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FINAL REPORT

EVALUATION OF ELASTOMERIC CONCRETE IN BRIDGE EXPANSION JOINT HEADER REPAIR APPLICATIONS

Jennifer Distlehorst, EIT
John Wojakowski, P.E.
Kansas Department of Transportation

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16 **Abstract**

Elastomeric concretes were developed to prevent the spalling of the portland cement concrete adjacent to bridge deck expansion joints. Two types of elastomeric concretes were installed on I-135 bridges in Wichita in 1991. These joints and several others on I-135 with both elastomeric and conventional concrete header materials were surveyed annually for the next ten years. Spalling at each joint, rutting of the elastomeric materials and overall condition of the materials were measured and recorded. Laboratory tests of field-cast specimens were performed to determine the mechanical properties of the materials. The results of the tests and surveys show that the elastomeric concretes reduced spalling at bridge expansion joints. However, the joint headers formed of elastomeric concretes were as likely to develop distress as were the portland cement concrete joint headers.

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Final Report

Prepared by

Jennifer Distlehorst, EIT
Kansas Department of Transportation

and

John Wojakowski, P.E.
Kansas Department of Transportation

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ABSTRACT

Elastomeric concretes were developed to prevent the spalling of the portland cement concrete adjacent to bridge deck expansion joints. Two types of elastomeric concretes were installed on I-135 bridges in Wichita in 1991. These joints and several others on I-135 with both elastomeric and conventional concrete header materials were surveyed annually for the next ten years. Spalling at each joint, rutting of the elastomeric materials and overall condition of the materials were measured and recorded. Laboratory tests of field-cast specimens were performed to determine the mechanical properties of the materials. The results of the tests and surveys show that the elastomeric concretes reduced spalling at bridge expansion joints. However, the joint headers formed of elastomeric concretes were as likely to develop distress as were the portland cement concrete joint headers.

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Introduction

Problems associated with bridge deck expansion joint assemblies were commonly noted in the 1980's. Congested anchorage and the configuration of the flats resulted in poorly-consolidated portland cement concrete (PCC) in these areas. Incomplete consolidation produced low-strength concrete and air pockets allowed water to collect and freeze, resulting in spalling. Additionally, water leaked through the interface between the header material and the deck concrete. To address these issues, several bridge expansion joint manufacturers developed elastomeric concrete compounds for use in the expansion joint header area. The elastomeric concretes used a polymeric binder and a prescribed aggregate to form a tough, flexible joint header material. See Figure 1 for a schematic cross section of an expansion joint with elastomeric concrete headers.

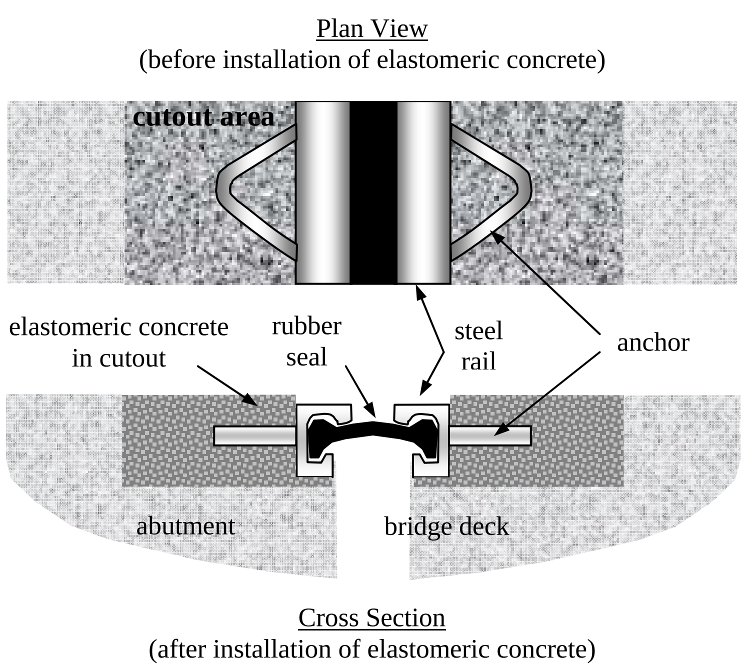

FIGURE 1: Typical Schematic of Bridge Expansion Joint, After the 2002 KDOT Bridge Design Manual

Project History

Maintenance contractors began using a hot-mixed elastomeric concrete for expansion joint rehabilitation projects on Kansas Department of Transportation (KDOT) bridges in the late 1980's. The material performed well in this area of the bridge deck in a maintenance installation and appeared to greatly reduce the spalling problem associated with traffic and snow plow blades.

