

**MAINTENANCE OF NEOPRENE SEALED  
CONCRETE PAVEMENTS**

**First Progress Report**

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## INTRODUCTION

On April 7, 1976, the Engineering Operations Committee approved a proposal for the development of procedures for maintaining concrete pavements sealed with neoprene seals. The project is a cooperative effort of the Maintenance Division and the Research Laboratory Section of the Testing and Research Division.

The specific objectives of the study are to:

- 1) determine the suitability of various materials in repairing spalled joints, develop repair techniques, and design and develop devices for accomplishing the task,
- 2) determine seal size and installation method for resealing joints with oversized grooves where the original seal is lost or ineffective,
- 3) determine equipment requirements and seal size for resawing and resealing expansion joints prior to damage from excessive compression,
- 4) explore the possibility of developing a quick and less expensive way of installing a dowelled joint at open transverse cracks.

A 34 mile section of I 69 from the Calhoun-Branch County Line north to Five Point Highway in Eaton County was approved for the experimental work. It consists of eight separate projects (Fig. 1). By selecting a long experimental section it is hoped that the whole spectrum of maintenance problems resulting from slab design, materials, construction techniques, environmental conditions, and workmanship will be covered.

## PAVEMENT INSPECTION

Before development of procedures for maintaining a certain type of pavement can begin, it is necessary to identify each distress type and its magnitude. On neoprene sealed pavement, eight different types of surface distress have been identified. Since pavement inspection is one of the most important aspects in establishing a maintenance repair procedure, an inspection system was developed to ensure uniformity and simplicity in conducting pavement surveys. The developed guidelines for inspecting neoprene sealed pavements are included in the Appendix. A discussion of their content and purpose follows.

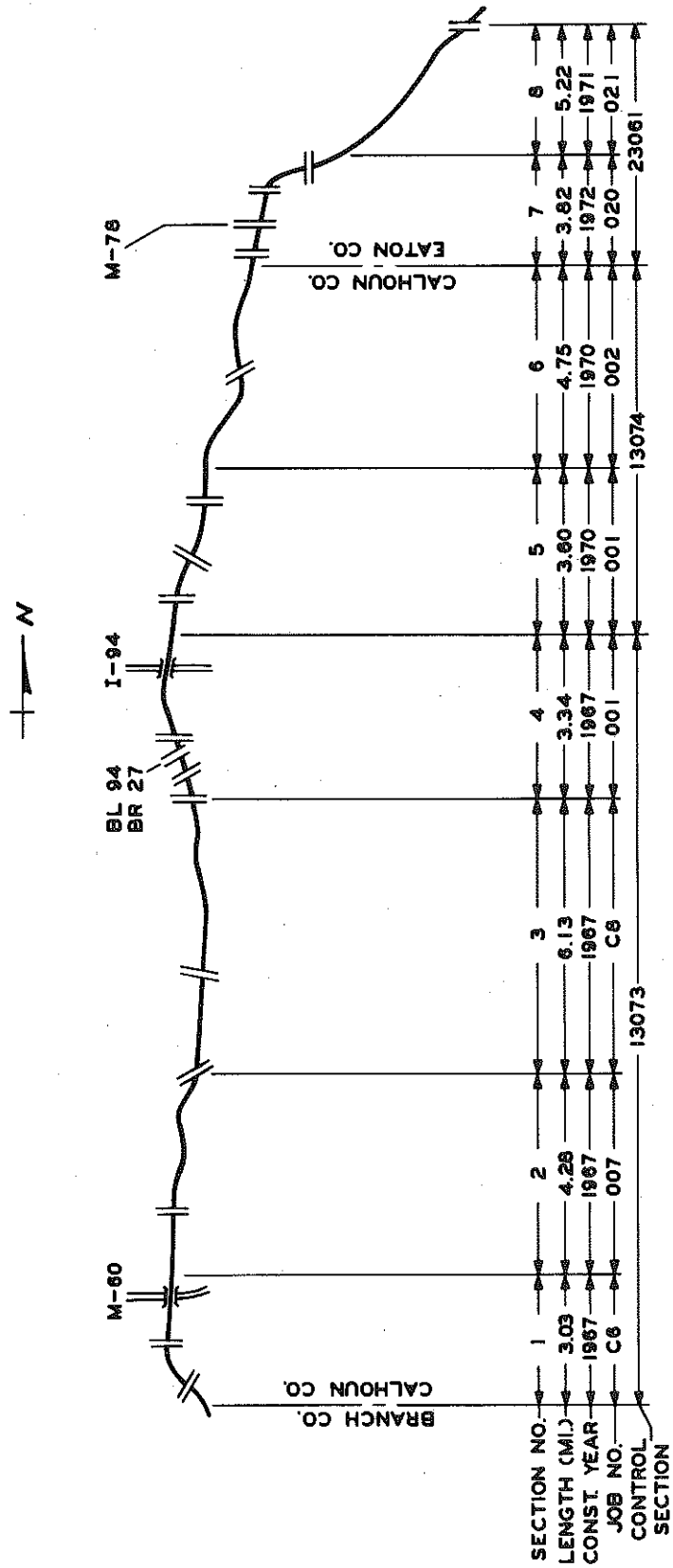


Figure 1. Location and project information for I 69 test pavement.

The introduction to the guidelines deals with the design, location, and functioning of expansion, contraction, and construction joints. Its purpose is to aid survey personnel in recognizing and locating the various types of joints.

Each type of distress is named, described in detail, and a rating number has been assigned to each. As a further aid in identifying the various distress types, a photograph of each is shown. Since the inspection system was not only designed to obtain a current condition of the pavement, but also to reflect time changes, it was necessary to name, describe, and give a rating number to good joints. Table 1 gives this information.

The guidelines, as detailed in the Appendix, include instructions for conducting the surveys and a sample data sheet. Basically, the instructions concern the procedures for recording the type and magnitude of the various distresses existing in the pavement. Since the types of distress occurring on different projects vary considerably, each project is considered as one pavement section.

The I 69 pavement selected for application of the developed maintenance procedures was surveyed in March, 1976. The pavement was divided into eight sections corresponding to the eight construction projects. These sections are numbered 1 through 8 beginning at the Branch-Calhoun County Line. The results of the survey are summarized in Table 2.

As shown in the summary totals in Table 2, the pavement test area contains a total of 5,157 joints. Of these, 3,513 joints (68.1 percent) were given a No. 0 rating (satisfactory joints). The remaining 1,644 joints exhibited some type of distress. Most of the distressed joints (985 or 19.1 percent) were given a No. 1 rating (shattered spall). A No. 2 rating (open spall) was assigned to 471 joints (9.1 percent). Only 13 joints (0.3 percent) were rated No. 3 (joint spall). Tight seal, and tight seal with spalled groove, were noted on 46 joints (0.9 percent) and 106 joints (2.0 percent), respectively. There were 10 joints (0.2 percent) rated No. 6 (loose seal) and the same number of joints were rated No. 7 (lost seal). There were three slabs with an open transverse crack.

From the survey results it is obvious that restoring the 1,644 joints to their intended function involves a good deal of work. If satisfactory procedures can be developed for maintaining concrete pavement joints in satisfactory working condition, it may be beneficial to begin maintenance operations shortly after the pavement is in service. This would keep each year's workload at a more reasonable level and ensure repair of distressed areas shortly after they are noticed.

TABLE 1  
JOINT RATING INFORMATION

Name	Rating No.	Description
Satisfactory Joint	0	Contains a neoprene seal that exerts sufficient pressure on the groove walls to prevent foreign material from entering the joint. The seal itself is generally without tears and only minor spalls have occurred along the groove edges.
Shattered Spall	1	The breaking or cracking of the concrete along the joint groove. Generally, most of the broken concrete pieces are still in place and the seal is still under compression. The spall may also be a solid piece.
Open Spall	2	The breaking or cracking of the concrete along the joint groove with the broken concrete missing. Seal compression is lost in the spall area.
Joint Spall	3	The breaking or shearing of the concrete along the joint groove. The spall extends from the bottom of the groove and several inches away from the joint. The broken concrete is missing and bituminous repair may be required. Compression in the seal is lost and the seal may be torn in the spall area.
Tight Seal	4	An expansion seal that is compressed beyond its design limit. The groove opening may range in width from 1/4 to 1/2 inch, the seal is usually torn, but no spalling has occurred. The seal is still sealing the joint satisfactorily.
Tight Seal With Spalled Groove	5	An expansion seal compressed beyond its design limit and spalling along the groove has occurred. The seal is usually torn and the spalls may be either shattered, open, or of the joint spall type.
Loose Seal	6	Pressure on the groove walls is lost. Spalls of either of the three types may be present.
Lost Seal	7	Part of, or the entire length of seal is missing. Spalls of either of the three varieties may be present.
Open Transverse Crack	8	A crack 1/8 inch or more in width at the pavement surface.

