# PREFORMED PHOENIX ETHYLENE PROPYLENE DIENE MONOMER (EPDM) COMPRESSION JOINT SEALS

Final Report
For
MLR-93-2

September 1999

Project Development Division

Iowa Department of Transportation

# Preformed Phoenix EPDM Compression Joint Seals

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MLR-93-2

By
Robert Steffes
515-239-1392
FAX: 515-239-1092
Assistant to the Research Engineer
Office of Materials
Project Development Division
Iowa Department of Transportation
Ames, Iowa 50010

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## TECHNICAL REPORT DOCUMENTATION PAGE

**1. REPORT NO.**

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Diene Monomer (EPDM) Joint Seals

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**5. AUTHOR(S)**

Robert Steffes
Assistant to the Research Engineer

**6. PERFORMING ORGANIZATION ADDRESS**

Iowa Department of Transportation
Materials Department
800 Lincoln Way
Ames, Iowa 50010

**7. ACKNOWLEDGMENT OF COOPERATING ORGANIZATIONS**

Phoenix AG
Hamburg, Germany

Dr. Grabe and Claudia Grassy

Phoenix N. America Inc.
1 Minue St. Carteret, New Jersey

Scott W. Poyner

**8. ABSTRACT**

There is an ongoing drive towards improvements and achieving success in effective and long term sealing of portland cement concrete (PCC) pavement contraction joints. A variety of joint sealing products and procedures have been applied in Iowa in search of improvements in seal performance. Hot poured rubberized asphalt products were mainly used for sealing all joints in earlier years for highways. In the 1980s, silicone sealant products were becoming popular, especially for the major highways. As a high level of sealant performance was not achieved from silicones in Iowa conditions, other sealing products were tried. Preformed neoprene compression seals are being tried as a substitution for silicone sealants. Due to high costs of materials and installation with neoprene seals, the search for improvements through other joint sealing products and procedures continued.

An agreement was made with Phoenix, North America, Inc. to provide and install preformed Ethylene Propylene Diene Monomer (EPDM) compression joint seals. The research site was a 600 ft. test section of northbound I-29 in Pottawattamie County, Iowa. Seal installation was done August 20, 1992.

Seal performance has been good over the past seven years and the seals are still showing no significant signs of decreasing performance.

**9. KEY WORDS**

Joint seals
Preformed
EPDM

**10. NO. OF PAGES**

18

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## DISCLAIMER

## INTRODUCTION

Due to unsatisfactory performance of most field molded contraction joint sealing materials, preformed compression seals were introduced. The major suppliers of preformed seals in the USA offer neoprene products. Although the neoprene seals should perform well for many years, if installed properly, their overall cost of materials and labor are comparatively high.

A European supplier of preformed compression seals, Phoenix AG®, through an American agent, Phoenix, North America, Inc. (Phoenix) offered to provide and install preformed Ethylene Propylene Diene Monomer (EPDM) seals in a test section using approximately 1,500 ft. of seal. Plans were made to carry out this experiment in 1992. This installation of EPDM seals in a PCC pavement is believed to be one of the first in the USA. A later application was in a "European Design" test highway section in Detroit, Michigan. Phoenix product literature is shown in Appendix A.

## OBJECTIVES

The objectives of this research are to broaden experience in the use of different preformed compression seals and to continue the search for better performing sealing materials at lower costs.

## PROJECT LOCATION

Most Iowa DOT projects of new construction, on interstate routes, let after 1991 were designated to use preformed neoprene compression joint seals. One of these projects was Pottawattamie/Harrison County IR-29-4(39)56--12-78. A test section, within this project, was selected for the experimental installation of the Phoenix EPDM compression seals. The site is located in the northbound lanes of I-29, between Sta. 806+60 and Sta. 812+40, near milepost 70, about ½ mile south of the I-680 eastbound on-ramp. The test area covers 600 ft. of both northbound lanes and includes 30 transverse joints plus the centerline joint.

## CONSTRUCTION

The agreements for the research were made between the Iowa DOT, the contractor, Irving F. Jensen Co., Inc., and Phoenix.

The PCC pavement was 11½ in. thick and 26 ft. wide in the test area and was placed in mid-August, 1992. The contractor did the sawing and cleaning of the joints.

Joint sawing was done with a wet diamond blade to a depth of "slab thickness divided by 4" (T/4). Joint width was ⅜ in. for the skewed transverse joints and ¼ in. for the longitudinal joint. Joint width tolerance was ± 1/16 in. Phoenix requested that a step cut joint be made so the seal would not be forced too deep into the joint. The step cut is formed by making a second pass with the saw following the same line, but using a wider blade and cutting at a shallow depth, thus forming the "step" within the joint. Phoenix sawed the beveled edges on the joints.

### Seal Installation

Joint sealing was done by Phoenix on August 19 and 20, 1992. The transverse joints were beveled and sealed first. The joint beveling was done to allow the seal to enter the joint more easily. In addition, the beveling removed weakened joint edges and spalls. The longitudinal joint was then beveled (Figure 1), which included the notching of the transverse seal. The longitudinal joint was sealed immediately after being beveled. Joint widths and seal widths are given in Table 1. It should be noted that a few joints which had cracked full thickness and had opened unusually wide did get wider seals than the normal joints. Figures 2 and 3 show equipment used for seal installation. A soap/water solution was used to clean and lubricate the seal before installation. Figure 4 shows the seal installed in the beveled joint. The top of the seal was installed approximately ¼ in. below the surface or down to just below the lowest point of the bevel.

