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EFFECTIVENESS OF NEOPRENE SEALS IN PREVENTING CONCRETE PAVEMENT CONTRACTION JOINT DETERIORATION

MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

EFFECTIVENESS OF NEOPRENE SEALS IN PREVENTING CONCRETE PAVEMENT CONTRACTION JOINT DETERIORATION

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INTRODUCTION

The Problem

The major problem with jointed portland cement concrete pavement is the failure of the joint sealant to perform its intended function; that is, prevent the infiltration of liquids and incompressible materials into the contraction joint. The gradual filling of the joint with incompressible material decreases the necessary expansion space while the infiltration of water and deicing salts accelerates the deterioration of the concrete below the seal, as well as promoting dowel bar corrosion. As the amount of deterioration increases, the area of the joint interface, which must withstand the compressive forces of expanding concrete, decreases. When the area of sound concrete decreases to a point where it can no longer withstand the compressive force, a 'blowup' occurs.

Prior to 1964, our standard slab length was 99 ft (30.2 m). The contraction joints had dowelled load transfer devices, a baseplate under the joint area, and 1/2-in. (1.27 cm) wide by 2-in. (5.08 cm) deep joint grooves sealed with hot-poured rubber-asphalt. Because of the inability of the hot-poured rubber-asphalt to seal this joint design for more than a year or so several changes were made in our joint design during the period 1964 to 1967. The slab length was decreased to 71 ft-2 in. (21.7 m), the sealant was changed from hot-poured rubber-asphalt to preformed neoprene compression seals, the joint grooves were formed by sawing instead of using temporary fillers, and the baseplate was deleted. With a few minor modifications, this is our current joint design (Appendix A).

It has been well established that neoprene seals are effective in preventing intrusion of solid materials but their effectiveness against intrusion of liquids has been questioned. In 1970 the Department conducted a limited study of cores removed from joints on projects constructed during the transition period of design and construction changes. The results reported in MDOT Research Report No. R-789 indicated that neoprene seals permit some leakage and that concrete deteriorates in the joint if liquids are trapped by a baseplate. Cores taken from a four-year old project without baseplates showed no deterioration. On the basis of these initial observations it was thought desirable to conduct a more comprehensive study of the effectiveness of neoprene seals in preventing joint deterioration.

The primary objective of this study was to determine whether there is sufficient penetration of deicing salts to cause joint deterioration and the rate of deterioration if it proves to be significant. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Research Procedure

The general plan of action was to select several of the earliest construction projects utilizing the current joint design and remove cores from the joint and also remove cores several feet from the joint for comparison. In addition, one project which utilized baseplates was selected to evaluate the effect of deleting the baseplate. Projects were selected to include both urban and rural areas since urban areas usually receive more deicing salts. Several joints were to be selected from each project and 6-in. (15.2 cm) diameter cores were to be taken from the joint area. The core and joint area would be examined for deterioration and a sample of the base material would be taken for chloride content determination. A second core was to be taken several feet away from the joint for control purposes.

Each core and core hole would be measured, photographed, and carefully examined in the field. The cores and samples of base material beneath the cores would be taken back to the laboratory for further measurements including chloride content of the base material and the top and bottom of the core. These same projects and additional projects would be cored once a year for four years to determine the rate of change in deterioration.

FIRST YEAR'S ACTIVITY

The first task was to construct a split plug to replace the core taken from the joint so that the function of the joint would be restored. The plug used was cast in a standard concrete cylinder mold using a 1/4-in. (0.6 cm) polyethylene sheet in the bottom portion and an oiled wood filler at the top to form the cavity for the neoprene seal (Fig. 1). The two halves were then cemented together with contact cement, sandwiching 1/4 in. (0.6 cm) of polyethylene foam in the bottom portion to take care of expansion of the pavement. Since the annual coring was to be done in April, this amount of expansion space was considered adequate.

The first fieldwork began in the spring of 1974. Six construction projects representing 21 miles (33.8 km) of dual highway were selected for the initial investigation. These projects had been paved in the 1968 and 1969 construction seasons. Four of the projects were classified as rural and two as urban.

The number of cores taken from each project was dependent upon the relative length of the project, and the total number from all projects was based upon the maximum number we estimated could be obtained during the month of April with the type of equipment available to us. Cores were taken near the beginning, at the middle, and near the end of each project. A better procedure would have been to take them randomly throughout each project, but this would have required setting up the signing and coning for traffic control for each core. The extra time required prohibited this procedure.

Once a joint that appeared to be typical of those in the area was selected, it was examined for spalling, the seal was examined and rated as to apparent performance, and the joint groove width was measured. The seal was then removed from the area where the core was to be taken and the cavity examined for intrusion of incompressibles. After the removed seal had relaxed for several minutes, its width was measured to determine recovery. The seal condition was rated from 1 to 3 with 1 as the best condition. Definitions are given in Appendix B.

Cores were usually taken at the center of the traffic lane and the locations of the dowel bars were determined with a Pachometer so that the core could be taken between them. This was quite critical in slip-form paved projects where it was found that the location of the dowel bars was more variable than with formed paving. The cores were cut with a 6 in. (15.2 cm) diameter diamond-tipped hollow bit attached to an electric portable drill rig. The rig was held in position using two vacuum pads (Fig. 2).

After the core was removed, it was examined for evidence of deterioration or cracking and measured for height at the joint area and at both sides perpendicular to the joint area. The core cavity was then examined and any rubble from the core was removed and retained for laboratory examination. The cavity was further examined for evidence of deterioration and the depth of the pavement measured. The core and cavity were then photographed. A sample of the base material under each core was also removed for chloride content determination. New base material was added and compacted so as to adjust the grade to the height of the replacement split plug (the nominal 9-in. (22.8 cm) pavement was usually greater than 9 in. and the cast plugs were exactly 9 in.). The replacement plug was coated with epoxy rich mortar and tamped into place. The joint faces were then coated with a high solids urethane lubricant-adhesive and the seal reinstalled (Fig. 3). A second core was taken a few feet from the joint. The procedure was similar to the above except that a solid replacement plug was used.

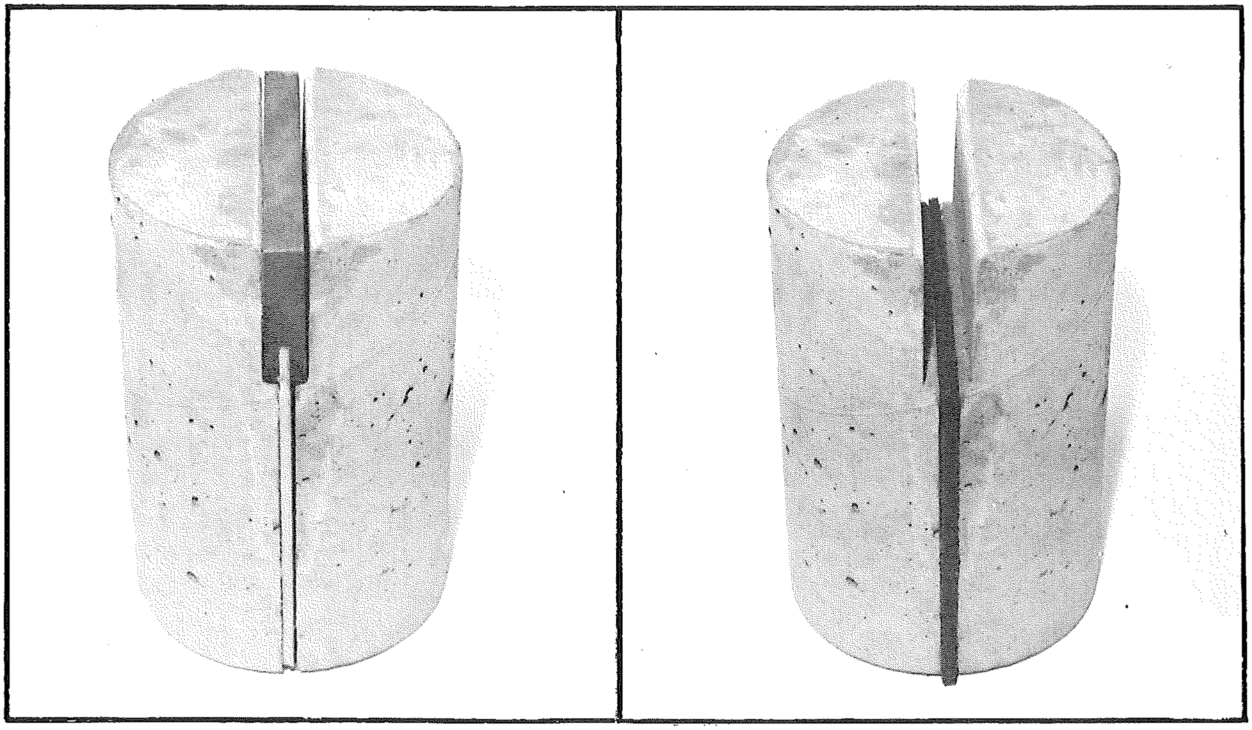


Figure 1. Replacement plug for restoring joint. Temporary filler in place at left and completed core with foam filler at right.

Figure 2. Cutting core with portable electric coring unit.

Figure 3. Replacement plug has been epoxied in place and the existing neoprene seal reinstalled.

After the field work was completed, the cores were assembled into groups for each project and photographed. Each core was measured to determine the volume loss from deterioration. Other measurements included density, air voids, and chloride content in the top and bottom of each core. Chloride contents of base materials were also determined.

Discussion

Review of the data (Table 1) indicated that a portion of the field work was not worthwhile since no meaningful information could be obtained. Specifically, the chloride content of the base material, both below the joint area and away from the joint area, were quite low, and much lower than that determined at the bottom of the core at the joint. It was decided that more valuable data could be obtained by taking cores only at the joints and increasing the number of joints sampled.