TABLE 2  
SUMMARY OF 1976 SURVEY

Project No.	Section No.	Construction Year	Total Joints	Number of Joints Rated (0) - (8)								
				(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
13073-C6	1 <sup>1</sup>	1967	478	228	120	87	4	16	21	1	0	1
13073-007	2 <sup>2</sup>	1967	641	390	103	75	1	17	53	0	0	2
13073D-C8	3 <sup>3</sup>	1967	907	532	176	186	1	1	11	0	0	0
13073E-001	4	1967	512	377	80	31	2	4	7	3	8	0
13074-001	5	1970	534	387	128	18	0	0	1	0	0	0
13074-002	6	1970	711	542	134	34	1	0	0	0	0	0
23061-020	7 <sup>2</sup>	1972	582	400	155	19	2	2	4	0	0	0
23061-021	8 <sup>2</sup>	1971	792	657	89	21	2	6	9	6	2	0
Summary Totals			5,157	3,513	985	471	13	46	106	10	10	3
Percent			68.1	19.1	9.1	0.3	0.9	2.0	0.2	0.2	0.2	0.1

<sup>1</sup> Expansion joints spaced at 356 ft and steel base plates utilized.

<sup>2</sup> Expansion joints spaced at 356 ft.

<sup>3</sup> Steel base plates utilized.

## DEVELOPMENT WORK

### Spall Repair

In the past there has been considerable work done to repair spalled joints. However, most of it has been concerned with materials and procedures where the work area could be closed for at least three days for curing of the repair material. In this study it is our goal to find materials that can cure in two to four hours so that no night closure will be necessary. This requirement eliminates many materials, especially since in addition to short curing time, the materials must also gain bond and compressive strength rapidly. On the basis of laboratory tests it was concluded that 'Set 45' (a magnesium oxide-ammonium phosphate mortar), epoxy mortar, and portland cement mortar with calcium chloride added for set acceleration would be suitable for experimental repairs in the field.

It has generally been customary to saw-cut the end limits of the area to be removed at a spall. To avoid the cost of the extra equipment and personnel required to saw each spalled area, it was decided that removal of the unsound concrete would be done by use of an air operated chipping hammer. The periphery of the spalls would be chipped to a vertical depth of not less than 1/2 in.

Two methods were planned for forming the groove in the repair area. One method would consist of inserting a thin steel plate between the seal and the groove face. This type of form was designed for relatively small spalls and where the steel plate would be of sufficient strength to maintain the compression in the seal. For large spalls the seal was to be pulled out to prevent it from interfering with the spall cleaning and forming work. The groove was to be formed by using 1/4-in. thick polyethylene sheet material 3 in. high. The form was to extend beyond the spall at both ends, and would be held in place with wood wedges.

No special procedure was planned for placing the various types of mortar, except that just prior to mortar placement, the area was to be cleaned with compressed air and primed. The epoxy mortar repairs were to be primed with a coat of liquid epoxy, the cement mortar repairs with a coat of cement slurry, and the Set 45 repairs were to be prewetted with water.

Since the mortars set in a few minutes, only small amounts can be mixed at one time. A five-gallon electric powered mixer was to be used for mixing in the field and mix proportions for 1/8 cu ft of each mortar type were calculated. To facilitate measuring the mix ingredients at the job site the mix proportions were given by volume, and calibrated measuring containers were prepared.



### Tight Seal Repair

The first requirement to repair a joint with a tight expansion seal is the removal of the existing seal. If spalls are present along the groove, repairs must be made before a new seal is installed. The procedure planned for use on the I 69 test pavement was based on experimental work done during the summer on US 127 just south of I 96.

During the first trial, removal of the tight seal and resawing the groove for a new expansion seal were attempted by making one pass with a saw having three diamond blades spaced to a width of 1-1/4 in. This method proved impractical, primarily because the old seal would get pinched between the blades which made sawing a proper groove very difficult. The second trial employed a two-step method. First a saw cut with a single blade was made through the neoprene seal. This relieved the compression in the seal sufficiently to allow the seal to be pulled out by hand. Once this was done the groove was sawed to the proper width using three or more diamond blades with spacers.

Installation of the new seal was preceded by application of seal lubricant on the groove walls. To install the seal in the vertical edge groove the shoulder material was excavated to the bottom of the slab. Although the vertical groove was not resawed the seal could be installed in such manner as to prevent infiltration of the shoulder material into the joint. Installation of the new seal followed procedures used during initial seal installation, except once the seal was installed in the lane closed to traffic the remaining portion of the seal was coiled up and placed near the center line and traffic shifted onto the completed lane. Seal installation was then completed in the usual manner.

### Lost or Loose Seal Repair

The type of repair required to reseal joints with these types of distress depends on what caused the distress. Basically a seal loses its compression because the joint groove increases permanently in width. Although the process by which the groove width increases with time is not fully understood, field data indicate that the problem is confined to contraction joints adjacent to expansion joints. Once the groove reaches a certain width the seal pulls out of the vertical edge groove and out of the surface groove as well. Occasionally a seal is lost as a result of the occurrence of a large joint spall. In this case, action of the traffic going over the seal in the spall area tears the seal apart, and once torn the entire seal is pulled out by traffic.

In the latter case, repairing the joint spall and installing a new neoprene seal would be the method to use in resealing the joint. Where the seal is ineffective, either because it is loose or lost entirely, as a result of the joint being filled with incompressibles, it appears that resealing with a liquid sealant would be the most economical method. The type of sealant selected for use is a PVC (polyvinyl chloride) hot-poured sealant. The Department has used this sealant on an experimental project with good results to date. Other states have also reported good service with the PVC sealer.

Currently, laboratory work is in progress to find a satisfactory material to fill the bottom of the groove to obtain (as near as practical) a sealer shape factor of 1. The material would also serve as a bond-breaker to increase seal performance. Work is under way to repair the Department's hot-pour sealing machine so that resealing joints which presently have ineffective seals can be done during the 1977 field work.

#### Transverse Crack Repair

There appears to be no easy and inexpensive method for repair of transverse cracks with fractured steel. Considering past experience with sealing of open cracks, it is evident that more extensive work will be required to restore the structural integrity of the pavement at a crack. Since we are concerned with the maintenance of relatively new pavements, it would be beneficial to eliminate entrance of incompressibles and prevent faulting at cracks. Therefore, on the experimental pavement, open transverse cracks are planned to be repaired by constructing a dowelled and sealed joint in a repair that is tied to the existing slab.

The exact procedure to be used in replacing a section of a pavement where an open transverse crack has developed is not as yet finalized. The main problem yet to be solved is finding equipment that can break out the concrete rapidly and eliminate air hammer work that previously has been necessary when tying a repair to an existing slab. At this time it is uncertain whether field work on this type of repair will be included in the 1977 work program.

#### 1976 Field Work

A 3,500-ft length on the southbound roadway in Section 2 (Construction Project 13073-007) was selected for the repair development work. It begins at Station 1591+82 and ends at Station 1556+89 and consists of 11 expansion joints and 40 contraction joints. The repairs were started September 27 and finished October 8, 1976.

Before the field work was begun, a meeting of Maintenance and Research personnel was held at the Marshall maintenance garage. Slide illustrations of the planned repair procedures were shown and discussed. The equipment and personnel to be furnished by each Division were determined and details concerning closure of the repair area was agreed to.

### Tight Seal Repair

The procedure developed on US 127 for removing and replacing a tight expansion seal was followed and appears to be a satisfactory method for restoring the functioning of joints with this type of distress. The basic steps involved are as follows:

- 1) saw a 3-in. deep cut through the center of the tight seal with a single diamond blade,
- 2) cut the seal at the pavement edge and pull it out of the surface groove by hand,
- 3) saw the groove to a predetermined width using three or more diamond blades with spacers between the blades.
- 4) excavate the shoulder full-depth at the vertical edge groove, remove the old seal from the groove with hand tools, and apply lubricant-adhesive to the groove edges with a brush after the groove has been cleaned with compressed air,
- 5) install the new seal, beginning at one edge and continuing across the slab.

The procedure used to accomplish each step may vary from job to job depending on the existing conditions. On this study, the sawing was done by beginning at one pavement edge and continuing about two feet across the center line. Once the traffic was shifted onto the sawed lane the sawing was continued from the center toward the pavement edge.