The mechanical seal installer was engine powered. Seal insertion rate and forward travel rate were both engine powered independently. The two rates are calibrated such that there should be no seal stretch or tuck during installation. However, during the installation of the longitudinal seal, in this project, it was noticed that 2% to 3% stretch was occurring. Typically, a compression seal manufacturer limits seal stretch to 5%, before rejecting the installation.

### Construction Comparisons

The Phoenix method of sealing was quick, trouble free and left no equipment cleanup problems. Compared to the method of installation of some other brands of preformed neoprene compression seals, Phoenix time required, overall, would be less by possibly 30%. The additional Phoenix operation of beveling required minimal additional time. In comparison, the cleanup of equipment for installing conventional (neoprene) compression seals consumed approximately 25% of the total time and the Phoenix method required no cleanup time, as no adhesive was used.

The detailed hand work for installing seals at ends of joints was a very simple operation for Phoenix. They simply wet the seals and tapped them into position with a tool. For the conventional preformed (neoprene) seals, lubricant adhesive is required and it is very sticky and unpleasant to handle by hand, with tools or with brushes. Due to the shape or design of the neoprene seals, in field tests, they required much more energy to install.

## LABORATORY TESTING

The Iowa DOT Standard Specification for Elastomeric Joint Seals states that the seal and the lubricant adhesive shall meet requirements of AASHTO M 220. This specification is intended for use on neoprene. A modified test was applied to the EPDM seals. Test results are in Appendix B. In general, the EPDM seal would take a permanent set or become vulcanized if tested at the high temperature conditions designated for neoprene. However, at lower temperatures, closer to field conditions, the seal performed in a satisfactory manner and was, therefore, considered for research and a field trial.

## MATERIAL COSTS

Materials, installation equipment and labor were provided by Phoenix at no cost for this research project.

## FIELD TEST RESULTS

Based upon a visual evaluation, the Phoenix seals appear to be performing well. Vacuum tests done with the Iowa Vacuum Joint Seal Tester (IA-VAC) showed some air leakage. It is apparent that air passes the Phoenix seals somewhat more freely than the neoprene seals since the neoprene seals also have the lubricant adhesive to block airflow along the interface between the joint seal and the concrete joint face.

After one winter of service, it was evident that some of the EPDM seals had slipped downward a small distance and were apparently sitting on the step cut ledge. This resulted in the seals being from ⅜" to ⅝" lower now than planned. Even with being lower, the seals are performing well. The space above the seals is generally blown clear of sand, etc., from the high speed interstate traffic (see Figure 5).

The installation operation of tapering the longitudinal joint and at the same time cutting a notch in the transverse seal (for the crossover intersection of seals) did initiate a problem for the transverse seals over time. As the transverse seals were (apparently) installed with some tension, approximately 27% of them fractured at the point of the notch (see Figure 6). The 1999 inspection shows that an opening of one or more inches is often found in the transverse seal on either side of the longitudinal joint. This is the result of the installation tension, notch weakening and seal parting which caused it to open and pull back from the centerline (see Table 1).

## DISCUSSION OF RESULTS

Three issues to be noted developed over the seven years of service.

1. During the first year, most of the seals settled downward approximately 3/8" to 5/8", landing on the step-cut ledge. This occurred as a result of the step-cut being made too deep at joint sawing time. If the step cut ledge is made higher, however, it will cause the top seal, at the

seals crossover point, to protrude above the pavement surface. Four options/solutions to the problems exist, but each has some negative aspects. They are:

a) Cut the transverse seal at each intersection.
b) Cut the longitudinal seal at each intersection.
c) Notch each seal together at their intersection, cutting each one half depth.
d) Saw the transverse stepcut to a deeper level for a short distance, only at the crossover position.

Option b would be selected if the seals can be installed without residual tension; otherwise, option d might be selected.

2. In the first year, several of the transverse seals parted at the intersection with the longitudinal joint. This occurred as a result of weakening from the notch made by the centerline tapering saw and also from being installed under tension.

3. Joint number 26, at Station 811+50 is showing signs of failure. This is occurring as a result of slab faulting movements due to the absence of dowel bar support. The cause of this specific seal failure is clearly outside of this research on seal performance.

## CONCLUSIONS

The installation of the EPDM seals required less time and less cleanup compared to most other installations of preformed neoprene seals using lubricant adhesives in Iowa.

Notching of either the transverse or longitudinal seal, at their intersection, will likely cause that seal to part, especially if that seal was installed with some tension.

Sawing a stepcut to the correct depth creates a problem at the intersection (crossover) of the transverse and longitudinal seals. It will cause the top seal to protrude above the roadway surface.

After seven years of Interstate service life, the Phoenix EPDM joint seals are still performing well. Except for the three issues discussed above, there are currently no signs of any other deficiencies in performance.

TABLE TITLE

1. Transverse and Longitudinal Joints and Seals Data

## Table 1

Transverse and Longitudinal Joints and Seals Data

PHOENIX EPDM Profiles
Installed August 19/20 1992
I-29 Pottawattamie County
MP 70 NBL
Sta 806+60 to Sta 812+40

