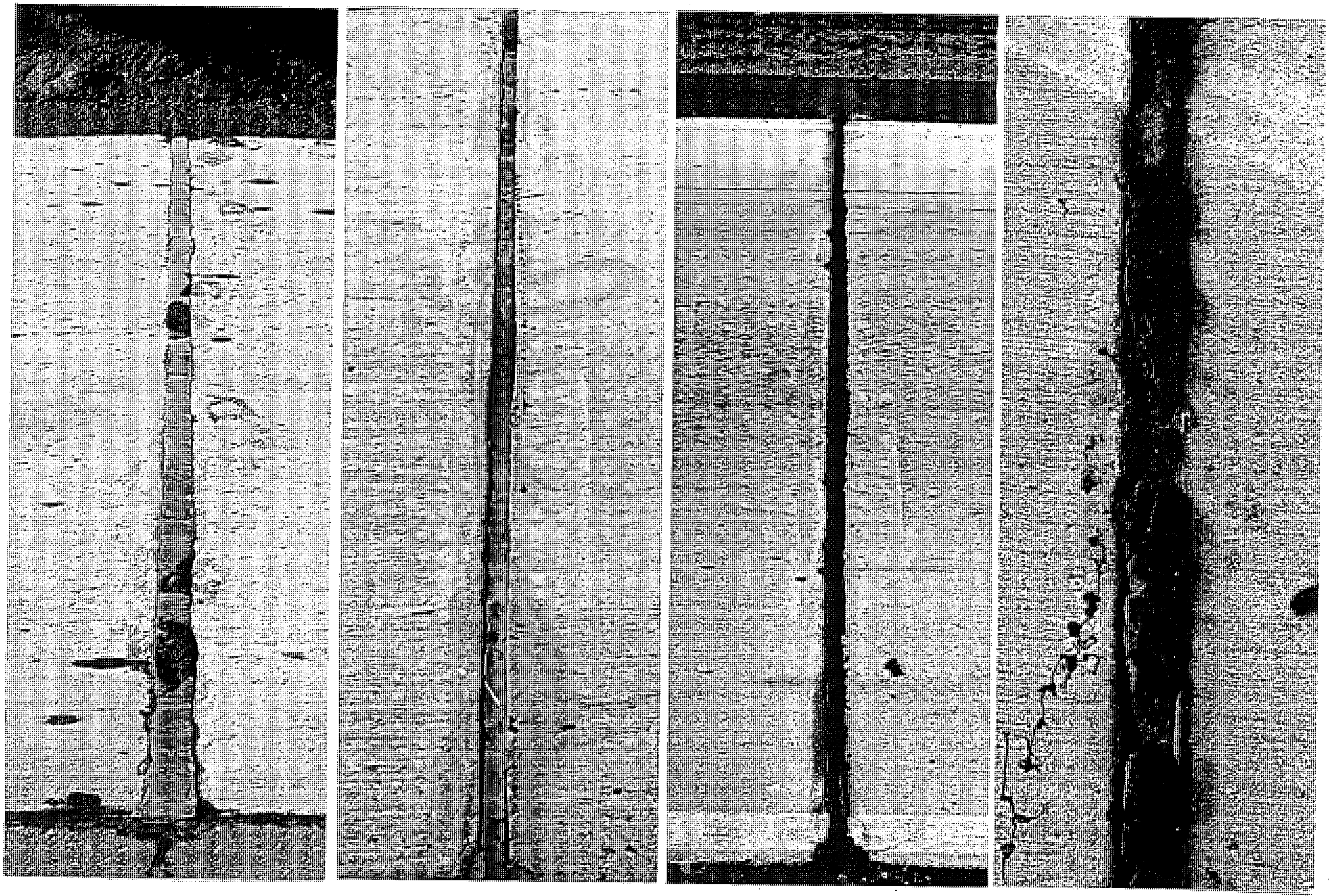
Sta. 636+11 (WB)
Columbia Ave. over I 94BL, Battle Creek
(Photo: 3-11-65)

Sta. 896+21 (WB)
I 196, Grand Rapids
(Photo: 3-16-65)

Sta. 446+24 (EB)
I 196, Grand Rapids
(Photo: 12-6-65)

US 10 Rest Area, Midland
(Photo: 12-10-65)

Figure 9. Factors in installation and groove formation, affecting neoprene performance in expansion joints, include unequal compression of sealer (left), twisting of sealer surface (left center), summer extrusion of sealer exposing it to subsequent traffic damage (right center), and groove edge spalling (right).