It was evident from our field observations that liquid was penetrating past the seals in most cases. Since the urban projects, which were expected to receive a higher dosage of deicing salts, did not show as much deterioration as some of the rural projects, it was thought that drainability of the base material could be a major factor affecting the rate of deterioration of the concrete. If deicing salts were trapped in the joint area by a base material with low permeability, the effect would be much the same as the use of baseplates. Based on this assumption, it was decided that for future coring, larger samples of base materials would be taken for permeability measurements to determine whether a correlation existed.

SECOND YEAR'S ACTIVITY

The scope of the second year was increased by the addition of nine construction projects representing 41 miles (66 km) of dual highway. These projects were constructed in 1968, 1969, and 1970. Three were classified as urban and six rural. The number of cores taken on the projects previously cored was increased where possible to give a better representation of the project.

The basic field procedure was the same as the previous year except that only joint cores were taken and depths of both base and subbase were measured when they were sampled for permeability measurements.

After completion of the field work, the cores were photographed, measured for volume loss, and tested as before. Tests were also conducted on the base samples to determine drainability.

TABLE 1
SUMMARY OF DATA FROM PROJECTS CORED IN 1974

Project No.	Project Type and Age	Station	Concrete Deterioration, percent of volume*	Chloride Content, lb/cu yd of concrete		Concrete		Seal Rating	Edge of Slab Sealed	Chloride Content of Base Material, lb/cu yd	
				Core Top	Core Bottom	Density, lb/cu yd	Air Voids, percent			Joint Area	Non-Joint Area
I 13073-007	Rural - 6 yr	1392+65	6.0	13.9	5.6	143.5	4.4	2	Yes	0.4	0.2
		1436+55	13.0	12.6	5.4	143.5	6.3	1	Yes	0.9	0.2
		1489+84	6.2	14.5	5.9	146.0	4.5	2	Yes	2.2	0.2
			avg 8.4								
I 13073D. C8	Rural - 6 yr	1763+00	4.1	13.3	5.4	147.3	11.3	1	Yes	baseplates	0.2
		1775+12	21.7	15.6	5.1	147.9	4.1	1	Yes	baseplates	0.2
		1806+03	16.3	11.5	5.7	145.4	4.9	2	Yes	baseplates	0.0
		1835+75	19.4	16.6	4.7	148.5	8.5	2	Yes	baseplates	0.0
		1893+27	9.2	14.1	5.8	146.6	6.4	2	Yes	baseplates	0.2
			avg 14.1								
F 25084-015	Rural - 5 yr	769+64	8.7	10.3	8.0	147.9	6.2	3	Yes	1.1	0.4
		774+82	4.9	10.7	4.8	144.1	5.6	1	Yes	0.9	0.7
		794+73	1.9	7.0	8.0	144.1	4.6	2	Yes	0.9	0.0
			avg 5.2								
U 33061-020	Urban - 6 yr	425+40	0.0	9.7	6.1	147.3	6.8	1	No	0.4	1.8
		431+12	0.0	11.7	8.0	149.8	4.4	1	No	0.4	0.7
		434+10	0.0	18.1	6.9	145.4	6.8	1	No	0.9	0.4
			avg 0.0								
U 33171-025	Urban - 5 yr	772+17	0.0	12.6	6.5	146.0	8.1	2	No	0.9	0.7
		775+75	0.0	12.2	3.6	141.7	7.1	2	No	0.9	0.9
			avg 0.0								
F 41132-022	Rural - 5 yr	851+20	15.5	12.5	5.5	145.4	5.1	1	No	0.9	0.4
		905+18	7.1	19.1	5.0	147.9	5.8	2	No	0.7	0.4
		1012+55	10.5	16.5	3.9	146.6	6.6	1	No	0.4	0.2
			avg 11.0								

* Deterioration at bottom of pavement slab at joint.

Discussion

The data obtained on the cores and joints showed little change in the amount of deteriorated concrete when averages were compared (Table 2). It was evident, however, that the amounts of deterioration varied significantly within some projects. Project Number F 41132-022, for example, had volume losses ranging from 0.0 to 21.0 percent. This project had end plates placed over the ends of the joint grooves instead of extending the neoprene seal down the vertical edge of the slab. In some cases, the end plate had moved away from the slab allowing ready access for deicing salts and water to enter which may account for some of the variation.

The base materials were tested for permeability and rated according to their ability to permit drainage of water when compacted to optimum density. The samples were rated A through D as the degree of drainability increased and are defined in Appendix B. Although there was no evident correlation between drainability and deterioration of concrete, it was decided to continue to obtain the data since drainability is considered essential to highway performance and a correlation might evolve.

THIRD AND FOURTH YEARS' ACTIVITY

A review of the previous year's research did not suggest that any changes be made in the field procedures. However, it was decided to core the projects in the same general locations as previously cored and to take the same number of cores in each area so that a better comparison between each year's work would exist.

The scope of the third year's activity was increased by the addition of two new projects which were constructed in 1971. They consisted of one urban and one rural project totaling 6.6 miles (10.6 km) of dual highway. The fourth year's activity remained the same as the previous year with no addition of new projects.

After each year's field activity the cores were grouped into projects and photographed. Each core was then examined and measured for deterioration. Samples from the top 1 in. (2.54 cm) and bottom 1 in. of the cores were taken and the chloride content was determined. Laboratory tests were conducted on the base material from each joint area to determine the drainability of the base.

TABLE 2
SUMMARY OF DATA FROM PROJECTS CORED IN 1975

Project No.	Project Type and Age	Station	Concrete Deterioration, percent of volume*	Chloride Content lb/cu yd of concrete		Density, lb/cu yd	Seal Rating	Base Rating	Edge of Slab Sealed
				Core Top	Core Bottom				
I 06111-007	Rural - 7 yr	2492+88	0.0	9.8	3.1	146.0	1	A	Yes
		2495+73	0.0	7.7	1.5	142.9	1	A	Yes
		2727+91	0.0	9.7	1.5	144.1	1	C	Yes
		2728+74	0.0	11.1	1.4	142.9	3	C	Yes
		2937+61	6.6	10.1	2.8	138.5	3	C	Yes
		2940+18	0.0	11.0	3.5	145.4	3	C	Yes
			avg 1.1						
I 06111-009	Rural - 7 yr	3171+12	0.0	8.3	3.4	141.0	2	B	Yes
		3173+93	2.0	8.9	7.1	142.9	3	B	Yes
			avg 1.0						
I 13073-007	Rural - 7 yr	1403+36	6.2	10.7	4.5	139.8	3	A	Yes
		1407+60	4.8	9.6	4.2	141.0	3	A	Yes
		1439+63	6.2	9.4	4.6	142.9	3	B	Yes
		1441+76	8.7	10.0	3.7	141.6	3	C	Yes
		1484+46	10.1	9.8	3.0	139.2	3	A	Yes
		1486+61	17.6	8.6	1.5	141.0	3	A	Yes
			avg 8.9						
I 13073D, C8	Rural - 7 yr	1631+92	12.4	12.3	5.7	144.8	2	baseplate	Yes
		1634+73	13.7	9.1	2.9	143.5	2	baseplate	Yes
		1807+34	21.4	---	---	---	3	baseplate	Yes
		1809+48	16.1	9.8	4.0	146.6	3	baseplate	Yes
			avg 15.9						
I 13074-002	Rural - 5 yr	2323+37	0.0	7.4	6.0	142.9	3	A	Yes
		2326+22	4.8	7.6	6.4	143.5	2	A	Yes
		2428+30	2.4	5.0	4.9	144.8	1	B-C	Yes
		2431+12	27.6	5.6	2.0	142.3	1	A	Yes
		2538+91	0.0	9.7	7.3	142.3	2	A	Yes
		2541+05	0.0	6.9	8.0	144.8	2	A	Yes
			avg 5.8						
I 23081-002	Urban - 6 yr	178+24	0.0	10.1	2.3	136.7	1	B	No
		180+39	3.6	10.3	4.5	142.9	3	B	No
		237+88	3.7	12.4	7.2	140.4	3	B	No
		240+76	10.9	12.7	6.2	139.8	3	A	No
			avg 4.6						
F 25084-015	Rural - 6 yr	762+02	4.1	5.6	3.1	142.9	3	B	Yes
		764+85	6.0	6.3	3.2	142.3	3	A	Yes
		792+07	3.6	7.7	7.0	142.9	3	A	Yes
		794+94	3.7	6.0	2.7	142.9	2	B	Yes
		879+92	1.1	7.6	5.6	134.8	3	A	Yes
			avg 3.7						

* Deterioration at bottom of pavement slab at joint.