In 1990, the Bridge Section of the KDOT Bureau of Design, proposed a controlled study to evaluate the performance of hot mixed and cold mixed elastomeric concretes in a side-by-side study of repairs on at least two expansion joints with similar movement, traffic loads and construction. The spalling resistance, rutting performance and overall integrity of each material would be evaluated. The southbound I-135 structure over the Arkansas River in Wichita, Kansas, (Bridge Number 006) was chosen for this project. Under Special Provision 90P-3011-R1, both cold and hot mixed elastomeric concretes were allowed on this project. The hot-mixed elastomeric concrete that had been used on I-135 bridge repairs the year before would be used for all but one joint on the project. Cold-mixed elastomeric concrete would be installed on one joint for the purposes of the study.

The Research Unit of the KDOT Bureau of Materials and Research incorporated the proposal into a formal experimental work plan. Under this plan, researchers would observe and record the installation of both elastomeric concrete products then monitor and record the performance of each annually.

The condition of additional hot-mixed elastomeric concrete expansion joint headers and portland cement concrete joint headers on other bridges on I-135 in Wichita were also monitored to provide additional data for comparison. Thirteen portland cement concrete-filled joint headers constructed between 1986 and 1989 were surveyed on each of the north and southbound I-135 viaduct bridges over the Canal Route. Eleven strip-seal style joints and two finger plate joints were surveyed on each bridge. All joint headers were filled with AAA-AE concrete and epoxy bonding glue was used to bond the header material to the deck concrete.

Twelve additional hot-mixed elastomeric concrete-filled expansion joint headers constructed in 1990 and 1991 were surveyed. These are referred to in this paper as “production WaboCrete” joints. Two of these joints were constructed in 1990 on the northbound I-135 bridge over the Arkansas River directly opposite the joints installed for the research project on the southbound bridge. Six of the hot-mixed elastomeric concrete-filled joint headers were located on southbound I-135 bridge over Pawnee Road and four were located on the northbound I-135 bridge over K-15. All ten of these joints were constructed in phases; the driving lane joints were installed in 1990 and the passing lane joints in 1991.

Methods: Installation and Annual Surveys

The materials selected for the study were Watson Bowman Acme’s hot-mixed WaboCrete and D.S. Brown’s cold-mixed Delcrete. WaboCrete is a heat cured elastomeric concrete. Delcrete is a polyurethane-based elastomeric concrete developed for use with D.S. Brown’s proprietary expansion joint systems. Both WaboCrete and Delcrete use two-component binders and a prescribed aggregate.

The elastomeric concretes were placed in September 1991. The contractor prepared the blockouts around the joints and cleaned the area prior to installation. The metal extrusions were suspended from steel angles in position above the cutouts and cleaned. WaboCrete, the hot applied material, was placed on the first joint. The two liquid resins were heated separately for about an hour in the manufacturer-supplied heating unit until they reached approximately 120 °F. While the resins were heating, a bag of pre-mixed aggregate was added to the mixer bucket and heated to 120 °F with a propane torch. The resins were drawn off the spigots individually into measuring cups and blended in a five-gallon bucket using a hand-drill mounted mixer. The resin mixture was added to the aggregate in the special WaboCrete mixing bucket and blended for approximately two minutes. This mixture was poured into the blockout area. The air temperature for the six-hour job ranged from 81 to 84 °F, so the material had optimum workability. Although the manufacturer specifies a minimum deck and air temperature of 35 °F, the material loses workability below 50 °F. The material was hand-compacted around the metal joint elements and troweled smooth. After installation the joint was hooded with a sheet metal duct and a propane hot air torpedo was used to heat the air in the duct to around 200 °F. The material cured within two hours of placement.

Cold-applied Delcrete-brand elastomeric concrete was used in the second test joint installation. Much of the existing concrete around this joint was in such poor condition that it was removed and replaced with a high early strength concrete epoxy-bonded to the existing concrete two days before the installation of the expansion joint. These concrete surfaces were primed with toluene and butanol before placement of the elastomeric concrete. The 40 foot long joint was installed in just over five hours, at air temperatures that ranged from 48° to 60° F. A manufacturer-supplied mixture of fiberglass and sand was used as aggregate. Both installations proceeded smoothly without major delays or mishaps.

