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KOCH BRIDGE JOINT SYSTEMS

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FINAL REPORT

Under the Supervision
of
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June, 1993

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TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. FHWA/OK 93(08)	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE "KOCH BRIDGE JOINT SYSTEMS"		5. REPORT DATE April, 1993	
		6. PERFORMING ORGANIZATION CODE Item Number 2716	
7. AUTHOR(S) Gary G. Williams		8. PERFORMING ORGANIZATION REPORT	
		10. WORK UNIT NO.	
9. PERFORMING ORGANIZATION ADDRESS Oklahoma Department of Transportation Research and Development Division 200 NE 21st Street, Room 2A2 Oklahoma City, Oklahoma 73105		11. CONTRACT OR GRANT NO.	
		13. TYPE OF REPORT AND PERIOD COVERED Final Report August, 1991 - March 1993	
12. SPONSORING AGENCY NAME AND ADDRESS Federal Highway Administration 200 N.W. 5th Street, Room 454 Oklahoma City, Oklahoma 73102		14. SPONSORING AGENCY CODE	
		15. SUPPLEMENTARY NOTES Performed in cooperation with the Federal Highway Administration.	
16. ABSTRACT <p>In July and August of 1991, The Oklahoma Department of Transportation (ODOT) had 27 KOCH BRIDGE JOINT SYSTEMS (KOCH BJS) installed on an elevated portion of I-40, in downtown Oklahoma City.</p> <p>When the KOCH BJS Units were inspected in January, 1992, 9 units had cracked. By April, 1992, 12 units had cracked. ODOT often places sand and/or deicers on bridges during winter, and this type of material tends to collect in open cracks.</p> <p>The BJS Units were next inspected in July, 1992. During this survey, it was noted that most of the cracks observed earlier had "healed". This was thought to be due to bridge deck expansion compressing the BJS Units together and the action of the traffic on the units. Sand and small rocks could be seen compressed into the modified AC where the cracks had been located.</p> <p>By March 1993, 19 of the units had cracked. Several has spalls located along the outside edges of the units, or adjacent to the cracks. Two of the units had open areas completely through the BJS Units. This was considered to be a substantial failure of the units, and the evaluation was terminated.</p>			
17. KEY WORDS Water Tight Bridge Joint Systems.		18. DISTRIBUTION STATEMENT No restrictions. This publication is available from the Research and Development Division, Oklahoma DOT.	
19. SECURITY CLASSIF. (OF THIS REPORT) Unclassified	20. SECURITY CLASSIF. (OF THIS PAGE) Unclassified	21. NO. OF PAGES 28	22. PRICE

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

in ²	square inches	645.2	millimetres squared	mm ²
ft ²	square feet	0.093	metres squared	m ²
yd ²	square yards	0.836	metres squared	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	kilometres squared	km ²

VOLUME

fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft ³	cubic feet	0.028	metres cubed	m ³
yd ³	cubic yards	0.765	metres cubed	m ³

NOTE: Volumes greater than 1000 L shall be shown in m³.

MASS

oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

TEMPERATURE (exact)

°F	Fahrenheit temperature	$5(F-32)/9$	Celsius temperature	°C
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APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

mm ²	millimetres squared	0.0016	square inches	in ²
m ²	metres squared	10.764	square feet	ft ²
ha	hectares	2.47	acres	ac
km ²	kilometres squared	0.386	square miles	mi ²

VOLUME

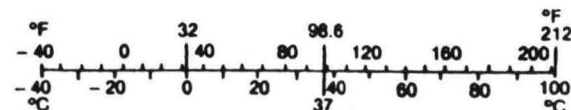
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m ³	metres cubed	35.315	cubic feet	ft ³
m ³	metres cubed	1.308	cubic yards	yd ³

MASS

g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T

TEMPERATURE (exact)

°C	Celsius temperature	$1.8C + 32$	Fahrenheit temperature	°F
----	---------------------	-------------	------------------------	----



* SI is the symbol for the International System of Measurement

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views of the Oklahoma Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation. While contractor names are used in this report, it is not intended as an endorsement of any machine, contractor, or product.

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INTRODUCTION

Between July 23rd and August 2, 1991, the Oklahoma Department of Transportation (ODOT) installed twenty seven (27) KOCH BRIDGE JOINT SYSTEMS (KOCH BJS) on I-40 in Oklahoma City. KOCH BJS unit locations are shown in Figure 1 and listed in Table 1. All of the installations were located on bridges making up an elevated section of I-40. ADT for this area is 80,000.

KOCH BJS units, and their installation, are described in an earlier Construction Report (1). Individual joint lengths and installation dates, are listed in Table 2.

Since installation, the KOCH BJS Units have been surveyed four times. On each of the surveys, some of the units were found to be cracked. The number of cracked units appears to increase with time, although many of the cracks close up as thermal expansion occurs during warm weather. The list of BJS unit locations from the Construction Report is repeated below for convenience in locating failures.