TABLE 2 (Cont.)
SUMMARY OF DATA FROM PROJECTS CORED IN 1975

Project No.	Project Type and Age	Station	Concrete Deterioration, percent of volume*	Chloride Content, lb/cu yd of concrete		Density, lb/cu yd	Seal Rating	Base Rating	Edge of Slab Sealed
				Core Top	Core Bottom				
F 25084-016	Rural - 6 yr	882+52	10.6	10.0	2.6	144.1	3	A	No
		996+45	1.0	7.0	3.3	146.6	1	A	No
		998+51	1.2	8.8	2.8	147.3	1	A-B	No
			avg 4.3						
I 33044-037	Urban - 7 yr	326+61	2.5	12.9	6.6	142.3	3	A	Yes
		329+44	0.0	12.0	7.9	134.2	3	B	Yes
		332+18	0.0	18.2	11.0	142.3	2	B	Yes
			avg 0.8						
I 33044-057	Urban - 5 yr	417+64	11.5	9.0	6.2	147.3	2	B	No
		421+18	0.0	14.0	5.7	144.8	3	C	No
		503+36	0.0	---	---	---	2	C	Yes
		506+24	4.7	11.6	1.4	144.1	3	C	Yes
			avg 4.0						
U 33061-020	Urban - 7 yr	409+72	3.6	7.5	4.2	145.4	-	-	No
		413+00	0.0	10.2	4.1	142.3	1	-	No
		422+90	0.0	9.6	4.1	142.9	3	-	No
		428+91	0.0	9.3	7.1	141.0	3	-	No
			avg 0.9						
U 33171-025	Urban - 6 yr	770+79	6.2	11.7	3.5	139.2	2	A	No
		771+52	8.7	11.4	2.8	137.9	1	B	No
		784+00	0.0	7.3	5.1	138.5	2	A	No
		786+55	0.0	7.6	3.5	140.4	2	A	No
			avg 3.7						
F 41132-022	Rural - 6 yr	854+76	5.2	8.7	3.6	137.3	1	B	No
		859+04	10.9	7.1	3.9	141.0	3	B	No
		899+50	6.4	12.1	2.3	138.5	1	B	No
		903+05	0.0	8.7	4.1	142.3	3	B	No
		966+12	8.7	6.9	2.8	144.8	1	B	No
		968+95	21.0	7.7	3.0	145.4	2	B	No
			avg 8.7						
F 44043-001	Rural - 5 yr	1242+81	9.1	6.2	3.5	144.8	2	A	Yes
		1245+67	15.2	6.0	6.5	143.5	-	A	Yes
		1313+00	9.4	6.6	3.2	142.3	3	A	Yes
		1315+85	4.6	6.8	3.9	142.9	3	A	Yes
		1415+79	5.6	8.3	3.4	142.9	2	B	Yes
		1417+24	3.3	8.5	6.5	142.3	3	A	Yes
			avg 7.9						
I 65041-002	Rural - 5 yr	70+98	1.0	4.6	3.4	142.3	2	B	Yes
		73+82	4.8	7.2	3.8	142.9	3	B	Yes
		207+49	1.2	6.8	2.6	146.6	3	B	Yes
		210+34	0.0	7.7	4.6	149.1	3	B	Yes
		370+30	0.0	7.5	3.6	144.8	3	B	Yes
		373+15	0.0	7.8	5.4	145.4	3	A	Yes
			avg 1.2						

* Deterioration at bottom of pavement slab at joint.

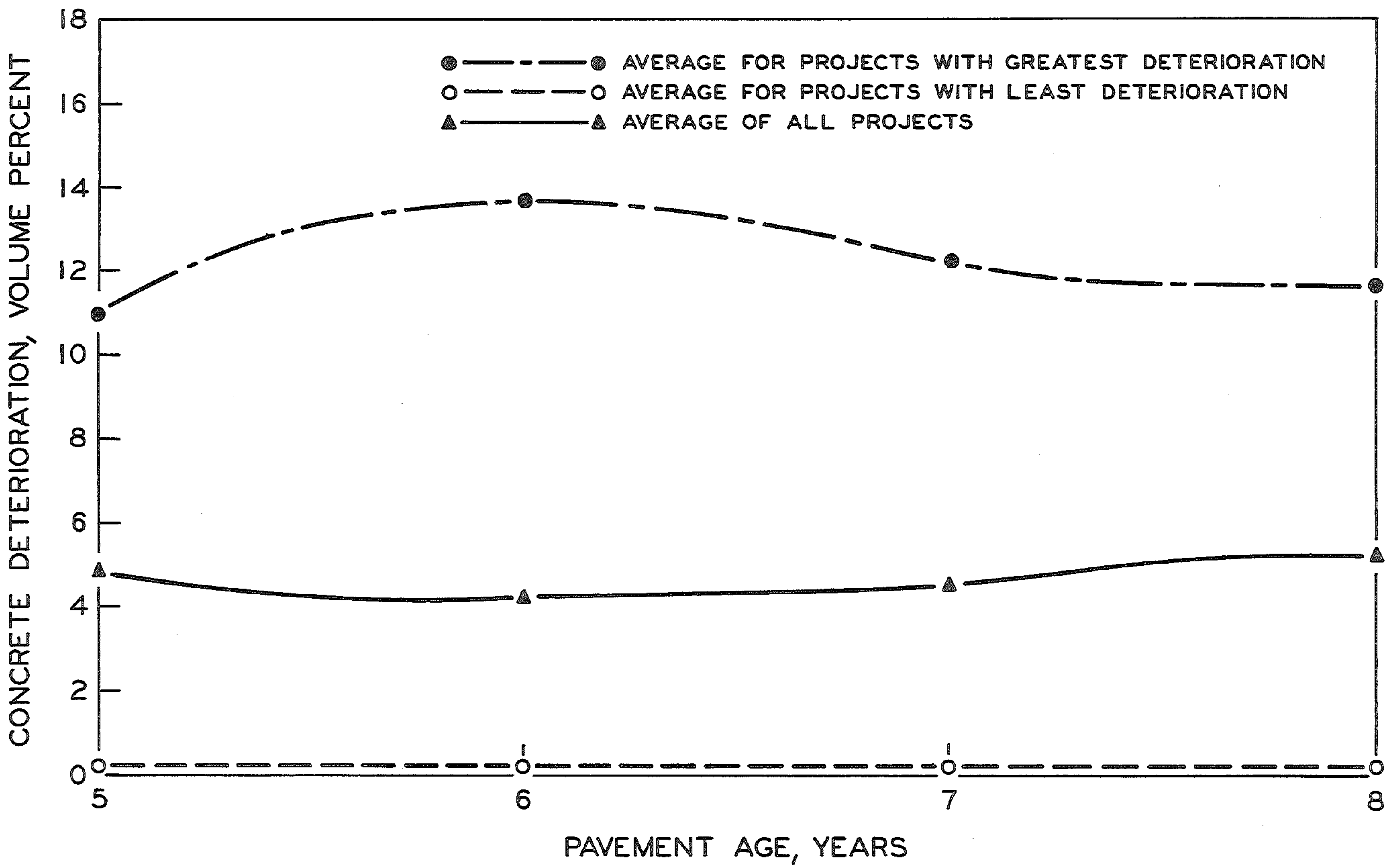


Figure 4. Concrete deterioration versus pavement age.

Discussion

The field data and laboratory test data were compiled in tabular form for the third and fourth year's activity and are presented in Tables 3 and 4, respectively.

A review of the data did not indicate a direct relationship between the amount or rate of deterioration and the drainability of the base material as had been anticipated. A summary of all coring data is provided in Table 5.

SUMMARY

Examination of over 200 cores and the joints from which they were removed has shown that the neoprene compression seal is doing a satisfactory job of preventing the entry of incompressible materials into our contraction joints, as was not the case for the previously used hot-poured rubber-asphalt.

It was also obvious that water and deicing salts are entering all joints, at least to some degree. Deterioration of the concrete at the bottom of joints is occurring but at a relatively low rate for most projects. The data indicate that most of the deterioration occurred during the first five years and little change is shown for the following years (Fig. 4).

It was observed in many cases that water was entering joints by passing between the seal and the joint face. One of the factors contributing to this problem is that the majority of the projects studied were constructed during the period when single-stage sawing of the joint groove was allowed. Since the saw cut had to be made before random cracking of the pavement occurred, the concrete would be quite 'green' and usually resulted in a joint face which had a rough texture thus making it difficult for the neoprene seal to conform to the surface (Fig. 5). Current specifications require two-stage sawing with a final sawing done after the concrete has attained at least 30 percent of the designed strength.

A second common avenue of entry for water was observed to be where the seal was terminated at the edge of the pavement instead of being extended down the vertical edge of the slab. This condition was found on five of the projects. One of these projects (F 41132-022) had significantly more concrete deterioration than all other projects (with the exception of the one with steel baseplates) while the others had amounts ranging from little to moderate. One project (I 33044-057) had a combination of both types of