| | Transverse Joint (Width, mm) | | | Longitudinal Joint (Width, mm) | | Transverse Seals Parted at Centerline * |
|---|---|---|---|---|---|---|
| Joint # | | PHOENIX Profile Seal | | | | |
| S to N | Actual Joint | Nominal | Actual | Actual Joint | Actual Seal | Opening (mm) |
| 1 | 10.7 | 10 | 16 | 6.8 | 12 | 0 |
| 2 | 12.8 | 12 | 18 | | | 0 |
| 3 | 11.1 | 10 | 16 | 6.4 | 12 | 0 |
| 4 | 11.9 | 10 | 16 | | | 120 |
| 5 | 10.7 | 10 | 16 | 6.2 | 12 | 0 |
| 6 | 11.9 | 10 | 16 | | | 0 |
| 7 | 11.0 | 10 | 16 | 6.6 | 12 | 200 |
| 8 | 10.5 | 10 | 16 | | | 0 |
| 9 | 12.8 | 12 | 18 | 7.1 | 12 | 0 |
| 10 | 11.0 | 10 | 16 | | | 0 |
| 11 | 11.0 | 10 | 16 | 6.5 | 12 | 0 |
| 12 | 11.8 | 10 | 16 | | | 0 |
| 13 | 10.0 | 10 | 16 | 7 | 12 | 0 |
| 14 | 11.3 | 10 | 16 | | | 0 |
| 15 | 11.4 | 10 | 16 | 6.8 | 12 | 0 |
| 16 | 12.5 | 12 | 18 | | | 0 |
| 17 | 10.5 | 10 | 16 | 6.8 | 12 | 0 |
| 18 | 11.8 | 10 | 16 | | | 0 |
| 19 | 10.5 | 10 | 16 | 6.5 | 12 | 0 |
| 20 | 11.8 | 10 | 16 | | | 200 |
| 21 | 11.7 | 10 | 16 | 6.6 | 12 | 100 |
| 22 | 10.3 | 10 | 16 | | | 150 |
| 23 | 12.4 | 12 | 18 | 6.6 | 12 | 0 |
| 24 | 10.7 | 10 | 16 | | | 0 |
| 25 | 13.0 | 12 | 18 | 6.2 | 12 | 250 |
| 26 | 10.3 | 10 | 16 | | | 0 |
| 27 | 11.5 | 10 | 16 | 5.9 | 12 | 80 |
| 28 | 10.0 | 10 | 16 | | | 50 |
| 29 | 13.2 | 12 | 18 | 6.8 | 12 | 0 |
| 30 | 10.4 | 10 | 16 | | | 0 |

*** Notes:**
Evaluation date 7-20-99
Number of seals parted is 8 out of 30, ie, 27%
Average opening of the 8 seals which parted is 144 mm

FIGURE CAPTIONS

1. Sawing Beveled Edge on Longitudinal Joint
2. Equipment and Personnel for Installing EPDM Seals
3. Adjusting EPDM Seals at Their Intersection
4. Beveled Edge Joint With EPDM Seal
5. Seal Settled Down Onto Step Cut Ledge
6. Transverse Joint Seal Parted from Notch and Tension