Annual surveys of rut depth, extent of spalling and general condition of these two joints and the additional hot applied elastomeric joints on I-135 were conducted between 1992 and 2001. Rutting was measured on either side of the metal plate in each wheel path for a total of four measurements per joint per lane. Rutting was measured in both driving and passing lanes on the Arkansas River Bridges, but only in the driving lanes on the Pawnee Road and K-15 bridges. The general condition and spalling at the portland cement concrete expansion joint headers on the Canal Route viaduct bridges were recorded annually as well. Laboratory tensile and compressive tests of specimens made on-site of the Delcrete and Wabocrete were also performed.

Results

The elastomeric concrete joint header materials performed somewhat better than the portland cement concrete studied. Although the elastomeric joint header materials showed about the same level of distress as the portland cement concrete joint headers, the joints and the pavements adjacent to the elastomeric materials were in better condition than those surrounding the non-elastomeric joint headers.

<u>Laboratory Tests</u>

Wabocrete was found to be more brittle than Delcrete in the laboratory compression tests. The WaboCrete specimens reached failure at an average load of 1530 psi, which is 15% lower than the manufacturer's specified minimum strength of 1800 psi. The Delcrete specimens deformed plastically and were compressed to 75% of their height at 1100 psi. No significant difference in the tensile strengths of the two materials was found. See the appendix for test results and manufacturer specifications.

Joint Integrity

The cold-applied Delcrete-brand elastomeric concrete gave outstanding performance over the course of the study. No distress was recorded in the joint header material; in 2000, nine years after installation the surveyor commented that it “looks like new material.”

The WaboCrete brand hot applied elastomeric concrete performed quite well also. No distress was recorded on any WaboCrete joint until four years after installation, when one small (0.1 $m^{2)}$ area in the production WaboCrete on the northbound Arkansas River Bridge was reported to be cracked and depressed about 6.35 mm. Later surveys showed that the size of the distressed area and the extent of damage did not increase; the failure was limited in scope and was not progressive. No further such damage was reported until eight years after installation, when one 0.7 m^2 area was found to be cracked and crumbling.

Six years after installation, cracks across the width of the joint header appeared at the centerline, the location of the construction joints separating the production Wabocrete installed in 1990 from that installed the next year on both the K-15 and the Pawnee Road Bridges. More cracks appeared at these locations in subsequent years, but no other locations showed this pattern of distress.

By the end of the study, 2 of the 14 (14%) elastomeric concrete joint headers had deteriorated from “good” to “fair” condition at nine to ten years of age. Of the elastomeric materials, only the WaboCrete joints showed distress. Neither of the joint headers installed under optimal, controlled conditions for this study was distressed. Of the portland cement concrete headers, 6 of 16 (23%) were in fair condition at eleven to fourteen years of age. The portland cement concrete headers were all in good condition until the ninth year after construction, when rapid deterioration set in. Repairs were required on the deteriorated joints to keep them in serviceable condition. See Figure 2 for a comparison of overall performance of the two types of joint header materials.

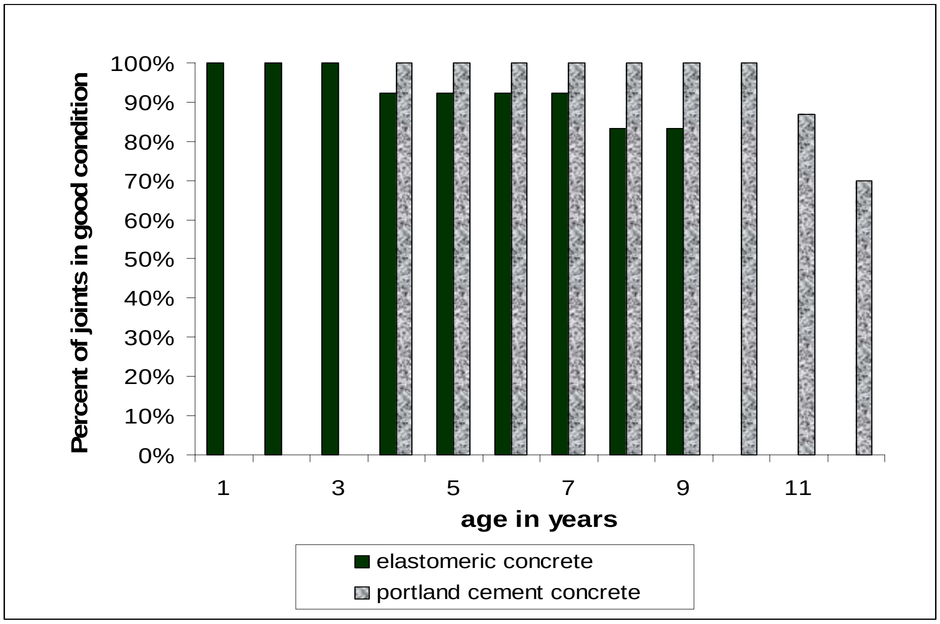

FIGURE 2: Condition of Bridge Expansion Joint Headers Constructed on I-135 Bridges in Wichita, Kansas, Between 1986 and 1991