Since the work was done during cool weather (40 to 55 F) the joints had opened somewhat and it was not always necessary to make the single blade cut to pull out the torn seal. Installation of a new seal began by tucking it into the vertical groove and proceeding to the center line. The seal was then coiled and tied until all joints were sealed in the closed lane. The seal installation proceeded from the center to the edge and down the vertical groove once the traffic was shifted over on the previously sealed lane. The shoulder excavation was repaired with cold-patch material.

Ten expansion joint seals were removed and five of these were replaced with 1-5/8 in. expansion joint seals and five with 1-1/4 in. contraction joint seals. The grooves for expansion seals were resawed to a width of approximately 1-1/16 in. and those for contraction seals were resawed to a width of about 3/4 in. The width to which the grooves should be resawed was determined on the basis of the theoretical movements caused by the temperature changes. The contraction joint seals were used in order to see if actual movements exceed their sealing capability. If contraction joint seals work satisfactorily, a savings of about \$33.00 in material cost can be realized per joint compared to using expansion joint seals.

### Spall Repairs

A total of 78 spalls were repaired using Set 45 mortar, epoxy mortar, and portland cement mortar with set accelerator added. It was planned that an equal number of spalls be repaired with each type of mortar. However, after two days work, it was evident that the Set 45 mortar was much easier to handle and place and had a much shorter curing time than the other two mortar types. Therefore, the use of accelerated portland cement and epoxy mortar were discontinued in favor of the Set 45 mortar. The number of spall repairs made with each mortar type is: 63 with Set 45, eight with accelerated portland cement; and seven with epoxy mortar. The repairs were opened to traffic after two to four hours curing time.

To facilitate field mixing, the mortars were proportioned by volume. The approximate proportions, to give a stiff but trowelable consistency, were: 1 part epoxy binder to 3.5 parts dry sand for the epoxy mortar; 1 part water to 6.5 parts Set 45 for the Set 45 mortar; and 1 part water to 2.3 parts cement to 3 parts dry sand for the portland cement mortar. Four percent calcium chloride (by weight) and an air-entraining agent were added to the cement mortar.

The procedures used in conducting the repairs were as follows.

- 1) All loose or cracked concrete was removed using an air-powered chipping hammer. The perimeter of the spalls was chipped to a vertical depth of at least 1/2 in. and most spalls were chipped back from the joint to reduce the slope of the bonding surface, thus reducing the shear stress. The debris was removed from the joint and final clean-out was done with compressed air.

- 2) The groove was formed by using 3-in. strips of 1/4-in. polyethylene sheet or, where the spalls were small, a steel plate was inserted between the seal and the groove wall. The steel plate was lubricated to prevent bonding.

3) Placing of the mortars was preceded by brushing a bonding coat on the old concrete surface, except for the Set 45 mortar where the spall area was prewetted with water. The operations required to place and finish each spall were identical to those normally used with mortar repairs.

A typical repair of each type is shown in Figure 2. Basically, the repair procedures worked satisfactorily, with some minor difficulties encountered. It was discovered that some spalls, especially at expansion joints, extended below the dowel bars. This greatly increased the amount of work required to remove the unsound concrete. It also made forming the groove more difficult because the plane-of-weakness crack needed to be preserved in the spall area. The problem was solved by inserting a highly compressible polyethylene foam in the crack. A coating of grease was applied to all exposed dowel bars to act as a bond breaker.

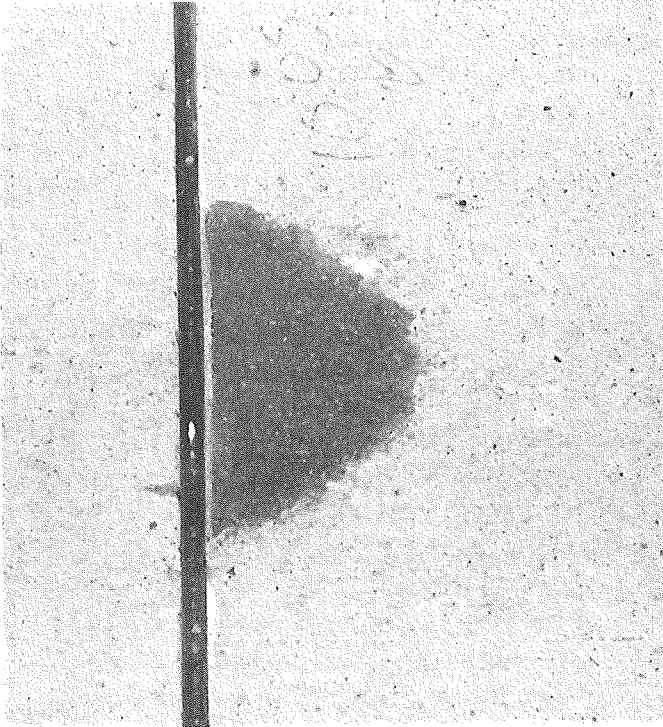
The polyethylene sheet form was found to warp after being used once, and difficulty was experienced in removing the forms. To prevent this on future repairs, new form material is being sought and it is anticipated that form removal problems can be greatly reduced by removing the forms immediately after the initial set has occurred.

Problems in placing the mortar mixes concerned completing placement before the mortar attained its initial set. Some lack of bonding was also experienced with the accelerated cement mortar, and a couple of the first day's repairs had to be replaced the next day.

#### Repair Cost

Since only a relatively small amount of development work has been done to date, there are no meaningful cost data available. The material cost per cu ft for the three mortar types was \$28, \$43, and about \$2 for Set 45, epoxy mortar, and cement mortar, respectively. Expansion and contraction joint seal prices were \$2.10, and \$0.82 per lineal ft, respectively.

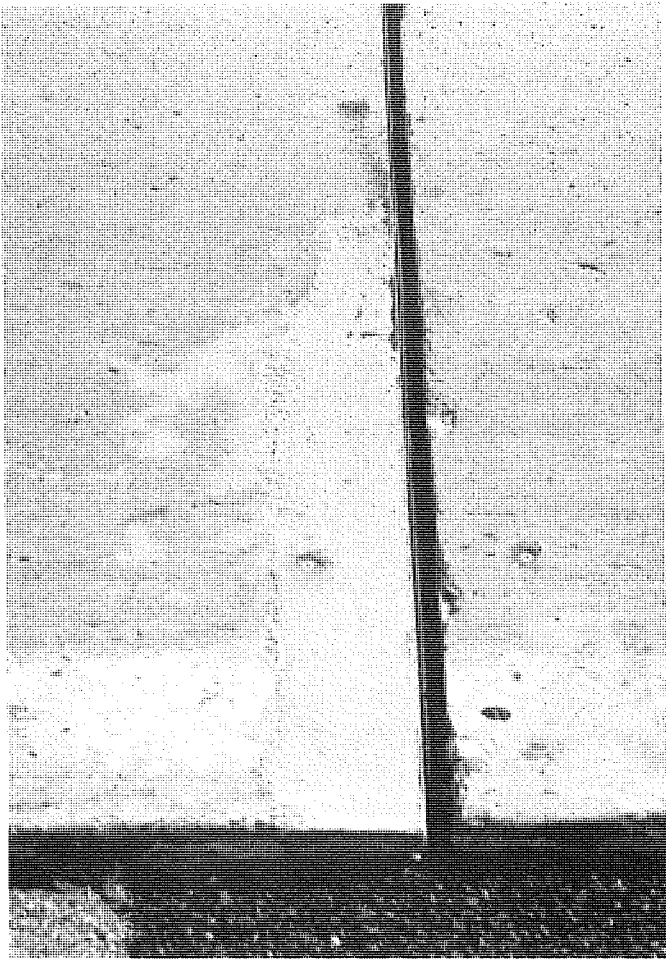
If successful procedures are developed for maintaining neoprene sealed pavements they should eventually replace spall patching with cold patch material and crack sealing with hot asphalt. It is doubtful that these current maintenance procedures can be replaced without increases in maintenance cost. However, it is hoped that the new procedures will prolong the life of the pavement substantially. Current and future cost of bituminous overlays and the possibility of shortage of this material makes the preservation of concrete pavement through better and more costly maintenance procedures look more attractive.



◀ Epoxy Mortar



▶ Portland Cement Mortar



◀ "Set 45" Mortar

Figure 2. Typical spall repairs just after curing.