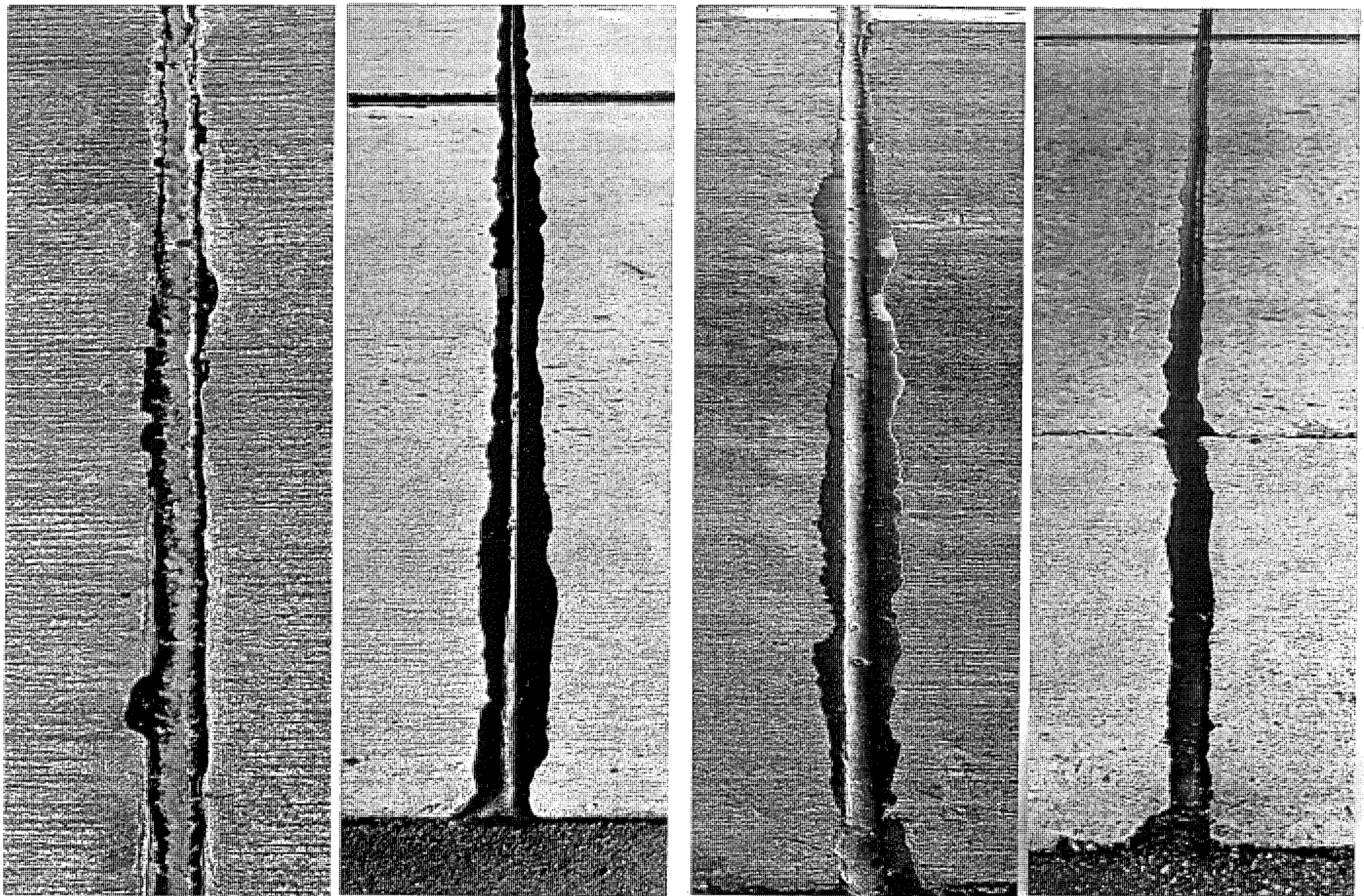


Sta. 314+73 (SB)
M 37, Newaygo
(Photo: 3-8-65)

I 75 Rest Area, Saginaw
(Photo: 2-17-65)

I 75 Rest Area, Saginaw
(Photos: 12-10-65)

Figure 10. Appearance of cold-applied sealers in expansion joints during the first winter is shown at left and left center. Some failed in adhesion after extrusion during the summer expansion cycle (right, with damage by traffic).