Spalling Resistance

No spalling of the bridge decks adjacent to any of the joints was reported until the fourth year after construction, when one 76 mm spall was recorded in adjacent to an elastomeric concrete header and two spalls 240 mm in length were noted adjacent to the portland cement concrete headers. Spalling at the portland cement headers continued to be more common and of greater extent over the entire course of the study. At six years of age the portland cement concrete joints showed twice as much spalling per joint as the elastomeric concrete joints of the same age. In subsequent years, the decks with portland cement joints deteriorated much more rapidly than those with elastomeric joints. All of the spalling in the elastomeric joint headers occurred in the production installations. Neither the WaboCrete joint installed for this study nor the cold-applied Delcrete joint spalled within the duration of the study. See Figure 3 for a comparison of the spalling performance of the different types of concrete with time.

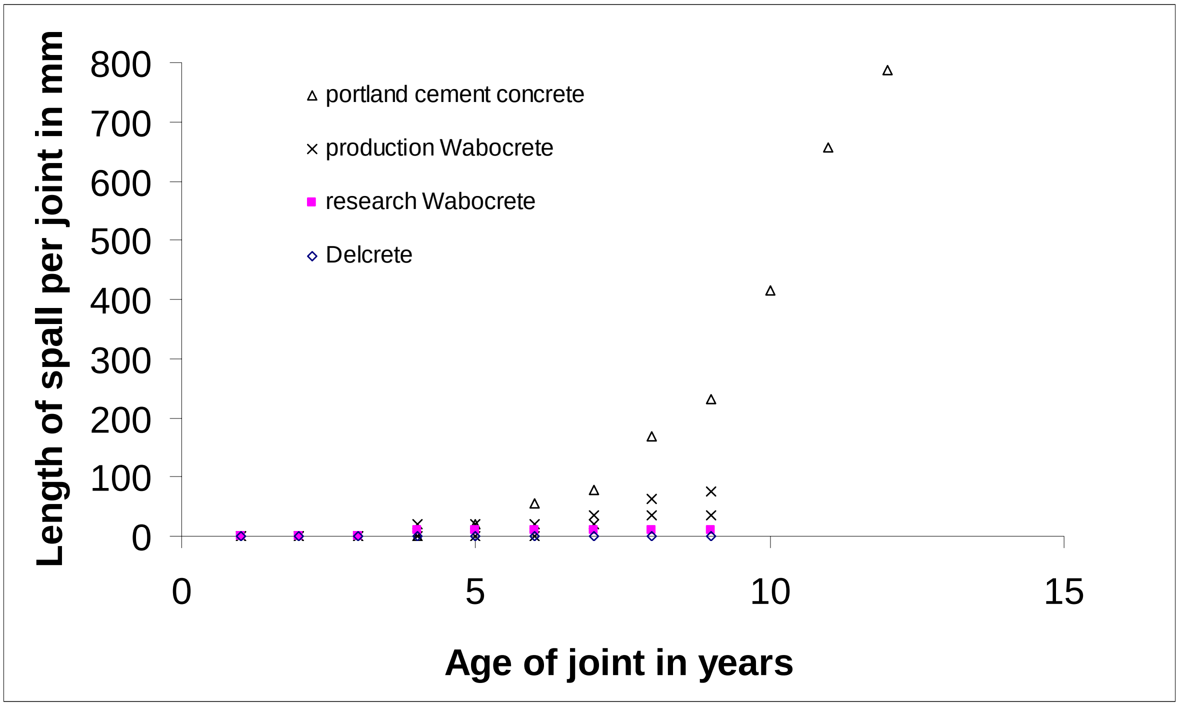

FIGURE 3: Comparison of Spalling Performance of Two Types of Elastomeric Concrete and Portland Cement Concrete Bridge Expansion Joint Headers Installed on I-135 in Wichita Between 1986 and 1991

Rutting Performance

The rutting performance of the two types of elastomeric concretes was also quite good. The Wabocrete material out-performed the Delcrete with consistently lower rutting measured every year of the study. This behavior is consistent with the laboratory test results that showed Delcrete to be softer and more likely to deform plastically than WaboCrete. At the end of the study the deepest measured rut was 4.5 mm in depth and the average rut was less than 3 mm in depth. If rutting continues at this rate, the Delcrete will have rutted 6.6 mm and the Wabocrete

5.1 mm after 20 years. See Figure 4. No rutting was observed in the portland cement concrete bridge headers.