## Evaluation

The performance of the spall repairs and resealed joints was observed in November, 1976 and again in February, 1977. On the first survey, four of the portland cement mortar patches were noticed to contain shrinkage cracks and some adhesion failure. These conditions were the same on the February survey. The seven epoxy mortar patches were found to be in good condition on both surveys. On the first survey, four Set 45 mortar repairs exhibited minor bond loss and spalls. One repair had cracked parallel to the joint groove. On the second survey, six more patches were found to contain minor spalls, some loss of bond, and one patch had failed completely. The minor spalls had occurred along the seal, but in no case is the function of the seal impaired.

The newly installed seals, on the basis of joint width measurements, are performing satisfactorily. However, the measurements also indicate that two of the joints with new seals are 'freezing up.'

## CONCLUSIONS

With respect to the seal removal and resealing of joints with tight expansion seals, the developed procedure appears satisfactory. If experimental use of PVC hot-pour sealant proves that this material is effective in sealing joints, its use in resealing joints where the neoprene seal is distressed will be investigated.

Of the three mortar materials used, the Set 45 mortar appears to possess the properties required for spall repair work. It is mixed and placed easily, cures sufficiently in two hours or less to carry traffic, tool and equipment clean-up can be done with water, and performance under traffic is good. The epoxy patches showed excellent performance but mixing, placing, and cleaning of equipment and tools are more difficult and must be done with more precision. The portland cement mortar patches show promise; however, curing time amounts to four hours or more which makes it less desirable for use in this application.

The procedure used to accomplish the spall repairs needs improvement. Specifically, a better method for forming the groove in long spall areas needs to be developed; form removal must be done as soon as the mortar has taken its initial set to make removal easier; joint groove edges through spall repairs must be beveled to minimize groove spalling; more care must be exercised in coating or wetting the old concrete surface to improve bonding of the two materials; and care must also be taken to ensure the mortars are placed well in advance of their initial set.

It appears a crew of six men would be ideal for the spall repair work. Of these, two would remove the distressed concrete, two would handle the form placement and removal, and two would mix and place the mortars.

#### GENERAL COMMENTS CONCERNING MAINTENANCE OF NEOPRENE SEALED PAVEMENTS

A frequently heard phrase these days is "zero maintenance pavements." Although this is a catchy phrase, and gets the attention of maintenance officials, it is doubtful that such a pavement will ever be built. A more realistic pavement would be one with minimal maintenance on which the problems are maintainable. As more and more research and experimental work is being done in the field of maintenance, it is noted that some problems simply are not maintainable but require extensive work, exceeding that which is normally considered within the scope of maintenance.

During the short time this study has been in progress, the inspection and repair work, coupled with surveys of other neoprene sealed pavements, have revealed distresses that are difficult to correct without excessive expenditure. However, it is believed a significant reduction in these hard-to-maintain problems can be attained by design changes and by more careful construction of the pavement segments where the distresses occur. The cost of correcting the problems at the design and construction stage would be very little compared to the cost of later corrective work. The problems, as is usual with jointed pavement, occur at the joints. Each problem and suggested improvements are discussed in the following.

#### Extrusion of Expansion Joint Seals

On the basis of theoretical calculation for the current seal design, coupled with precise sawing of the joint groove, there should be no reason for the seals to extrude above the pavement surface. The seal grooves are specified to be sawed to 1-1/4 in. plus or minus any opening or closing of the joint which occurs prior to the second stage of sawing. The seal installed in this groove will usually compress to 1/2 in. before it becomes solid and begins to extrude. This means that in a correctly sawed groove the joint filler must compress to 1/4 in. before the seal is solid. On the basis of compression tests of the filler, the pressure at 1/4 in. is about 4,500 psi. Although the concrete design strength is 3,500 psi, it is not uncommon that actual strength obtained during testing of core samples exceeds 4,500 psi. Since the current design does not have any built-in safety factor against grooves sawed too narrow, or against the filler compressing beyond 1/4 in., one would conclude that either factor could cause seal extrusion.



Some improvements might be effected in the light of the following comments. Although extruded seals are accessible and can be replaced, it would be better to take action to ensure that the problem does not occur. First, steps should be taken to make sure that the sawed groove widths reflect any movement prior to sawing. Second, the filler width should be reduced to 3/4 in. These changes would provide a 1/4 in. safety factor against seal extrusion from too narrowly sawed joint grooves and from the filler compressing beyond 1/4 in.

To compensate for the reduction in filler width, the spacing of expansion joints could be altered. However, results of coring joints having neoprene seals indicate that deterioration of the joints at the bottom surface is not nearly as serious as it is at joints sealed with the old hot-pour seal. Therefore, the reduction in the rate of deterioration should hopefully allow sufficient cross-section to resist any additional compressive forces resulting from a reduction in the filler width.

#### Inadequate Filler Support

Before changing to sawed joint grooves, the filler was supported by a steel channel placed over the filler top and staked to the ground. However, when sawed grooves were specified, this method of filler support could not be used. No serious effect of the discontinuance of this support method was noted until the slipform paver came into use. Whereas the form-riding spreaders could be lifted over the filler the slipform equipment rolls over the filler at its pre-set height. Consequently, the thrust of the concrete occasionally puts a permanent bow in the filler, which results in the groove being misaligned over the filler since the grooves normally are sawed straight across the pavement. In areas where the groove is misaligned, joint spalls can develop as a result of the upward force against the overhanging concrete when the slab expands.

Although this, as well as tight expansion seals, is a maintainable problem, it appears that it can be minimized by designing a more rigid filler support system and through more care in locating the filler during pavement placement. Changes made in the filler supports last year may provide sufficient rigidity for a 3/4-in. filler should the decision be made to change to a narrow filler. If not, a more rigid filler support design must be developed. To further guard against misaligned grooves, the exact location of the filler at several points across the slab could be required during paving operations.

## Non-Uniform Joint Movements

Joints in concrete pavement are generally designed on the basis that all joints open and close uniformly. This is not always the case; especially when expansion joints are installed among contraction joints. Certainly some differences in movements are expected as a result of pour temperature variations and subgrade friction variations, but these variations cause no problem since they are within the design limits of the seal. The problem develops into a maintenance headache after about 10 years in the form of loose or lost seals and transverse cracks with fractured steel.

To investigate the problem of unequal joint movements, the groove widths of 50 consecutive joints were measured on Project I 13073-007 on I 69. The measurements were made at a temperature of 74 F in the summer of 1976 and in the winter of 1977 at a 20 F temperature. The pavement is 10 years old and contains expansion joints at 356-ft spacings.

The high, low, and average movements measured at contraction joints adjacent to expansion joints were 0.42, 0.25, and 0.32 in. At the interior contraction joints between expansion joints the high, low, and average movements were 0.26, 0.13, and 0.20 in. For the expansion joints the high movement was 0.20 in., the low 0.02 in., and the average 0.11 in. Although the reasons for the differences in the movements are not known, it is suspected that the expansion joints are 'freezing,' thus the adjacent contraction joints open more during contraction of the pavement.

The winter joint groove width measurements also revealed that 15 of 20 contraction joints adjacent to expansion joints on the measurement section had groove widths of more than 1 in. Since 1 in. is the manufacturer's recommended maximum groove width for contraction joint seals it is quite likely that contamination of these joints occurred during cold weather. The summer readings for the same 15 joints ranged from 0.70 to 0.84 in., which would indicate that incompressible material has entered the joints, or the grooves were sawed more than 1/2 in. wide during pavement construction.

The problem of unusually large groove widths of contraction joints next to expansion joints has also been observed at structures and adjacent to single expansion joints installed at various locations along the pavement.

Once a joint ceases to move, the additional tension induced in the slab by doubling the slab length will increase the possibility of the steel breaking at a transverse crack. Immobilized joints are of both joint types. However, on one job (US 127 just south of I 96) it was noted that at about 33

percent of the expansion joints, an adjacent slab had an open transverse crack. This is by no means considered normal, but does point out that expansion joints under certain circumstances have the potential to cause transverse crack problems.

To reduce the maintenance problem associated with loose or lost seals and open transverse cracks require two separate actions:

- 1) Theoretically there is no reason why expansion joints should cause non-uniform movement. If both contraction and expansion joint dowels are equally well lubricated and expansion joint dowel caps are functioning properly, the movements should be fairly equal. Certainly it would be reasonable to assume that both dowel types were lubricated in the same manner on each project. Then the reason for the difference in joint opening would point to malfunctioning dowel caps.

