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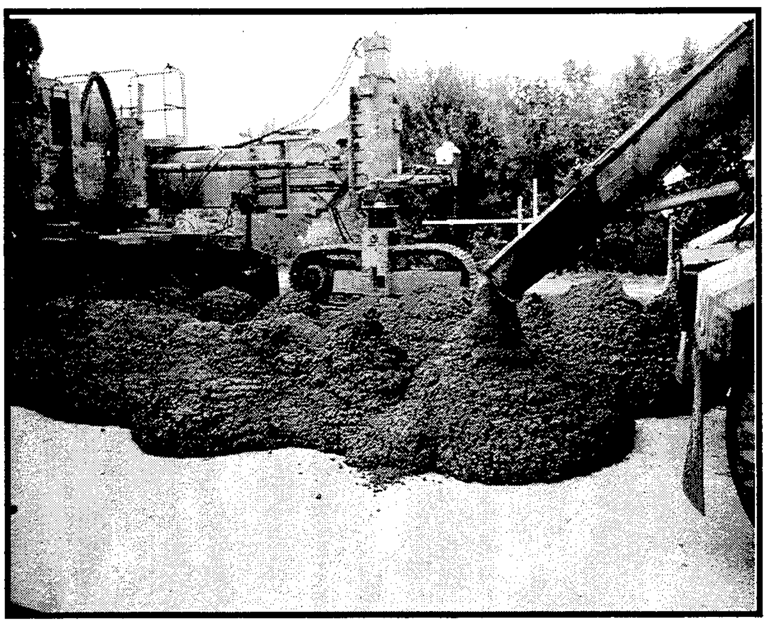
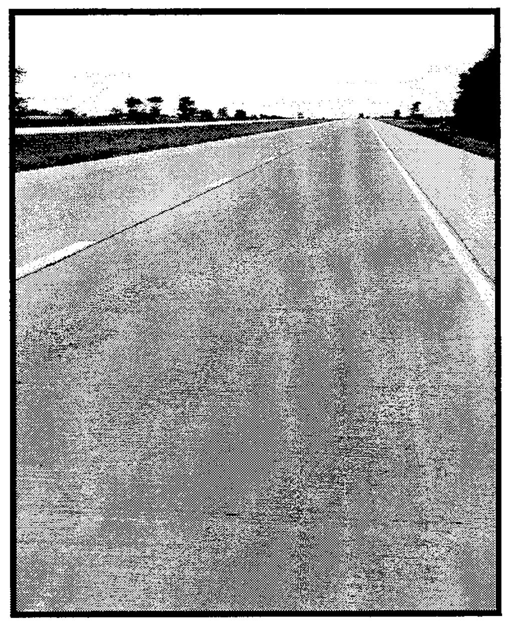
PERFORMANCE OF THIN BONDED CONCRETE OVERLAYS IN ILLINOIS





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Interim Report

PERFORMANCE OF THIN BONDED CONCRETE OVERLAYS IN ILLINOIS

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16. Abstract

In recent years, two bonded concrete overlays (BCO) have been constructed in Illinois. The first was constructed in 1994 - 1995 on a section of Interstate-80 (I-80), east of Moline, Illinois. The second bonded concrete overlay was placed in 1996 on a section of Interstate-88 (I-88), further east of Moline. Both the I-80 and the I-88 BCO sections were placed on 8-inch (203 mm) thick continuously reinforced concrete pavements. The I-80 BCO is 4 inches (102 mm) thick and includes six experimental sections with various percentages of microsilica added to the standard mix design and different bonding agents used between the original pavement and the BCO. The I-88 BCO is 3 inches (76 mm) thick and includes two experimental sections involving different surface preparation methods prior to BCO placement.

This report summarizes the performance of the bonded concrete overlays to date. Visual distress surveys were conducted annually on selected test sections of the I-80 and I-88 overlays. The I-80 and I-88 overlays were also tested annually for *International Roughness Index* values. *Condition Rating Surveys* were conducted every two years on I-80 and I-88 to define the overall condition of the pavement. The results of the tests and surveys are included in this report.

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DISCLAIMER

The content of this report reflects the views of the author, who is responsible for the facts and accuracy of the data presented herein. The content does not necessarily reflect the official views or policies of the Illinois Department of Transportation. This report does not constitute a standard, specification, or regulation.

EXECUTIVE SUMMARY

In 1992, the Bureau of Materials and Physical Research (BMPR) canvassed the state for pavements that would be suitable for a bonded concrete overlay (BCO). Candidate sections were then submitted to top management for approval. A section of I-80 was selected in 1993 as the first BCO project. Approximately a year later, a section of I-88 was selected as the second BCO project. The I-80 BCO, constructed in 1994 - 1995, includes six experimental sections with various percentages of microsilica added to the standard mix design and different bonding agents used between the original pavement and the BCO. The I-88 BCO, constructed in 1996, includes two experimental sections involving different methods of preparing the surface of the original pavement before the BCO was placed.

Rehabilitation was necessary on the I-80 BCO soon after construction. A patching contract for I-80 was awarded in November 1997 and was completed by October 1998. In contrast, the I-88 BCO performance has been excellent. No rehabilitation has been necessary on I-88 since the overlay was constructed.