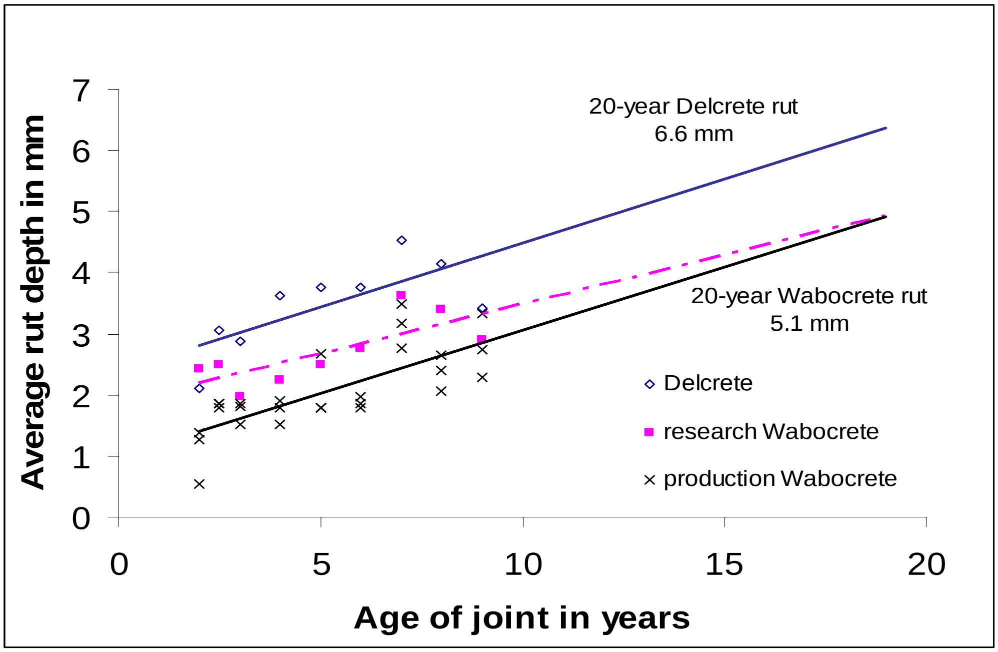

FIGURE 4: Comparison of Rutting Performance of Two Types of Elastomeric Concrete Expansion Joint Headers Installed on I-135 in Wichita, Kansas Between 1989 and 1991

Conclusion

Both the cold-applied elastomeric concrete (Delcrete) and the hot-applied elastomeric concrete (WaboCrete) reduced spalling dramatically in the bridge expansion joint header applications surveyed in this study. Although both of the joints installed under the supervision of researchers performed well and were in excellent condition at the end of the study, the elastomeric joint headers installed under production conditions were as likely to be distressed as the portland cement concrete joint headers. This distress, not rutting, is most likely to cause failures of the elastomeric concrete joint headers. The cold-applied Delcrete joint header material showed much less deterioration than the hot-applied WaboCrete.

APPENDIX

TABLE 1: Specified Properties of Combined Binder and Aggregate

Compressive Strength, psi		Tensile Load at Failure, lbs.	
WaboCrete	**Delcrete**	**WaboCrete**	**Delcrete**
1410	1325	385	292
1530	1260	310	293
1520	910	425	312
1540	910	270	405
1635	900	395	345
1530			355

TABLE 2: Specified Properties of Combined Binder and Aggregate

Physical Property	WaboCrete	Delcrete
Resilience @ 5% deflection, minimum	95 %	70%
Bond strength to concrete, psi, minimum	300-325	350
Wet bond strength to concrete, psi, minimum	250	250
Impact resistance (ball drop) @ -20 °F	no cracks	no cracks
Compressive strength, psi	1800-2000	800

TABLE 3: Specified Properties of Binder Only

Physical Property	Test Method	WaboCrete	Delcrete
Tensile strength, psi	ASTM D 638	750 to 1150	>1500
Elongation, %	ASTM D 638	200 to 350	> 200
Hardness, type D durometer	ASTM D 2240	35 ± 3	90 ± 3