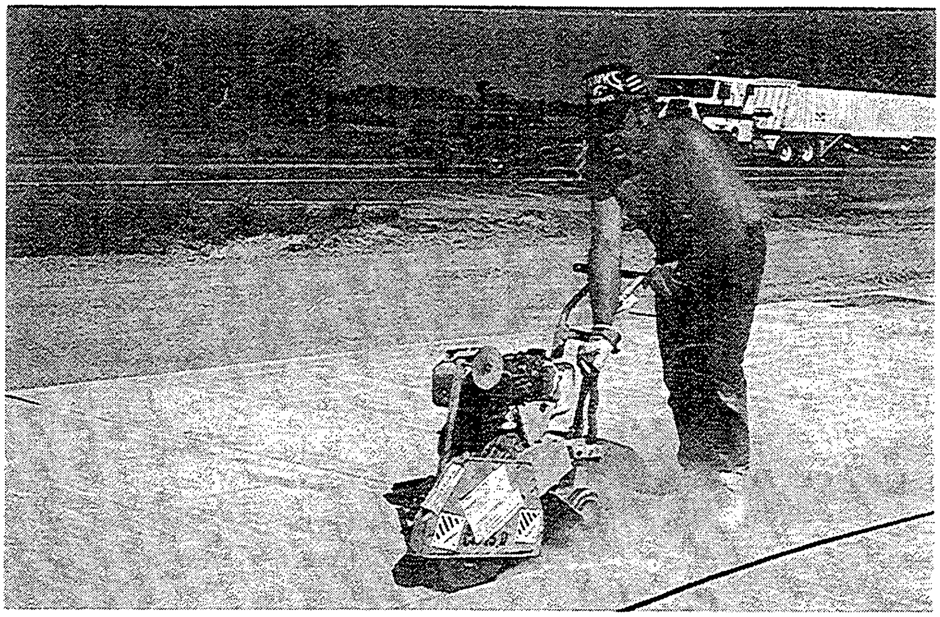


Figure 1
Sawing Beveled Edge on Longitudinal Joint

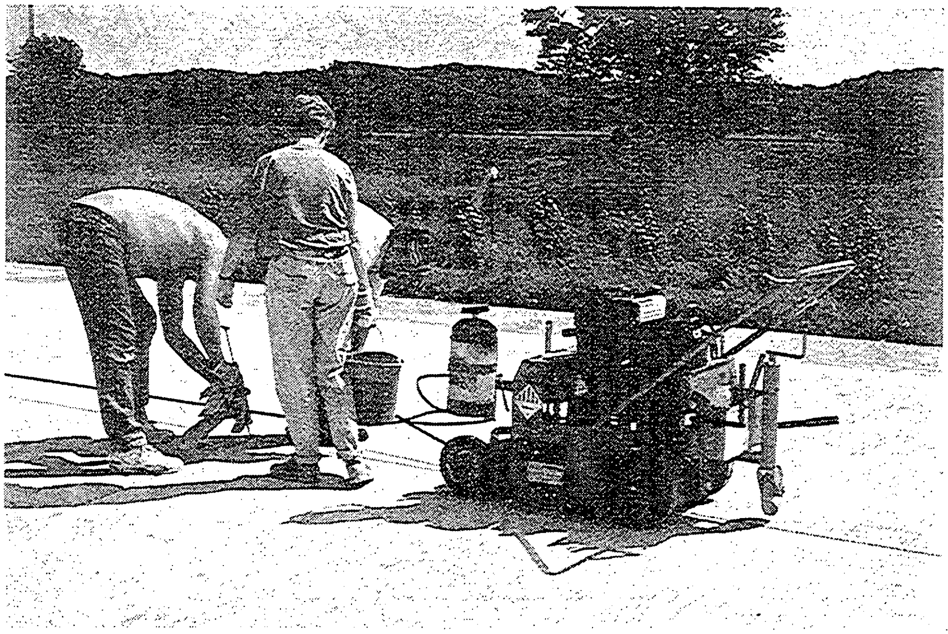


Figure 2
Equipment and Personnel for Installing EPDM Seals

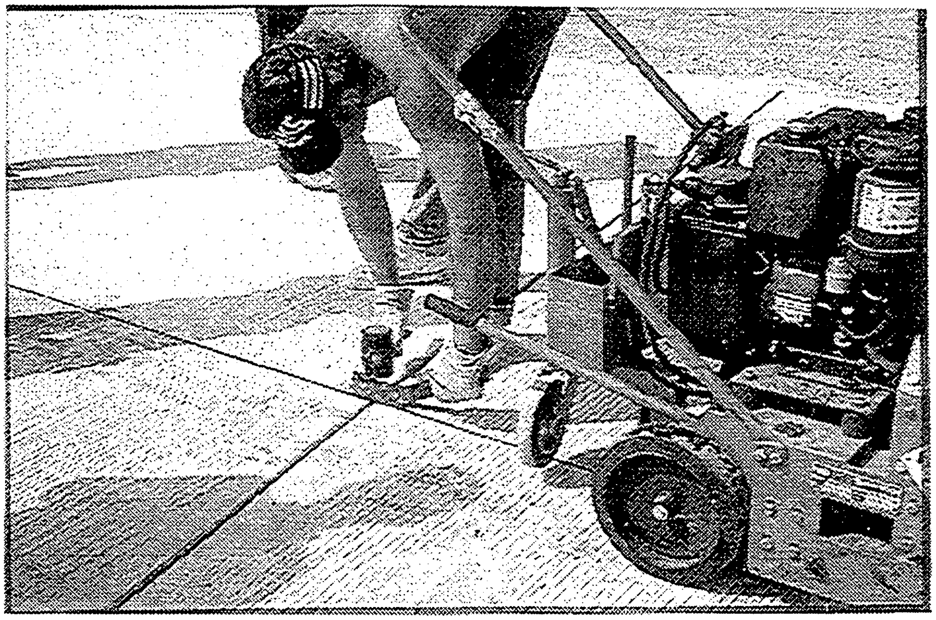


Figure 3
Adjusting EPDM Seals at Their Intersection