The performance of dowel caps can only be determined by examination of samples removed from the pavement. Needless to say, this would entail a good deal of work to prove without doubt that the caps are not functioning properly. A few samples of expansion joint dowels were removed some time ago for examination and testing. Four stainless steel dowels and one standard steel dowel were tested. Each dowel was bedded in a block of concrete 24 in. long, 12 in. wide and 9 in. thick. The blocks were pulled apart to determine the dowel friction. The loads for the stainless dowels were 800, 4,200, 9,000, and 9,600 lb and the load on the standard dowel was 1,600 lb. Considering that the stainless steel dowels had sawed ends and were free of rust, it was rather surprising that the loads required to move the 'free sliding' end of the dowels were so high, except for one case. After the sliding resistances of the dowels were determined, the concrete around the dowels was carefully removed. At least in one case it was evident that the dowel had been forced into the partially collapsed cap. This, of course, is scanty evidence on which to conclude that the dowel caps are causing problems, but coupled with joint opening measurements next to expansion joints, plus the occurrence of open transverse cracks in slabs next to expansion joints, it would appear that dowel caps interfere with the joint movement. Therefore, it is suggested that the dowel cap be redesigned to ensure it is of sufficient strength to eliminate any possibility of collapse or misalignment during concrete placement.

- 2) In recent years a good deal of work has been done to eliminate the corrosion problem associated with steel dowels, and coated or stainless steel (clad or solid) bars are now required. Unfortunately only one of the approved dowel types does not require lubrication to prevent bonding to the

concrete. Problems with application of the debonding coat have been reported in the past and have ranged from too much to no coating at all. Although specifications could be written to govern the application of the bond breaker, ultimately the inspection for conformity to the requirements will determine if the coating is satisfactory. Therefore, it is suggested that careful inspection of the bond breaker be made on the grade to ensure the coat is clean and uniformly applied in the amount necessary to ensure more uniform movements of the joints.

As a further aid in improving the performance of neoprene sealed joints the authors suggest a slide-talk program be prepared for showing to personnel involved with the design, construction, and maintenance of pavement joints. Such a program would be developed from input from the Design, Construction, Maintenance, and Testing and Research Divisions. It would be oriented toward understanding why joints are needed, how they function, why proper installation is so important, and the reasons for maintaining joints. It is felt that personnel who understand the benefits of well designed, well built, and well maintained joints will make an extra effort to minimize the problems associated with joints.

**APPENDIX**

**PRELIMINARY GUIDELINES FOR  
INSPECTING NEOPRENE  
SEALED PAVEMENTS**

The length of maintenance-free service of reinforced concrete pavements is closely related to the performance of the transverse joints. If the joints perform satisfactorily -- that is the neoprene seal prevents entrance of foreign substances and the load transfer device allows easy movement at the joint -- the service life of a pavement will be increased.

Joints are installed in concrete pavements at predetermined intervals to accommodate shortening and lengthening of the slab. There are three types of joints in use: expansion, contraction, and construction.

Expansion joints allow the pavement to both decrease and increase in length. Length increase is provided by a compressible fiber filler in each expansion joint. Expansion joints are located at structures, at ramp and street intersections, at the beginning and end of curves, and in pavements built between September 15 and April 15. For the latter, expansion joints are spaced 356 ft apart (every fifth joint).

Contraction joints provide only for shortening of the pavement. They are located between expansion joints at a spacing of 71 ft 2 in.

Construction joints generally provide only for contraction of the slab. A construction joint is used at the end of a days pour, or between projects, or where pavement construction is interrupted for a specified period. This type of joint can be distinguished from a contraction joint by having the station and date stamped in the surface and also, occasionally, the surface texture or color changes radically at a construction joint.

The components of transverse joints are: load transfer assembly, joint groove, and neoprene seal.

The load transfer assembly for contraction joints consists of two wire side frames into which 18-in. long by 1-1/4-in. diameter steel bars are fastened on 12-in. centers. Alternate bar ends are free to move and to prevent bond with the concrete; the free end of each dowel is coated with a bond breaker.

The assembly for expansion joints is identical to the contraction joint assembly except that two zig-zag wires are welded to the dowel bars 1 in. apart at the center of the bars. These wires hold a 1 in. thick fiber filler in position during concrete pouring. A steel cap is placed on each free dowel end to allow closure of the joint.

Construction joints contain either a contraction or expansion joint assembly, except where paving operations have been discontinued for more than seven days. In this case, the dowel bars consist of two 9-in. long bars threaded into a steel sleeve. One 9-in. bar and the sleeve are cast into the slab when paving is stopped and the other 9-in. piece is screwed into the sleeve when operations start up again.

The joint groove is sawed across the slab over the center of the dowel bars. The basic dimensions of expansion joint grooves are: width 1-1/4 in., and depth 3 in. Contraction joint grooves are sawed 1/2 in. wide and 2-1/2 in. deep. The joint grooves at construction joints, containing either an expansion or contraction joint assembly, are sawed to the dimensions given for these types of joints. Construction joint grooves at joints containing the two-part dowel assembly are sawed 1/2 in. wide and 2-1/2 in. deep.

Neoprene seals are of cellular design and made of rubberlike material. The seals for expansion joints are 1-5/8 in. wide, and contraction and construction joint seals are 1-1/4 in. wide. When the seals are installed in the narrower grooves the top and bottom surfaces and the interior members of the seals exert pressure on the groove walls. As the groove opens and closes the pressure changes, but for normal movements, it remains of sufficient magnitude to prevent materials from entering the joints.

With time and service, joint groove and seal distresses develop. It is the objective of these guidelines to identify the various types of distresses associated with joints in concrete pavement sealed with neoprene seals.

On the following pages, each type of distress is named and described in detail, and a rating number has been assigned to each one. As a further aid in identifying the various distress types a photograph of each is shown.

#### JOINT CONDITION SURVEY INSTRUCTIONS

1) Record construction project number, route, and roadway direction on the first sheet for each roadway.

2) The joints will be numbered consecutively from the beginning to the end of each project.

3) A crack found during the first survey will be numbered the same as the preceding joint and the subscript (a) will be added. During subsequent surveys new cracks will be recorded by a short wiggly line drawn between the joint numbers, and a line will also be drawn in the year column to note when the crack occurred.

4) All expansion joint numbers will be preceded by the letter E. All other joints will be noted by number only.

5) Record station of first and last joint on each project in the 'Remarks' column. Tie-in with stations about every 1/2 mile or more often if stationing is readily available.

6) In the 'Year' and 'Rating' columns, record survey year and for each joint or crack note rating number.

7) If a joint exhibits more than one type of distress, the rating number will be based on the type of distress most prevalent.

8) In the 'Year' and 'Accumulated Length or Size of Distress' column, record survey year and for each joint record the length or size of the distress.

9) All types of spalls will be recorded by size in inches. (Size is the average width by total estimated length, in inches. Where unusually large amounts of spalling have occurred, the size may be recorded in average width in inches by length in feet, but note that the foot symbol must be used. Where more than one type of spall has occurred on the same joint, record size of distress as the total of all types of distress. Also, note in 'Remarks' column that more than one type of spall was present.

10) Length of tight expansion seal, loose seal, lost seal, and transverse crack need not be shown. It is assumed that these types of distresses exist for the entire pavement width.

11) Conduct survey from car driven on right hand shoulder. Occasionally it may be necessary to walk onto the pavement to ascertain the type and size of distress or to locate station numbers.

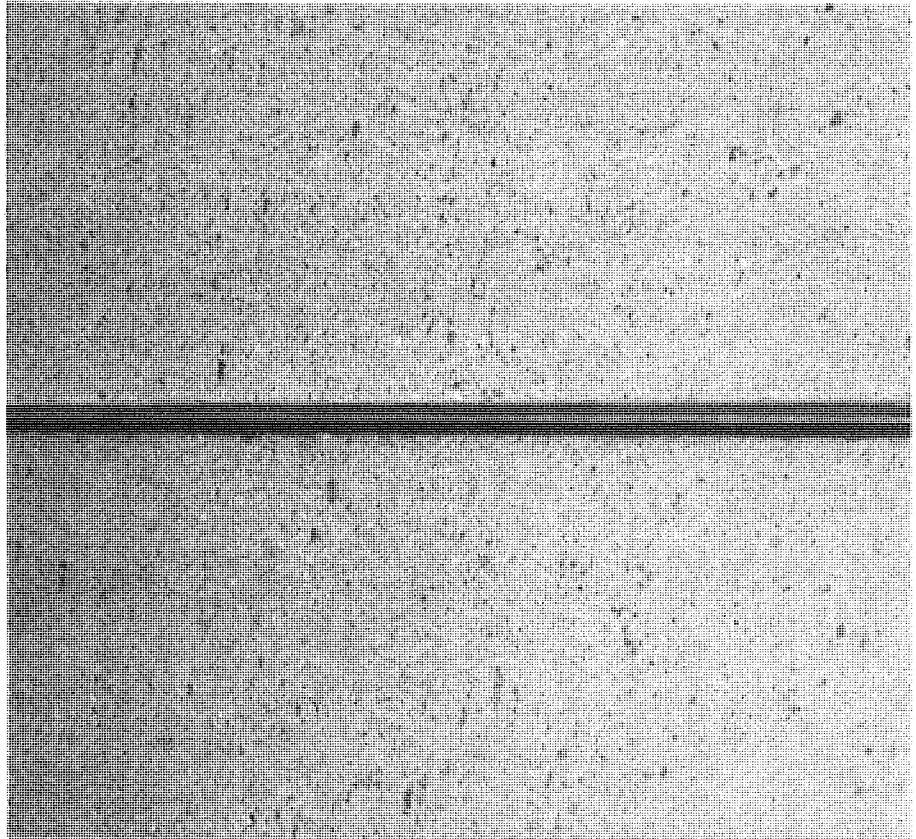
A sample data sheet is attached.