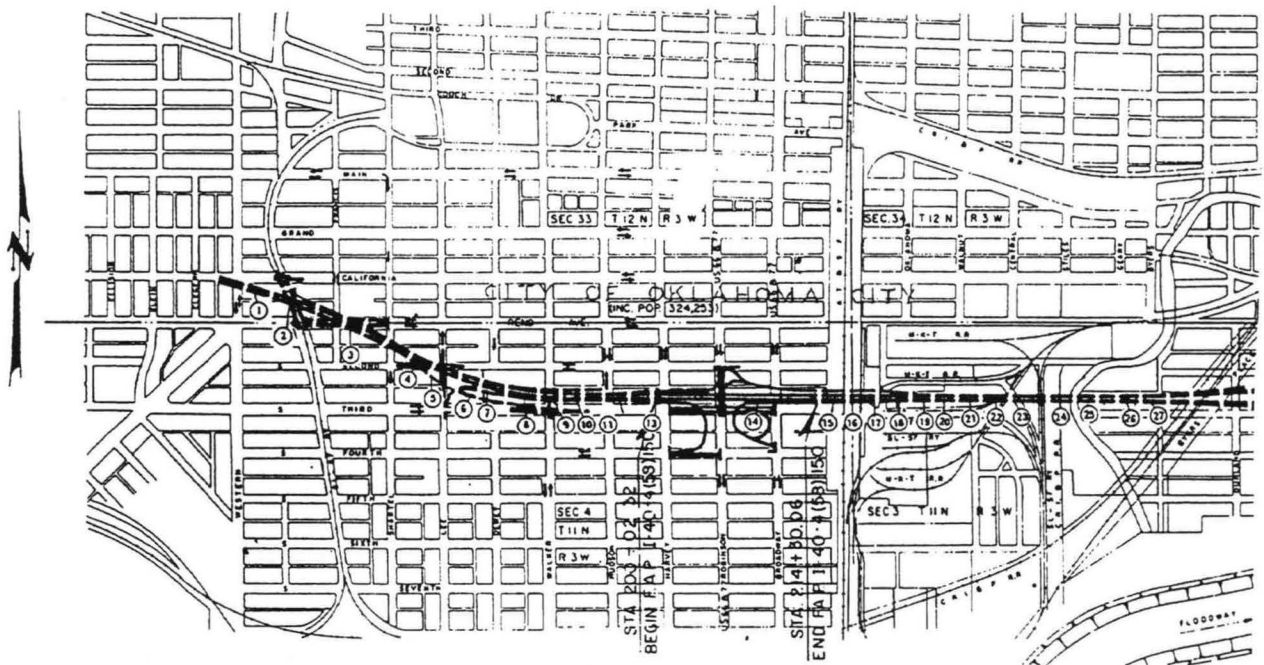


Figure 1. KOCH BJS Locations.

Table 1. KOCH BJS Unit Locations.

Unit Number and Location.

1. 200 feet east of Western Avenue Overpass.
2. 150 feet east of Classen Avenue Overpass.
3. 120 feet east of Francis Avenue Overpass.
4. 300 feet west of Lee Street Overpass.
5. 200 feet west of Lee Street Overpass.
6. Above west abutment, Walker Street Exit Ramp.
7. East end of Walker Street Exit Ramp.
8. Above west abutment, Lee Street Entrance Ramp.
9. East end of Lee Street Entrance Ramp.
10. 100 feet east of Lee Street Entrance.
11. 200 feet east of Lee Street Entrance.
12. 150 feet east of Hudson Street Overpass.
13. 100 feet west of Harvey Street Overpass.
14. 100 feet west of Broadway Avenue Overpass.
15. 100 feet east of Broadway Street Overpass.
16. 175 feet east of Broadway Avenue Overpass.
17. 300 feet east of Broadway Avenue Overpass.
18. 500 feet east of Broadway Avenue Overpass.
19. 650 feet east of Broadway Avenue Overpass.
20. 800 feet east of Broadway Avenue Overpass.
21. 1,000 feet east of Broadway Avenue Overpass.
22. 1,150 feet east of Broadway Avenue Overpass.
23. 1,250 feet east of Broadway Avenue Overpass.
24. 1,500 feet east of Broadway Avenue Overpass.
25. 1,700 feet east of Broadway Avenue Overpass.
26. 700 feet west of Lincoln Avenue Exit.
27. 500 feet west of Lincoln Avenue Exit.

Table 2. Joint Lengths and Installation Dates.

<u>BJS Unit</u>	<u>Joint Length</u> (feet)	<u>Date Installed</u>
1.	37.25	08-07-91
2.	37.16	08-07-91
3.	37.16	08-07-91
4.	37.33	08-07-91
5.	37.00	08-08-91
6.	18.00	08-15-91
7.	18.00	08-15-91
8.	18.00	08-15-91
9.	18.00	08-15-91
10.	37.00	08-08-91
11.	38.00	08-08-91
12.	50.00	08-09-91
13.	37.00	08-09-91
14.	49.00	08-09-91
15.	49.50	08-09-91
16.	47.25	08-12-91
17.	37.00	08-12-91
18.	37.08	08-12-91
19.	37.16	08-12-91
20.	37.00	08-13-91
21.	37.25	08-13-91
22.	37.00	08-13-91
23.	37.08	08-13-91
24.	37.16	08-13-91
25.	37.16	08-14-91
26.	37.00	08-14-91
27.	64.50	08-15-91

EVALUATION

The BJS Units have been surveyed four times since installation (Table 1). Observations from each survey are summarized below.