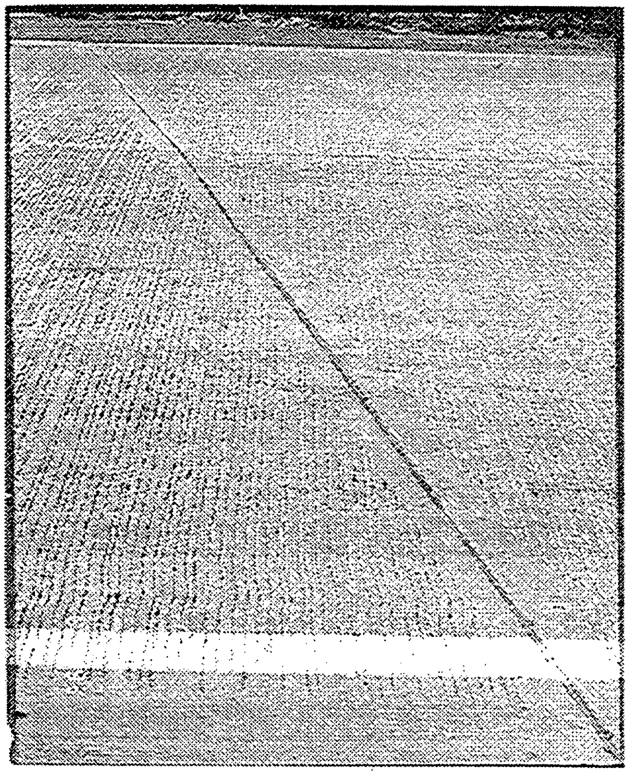


Figure 4
Beveled Edge Joint with EPDM Seal

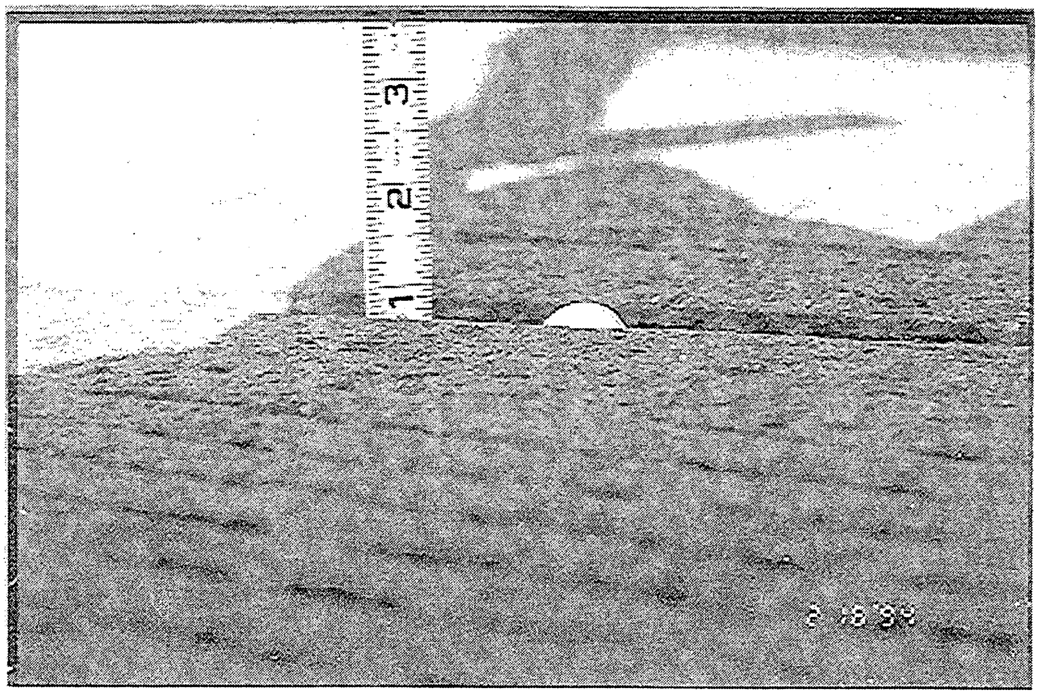


Figure 5
Seal Settled Down Onto Step Cut Ledge.

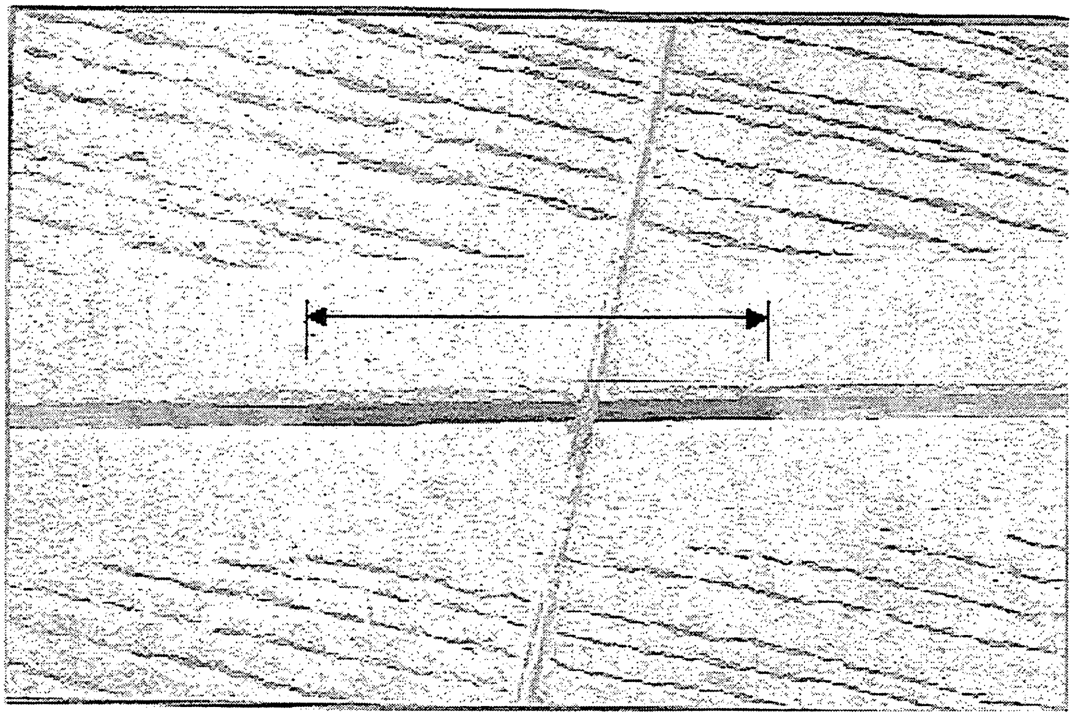


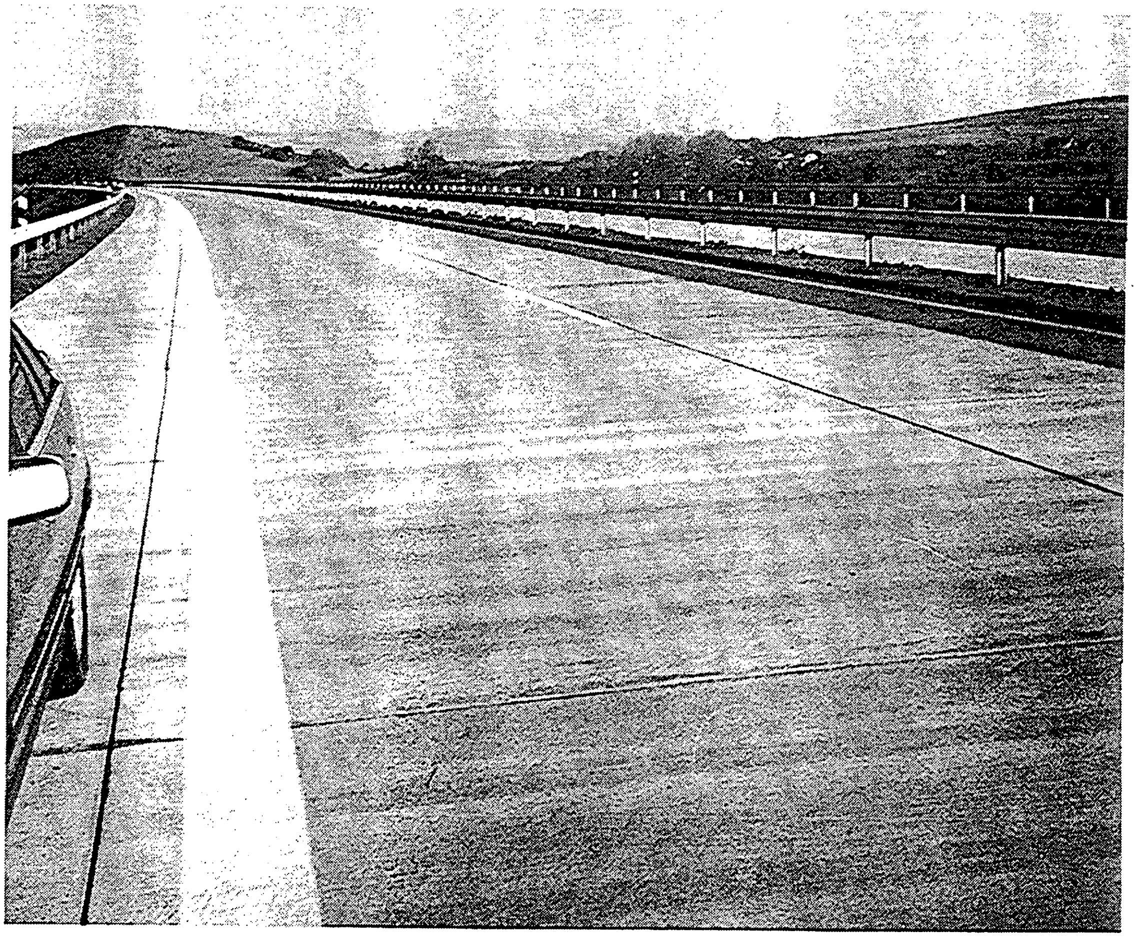
Figure 6
Transverse Joint Seal Parted From Notch and Tension

