National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

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Evaluation of Preformed Elastomeric Pavement Joint Sealing Systems

An NCHRP staff digest of the essential findings from the final report on NCHRP Project 4-9, "Evaluation of Preformed Elastomeric Pavement Joint Sealing Systems and Practices," by D. E. Peterson and J. C. McBride, Utah Department of Transportation, Salt Lake City, Utah.

THE PROBLEM AND ITS SOLUTION

The problem of sealing transverse joints in portland cement concrete pavements to prevent intrusion of objectionable materials is of prime importance to many state highway and transportation agencies. The failure of a pavement joint results in extensive pavement damage such as spalling, faulting, and blowups. These types of failure are expensive to repair and cause considerable interference to the traveling public. Preformed elastomeric seals are being used to seal transverse joints with varying degrees of success. The objectives of this study were to evaluate the performance of preformed elastomeric joint seals and develop guide specifications for their use in portland cement concrete pavements with joint configurations generally used throughout the United States.

This project has achieved the objective of developing guide specifications for preformed elastomeric seals by the accomplishment, over a 10-year period, of the following activities: (1) evaluation of previous research and field performance information, (2) theoretical study of the kinematics of sealer

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deformation, (3) laboratory testing of the effects of various conditioning procedures on the force-deflection characteristics of seals, (4) development of an accelerated aging process, and (5) field evaluation of seal performance in relation to laboratory test results and the accelerated aging process. Because of the extensive nature of the study, the resulting guide specifications are suitable for immediate implementation by highway and transportation agencies. Consequently, the findings will be of particular interest to highway design, materials, and specification engineers.

FINDINGS

The principal efforts of this study were directed toward obtaining information leading to development of improved specifications for the selection of preformed elastomeric seals for sealing transverse joints in PCC pavements, for the design and preparation of the joint, and for the installation of the seals. The laboratory testing under Phase I of the study was conducted using sections of preformed elastomeric seals obtained from commercial producers. The testing involved environmental cycling, heat aging, ozone resistance, oil resistance, tension, hardness, and watertightness. The thermal cycling procedures were used to simulate field conditions with force-deflection tests performed before and after the cycling. During Phase II of the study, seals from 3 commercial producers were installed in new PCC construction projects in 7 states, representing a wide range of climatic conditions, joint spacing, and joint widths. Each test section contained 48 consecutive transverse contraction joints. Field performance of the joints and seals was monitored through quarterly visual inspections by personnel in the states and through semiannual evaluation and sampling by the researchers from Utah Department of Transportation. Laboratory tests were run on removed portions of seals.

On the basis of the findings of the research and field experience compiled during this study, the following major findings appear to be warranted:

1. Of the four types of conditioning tested in Phase I, heat aging, thermal cycling, mechanical cycling, and environmental aging, the heat aging produced results similar to those sealers obtained from pavements. The heat-aged series of tests produced the most significant effect on the sealers in the shortest time period.

2. The force-deflection test served as the basic means for characterizing the response of sealers to a given deflection. This test examined the sealer's response to the opening and closing of the pavement joint. Criteria were developed for this test method in Phase I and verified in Phase II. It proved to be an excellent method for evaluating sealers.

3. A correlation was made between initial and heat-aged test results and the field performance of the joint sealers producing the following general results within the range of materials tested: (a) sealers with higher force values at 20 percent deflection for new materials were in better condition at the end of 4 years; (b) lower hardness for new materials is desirable; (c) sealers with higher percent elongation for new materials performed better; (d) sealers with higher tensile strength for new materials performed better; and (e) higher force values at 20 percent deflection for heat-aged specimens were desirable.

4. Sealers must be properly installed to ensure good long-term performance. This requires at a minimum the following items: (a) joints must be sawed to the proper depth and width; (b) sealers must be properly sized for the joint size and width; (c) sealers with good performance characteristics should be selected; (d) lubricant-adhesive that is compatible with the sealer and has long-term-bonding capabilities must be used; (e) proper equipment for installing the sealers in the joints should be specified and used; (f) manual installation should not be allowed; and (g) qualified personnel who have the training and experience to do a good job must be used.

5. The proper use of a quality lubricant-adhesive is necessary for long-term performance of a sealer. The force required of the sealer to maintain a watertight joint is too great without the lubricant-adhesive and grit can work its way down the sidewall of the sealer unless the sealer is adequately bonded to the concrete.