**Table 3. Survey Dates, KOCH
BJS Units**

<u>Survey</u>	<u>Date</u>	<u>Time Since Installation</u>
1.	January 9, 1992	5 Months.
2.	April 9, 1992	8 Months.
3.	July 10, 1992	11 Months.
4.	March 4, 1993	19 Months

A summary of the results of each survey is contained in Appendix "A".

January 9, 1992 Survey

Of the twenty-seven BJS Units, nine (33 percent) had some cracking at the time of this survey (Figures 2 - 4). Crack lengths ranged from half of the bridge width to full width. All of the cracks appeared to be located over the outside edges of the bridge plates. Due to the high ADT in this area, it was not practical to close lanes to test water-tightness of the joints with a water truck. Visual inspection indicated that cracks extended at least down to the bridge plate. The asphaltic plug in the expansion gap is directly below the bridge plate, so there is a possibility that the BJS Units may still have been functioning as water tight seals on the survey date.

Every winter, Oklahoma City has freezing rain, sleet, and other weather conditions which require bridges to be sanded or salted. Some of this material goes into open cracks (Figures 2 - 4). It was thought at the time of the survey that the cracks might close up (at least to some extent) in warmer weather, as thermal expansion of the decks occurs. However, the sand and salt would still be in the crack, and it was expected that they would crack more easily the next winter.

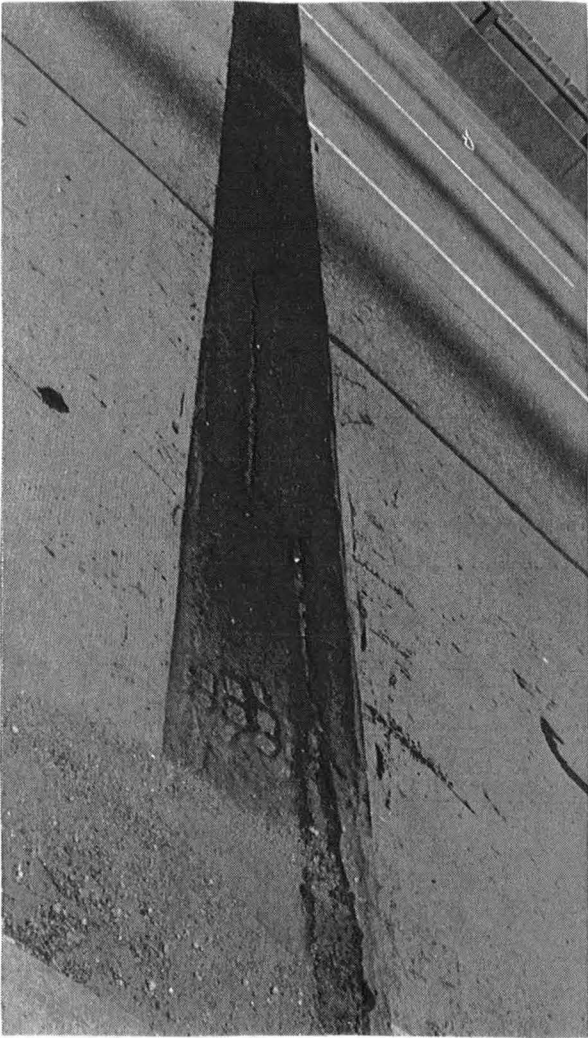


Figure 2. Typical Cracks in BJS Units,
January 9, 1992.

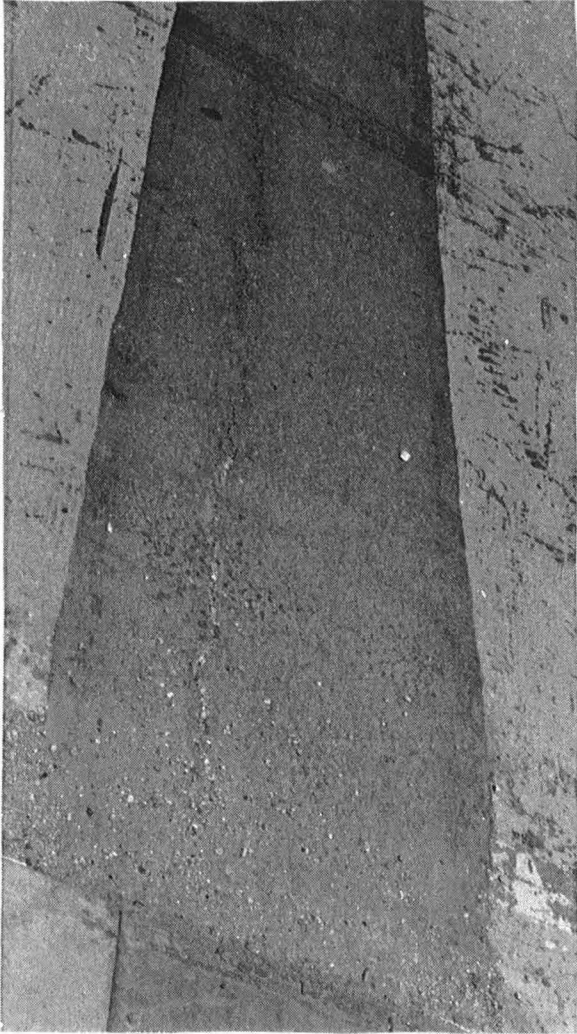


Figure 3. Cracks in BJS Units,
January 9, 1992.