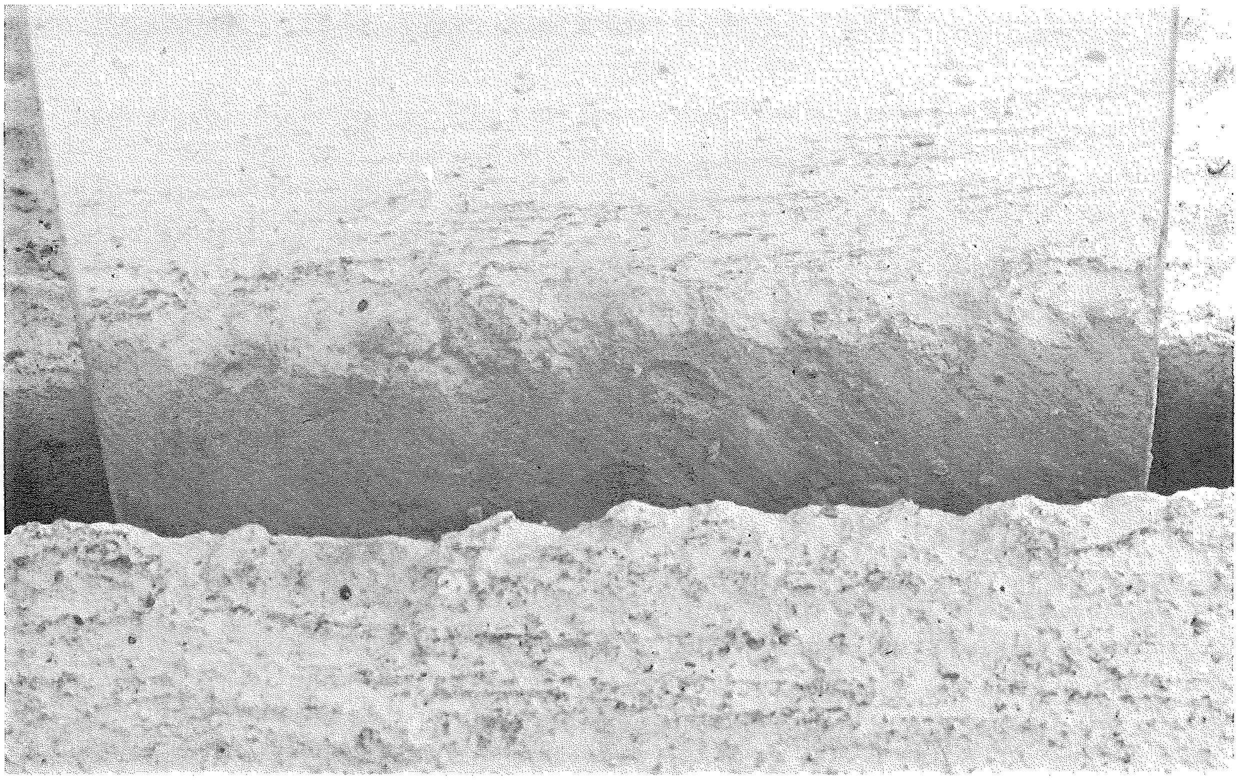


Figure 5. Typical rough texture of joint faces caused by single-stage sawing.

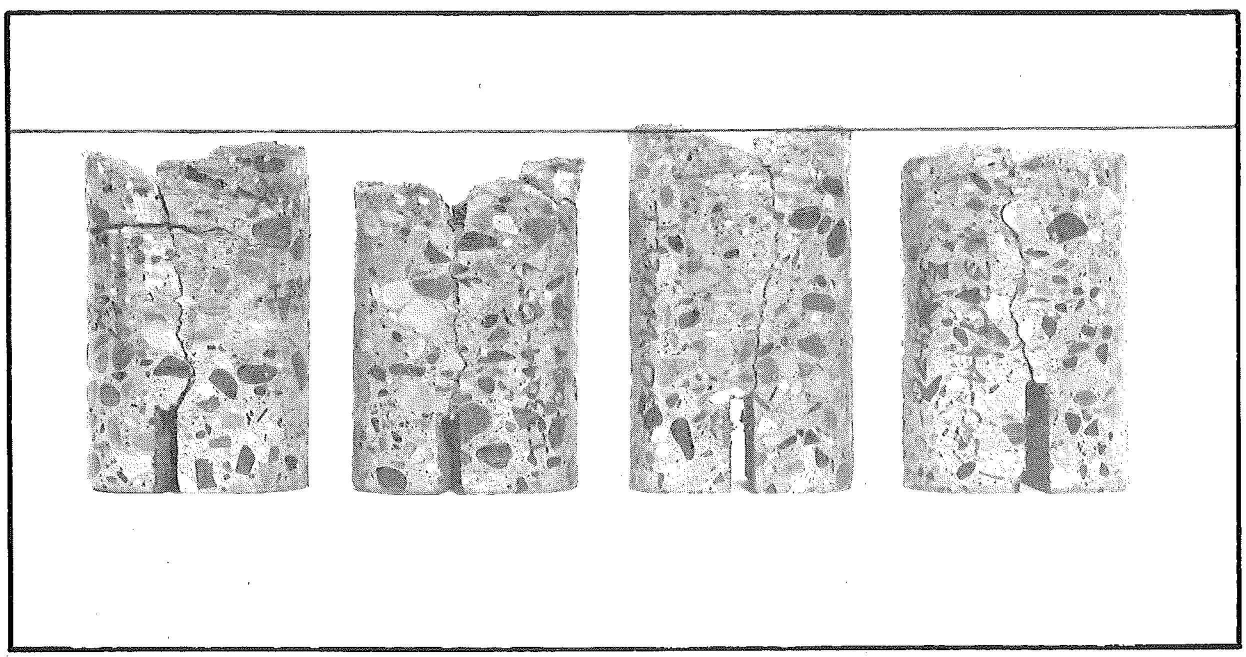


Figure 6. These four cores are from the same seven-year old pavement. The two on the left are from joints where the seal ended at the pavement edge and the two on the right are from joints which had the seal extending down the vertical edges. The line represents the average original depth of concrete. The cores are shown upside down.

joints. The core samples from the section where the seal was terminated at the pavement edge, consistently showed more deterioration (Fig. 6 and Table 6). It was also observed that much more silt was usually present in the contraction crack in this type of joint.

One project (I 13073D, C8) with steel baseplates under the joints was included in the study for the purpose of evaluating their effect on concrete deterioration below the joint groove. An adjacent project (I 13073-007) of the same age without baseplates was selected for comparison. Examination of the data shows that the project with baseplates had more deterioration than any of the other projects and significantly more than the adjacent project (Figs. 7 and 8).

Several factors believed to affect durability of concrete in the joint area such as base material drainability, aggregate resistance to freeze-thaw, and length of concrete cure before exposure to deicing chemicals were investigated for possible correlation with amount of concrete deterioration. No direct correlation was found, probably because we were unable to measure the amount of influx of water into the joint and more important, the length of time the joint concrete was saturated during freeze-thaw cycles.

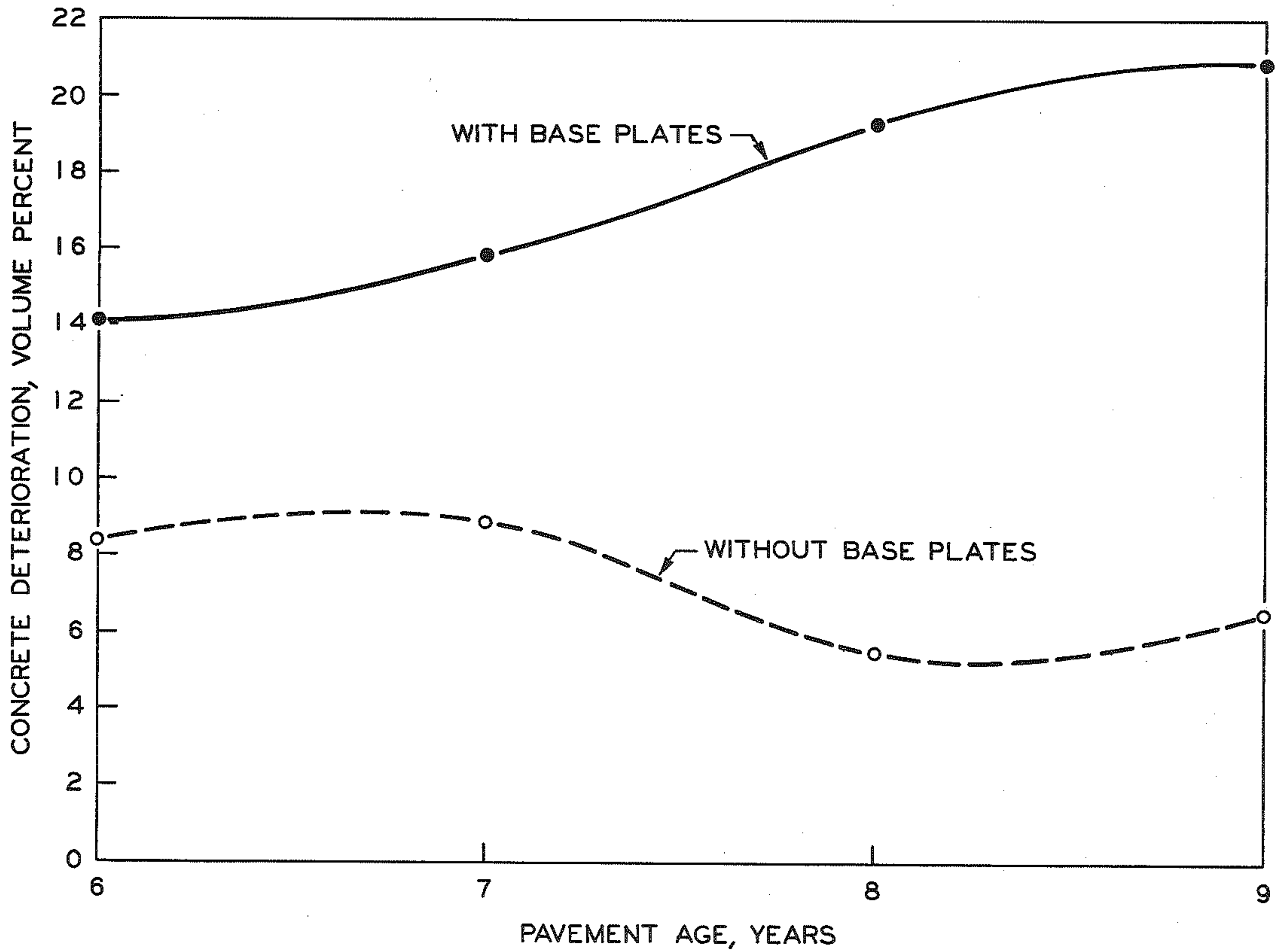


Figure 7. Effect of baseplates on deterioration of concrete, adjacent projects.