6. It is desirable to saw the joint vertically along the edge of the pavement to enable wrapping the sealer over the edge of the pavement. This is a technique used in both New York and Michigan and helps ensure better watertightness and improved performance of the sealer.

APPLICATIONS

The field evaluation phase of the study verified the provisions of the guide specifications developed during the initial phase. The addition of the heat-aging performance-related test to the generally accepted materials tests and current practice should result in the specifications being an improvement over those in use previously. The specifications are prepared in AASHTO format. Consequently, they are suitable for immediate application without being combined with other research results or modification to conform to conventional practices.

APPENDIX

GUIDE SPECIFICATIONS

MATERIALS

Both sealers and lubricant-adhesives shall meet the requirements of AASHTO Designation: M220-67 "Standard Specifications for Compression Joint Seals for Concrete" except for the deletion of "Permanent Set at Break" and "Weight Change in Oil." The properties and required limits from this specification are given in Table 1. In addition, the requirements given in Table 2 shall be met by the sealer.

The specimens used for determining the original force-deflection relationship will then be heat aged in an oven for 70 hr at 212 F (100 C) under 50 percent deflection. After heat aging, the specimens will again be subjected to force-deflection testing and shall comply with additional requirements given in Table 3.

A 15-ft (4.6-m) sealer length shall be submitted initially for testing to determine compliance with the requirements of these specifications. If it meets the requirements in the initial testing, the sealer will be approved for use. The sealer will be sampled again by the specifying agency upon delivery to the construction project and tested to determine uniformity and compliance. Three 6-ft (1.8-m) samples will be obtained from each lot on a random basis and tested. All samples shall comply with the specifications for a lot to be accepted.

The lubricant-adhesive shall have the physical properties given in Table 4.

The viscosity of the lubricant-adhesive shall be such that it will perform suitably with the application equipment. Any lubricant-adhesive not used within 9 months of manufacture will be rejected. (A bond strength using the actual joint sealers and the lubricant-adhesive with two concrete blocks is desirable. However, this study did not produce definable levels of acceptance, and further effort is needed.)

JOINT CONSTRUCTION

Transverse contraction joints shall be constructed in two stages. The first stage shall consist of sawing or forming the joint to prevent random cracking. This relief cut or the first stage shall be 1/8 in. (0.32 cm) minimum in width. The relief cut shall be a minimum of one-fourth the slab thickness in depth. The second-stage cut shall be made no earlier than 72 hr after the concrete is placed. It shall be cut to a width equal to 50 percent of the nominal joint sealer width planned for use. The width shall be appropriately adjusted for temperature extremes. A rule of thumb for adjusting width would be to add the amount of edge cracking in excess of the first stage cut width to the specified joint width. The width tolerance shall be plus or minus 5 percent of the nominal joint sealer width. The joints may be beveled with a 1/16 in. (0.16 cm) nominal, 1/4 in. (0.64 cm) maximum beveled edge.

TABLE 1

Property	AASHTO Test Procedure	Requirement
Tension	220-67	2000+(1.379 x 10^7 pascals)
Elongation at break, %, min.	220-67	250+
Hardness, Type A Durometer	(modified) 220-67	55$\pm$5
Oven aging, 70 hr, 212 F (100 C):	220-67	
Tensile strength change, %, max.		-30
Elongation change, %, max.		-40
Hardness change, points		+10
Ozone resistance, 20% strain, 300 pphm in air, 70 hr, 140 F (60 C)	220-67	No cracks
Preformed polychloroprene elastomeric joint sealers for concrete pavements:	220-67	
72 hr at 14 F (-10 C), 50% deflection		Min. recov. 88%
22 hr at -20 F (-28.9 C), 50% deflection		Min. recov. 83%
70 hr at 212 F (100 C), 50% deflection		Min. recov. 85%

TABLE 2

Deflection Based on Nominal Width (%)	Required Force Before Heat Aging (Force-Deflection Test)
7/16 in. (1.11 cm) and smaller joint sealer:	
20	2 lb/lin. in., min (357.2 gm per cm)
50	12 lb/lin. in., max. (2.14 kg per cm)
1/2 in. (1.27 cm) and larger joint sealer:	
20	3 lb/lin. in., min. (535.8 gm per cm)
50	12 lb/lin. in., max. (2.14 kg per cm)

TABLE 3

Deflection Based on Nominal Width (%)	Required Force After Heat Aging (Force-Deflection Test)
7/16 in. (1.11 cm) and smaller sealer:	
20	1 lb/lin. in., min. (178.6 gm per cm)
50	12 lb/lin. in., max. (2.14 kg per cm)
1/2 in. (1.27 cm) and larger sealer:	
20	1.5 lb/lin. in., min. (267.9 gm per cm)
50	12 lb/lin. in., max. (2.14 kg per cm)

The vertical pavement edge shall be sawed with a portable saw as a continuation of the transverse joint and the same depth and width. This edge joint will allow bending the sealer over the edge of the pavement to reduce water entering the joint through the edge of the slab.