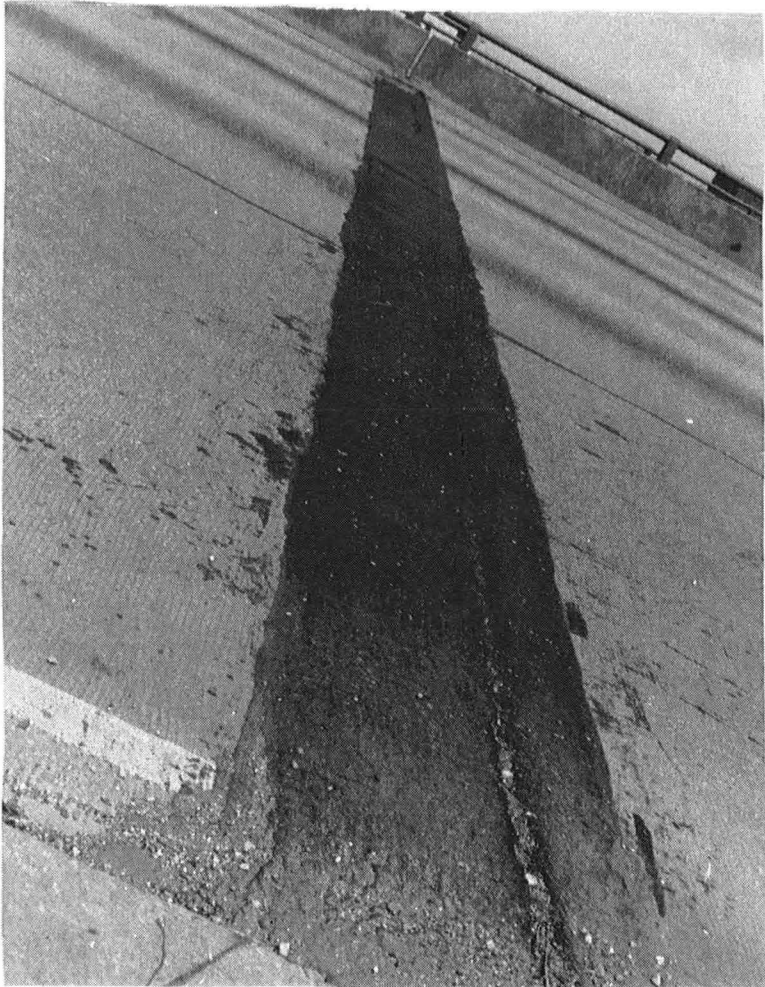


Figure 4. Cracks in BJS Units. January 9, 1992

April 9, 1992 Survey

Twelve of the twenty seven BJS units (44 percent) were found to be cracked during this survey. Crack lengths ranged from half of the bridge width to full width, as during the previous survey. Cracks which were not full width during the previous survey had lengthened, aside from this, there was no change in appearance of the cracks. As during the previous survey, all cracks appeared to be located over the outside edges of the bridge plates, and to extend (at least) down to the bridge plate. Appearance of the cracks was similar to that noted during the previous survey, including sand and salt collected in them, except that three more units had cracked.