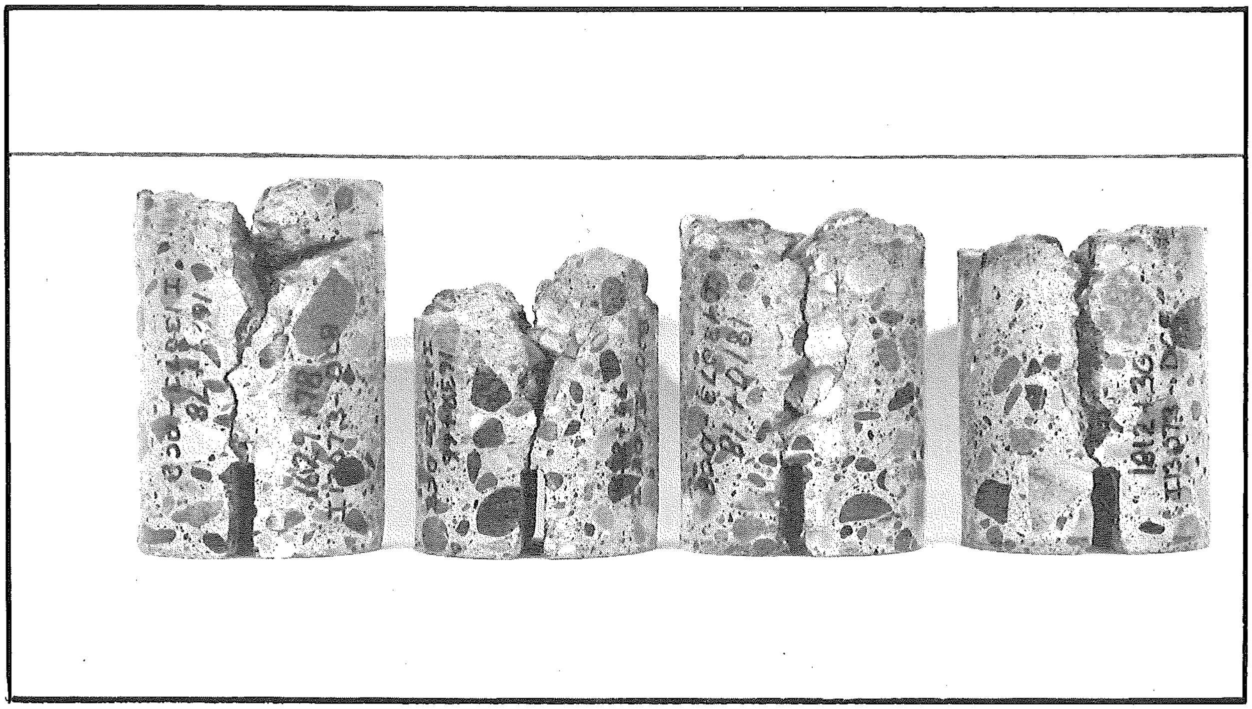


Figure 8. Cores taken from adjacent projects when the pavement was seven years old. The group above represents the baseplate project and the group below is the non-baseplate project. The line in both photographs represents the average thickness of the pavement at the core location. The cores are shown upside down.

TABLE 3
SUMMARY OF DATA FROM PROJECTS CORED IN 1976

Project No.	Project Type and Age	Station	Concrete Deterioration, percent of volume*	Chloride Content, lb/cu yd of concrete		Density, lb/cu yd	Seal Rating	Base Rating	Edge of Slab Sealed
				Core Top	Core Bottom				
I 06111-007	Rural - 8 yr	2908+56	2.4	4.4	3.7	141.6	3	D	Yes
		2910+71	5.1	5.8	4.2	141.6	3	D	Yes
		2725+18	0.0	4.3	1.6	144.8	1	A-B	Yes
		2720+92	0.0	5.6	1.9	141.6	1	B	Yes
		2497+12	0.0	4.3	3.4	142.9	1	C	Yes
		2493+60	0.0	4.3	2.2	144.8	1	B	Yes
			avg 1.2						
I 06111-009	Rural - 8 yr	3145+50	2.5	4.5	3.0	139.8	1	D	Yes
		3141+99	0.0	8.2	3.2	139.8	1	B-C	Yes
			avg 1.2						
I 13073-007	Rural - 8 yr	1394+10	15.6	6.8	3.0	141.6	3	B	Yes
		1396+21	2.7	8.4	4.1	143.5	1	C	Yes
		1480+20	3.6	7.6	5.0	143.5	2	C	Yes
		1482+33	0.0	5.8	2.8	139.2	3	B	Yes
			avg 5.5						
I 13073D, C8	Rural - 8 yr	1629+78	6.7	8.4	3.2	141.0	2	baseplate	Yes
		1632+66	28.4	7.1	2.7	141.6	3	baseplate	Yes
		1810+18	20.1	8.5	2.8	144.1	2	baseplate	Yes
		1812+30	22.0	5.9	2.8	141.0	3	baseplate	Yes
			avg 19.3						
I 13074-002	Rural - 6 yr	2379+79	5.1	5.9	2.1	144.8	2	C	Yes
		2377+67	2.4	6.0	2.2	142.3	3	C	Yes
		2537+48	5.2	7.3	4.9	141.0	1	B	Yes
		2535+33	0.0	5.8	2.4	142.3	2	B	Yes
			avg 3.2						
I 23061-014	Rural - 5 yr	1258+09	7.6	6.0	2.4	143.5	1	B	Yes
		1255+93	12.0	7.1	2.2	141.0	3	C	Yes
		1321+36	18.5	6.0	2.3	139.8	3	B	No
		1319+21	4.8	6.2	1.7	144.8	1	C	Yes
		1429+05	7.0	8.5	2.0	142.3	1	B	Yes
		1426+90	2.4	6.8	6.6	141.0	3	B	Yes
			avg 8.7						
I 23081-002	Urban - 7 yr	181+10	4.6	9.3	3.3	144.1	2	A	No
		179+00	4.5	11.8	1.7	142.3	1	B	No
		248+58	5.8	9.0	3.2	139.8	3	A	No
		246+45	4.0	11.2	2.7	139.2	3	C	No
			avg 4.7						
F 25084-015	Rural - 7 yr	786+37	0.0	6.8	3.2	146.0	1	B	Yes
		760+42	4.8	4.8	3.9	143.5	3	B	Yes
		878+13	0.0	8.0	2 7	142.9	1	C	Yes
		789+16	0.0	5 9	3.7	149.1	1	C	Yes
			avg 1.2						

* Deterioration at bottom of pavement slab at joint.

TABLE 3 (Cont.)
SUMMARY OF DATA FROM PROJECTS CORED IN 1976

Project No.	Project Type and Age	Station	Concrete Deterioration, percent of volume*	Chloride Content, lb/cu yd of concrete		Density, lb/cu yd	Seal Rating	Base Rating	Edge of Slab Sealed
				Core Top	Core Bottom				
F 25084-016	Rural - 7 yr	881+94	6.5	7.3	5.6	142.3	3	C	Yes
		1009+48	2.8	9.1	4.2	146.6	3	C	Yes
		1007+40	12.0	7.9	3.5	146.0	3	A	Yes
			avg 7.1						
U 25084-028	Urban - 5 yr	692+73	0.0	5.9	4.8	139.8	1	C	Yes
		694+99	0.0	6.3	5.1	141.6	1	B	Yes
			avg 0.0						
I 33044-037	Urban - 8 yr	332+90	0.0	10.0	3.3	146.0	2	A	Yes
		330+15	avg 0.0	8.7	2.5	140.4	3	C	Yes
I 33044-057	Urban - 6 yr	399+96	7.2	5.2	3.1	143.5	1	B	No
		397+12	1.5	7.9	3.0	146.6	3	B	No
		508+40	0.7	6.2	3.6	143.5	3	C	Yes
		504+82	0.1	8.6	2.0	141.0	1	B	Yes
			avg 2.4						
U 33061-020	Urban - 8 yr	421+49	1.9	6.2	3.5	139.2	1	C	No
		420+24	4.2	11.0	3.0	139 2	2	C	No
		433+02	0.0	9.6	6.2	143.5	1	B	No
		431+78	2.8	10.1	5.1	146.0	3	C	No
			avg 2.2						
U 33171-025	Urban - 7 yr	785+82	4.5	6 7	2.7	141.0	3	B	No
		772+90	5.0	6.3	4.1	142.3	2	B	No
			avg 4.8						
F 41132-022	Rural - 7 yr	850+50	21.6	6.3	4.6	141.6	1	B-C	No
		852+64	9.6	5.1	4.8	142.3	1	B	No
		900+27	0.0	7.6	2.7	141.6	1	C	No
		902+36	24.7	8.1	3.6	144.1	3	C	No
		965+39	11.1	8.4	3.9	142.9	2	C	No
		968+24	6.1	6.4	2.3	148.5	3	C	No
			avg 12.2						
F 44043-001	Rural - 6 yr	1251+79	5.1	5.9	2.2	144.8	3	B	Yes
		1249+70	2.4	5.0	3.3	145.4	1	A	Yes
		1314+36	3.0	8.1	3.1	144.1	2	B	Yes
		1312+24	0.5	8.2	4.6	145.4	1	B	Yes
		1420+33	0.0	5.4	4.9	141.6	3	B	Yes
		1418+21	0.0	7.6	3.4	141.6	1	B	Yes
			avg 1.8						
I 65041-002	Rural - 6 yr	65+30	2.4	7.9	3.3	146.0	3	C	Yes
		69+58	0.0	5.0	2.5	139.8	3	D	Yes
		200+39	0.0	5.1	3.3	146.0	2	C	Yes
		202+51	0.0	5.2	2.6	145.4	3	C	Yes
		369+60	2.0	8.2	4.3	145.4	1	B	Yes
		371+70	5.3	6.5	5.4	146.6	2	C	Yes
			avg 1.6						

* Deterioration at bottom of pavement slab at joint.