Table 5 gives the sealer width, the joint width at 50 percent deflection, and the tolerance on the second saw cut.

After the joints have been sawed and cleaned, they shall be inspected for voids and spalls. Any voids or spalls in excess of the specified width plus tolerance, as given in Table 5, shall be patched with epoxy resin mortar. All loose, unsound, or damaged concrete shall be removed and the area shall be thoroughly cleaned by sand blasting or wire brushing. The area shall then be blown clean with use of compressed air. A heavy polyethylene sheet, or other rigid material covered with polyethylene film, shall be inserted into the joint groove and held tightly against the joint face that is to be patched. The concrete surface shall be clean and dry at the time of placing the epoxy resin mortar. The epoxy resin mortar shall normally consist of a mixture of 2 parts epoxy resin to one part curing agent for the epoxy binder. One part epoxy binder to 3.5 parts dry sand will be the normal mix. Some epoxy binder shall be used to prime the surface being repaired prior to placing the mortar mix. The mix shall be shaped to the original proper joint configuration.

Longitudinal joints shall be sawed in one stage to the proper width and depth. Normally a 7/16-in. (1.11-cm) preformed joint seal will be used for longitudinal joints. The saw cut shall be 7/32 in. (0.56 cm) in width and 2-1/2 in. (6.35 cm) in depth. The tolerances and repairs shall be as described for transverse contraction joints.

JOINT SEALING

All joints shall be sealed prior to traffic using the roadway. The joints shall be clean and dry at the time the joint sealer is installed. All joint sealers shall be machine installed. The installation equipment shall be approved by the Engineer prior to use. The joint sealers shall be installed in such a manner that elongation shall not exceed 5 percent and compression shall not exceed 2 percent. Lubricant-adhesive shall be used, and it shall be properly placed by the installation equipment at the time the joint sealer is placed. A sufficient quantity of lubricant-adhesive will be used to ensure adequate coating of the sealer surface for bonding to the concrete. Any lubricant-adhesive that gets on top of the sealer shall be removed.

The sealer shall be extended over the edges of the pavement placed in the vertical joints at both shoulders of the pavement to reduce water entering the pavement through the ends of the joints. The installed joint sealer shall be free of twisting, warping, and other defects. All improperly installed sealers shall be removed and replaced. The joint sealers shall be placed to a depth of 1/4 in. ± 1/16 in. (0.64 cm ± 0.16 cm) below the pavement surface. When joints are beveled the sealers shall be placed 3/16 in. ± 1/16 in. (0.48 cm ± 0.16 cm) below the bottom of the bevel.

TABLE 4

Property	ASTM Test Procedures	Requirements
Average net weight per gal lb		7.84 ± 5%
Solids content, % by wt.	D553	25± 3.0
Film tensile strength, psi, min.	D412	2300 (1.586×10^7 pascals)
Elongation before break, %, min.	D412	750

TABLE 5

Sealer Width (in.)	Joint Wdith (in.)	Width Tolerance (in.)
5/16 (7.94 mm)	0.156 (3.96 mm)	±0.016 (+0.41 mm)
7/16 (1.11 cm)	0.219 (5.56 mm)	±0.022 (±0.56 mm)
9/16 (1.43 cm)	0.281 (7.14 mm)	±0.028 (±0.71 mm)
11/16 (1.75 cm)	0.344 (8.73 mm)	±0.034 (±0.87 mm)
13/16 (2.06 cm)	0.406 (1.03 cm)	±0.041 (±1.03 mm)
1 (2.54 cm)	0.500 (1.27 cm)	±0.050 (±1.27 mm)
1 1/4 (3.18 cm)	0.625 (1.59 cm)	±0.063 (±1.59 mm)

The longitudinal joint sealers shall be placed first, and they shall not have pieces installed shorter than 200 ft (61 m) in length. After the longitudinal sealer is placed, it shall be notched and sealed with the lubricant-adhesive at the intersections with the transverse joints. The transverse joint sealers shall then be installed.

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