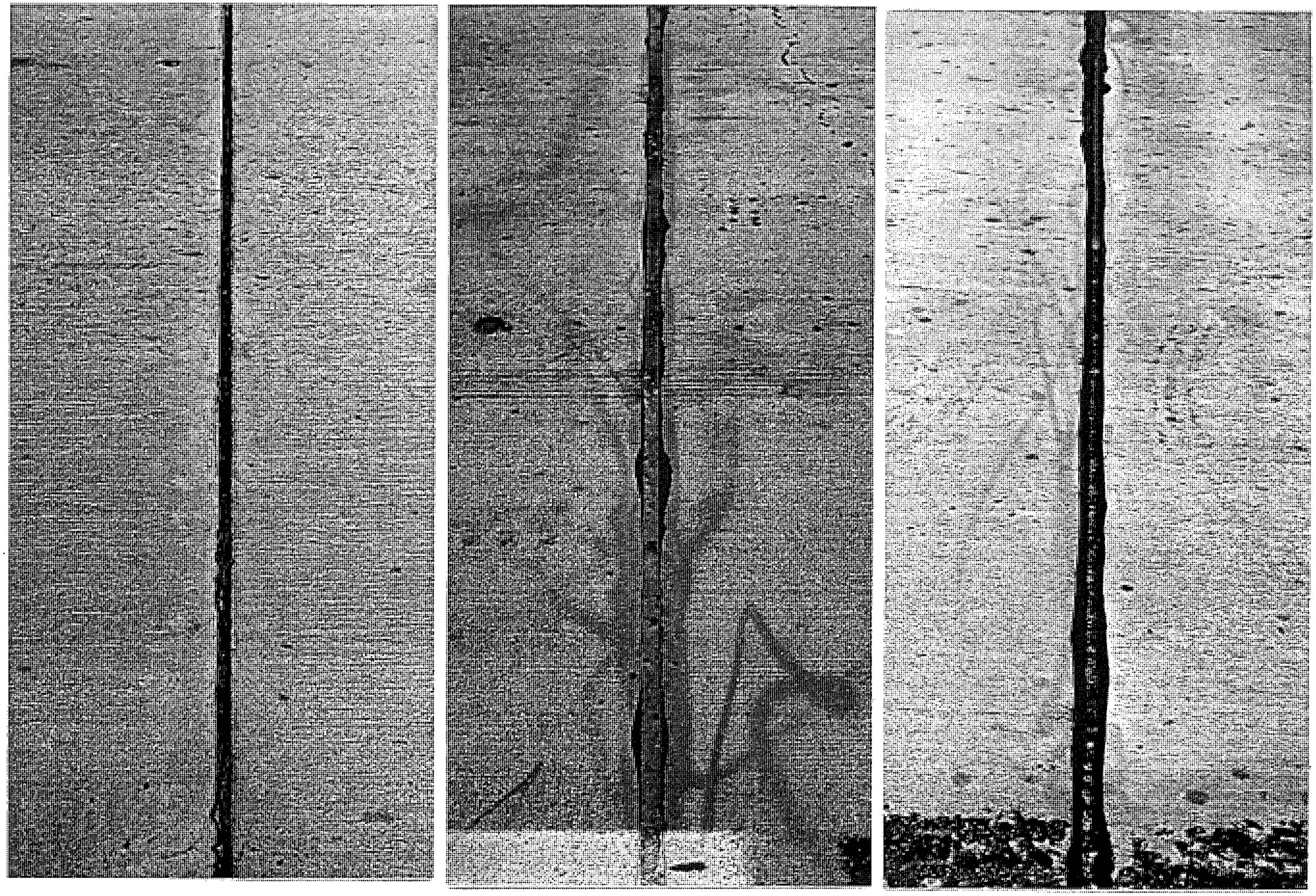
(Photo: 2-23-65)