TABLE 4
SUMMARY OF DATA FROM PROJECTS CORED IN 1977

Project No.	Project Type and Age	Station	Concrete Deterioration, percent of volume*	Chloride Content, lb/cu yd of concrete		Density, lb/cu yd	Seal Rating	Base Rating	Edge of Slab Sealed
				Core Top	Core Bottom				
I 06111-007	Rural - 9 yr	2494+98	0.0	12.1	4.0	145.4	2	A	Yes
		2496+40	0.0	8.0	2.2	139.8	1	B	Yes
		2727+30	0.0	7.5	1.7	146.0	1	C	Yes
		2730+85	0.0	9.9	3.8	142.9	1	A	Yes
		2913+45	0.0	6.2	5.4	144.8	3	B	Yes
		2914+96	1.9	7.5	5.5	146.0	3	B	Yes
			avg 0.3						
I 06111-009	Rural - 9 yr	3159+02	4.8	8.6	3.8	137.9	2	C	Yes
		3160+42	1.6	6.9	5.1	139.8	1	A	Yes
			avg 3.2						
I 13073-007	Rural - 9 yr	1396+92	4.9	6.5	6.3	144.8	2	B	Yes
		1398+36	7.2	8.2	5.3	136.7	3	B	Yes
		1483+06	8.2	8.4	5.0	142.9	-	B	Yes
		1485+20	5.7	13.7	5.1	136.7	-	A	Yes
			avg 6.5						
I 13073D, C8	Rural - 9 yr	1813+72	24.0	6.4	6.9	143.5	2	baseplate	Yes
		1815+24	19.2	10.5	3.9	141.0	2	baseplate	Yes
		1833+13	25.2	12.1	7.0	142.3	2	baseplate	Yes
		1835+45	15.6	7.8	5.3	144.8	2	baseplate	Yes
			avg 21.0						
I 13074-002	Rural - 7 yr	2322+64	2.7	7.7	4.3	142.9	2	B	Yes
		2324+08	2.5	10.7	4.3	144.1	3	B	Yes
		2376+95	5.3	13.7	2.1	142.9	2	A	Yes
		2378+37	6.2	8.4	3.6	143.5	2	B	Yes
		2532+50	9.6	15.7	4.5	150.4	3	B	Yes
		2533+91	9.5	9.4	1.7	142.3	3	A	Yes
			avg 6.0						
I 23061-014	Rural - 6 yr	1258+78	24.0	10.4	3.2	142.3	2	B	Yes
		1259+45	26.4	7.1	2.5	141.0	2	A	Yes
		1314+96	10.2	10.5	3.1	142.9	2	A	Yes
		1316+40	6.8	9.9	4.1	142.3	2	B	Yes
		1426+21	8.1	9.1	2.5	140.4	2	A	Yes
		1428+35	8.2	10.9	2.9	141.6	2	A	Yes
			avg 14.0						
I 23081-002	Urban - 8 yr	179+85	5.5	9.1	3.5	138.5	2	A	No
		181+82	10.2	14.7	3.4	136.1	2	B	No
		245+70	8.4	14.0	4.5	142.9	3	A	No
		247+86	12.0	18.1	5.0	138.5	3	A	No
			avg 9.0						
F 25084-015	Rural - 8 yr	762+76	8.1	9.4	6.2	146.0	2	B	Yes
		764+15	7.4	6.0	6.8	143.5	2	B	Yes
		877+80	10.8	6.0	3.2	140.4	2	A	Yes
		879+20	9.9	4.9	4.0	140.4	2	B	Yes
			avg 9.0						
F 25084-016	Rural - 8 yr	883+24	2.6	9.3	4.4	147.3	1	A	No
		1006+68	12.0	9.3	4.7	143.5	2	A	No
		1008+75	3.2	12.2	2.6	147.3	2	A	No
			avg 5.9						

TABLE 4 (Cont.)
SUMMARY OF DATA FROM PROJECTS CORED IN 1977

Project No.	Project Type and Age	Station	Concrete Deterioration, percent of volume*	Chloride Content, lb/cu yd of concrete		Density, lb/cu yd	Seal Rating	Base Rating	Edge of Slab Sealed
				Core Top	Core Bottom				
U 25084-028	Urban - 6 yr	693+40	0.2	12.7	4.7	139.2	2	B	Yes
		695+73	0.0	7.8	4.1	142.3	2	A	Yes
			avg 0.1						
I 33044-037	Urban - 9 yr	325+18	5.8	9.1	6.2	143.5	-	B	Yes
		327+30	0.0	11.2	1.1	137.3	-	A	Yes
			avg 2.9						
I 33044-057	Urban - 7 yr	398+56	7.1	9.6	5.6	146.0	1	A	No
		400+67	10.5	9.7	6.3	147.9	2	B	No
		505+55	2.4	7.6	1.5	144.8	1	B	Yes
		507+70	3.2	8.8	1.9	144.1	1	A	Yes
			avg 5.8						
U 33061-020	Urban - 9 yr	408+40	0.0	18.1	6.1	144.1	2	B	No
		422+90	0.0	10.3	4.6	141.0	2	C	No
		430+12	0.0	15.3	6.1	139.2	2	A	No
		434+73	0.0	9.3	8.2	144.1	2	-	No
			avg 0.0						
U 33171-025	Urban - 8 yr	774+33	0.0	8.8	4.8	136.7	3	A	No
		775+05	19.3	10.7	6.6	144.1	2	A	No
		786+50	1.0	6.8	3.7	141.0	3	A	No
		787+25	8.4	9.4	4.2	144.8	3	A	No
			avg 7.2						
F 41132-022	Rural - 8 yr	851+90	18.2	6.9	6.8	140.4	1	A	No
		853+33	15.9	8.3	4.5	141.6	2	A	No
		898+80	3.9	9.3	5.7	144.1	2	A	No
		900+90	1.2	7.5	3.0	145.4	2	B	No
		969+70	8.4	7.7	5.9	143.5	2	A	No
		971+10	22.6	8.6	3.8	142.9	2	A	No
			avg 11.7						
F 44043-001	Rural - 7 yr	1248+97	3.0	9.1	8.1	142.9	1	A	Yes
		1251+10	5.8	9.1	6.4	142.9	2	B	Yes
		1311+51	4.3	11.0	6.7	145.4	1	B	Yes
		1313+65	1.7	10.9	8.2	144.1	1	C	Yes
		1416+08	1.8	7.6	14.3	144.1	2	A	Yes
		1417+50	4.2	7.6	8.6	144.8	2	A	Yes
			avg 3.5						
I 65041-002	Rural - 7 yr	72+39	2.3	6.8	4.0	145.4	1	B	Yes
		75+23	0.9	6.2	3.5	141.0	2	A	Yes
		203+95	0.2	6.0	5.2	144.1	1	A	Yes
		205+36	7.0	7.4	6.1	144.1	1	A	Yes
		371+00	0.9	5.8	5.2	142.9	2	B	Yes
		372+42	2.4	8.7	5.3	145.4	3	A	No
			avg 2.3						

*Deterioration at bottom of pavement slab at joint.

TABLE 5
SUMMARY OF DATA FROM ALL CORING, 1974 THROUGH 1977

Pavement Age		Five Years					Six Years					Seven Years					Eight Years					Nine Years				
		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating	
Project No.	Joint No.		Top	Bottom	Seal	Base		Top	Bottom	Seal	Base		Top	Bottom	Seal	Base		Top	Bottom	Seal	Base		Top	Bottom	Seal	Base
SUMMARY BY AGE - URBAN PROJECTS																										
I 23081-002	1						0.0	10.2	2.3	1	B	4.6	9.3	3.3	2	A	5.5	9.1	3.5	2	A					
	2						3.6	10.3	4.5	3	B	4.5	11.8	1.7	1	B	10.2	14.7	3.4	2	B					
	3						3.7	12.5	7.2	3	B	5.8	9.0	3.2	3	A	8.4	14.0	4.5	3	A					
	4						10.9	12.7	6.2	3	A	4.0	11.2	2.7	3	C	12.0	18.1	5.0	3	A					
	avg						4.6	11.4	5.1			4.7	10.3	2.7			9.0	14.0	4.1							
U 25084-028	1	0.0	5.9	4.9	1	C	0.2	12.7	4.7	2	B															
	2	0.0	6.3	5.1	1	B	0.0	7.8	4.1	2	A															
	avg	0.0	6.1	5.0			0.1	10.2	4.4																	
I 33044-037	1											2.5	13.0	6.6	3	A	0.0	10.0	3.3	2	A	5.8	9.1	6.2	-	B
	2											0.0	12.1	8.0	3	B	0.0	8.8	2.5	3	C	0.0	11.2	1.1	-	A
	3											0.0	18.2	11.0	2	B										
	avg											0.8	14.4	8.5			0 0	9 4	2.9			2.9	10.1	3.7		
I 33044-057	1	11.5	9.0	6.2	2	B	7.2	5.2	3.1	1	B	7.1	9.6	5.6	1	A										
	2	0.0	14.0	6.7	3	C	1.5	7.9	3.0	3	B	10.5	9.7	6.3	2	B										
	3	0.0	---	---	2	C	0.7	6.2	3.6	3	C	2.4	7.6	1.5	1	B										
	4	4.7	11.6	1.4	3	C	0.1	8.6	2.0	1	B	3.2	8.8	1.9	1	A										
	avg	4.1	11.5	4.4			2.4	7.0	2.9			5.8	8.9	3.8												
U 33061-020	1						0.0	9.7	6.1	1		3.6	7.5	4.2	-	-	1.9	6.2	3.5	1	C	0.0	18.1	6.1	2	B
	2						0.0	11 7	8.0	1		0.0	10.2	4.1	1	-	4.2	11.0	3.0	2	C	0.0	10.3	4.6	2	C
	3						0.0	18 1	6.9	1		0.0	9.6	4.1	3	-	0.0	9.6	6.2	1	B	0.0	15.3	6.1	2	A
	4											0.0	9.3	7.1	3	-	2.8	10.1	5.1	3	C	0.0	9.3	8.2	2	-
	avg						0.0	13.2	7.0			0.9	9.1	4.9			2.2	9.2	4.4			0.0	13.3	6.3		
U 33171-025	1	0.0	12.6	6.5	2		6.2	11.7	3.5	2	A	4.5	6.8	2.7	3	B	0.0	8.8	4.8	3	A					
	2	0.0	12.2	3.6	2		8.7	11.4	2.8	1	B	5.0	6.3	4.1	2	B	19.3	10.7	6.6	2	A					
	3						0.0	7.3	5.1	2	A						1.0	6.8	3.7	3	A					
	4						0.0	7.6	3.5	2	A						8.4	9.4	4.2	3	A					
	avg	0.0	12.4	5.0			3.7	9.5	3.7			4.7	6.5	3.3			7.2	8.9	4.8							

* Deterioration at bottom of pavement slab at joint.