Name: Satisfactory Joint

Description: A satisfactory joint contains a neoprene seal that exerts sufficient pressure on the groove walls to prevent foreign materials from entering the joint. The seal itself is generally without tears and only minor spalls have occurred along the groove edges.

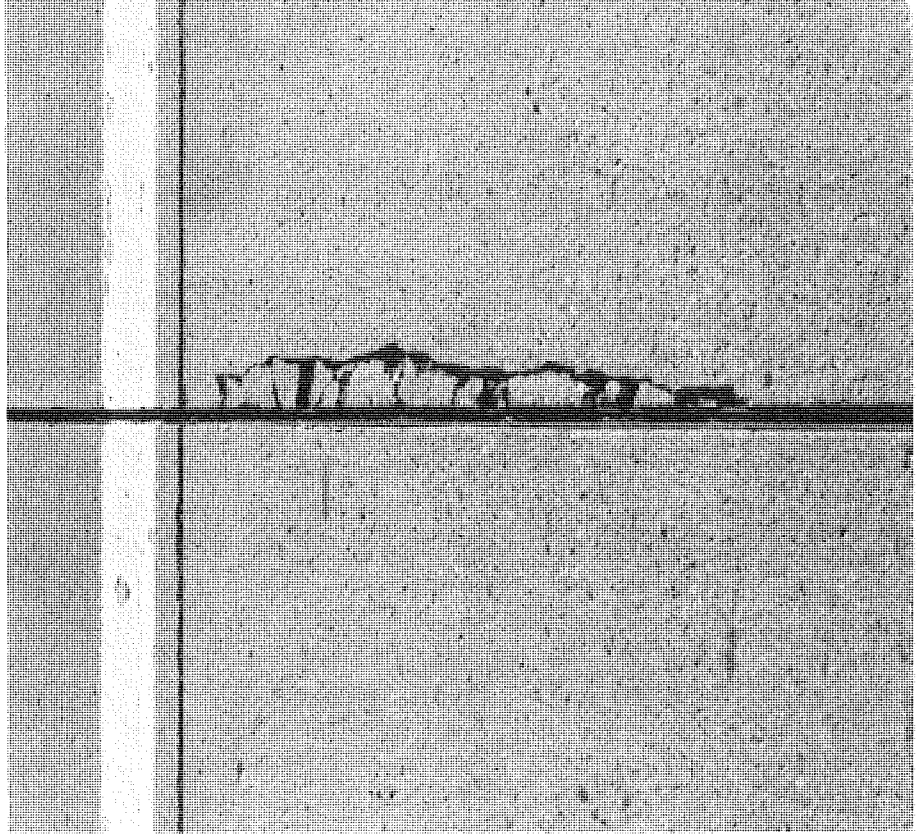
Rating Number: 0



Name: Shattered Spall

Description: Shattered spall is the breaking or cracking of the concrete along the joint groove. Generally, most of the broken concrete pieces are still in place and the seal is still under compression. The spall can also be a solid piece.

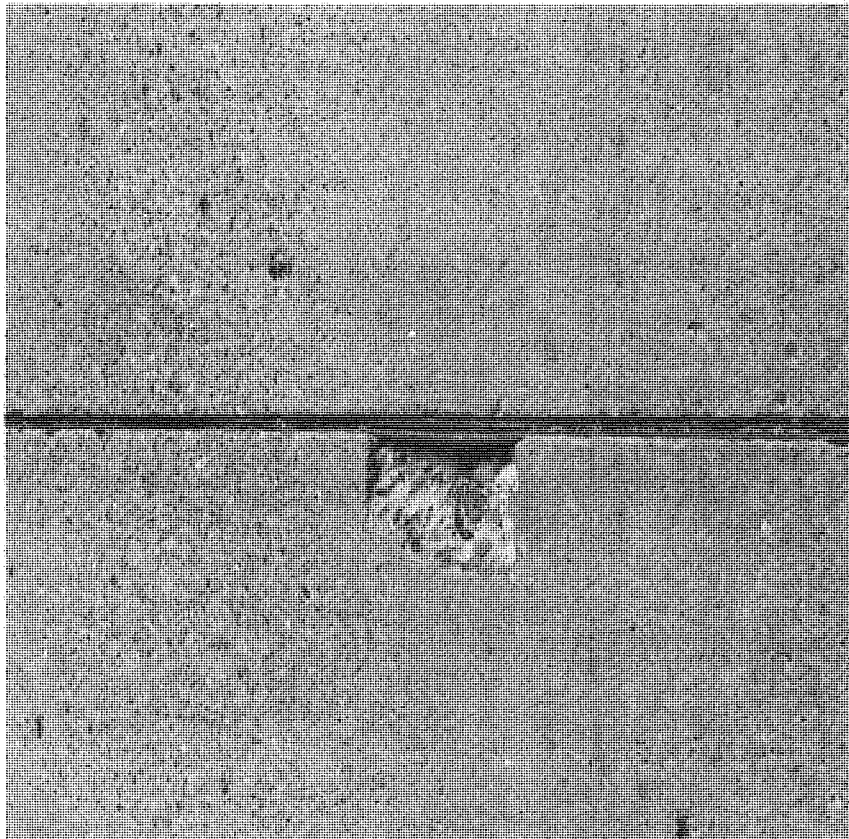
Rating Number: 1



Name: Open Spall

Description: An open spall is the breaking or cracking of the concrete along the joint groove and the broken concrete is missing. Seal compression is lost in the spall area.

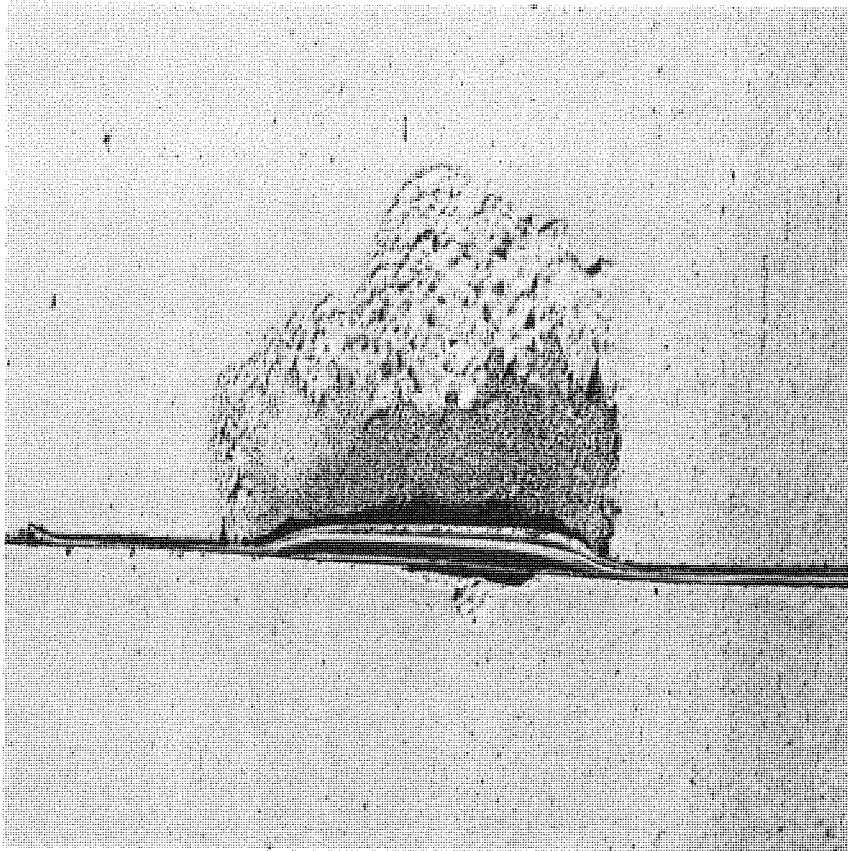
Rating Number: 2



Name: Joint Spall

Description: A joint spall is the breaking or shearing of the concrete along the joint groove. The spall extends from the bottom of the groove and several inches away from the joint. The broken concrete is missing and bituminous repair may be required. Compression in the seal is lost and the seal may be torn in the spall area.