APPENDIX A

Phoenix Product Literature

**PHOENIX AG**
Postfach 90 08 54
2100 Hamburg 90
Fernruf 040 / 76 67 - 25 94, 23 22
Telegramm-Adresse phoenix ag
Fernschreiber 2 17 611 pxhh d
Telefax 040 / 76 67 - 22 11

PHOENIX



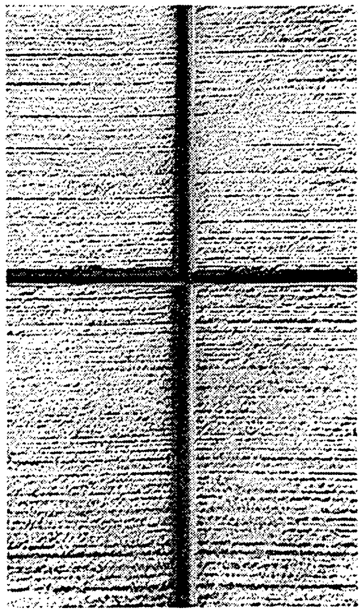
**Advantages**

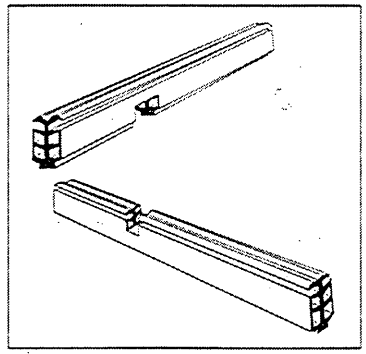
1. The EPDM section is a compression seal, that only requires clean but not dry joints during insertion. Sections can thus be laid under weather conditions in which joint grouting would not be permitted.
2. The sections are resistant to liquids found on highway surfaces, such as fuels, hydraulic oils and deicing agents.
3. Joints protected by elastomeric seals have at least twice the service life of grouting.
4. The Shore hardness of a section is so high, that it prevents stones and dirt from being pressed in by passing traffic. The sections are heat stabile and change their hardness only slightly when there is a change in temperature.
5. The section adapts to the changes in volume of the joint gap without displacing the substance over the upper edge of the joint.
6. The sections can rapidly be placed in the joints with an insertion apparatus, without producing a section expansion.
7. The seal at the transition points is obtained by a mechanical interlock of the crossing sections together with associated adhesion.
8. Replacement of damaged sections can be carried out quickly and cleanly.

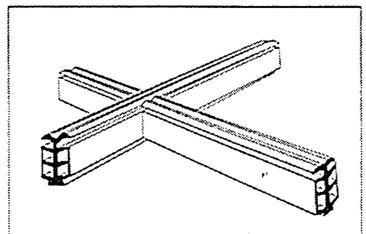
From Europe please call 25 94
From Overseas call 23 22

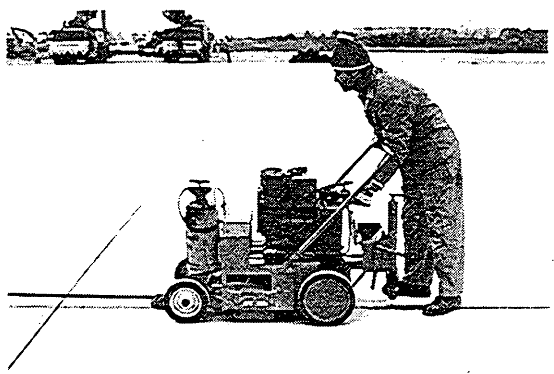
**Transition point**
When making transition points, two different processes have been proven in practice:

1. Making the transition point of longitudinal and transverse joints by mechanically passing over the initially filled transverse joints. The transverse section is then disengaged along the line of the longitudinal joint in the upper half section. The longitudinal joint section is then disengaged along the transverse joint in the lower half section.
   After a permanently resilient adhesive has been pressed in, the longitudinal joint section is inserted in the transverse joint section and then hammered into the joints so that the disengaged sectors become mechanically combined transition points.
2. Following mechanical placement of the longitudinal joint section, this is ground out along the transverse joint to 2/3rds of its section depth. After a permanently resilient adhesive has been pressed in, the transverse joint section is inserted in the longitudinal joint section so that an enclosed crossing point is produced. The overlap of the transverse section, compared with the level of the longitudinal joint section, is reduced by being filled with adhesive to provide a slight elevation, to prevent any negative effects from cleaning machinery.