TABLE 5 (Cont.)
SUMMARY OF DATA FROM ALL CORING, 1974 THROUGH 1977

Pavement Age		Five Years					Six Years					Seven Years					Eight Years					Nine Years				
Project No.	Joint No.	Concrete Deterioration, percent by volume*	Chloride, lb/cu yd Top	Chloride, lb/cu yd Bottom	Rating Seal	Rating Base	Concrete Deterioration, percent by volume*	Chloride, lb/cu yd Top	Chloride, lb/cu yd Bottom	Rating Seal	Rating Base	Concrete Deterioration, percent by volume*	Chloride, lb/cu yd Top	Chloride, lb/cu yd Bottom	Rating Seal	Rating Base	Concrete Deterioration, percent by volume*	Chloride, lb/cu yd Top	Chloride, lb/cu yd Bottom	Rating Seal	Rating Base	Concrete Deterioration, percent by volume*	Chloride, lb/cu yd Top	Chloride, lb/cu yd Bottom	Rating Seal	Rating Base
SUMMARY BY AGE - RURAL PROJECTS																										
I 06111-007	1											0.0	9.8	3.2	1	A	2.4	4.4	3.7	3	D	0.0	12.1	4.0	2	A
	2											0.0	7.7	1.5	1	A	5.1	5.8	4.2	3	D	0.0	8.0	2.2	1	B
	3											0.0	9.7	1.6	1	C	0.0	4.3	1.6	1	A-B	0.0	7.5	1.7	1	C
	4											0.0	11.1	1.4	3	C	0.0	5.6	1.9	1	B	0.0	9.9	3.8	1	A
	5											6.6	10.1	2.8	3	C	0.0	4.3	3.4	1	C	0.0	6.2	5.4	3	B
	6											0.0	11.0	3.5	3	C	0.0	4.3	2.3	1	B	1.9	7.5	5.5	3	B
	avg											1.1	9.9	2.3			1.3	4.8	2.9			0.3	8.5	3.8		
I 06111-009	1											0.0	8.3	3.4	2	B	2.5	4.5	3.0	1	D	4.8	8.6	3.8	2	C
	2											2.0	8.9	7.1	3	B	0.0	8.2	3.1	1	B-C	1.6	6.9	5.1	1	A
	avg											1.0	8.6	5.2			1.3	6.3	3.0			3.2	7.8	4.4		
I 13073-007	1						6.0	13.9	5.6	2		6.2	10.7	4.5	3	A	15.6	6.8	3.1	3	B	4.9	6.5	6.3	2	B
	2						13.0	12.6	5.4	1		4.8	9.6	4.2	3	A	2.7	8.4	4.1	1	C	7.2	8.2	5.3	3	B
	3						6.2	14.5	5.9	2		6.2	9.4	4.6	3	B	3.6	7.6	5.0	2	C	8.2	8.4	5.0	-	B
	4											8.7	10.0	3.7	3	C	0.0	5.8	2.8	3	B	5.7	13.7	5.1	-	A
	5											10.1	9.8	3.0	3	A										
	6											17.6	8.6	1.5	3	A										
	avg						8.4	13.7	5.6			8.9	9.7	3.6			5.5	7.2	3.7			6.5	9.2	5.4		
I 13074-002	1	0.0	7.4	6.0	3	A	5.1	5.9	2.1	2	C	2.7	7.7	4.3	2	A										
	2	4.8	7.6	6.4	2	A	2.4	6.0	2.2	3	C	2.5	10.7	4.3	3	B										
	3	2.4	5.0	4.9	1	B-C	5.2	7.3	4.9	1	B	5.3	13.7	2.1	2	A										
	4	27.6	5.6	2.0	1	A	0.0	5.8	2.4	2	B	6.2	8.4	3.6	2	B										
	5	0.0	9.7	7.3	2	A						9.6	15.7	4.5	3	B										
	6	0.0	6.9	8.0	2	A						9.5	9.4	1.7	3	A										
	avg	5.8	7.0	5.8			3.2	6.3	2.9			6.0	10.9	3.4												
I 23061-014	1	7.6	6.0	2.4	1	B	24.0	10.4	3.2	2	B															
	2	12.0	7.1	2.2	3	C	26.4	7.1	2.5	2	A															
	3	18.5	6.0	2.3	3	B	10.2	10.5	3.1	2	A															
	4	4.8	6.2	1.7	1	C	6.8	9.9	4.1	2	B															
	5	7.0	8.5	2.0	1	B	8.1	9.1	2.5	2	A															
	6	2.4	6.8	6.6	3	B	8.1	10.9	2.9	2	A															
	avg	8.7	6.8	2.9			13.9	9.7	3.1																	

* Deterioration at bottom of pavement slab at joint.

TABLE 5 (Cont.)
SUMMARY OF DATA FROM ALL CORING, 1974 THROUGH 1977

Pavement Age		Five Years					Six Years					Seven Years					Eight Years					Nine Years				
Project No.	Joint No.	Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating		Concrete Deterioration, percent by volume*	Chloride, lb/cu yd		Rating	
			Top	Bottom	Seal	Base		Top	Bottom	Seal	Base		Top	Bottom	Seal	Base		Top	Bottom	Seal	Base		Top	Bottom	Seal	Base
F 25084-015	1	8.7	10.3	8.0	3		4.1	5.7	3.1	3	B	0.0	6.8	3.1	1	B	8.1	9.4	6.2	2	B					
	2	4.9	10.7	4.8	1		6.0	6.3	3.2	3	A	4.8	4.8	4.0	3	B	7.4	6.0	6.8	2	B					
	3	1.9	7.0	8.0	2		3.6	7.7	7.0	3	A	0.0	8.0	2.7	1	C	10.8	6.0	3.2	2	A					
	4						3.7	6.0	2.7	2	B	0.0	5.9	3.8	1	C	9.9	4.9	4.0	2	B					
	5						1.1	7.6	5.6	3	A															
	avg	5.2	9.3	6.9			3.7	6.6	4.3			1.6	6.4	3.4			9.1	6.6	5.1							
F 25084-016	1						10.6	10.0	2.6	3	A	6.5	7.3	5.6	3	C	2.6	9.3	4.4	1	A					
	2						1.0	7.0	3.3	1	A	2.8	9.1	4.2	3	C	12.0	9.3	4.7	2	A					
	3						1.2	8.8	2.8	1	A-B	12.0	7.9	3.5	3	A	3.2	12.2	2.6	2	A					
	avg						4.3	8.6	2.9			7.1	8.1	4.4			5.9	10.3	3.9							
F 41132-022	1	15.5	12.5	5.5	1		5.2	8.7	3.6	1	B	21.6	6.3	4.5	1	B-C	18.2	6.9	6.8	1	A					
	2	7.1	19.1	5.0	2		10.9	7.1	3.9	3	B	9.6	5.1	4.8	1	B	15.9	8.3	4.5	2	A					
	3	10.5	16.5	3.9	1		6.4	12.1	2.3	1	B	0.0	7.6	2.7	1	C	3.9	9.3	5.7	2	A					
	4						0.0	8.7	4.1	3	B	24.7	8.1	3.6	3	C	1.2	7.5	3.0	2	B					
	5						8.7	6.9	2.7	1	B	11.1	8.4	3.9	2	C	8.4	7.7	5.9	2	A					
	6						21.0	7.7	3.0	2	B	6.1	6.4	2.3	3	C	22.6	8.6	3.8	2	A					
	avg	11.0	16.0	4.8			8.7	8.5	3.3			12.2	7.0	3.6			11.7	8.0	5.0							
F 44043-001	1	9.1	6.2	3.5	2	A	5.1	5.9	2.3	3	B	3.0	9 1	8.1	1	A										
	2	15.2	6.0	6.5	-	A	2.4	5.1	3.3	1	A	5.8	9.1	6.4	2	B										
	3	9.4	6.7	3.2	3	A	3.0	8.1	3.1	2	B	4.3	11.0	6.7	1	B										
	4	4.6	6.9	3.9	3	A	0.5	8.2	4.6	1	B	1.7	10.9	8.2	1	C										
	5	5.6	8.3	3.4	2	A	0.0	5.4	4.9	3	B	1.8	7.6	14.3	2	A										
	6	3.3	8.5	6.5	3	A	0.0	7.6	3.4	1	B	4.2	7.6	8.6	2	A										
	avg	7.9	7.1	4.5			1.8	6.7	3.6			3.5	9.2	8.7												
I 65041-002	1	1.0	4.6	3.4	2	B	2.4	7.9	3.3	3	C	2.3	6.8	4.0	1	B										
	2	4.8	7.2	3.8	3	B	0.0	5.0	2.5	3	D	0.9	6.2	3.5	2	A										
	3	1.2	6.9	2.6	3	B	0.0	5.1	3.3	2	C	0.2	6.0	5.2	1	A										
	4	0.0	7.7	4.7	3	B	0.0	5.2	2.6	3	C	7.0	7.4	6.1	1	A										
	5	0.0	7.5	3.6	3	B	2.0	8.2	4.4	1	B	0.9	5.8	5.2	2	B										
	6	0.0	7.8	5.4	3	A	5.3	6.5	5.4	2	C	2.4	8.7	5.3	3	A										
	avg	1.2	7.0	3.9			1.6	6.3	3.6			2.3	6.8	4.9												
BASEPLATE PROJECT																										
I 13073D, C8	1						4.1	13.3	5.4			12.4	12.3	5.7	2		6.7	8.5	3.2	2		24.0	6.4	6.9	2	
	2						21.7	15.6	5.1			13.7	9.1	2.9	2		28.4	7.1	2.7	3		19.2	10.5	3.9	2	
	3						16.3	11.5	5.7			21.4	---	---	3		20.1	8.5	2.8	2		25.2	12.1	7.0	2	
	4						19.4	16.7	4.7			16.1	9.8	4.0	3		22.0	5.9	2.9	3		15.6	7.8	5.3	2	
	5						9.2	14.0	5.8																	
	avg						14.1	14.2	5.3			15.9	10.4	4.2			19.3	7.5	2.9			21.0	9.2	5.8		