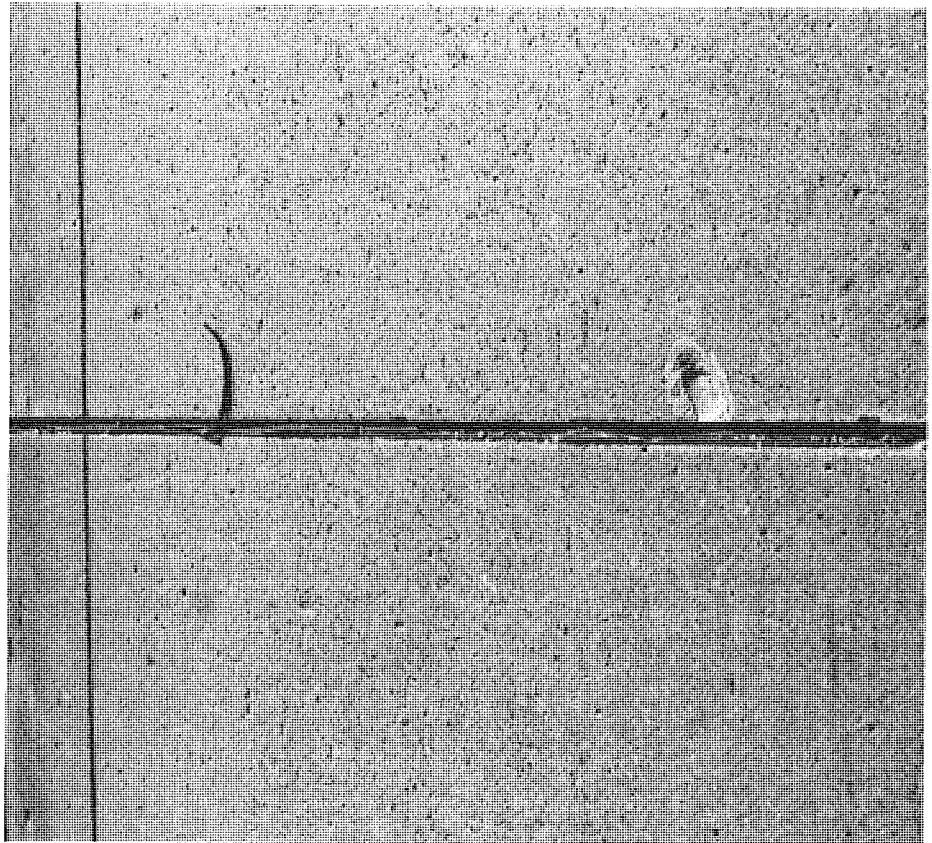
Rating Number: 3



Name: Tight Seal

Description: A tight seal is an expansion joint seal that is compressed beyond its design limit. The groove opening may range in width from 1/4 to 1/2 inch, the seal normally is torn, but no spalling has occurred. The seal is still sealing the joint satisfactorily.

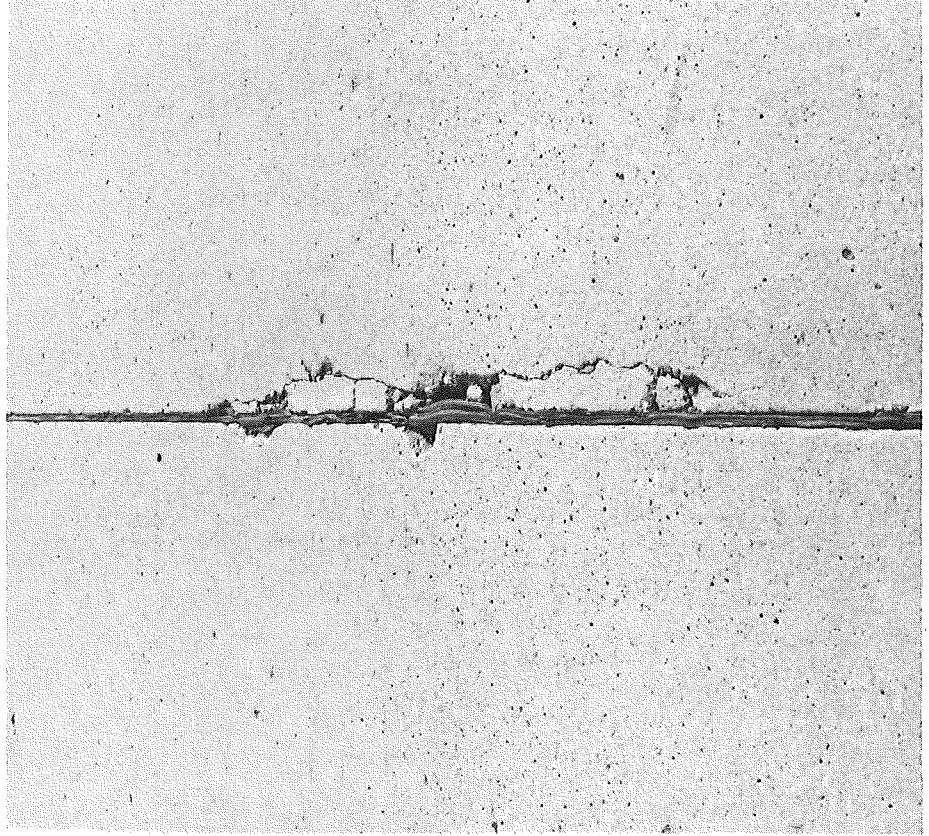
Rating Number: 4



Name: Tight Seal with Spalled Groove

Description: A tight seal with spalled groove is an expansion seal compressed beyond its design limit and spalls along the groove have occurred. The seal normally is torn and the spalls may be either shattered, open, or of the joint spall type.