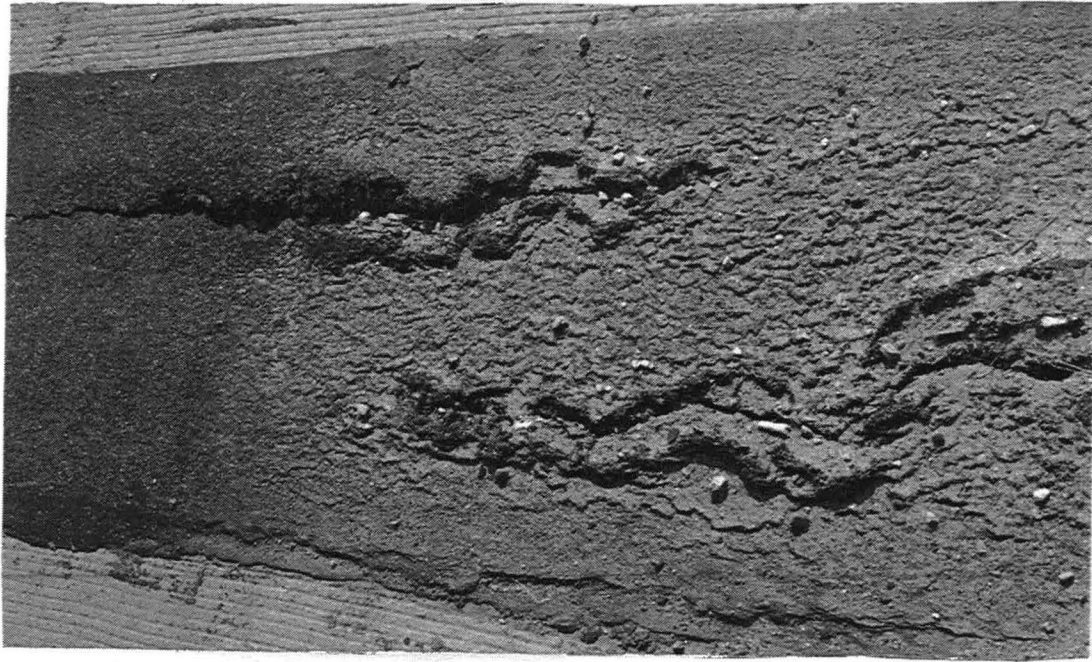
July 10, 1992 Survey

When this survey was done, all but two of the cracks noted during the two previous surveys appeared to have closed. A check with the Oklahoma City Maintenance Branch Manager confirmed that no work had been done on the BJS units, either by ODOT forces or the installation contractor's employees. Temperature at the time of this survey was higher than the previous surveys (Table 4). Because of this, the expansion gaps in the joints were closed relative to the January and April Surveys. The cracks appeared to have "healed". This was probably due to a combination of two actions, the expansion gaps closing and the action of the tires on the BJS units. On some of the units, the previous cracks could be seen as depressed areas (Figure 5). On others, sand, rock, and other foreign material could be seen compressed into the previously cracked area (Figure 6).

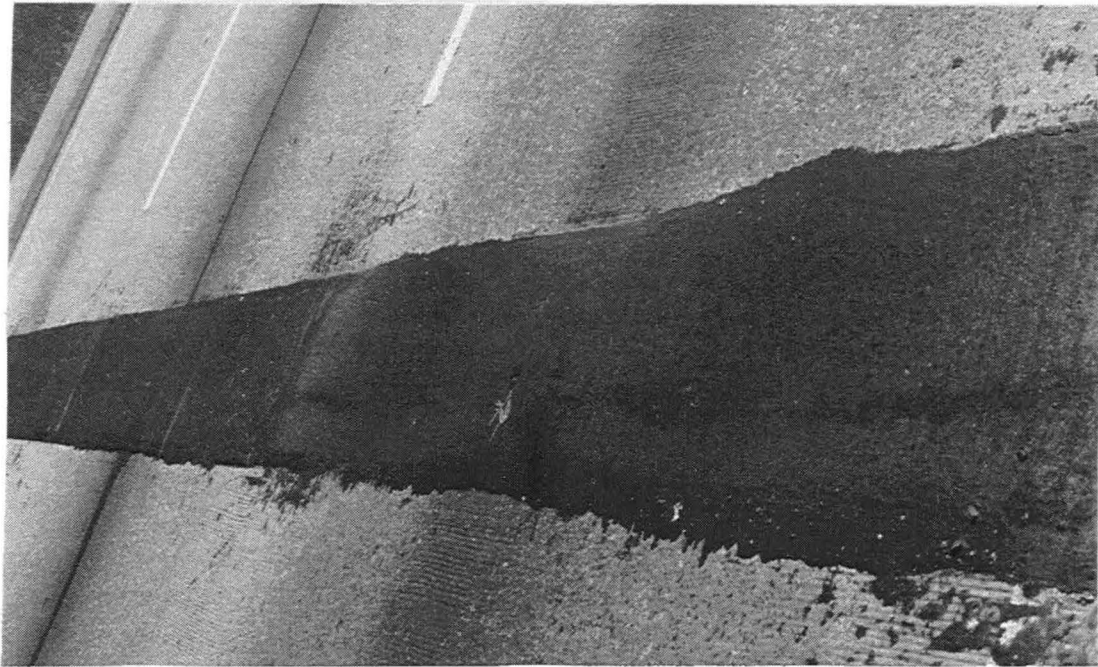
Table 4. Temperatures, Installation and Inspection Dates.

Date	Temperature (Degrees F)*	
	High	Low
<u>Installation</u>		
7-23-91	96	74
7-24-91	87	68
7-25-91	88	67
7-26-91	83	67
7-27-91	82	70
7-28-91	90	70
7-29-91	94	71
7-30-91	96	66
7-31-91	99	72
8-01-91	98	72
<u>Inspections</u>		
1-09-92	49	27
4-09-92	83	59
7-10-92	93	75
3-04-93	47	35

*From Oklahoma Climatological Survey.



**Figure 6. Previously Cracked BJS Unit.
Rock compressed into crack.**



**Figure 5. BJS Unit with "healed" crack
(depressed area).**



Figure 7. Cracked BJS Unit, 7-10-92.



Figure 8. Cracked BJS Unit, 7-10-92.

March 4, 1993 Survey

Nineteen of the twenty-seven BJS units (70 percent) were observed to be cracked during the survey. Also, there were two units where the bridge plate was either missing or moved out of position for part of the joint length, resulting in a joint without anything in that part of it (Figure 13). The other 17 cracked joints might (possibly) still be functioning as water-tight joints, but these have definitely failed. Cracking appears to be more severe than in previous surveys. Also, chunks of the KOCH Modified Asphalt Concrete making up the units have spalled along the cracks (Figures 10 and 11). Some spalls were also observed on the outside edges of the units (Figure 12).