**Insertion apparatus**
By using a insertion apparatus specially developed for these sections, it is possible to lay the joint section without elongation at high speed. Insertion can take place under all weather conditions, except with snow and ice, thus extending the previously possible active construction times.

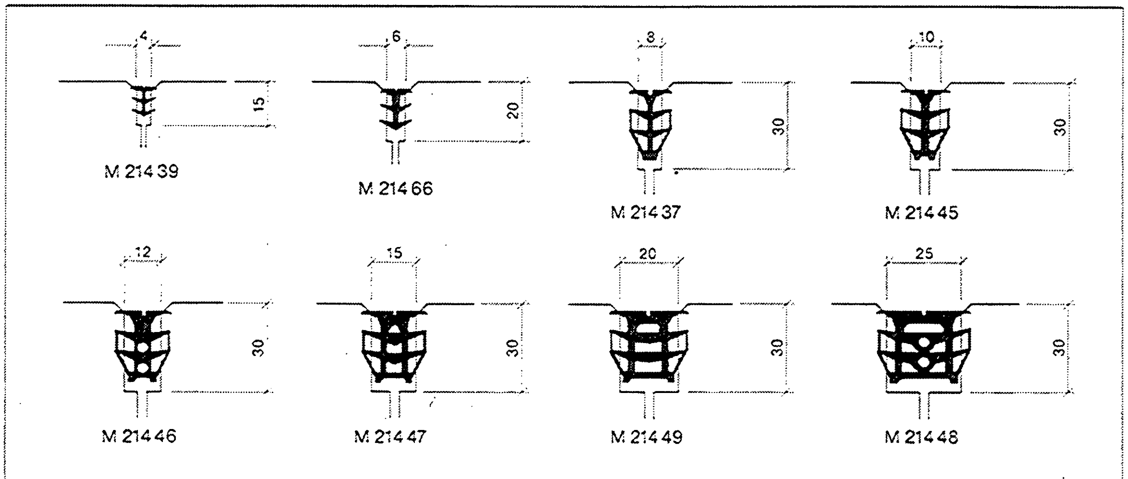
# Joint seals for concrete surfaces. Mechanically installed EPDM sections for airports and roads.

Ever since 1975, Phoenix AG has been gaining experience in the use of elastomeric joint sections to seal concrete joints on motorways.

Through the growing demands for environmental protection and the experience gained in the meantime on the damaging effects of water movement between the concrete surface and the support layer, further development of the sectional geometry was begun, aimed particularly at the water seal at the intersection of longitudinal and transverse joints. This new development was tested in 1985 on the A31 motorway near Gescher, under the supervision of the Federal German Institute for Highways. Tests on the profile lengths and especially on the transition points have resulted in the meantime in the desired watertight integrity. Since then, short test sections have been installed in several Federal States.

For sealing the customary joint dimensions with joint widths from 8 to 25 mm, as well as for special joint dimensions from 4 to 6 or 30 mm a range of sections are available for use on concrete surfaces. The table lists the minimum joint width required for mechanical assembly as well as the maximum joint width for joint openings in which adequate sealing is still obtained.

Since 1986, joint sections are also used at airports, whereby the customary specifications from the motorway sector are modified by requirements for resistance to kerosene, hydraulic oil and various deicing agents.




Phoenix joint sections have successfully passed all the specified tests at the Otto-Graf-Institute in Stuttgart applicable for practical use in motorway and airport areas. These are:

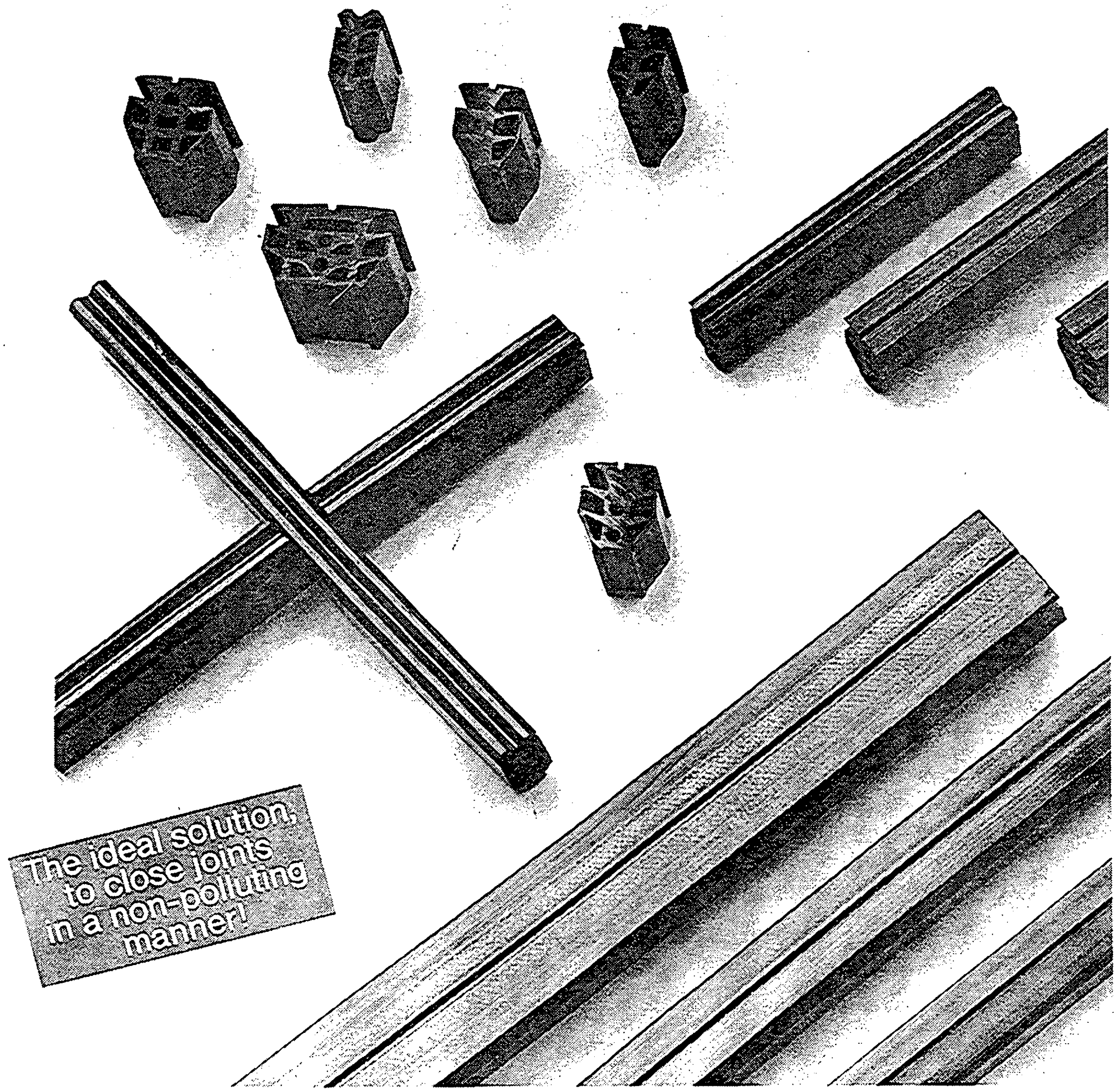
1. Resistance to ASTM reference petroleum B.
2. Recovery capacity at various temperatures in accordance with ASTM-D 2628-81.
3. Test for recovery force after being subjected to hydraulic fluid.
4. Test for recovery force after being subjected to kerosene.
5. Test for recovery force after being subjected to deicing agents.
6. Test for relaxation capacity in accordance with DIN 4060 (3 months at 50°C).

**Phoenix motorway and airport joint sections**

| Nominal joint width | Profile designation | Minimum joint width during assembly | Maximum joint width in winter |
|---|---|---|---|
| mm | mm | mm | mm |
| 4 | M 21439 | 3.5 | 6.8 |
| 6 | M 21466 | 5.0 | 9.7 |
| 8 | M 21437 | 8.0 | 12.7 |
| 10 | M 21445 | 9.0 | 14.7 |
| 12 | M 21446 | 11.0 | 16.5 |
| 15 | M 21447 | 14.0 | 19.5 |
| 20 | M 21449 | 19.0 | 24.2 |
| 25 | M 21448 | 24.0 | 29.2 |

PHOENIX

# Joint seals for concrete surfaces




PHOENIX
ELASTOMER SECTIONS

# APPENDIX B
Laboratory Reports

ARR2-0055
00

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - RUBBER PRODUCTS
LAB LOCATION - AMES

LAB NO....:ARR2-0055

MATERIAL........:PREFORMED JOINT
INTENDED USE....:DEPT. INFO.
PROJECT NO......:IM-29-4(39)56-13-78
UNIT OF MATERIAL:PHOENIX EPDM JOINT FOR 6MM OR 1/4" SAW CUT
CENTER LINE NORTH BOUND LANE
SAMPLED BY......:STEFFES SENDER NO.:
DATE SAMPLED: 05/20/92 DATE RECEIVED: 08/27/92 DATE REPORTED: 09/11/92

| | |
|---|---|
| DUROMETER HARDNESS | 70 |
| MEDIAN TENSILE STR. PSI | 2140 |
| MEDIAN ELONG. IN 1" - % | 225 |
| PROPERTIES AFTER HEAT AGING 70 HRS. @ 212 F. | |
| CHANGE IN DUROMETER HARDNESS- POINTS | +5 |
| CHANGE IN TENSILE STR. - % | -11.7 |
| CHANGE IN ELONGATION - % | -44.4 |

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YOUNKIN

DISPOSITION: DEPT. INFO.

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

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ARR2-0056
00

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - RUBBER PRODUCTS
LAB LOCATION - AMES

LAB NO....:ARR2-0056

MATERIAL........:PREFORMED JOINT
INTENDED USE....:DEPT. INFO.
PROJECT NO......:IM-29-4(39)56-13-78
UNIT OF MATERIAL:PHOENIX EPDM JOINT FOR 10 MM OR 3/8" SAW CUT
NORTH BOUND LANE
SAMPLED BY......:STEFFES                SENDER NO.:
DATE SAMPLED: 08/20/92    DATE RECEIVED: 08/27/92    DATE REPORTED: 09/11/92

---

| | |
|---|---|
| DUROMETER HARDNESS | 73 |
| MEDIAN TENSILE STR. PSI | 1780 |
| MEDIAN ELONG. IN 1" - % | 275 |

PROPERTIES AFTER HEAT AGING 70 HRS. @ 212 F.

| | |
|---|---|
| CHANGE IN DUROMETER HARDNESS- POINTS | +6 |
| CHANGE IN TENSILE STR. - % | +12.9 |
| CHANGE IN ELONGATION - % | -36.4 |

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