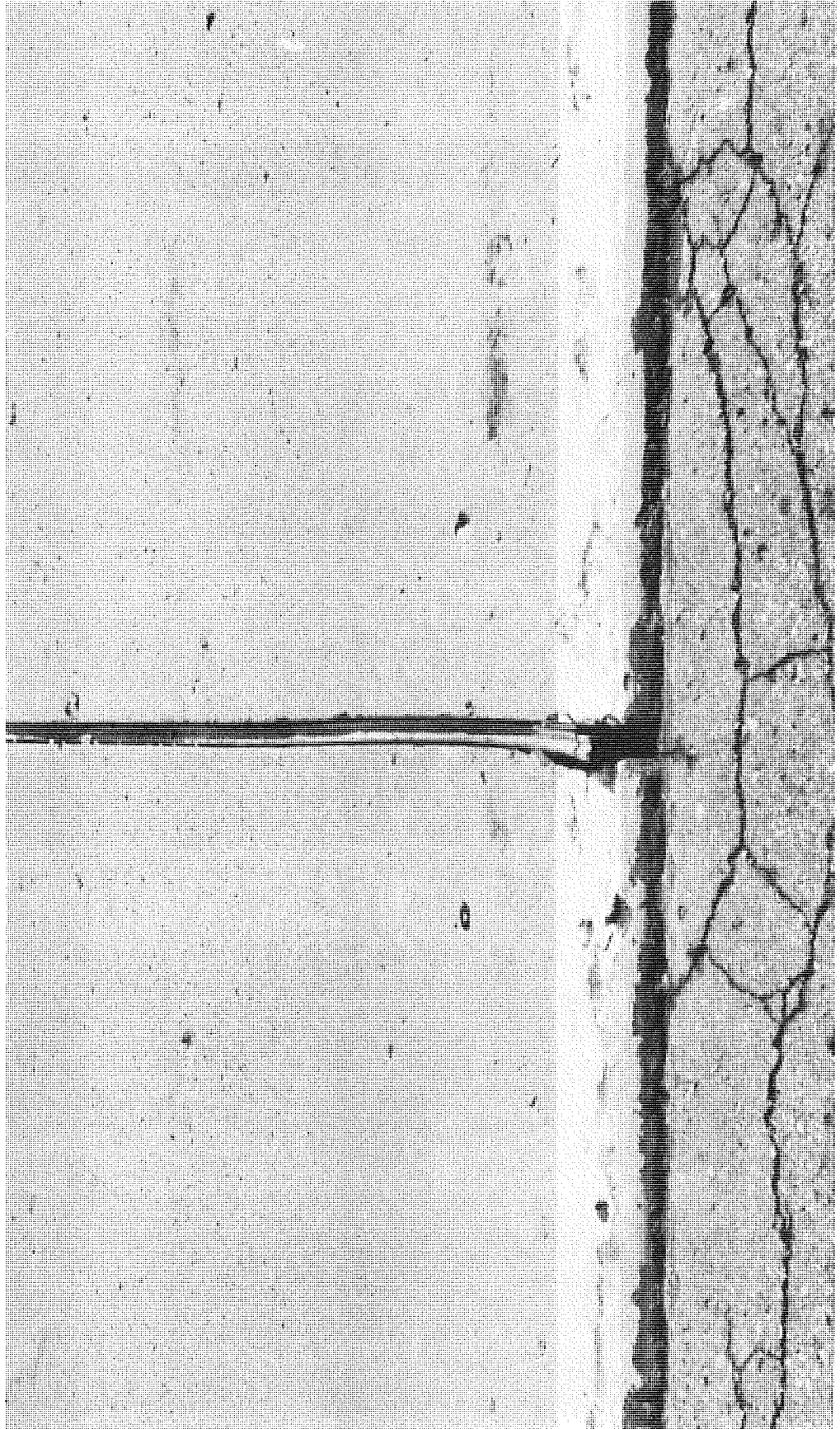
Rating Number: 5



Name: Loose Seal

Description: A loose seal is one where the pressure on the groove walls is lost. Spalls of either of the three types may be present.

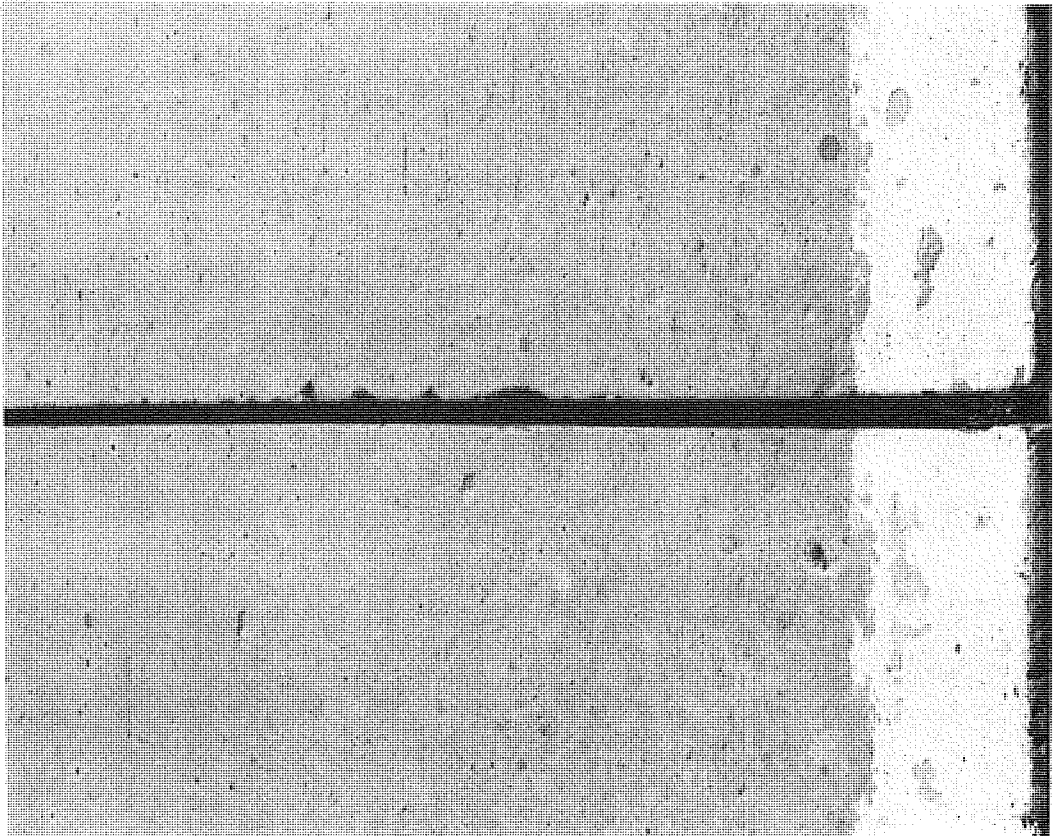
Rating Number: 6



Name: Lost Seal

Description: A lost seal is where part of, or the entire length of seal is missing. Spalls may be present.

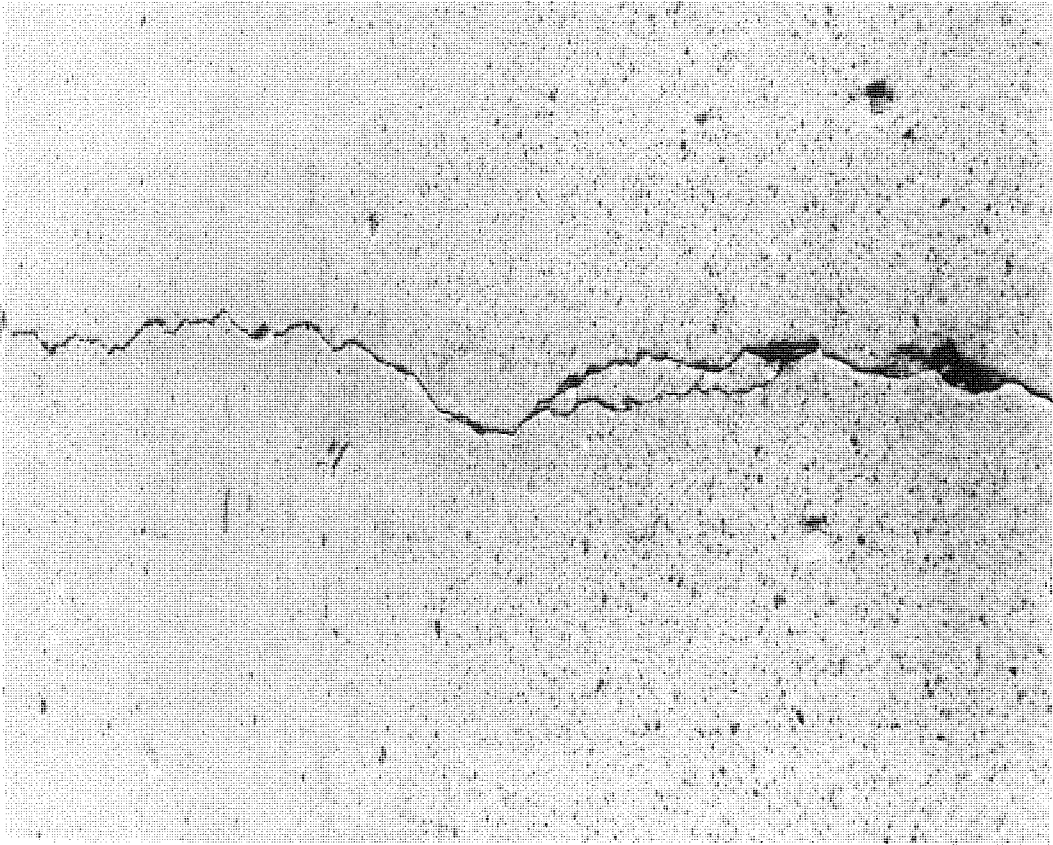
Rating Number: 7



Name: Open Transverse Crack

Description: An open transverse crack is 1/8 inch or more in width at the surface.

Rating Number: 8





JOINT CONDITION SURVEY DATA  
Construction Project SAMPLE

Route I-69 SOUTHBOUND

Joint No. and Type	Year and Rating				Year & Accumulated Length or size of Distress, in.				Station Tie-ins and Remarks
	76				76				
1	0								0+00
2	0								
E 3	0								
4	0								2+88
5	0								
6	1				1x3				
7	0								
7a	8								
E 8	4								
9	1				1x8				
10	2				1x2				
11	0								
12	0								
E 13	0								
14	3				12x2				
15	0								
16	1				2x4				
17	0								
E 18	0								
19	0								
20	0								
21	2				2x4				
22	1				1x6				
E 23	5				1x18				
24	1				1x2				
25	1				2x4				
26	0								
27	7								
E 28	4								
29	6								
30	0								21+60
31	0								
32	2				2x2				
E 33	0								
34	1				1x4				