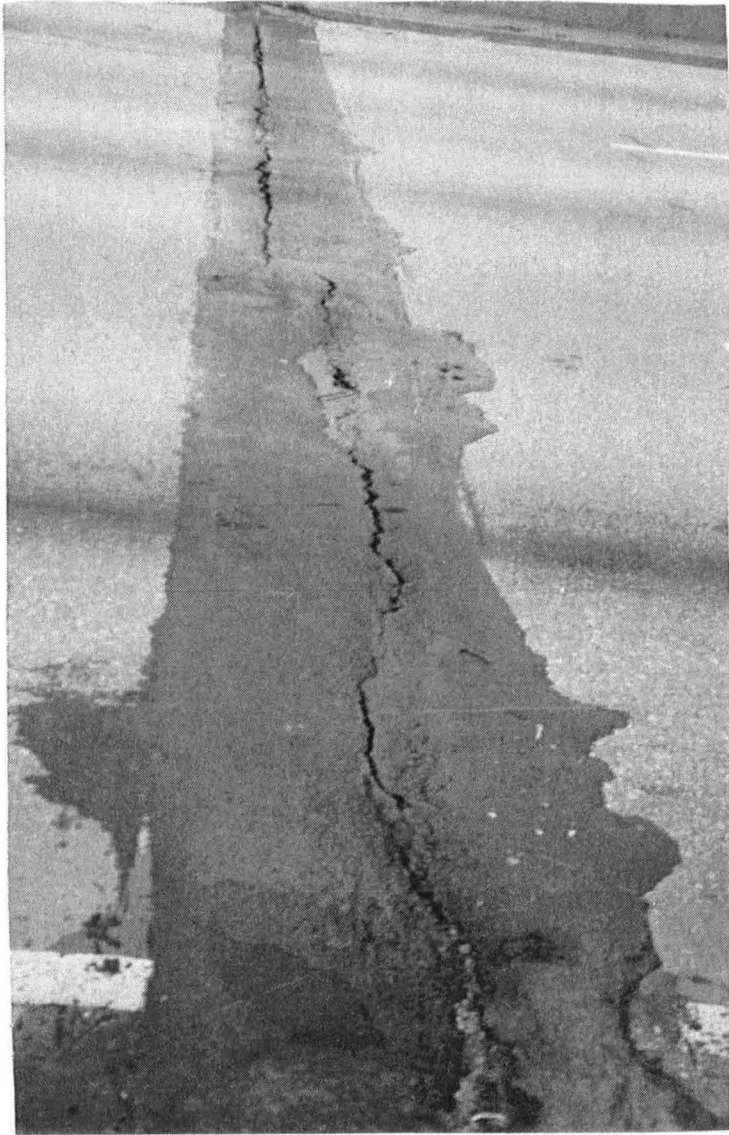


Figure 9. Typical cracked BJS Unit, March 4, 1993

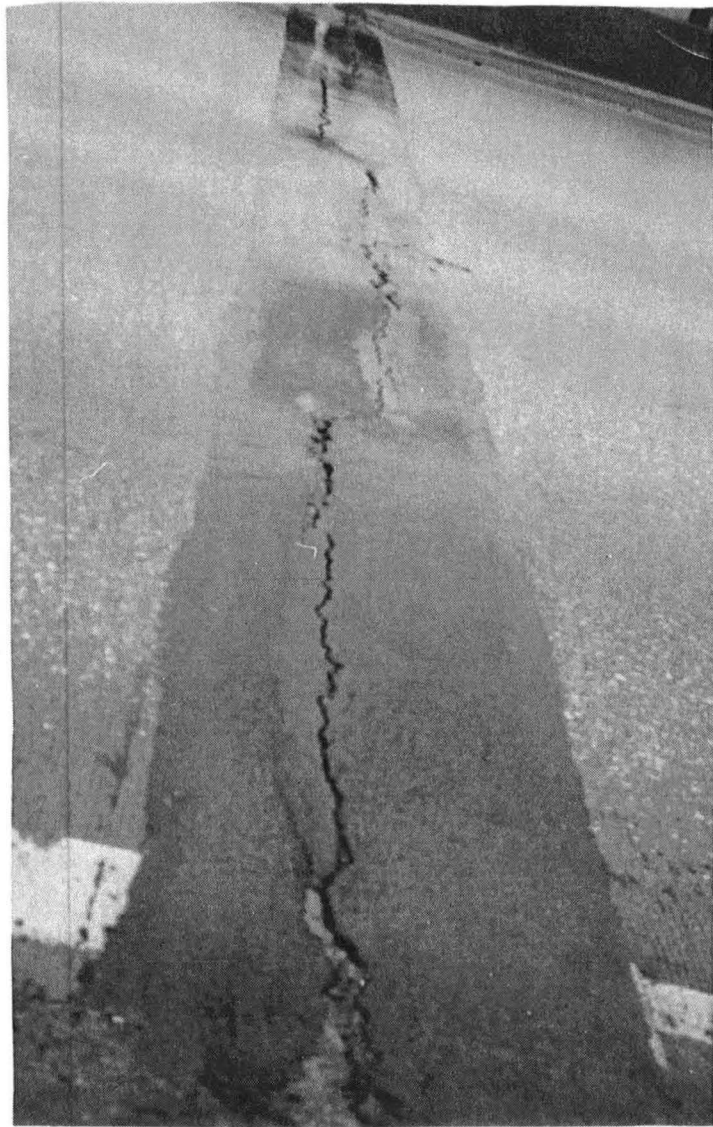


Figure 10. Typical cracked BJS Unit, March 4, 1993



Figure 11. Spalling at edge of BJS Unit,
March 4, 1993



Figure 12. Spalls at Edge of Unit and Along
Crack, March 4, 1993



**Figure 13. Hole through BJS, Part of Bridge
Plate Missing, March 4, 1993.**

DISCUSSION

Temperatures during installation and survey dates are listed in Table 4. Cracks have generally been developing during winter, and "healing" during summer. The amount of cracking during the second winter (1992 - 1993), was considerably worse than the first (1991 - 1992). Cracking will probably continue to get worse each winter, due to sand and other foreign matter being collected in the cracks during winter; then being compressed into the modified asphalt, during warmer weather.

Performance of the BJS Units might be improved if installation of the units was scheduled during cold weather, when joints would be in a relatively open position, due to contraction of the deck. Compression might then be a problem.

All cracks observed appear to be located over the outside edges of the BJS Bridge plates, and to extend (at least) down to the bridge plates. It is possible that some of the asphaltic plugs below the bridge plates may not be cracked.

With the amount of cracking that has occurred on the BJS Units, it appears likely that most are no longer sealed. Sand and debris that has been collecting in the cracks will work its way down to the expansion gap. With cracking above the expansion gap, there is nothing to keep water from collecting there, even if the gap itself is still sealed. With debris, sand, and water getting into joints that are constantly moving, any seals still in place will probably not last long.

When the BJS Units were installed, the president of Alpha Pavement Technology indicated that he thought that two of the joints had movement in excess of two inches. Two inches is the maximum amount the BJS Units are supposed to handle, under the two year warranty. His notes on the joints were not available, and he was not sure which two were subject to this amount of movement. Alpha Pavement Technology is