* Deterioration at bottom of pavement slab at joint.

TABLE 6
EFFECT OF SEAL TREATMENT AT PAVEMENT EDGE

Ratings	Seal Continuous Down Edge of Pavement			Seal Ends at Edge of Pavement		
	Pavement Age, years			Pavement Age, years		
	5	6	7	5	6	7
Deterioration of Joint, percent of volume	2.3	0.4	2.8	5.7	4.3	8.8
Chloride Content of Core Bottom, lb/cu yd	1.4	2.8	1.7	5.9	3.1	5.9
Seal Rating	2 3	3 1	1 1	2 3	1 3	1 2
Base Material Rating	C C	C B	B A	B C	B B	A B

CONCLUSIONS AND RECOMMENDATIONS

The neoprene compression seal is effectively sealing the contraction joint against the intrusion of incompressibles, but permits the intrusion of water and deicing salts to some degree in all joints. This is shown by the presence of chlorides in the bottom portion of all cores.

The current joint design has been relatively effective in preventing serious deterioration of concrete at the bottom of contraction joints. There are, however, several facets of the design and installation procedures which should be changed to produce a more effectively sealed joint. Our recommendations are as follows:

1) Use a high solids, single component, polyurethane lubricant-adhesive applied directly to the joint faces just prior to installation of the seal instead of the low solids neoprene solution currently used. The high solids material will more effectively fill any imperfections in the joint faces, will retain its lubricity longer for adjustment of improperly positioned seals, may reduce the amount of longitudinal seal stretch during installation, and will ultimately provide a better bond between the seal and the joint face.

2) The neoprene seal should extend down the vertical edge of the pavement because no effective method has been found to seal the end of the joint when the seal is terminated at the horizontal end of the joint groove.

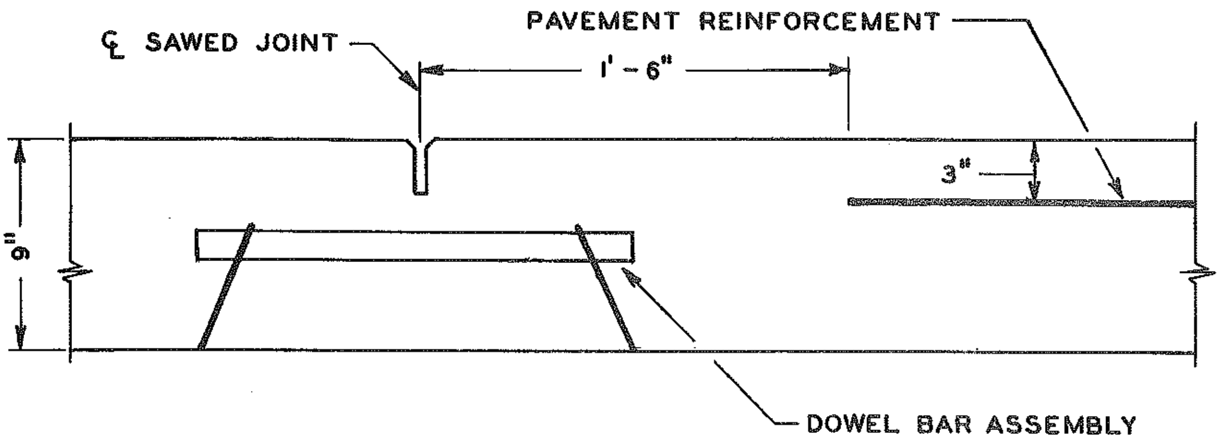
3) Hot-poured rubber-asphalt should be used to seal the longitudinal joint instead of the cold-applied sealant currently used. The hot-poured material should more effectively fill the joint groove by virtue of its lower viscosity when applied and should help to prevent the intrusion of water and deicing salts at the junction of the longitudinal and transverse joints.

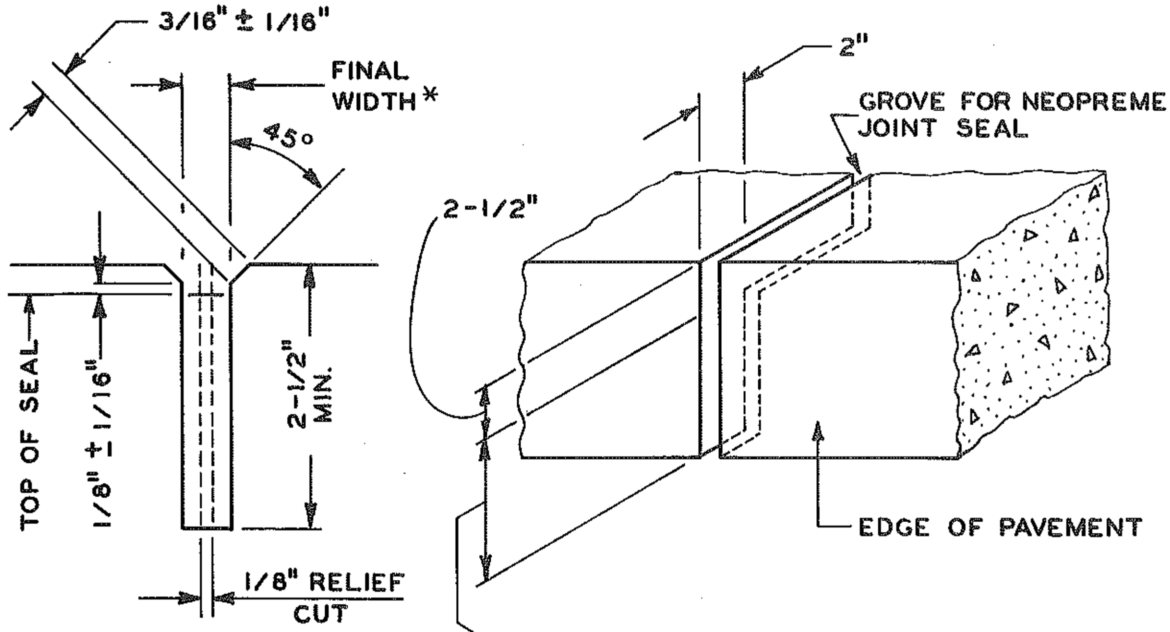
4) The current slab length should be reduced while maintaining the current joint configuration. This would reduce the movement range required for the seal, thus allowing a greater safety factor to compensate for erratic joint movements and the eventual reduction of contact pressure due to permanent set of the neoprene seal.

The above four items are either in the process of being implemented or are under study at this time.

In addition to the above, we recommend that a program of preventive maintenance for neoprene sealed concrete pavements be adopted. A research study has been conducted and repair procedures developed for maintaining neoprene sealed pavements, but the field work has been carried out on only a small scale research basis (MDOT Research Project 75 G-217, "Maintenance of Neoprene Sealed Concrete Pavements").

APPENDIX A





*FINAL WIDTH OF SAWED JOINT SHALL BE 1/2" ± 1/16" PLUS ANY INCREASE IN WIDTH OF RELIEF CUT. THE JOINT SHALL BE SEALED WITH 1-1/4" WIDE PREFORMED NEOPRENE JOINT SEAL.

CONTINUE JOINT SEAL DOWN EDGE OF PAVEMENT EXCEPT WHEN ADJACENT TO CONCRETE SHOULDERS OR CURB AND GUTTER.

Transverse contraction joint with load transfer assembly.

APPENDIX B

NEOPRENE JOINT SEAL RATING

Rating	Description
1	The seal has less than 10 percent permanent set with no evidence of dirt or moisture between the seal and joint faces.
2	The seal has 10 to 20 percent permanent set, minor web sticking, or is slightly twisted and/or moisture and dirt are evident along the side of the seal, but have not penetrated past the bottom of the seal.
3	The seal has more than 20 percent permanent set, considerable web sticking, or is badly twisted and/or moisture and dirt are evident below the seal.

LABORATORY RATING OF BASE MATERIALS

Rating	Description
A	Bottom side of the pavement slab should remain wet and salt saturated all year long.
B	Bottom side of the pavement slab should be wet much of the time but salt can be removed after each winter season.
C	Bottom side of the pavement slab will be wet only during influx of surface water and for a short time thereafter. There should be only seasonal exposure to salt.
D	Bottom side of the pavement slab will be wet only during influx of surface water. Salt exposure is minimal.