Sta. 594+50 (WB)
M 153, Ypsilanti
(Photo: 12-8-65)

Sta. 335+58 (WB)
I 196, Grand Rapids
(Photo: 12-8-65)

Sta. 565+88 (WB)
M 14, Ypsilanti
(Photo: 12-8-65)

Figure 11. "Self-correction" of adhesion failure in expansion joints was noted in hot-poured material where a winter failure (left, at right edge) was obliterated by summer softening and extrusion of sealant (left center). Other joints well sealed with hot-poured material are shown at center and right.

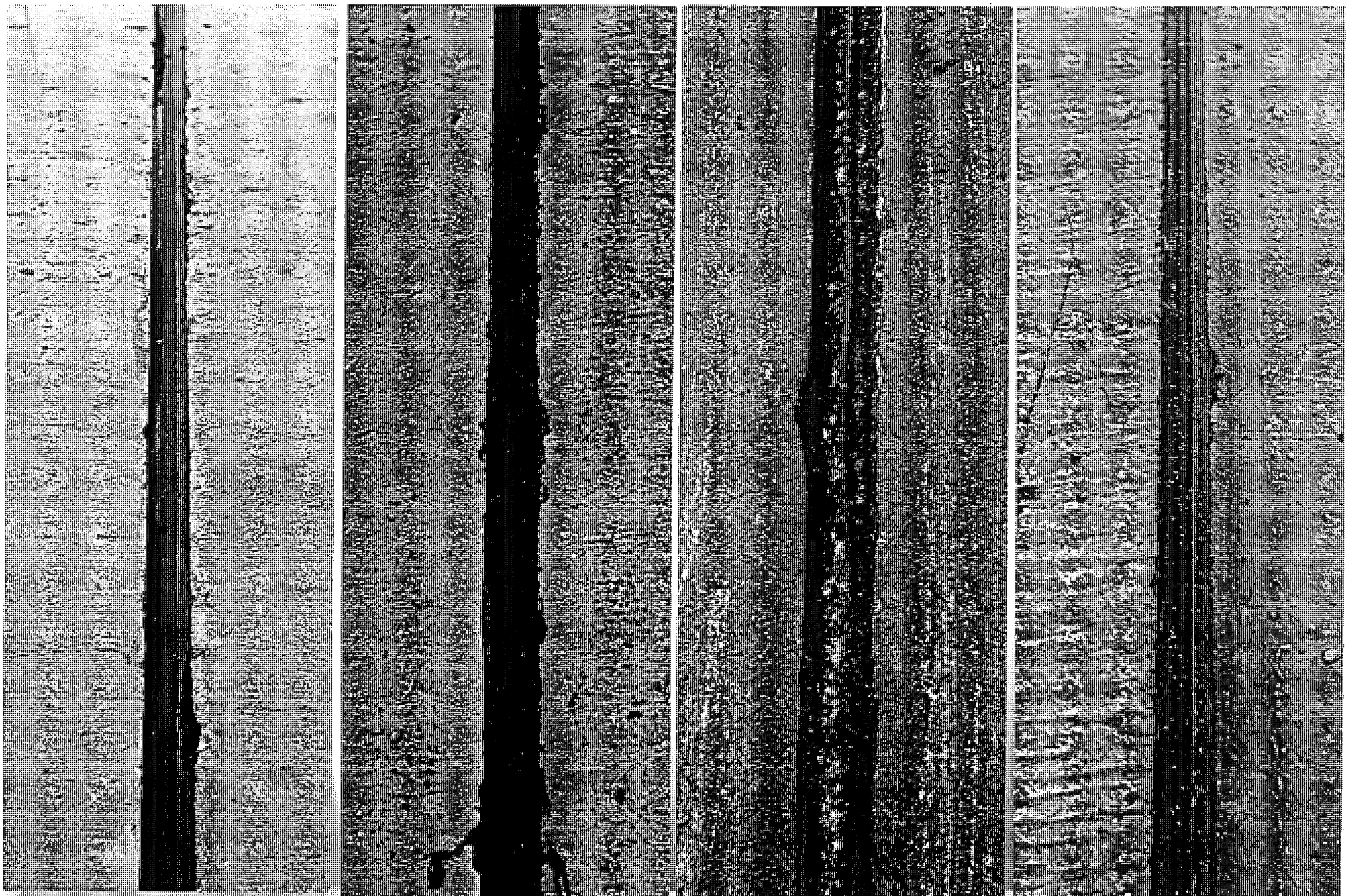


Sta. 860+79 (SB)
M 53, Utica
(Photo: 12-15-65)

Sta. 939+54 (NB)
M 53, Utica
(Photo: 12-15-65)

Sta. 894+91 (EB)
M 14, Ann Arbor
(Photo: 12-13-65)

Figure 12. Recently sealed expansion joints in good condition at time of inspection included the cold-applied joint at left, and two typical hot-poured joints (center and right).



1-3/8-in. Thin-Wall Sealer
1-in. Formed Groove
Sta. 10+50, Holland

1-1/2-in. Thin-Wall Sealer
1-in. Formed Groove
Sta. 300+70, Holland

1-5/8-in. Thin-Wall Sealer
1-1/4-in. Sawed Groove
Sta. 314+60, Holland

1-5/8-in. Regular Sealer
1-1/4-in. Sawed Groove
Sta. 319+46, Holland

Figure 13. Typical experimental expansion joints with variation of neoprene sealer and groove formation.