licensed by Koch Materials Corporation for installation of BJS Units. This firm did the BJS Unit installation on this project. No calculation or analysis of joint movement was made as part of this study. Nineteen (70 percent) of the BJS Units are now showing cracks, spalls, or holes through the joint. Whatever the amount of movement in these joints is, the BJS Units are not able to absorb it without cracking.

Installation of the BJS Units was completed in August, 1991. The units are still in the two-year warranty period. It may be worthwhile to have them replaced or repaired under warranty. In a high ADT area such as this, user costs associated with repairs would also be high. This may indicate using another type of sealing system, with a longer demonstrated life, if the units are replaced.

REFERENCE

1. Williams, G., Installation of KOCH BRIDGE JOINT SYSTEMS on Board of Affairs Contract Number 100725, Oklahoma Department of Transportation, March, 1992.

APPENDIX "A", SURVEY RECORDS

SURVEY OF KOCH BJS UNITS, BOARD OF AFFAIRS CONTRACT 100725. SURVEYED 01-09-92

Unit Number	Failure Type	Percent Failed	Comments
1.	NA	0	In good condition. No cracking.
2.	Cracked	100	Some spalling along edge of crack. Width of crack is approx. 2" at spalls.
3.	NA	0	
4.	Cracked	62	Entire outside lane cracked. Spalling at edge of cracks in some spots. crack width at top of crack is 1" - 2" at spalls.
5.	NA	0	
6.	NA	0	
7.	NA	0	
8.	NA	0	
9.	NA	0	
10.	NA	0	
11.	NA	0	
12.	Cracked	67	Inside and outside lanes of a 3 lane section are cracked.
13.	Cracked	100	Some spalls at edges of cracks. Crack width is approx. 2" at spalls.
14.	Cracked	100	Some spalls at edges of cracks. Crack width is approx. 2" at spalls.
15.	NA	0	

SURVEY OF KOCH BJS UNITS, BOARD OF AFFAIRS CONTRACT 100725. Surveyed 01-09-92

Unit Number	Failure Type	Percent Failed	Comments
16.	NA	0	
17.	NA	0	
18.	NA	0	
19.	Cracked	50	Cracks are intermittent, distributed over entire width.
20.	Cracked	50	Cracks are intermittent, distributed over entire width.
21.	Cracked	100	Spalling at edges of crack. Crack width is approx. 2" at top of crack.
22.	NA	0	
23.	Cracked	100	Spalling at edges of crack. Crack width is approx. 1" at top of crack.
24.	NA	0	
25.	NA	0	
26.	NA	0	
27.	NA	0	