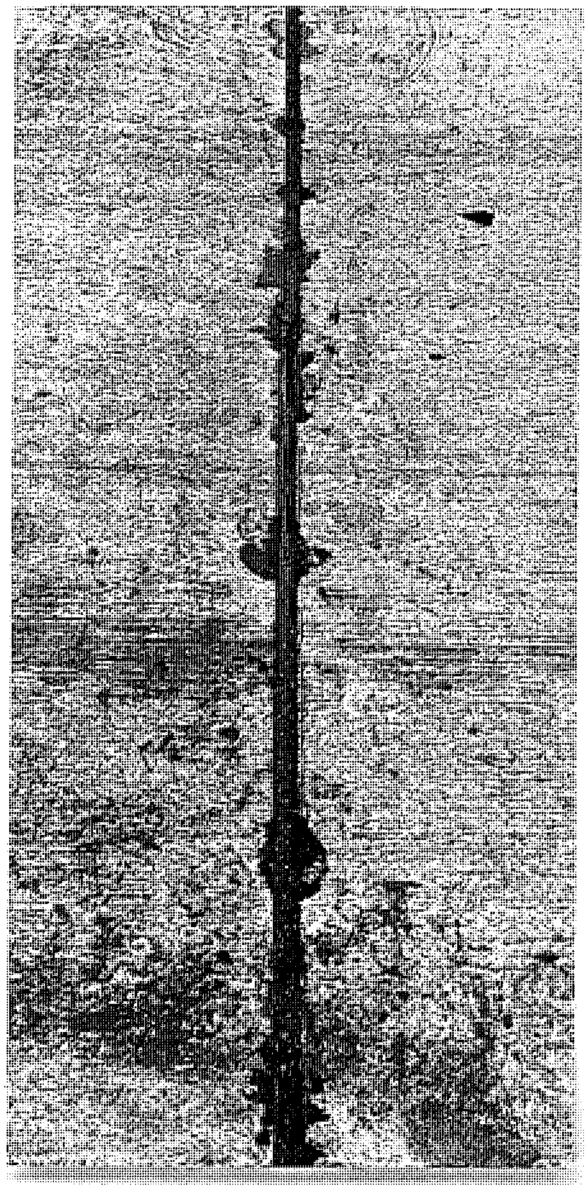
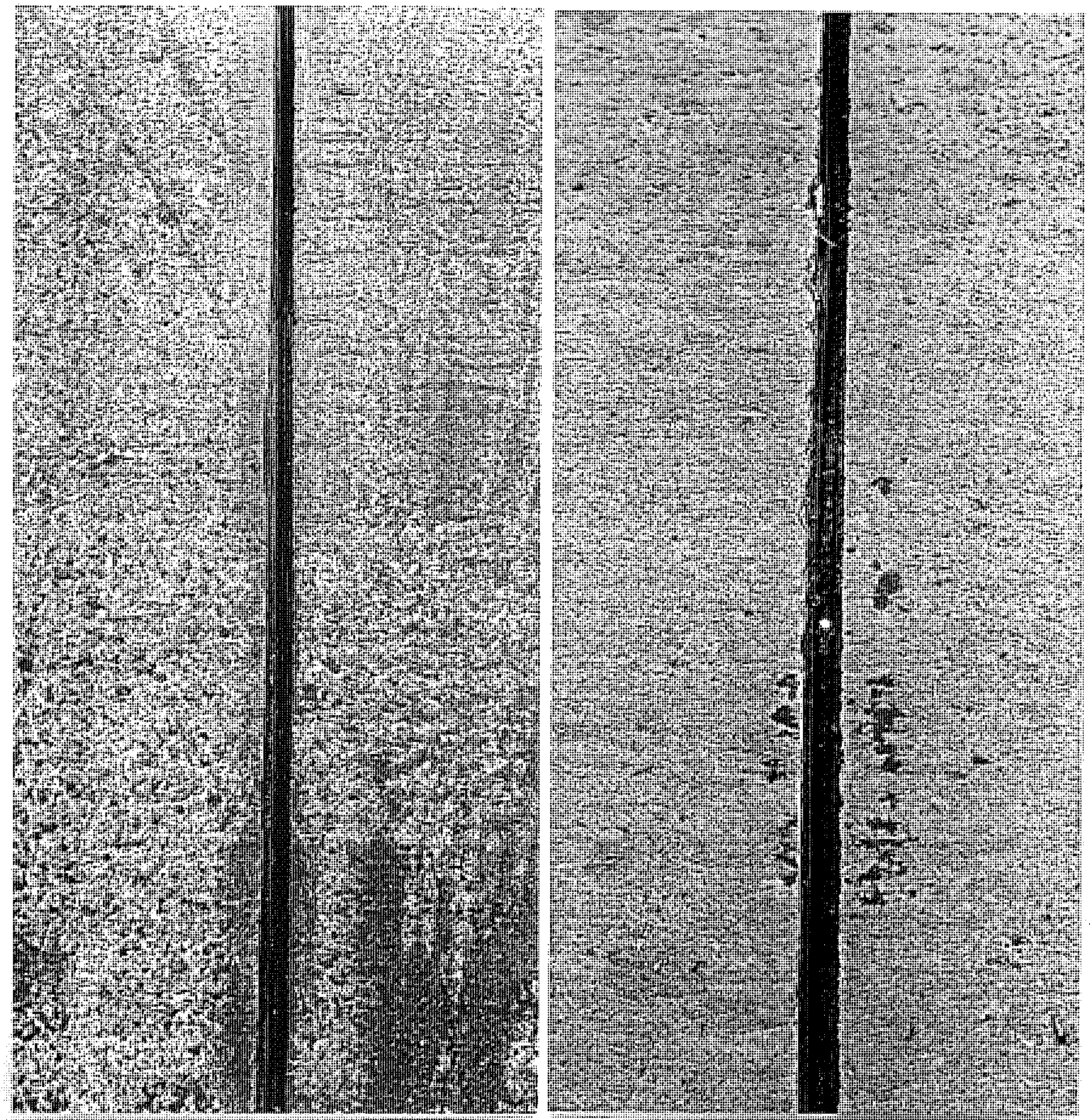


Figure 14. Abnormal frequency of spalling caused by difficulty of determining optimum time for sawing: 1-5/8-in. light-weight neoprene expansion joint sealer in 1-in. groove (Sta. 109+85, Holt).



13/16-in. Sealer
3/8-in. Sawed Groove
Sta. 99+85, Holt

1-1/4-in. Sealer
1/2-in. Sawed Groove
Sta. 303+12, Holland

Figure 15. Typical experimental contraction joints with variation of neoprene sealer and groove formation.