SURVEY OF KOCH BJS UNITS, BOARD OF AFFAIRS CONTRACT 100725. SURVEYED 04-09-92

Unit Number	Failure Type	Percent Failed	Comments
1.	NA	0	Appears to be in good condition. No cracking.
2.	Cracked	100	Crack extends through joint. Spalls along edge of crack.
3.	NA	0	
4.	Cracked	62	Entire outside lane cracked. Spalling at edge of cracks in some spots. Crack width at top of crack is 1" - 2" at spalls.
5.	NA	0	
6.	NA	0	
7.	Cracked	33	2/3 of outside lane cracked.
8.	NA	0	
9.	NA	0	
10.	Cracked	33	2/3 of inside lane cracked.
11.	NA	0	
12.	Cracked	67	Inside and outside lanes of a 3 lane section are cracked.
13.	Cracked	50	Intermittent cracking-distributed over entire length.
14.	Cracked	100	Some spalls at edges of cracks. Width of crack is approx. 2" at top of crack.
15.	Cracked	75	All cracked but 1/2 of inside lane.

SURVEY OF KOCH BJS UNITS, BOARD OF AFFAIRS CONTRACT 100725. Surveyed 04-09-92

Unit Number	Failure Type	Percent Failed	Comments
16.	Cracked	50	Outside lane cracked.
17.	NA	0	
18.	NA	0	
19.	NA	0	
20.	NA	0	
21.	Cracked	50	Intermittent cracking over entire length.
22.	NA	0	
23.	Cracked	33	2/3 of one lane cracked (2-lane area).
24.	Cracked	75	All but half of one lane cracked.
25.	NA	0	
26.	Cracked	50	Inside lane is cracked.
27.	NA	0	

SURVEY OF KOCH BJS UNITS, BOARD OF AFFAIRS CONTRACT 100725. SURVEYED 07-10-92

Unit Number	Failure Type	Percent Failed	Comments
1.	NA	0	Appears to be in good condition. No cracking.
2.	Cracked	100	Some spalling along edge of crack. Crack width at spalls is approx. 2" at top of crack.
3.	NA	0	
4.	NA	0	No cracking, but rocks and debris are compressed into the area where the crack was located.
5.	NA	0	
6.	NA	0	
7.	NA	0	
8.	NA	0	
9.	NA	0	
10.	Cracked	50	Intermittent cracking. Approx. half of each lane is cracked.
11.	NA	0	
12.	NA	0	No cracking, but there is a depression where the crack was located.
13.	NA	0	No cracking. Area where crack was located is visible (darker color).
14.	NA	0	Area where crack was located can be seen as a slight depression.
15.	NA	0	Rock (not the aggregate from the modified AC) is visible, compressed into the area where the crack was located.

SURVEY OF KOCH BJS UNITS. BOARD OF AFFAIRS CONTRACT 100725. Surveyed 07-10-92

Unit Number	Failure Type	Percent Failed	Comments
16.	NA	0	
17.	NA	0	
18.	NA	0	
19.	NA	0	
20.	NA	0	
21.	NA	0	No cracking, but area where crack was is depressed, also has some rock compressed into it.
22.	NA	0	
23.	NA	0	
24.	NA	0	
25.	NA	0	
26.	NA	0	
27.	NA	0	

SURVEY OF KOCH BJS UNITS, BOARD OF AFFAIRS CONTRACT 100725. SURVEYED 03-04-93

Unit Number	Failure Type	Percent Failed	Comments
1.	Cracked	20	Several short (approx. 3' long), intermittent cracks. Spall (1'X 1') on edge of unit.
2.	Cracked	100	Some spalling along edge of crack. Width of crack is approx. 4" at spalls.
3.	Cracked	50	Half of each lane cracked. Spalls along edges of crack. Width of crack at spalls is approx. 2".
4.	Cracked	100	Spalls along edges of crack. Width of crack is approx. 3" at spalls.
5.	NA	0	
6.	Cracked	100	
7.	Cracked	100	
8.	Cracked	100	
9.	Cracked	100	
10.	Cracked	100	Spalls along edges of crack. Width of crack is approx. 3" at spalls.
11.	Cracked	100	
12.	Cracked	80	Less than half of one lane is OK (not cracked).
13.	Cracked	100	Spalls along edge of crack. Crack width is approx. 3" at spalls. There is a hole, 3 1/2' X 6" completely through the BJS.
14.	Cracked	100	Some spalls at edges of cracks. Crack is up to 3" wide at spalls.
15.	Cracked	75	All of one lane cracked. Intermittent cracks in the other.

SURVEY OF KOCH BJS UNITS, BOARD OF AFFAIRS CONTRACT 100725. Surveyed 03-04-93

Unit Number	Failure Type	Percent Failed	Comments
16.	NA	0	
17.	NA	0	
18.	NA	0	
19.	Cracking	100	Crack is approx 4" wide in places due to spalls along edges of crack.
20.	Hole	12	Hole is approx. 3' X 8". No bridge plate, or any other material, left in it.
21.	Cracked	100	Spalling at edges of crack. Crack width is approx. 3" at top of crack.
22.	NA	0	
23.	Cracked	100	Spalling at edges of crack. Crack width is approx. 2" at top of crack.
24.	NA	0	
25.	Cracked	100	Spalling at edges of crack. Crack width is approx. 2" at top of crack.
26.	NA	0	
27.	NA	0	