Pre-construction and annual post-construction visual distress surveys have been conducted on I-80 and I-88. The pre-construction surveys of I-80 indicate that the eastbound and westbound lanes appeared to be in about the same condition before the overlay was placed. However, I-80 post-construction distress surveys indicate that the eastbound lanes have deteriorated more rapidly than the westbound lanes. Distress surveys of I-88 before construction of the BCO indicate that the eastbound and westbound lanes appeared to be in very good condition. Recent distress surveys indicate that I-88 remains in good condition to date.

International Roughness Index (IRI) values decreased after construction of the I-80 and I-88 overlays. The I-80 average IRI values gradually increased in the years after construction but decreased significantly after sections of the I-80 BCO were patched in

1998. The I-88 average IRI values have not fluctuated significantly since construction of the BCO in 1996.

The Condition Rating Survey (CRS) ratings for I-80 and I-88 improved with the overlays, as expected. Prior to the construction of the overlay, the I-80 CRS value of 6.3 indicated that the pavement was in good condition. At the time that I-80 was submitted to top management as one candidate for a BCO, the 1992 CRS was not yet available but was estimated to be 6.5. Furthermore, the section of I-80 under consideration was not included in the current Illinois Department of Transportation proposed five-year improvement program. By the time the I-80 BCO was constructed, the CRS rating was estimated to be 6.1.

Even though the I-80 BCO was assigned a CRS of 9.0 in 1994, the year of construction, it quickly decreased to 6.9 in 1996, just two years after construction. A 1998 CRS value of 7.7, the most recent CRS value available for I-80, indicates that the patching completed in 1998 significantly improved the condition of the I-80 BCO. The 1994 CRS value of 7.8, assigned to I-88 before the BCO, indicates that the pavement was already in excellent condition. Furthermore, the 1998 CRS value for I-88 of 8.2 verifies that the BCO is still in excellent condition.

Traffic loading is one factor that has influenced the performance of the I-80 and I-88 overlays. Since the construction of the bonded concrete overlays, the cumulative equivalent single axle loads (ESALs) to date are 8.7 million on the I-80 BCO and 3.2 million on the I-88 BCO.

This is an interim report. Performance will continue to be monitored for at least another year. A final report covering the constructability, cost, and performance of the I-80 and I-88 bonded concrete overlays is planned for completion by 2001. Conclusions and recommendations will also be included in the final report.

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INTRODUCTION

The most common rehabilitation method for existing pavements in Illinois is the asphalt concrete (AC) overlay. The current Illinois Department of Transportation (IDOT) policy for interstate AC overlays generally requires a thickness of 3.25 inches (83 mm). Policy overlays are expected to last approximately 8 to 12 years [1].

As an alternative to policy overlays, the bonded concrete overlay (BCO) was investigated by IDOT for the purpose of extending the rehabilitation life of overlays on bare concrete pavements. The BCO is expected to last at least 20 years with minimal maintenance necessary [2]. While a 3.25 inch (83 mm) AC overlay is expected to hold the same traffic as the original pavement, a typical BCO is a structural overlay designed to allow an increase in the load carrying capacity of the pavement.

In 1992, the Bureau of Materials and Physical Research (BMPR) canvassed the state for pavements that would be suitable for a BCO. Candidate sections were then submitted to top management for approval. A section of I-80 was selected in 1993 as the first BCO project, and approximately a year later a section of I-88 was selected as the second BCO project. The I-80 and I-88 BCO sections, both located in District 2, were placed on 8-inch (203 mm) thick continuously reinforced concrete pavements (CRCP). Table 1 summarizes the BCO contract numbers, locations, milepost limits, and dates of construction. The I-80 and I-88 project maps are located in Appendix A.

Table 1

I-80 and I-88 Bonded Concrete Overlays

Marked Route	Contract #	Direction	Milepost Limits	Paving Dates
Interstate 80	84815	Eastbound	1.7 to 3.4	October 7 - October 13, 1994
		Westbound	3.4 to 1.7	April 21 - April 28, 1995
Interstate 88	84988	Eastbound	13.3 to 16.4	April 18 - May 1, 1996
		Westbound	16.4 to 13.3	June 4 - June 14, 1996

The I-80 BCO is 4 inches (102 mm) thick and includes six experimental sections in each direction. The typical concrete mix design was modified with various percentages of microsilica. Furthermore, different bonding agents were used between the original pavement and the BCO. The following combinations are included in each direction of I-80:

- no microsilica with no grout
- no microsilica with microsilica grout
- 3% microsilica with no grout
- 3% microsilica with microsilica grout
- 5% microsilica with no grout
- 5% microsilica with microsilica grout

The I-88 BCO includes two experimental sections involving different surface preparation methods prior to BCO placement. The I-88 BCO is 3 inches (76 mm) thick with no grout used as a bonding agent. Two experimental sections of original pavement surface preparation are included in the I-88 BCO. The two methods of surface preparation are as follows:

- cold milling with light shot blasting (eastbound)
- shot blasting (westbound)

Rehabilitation was necessary on the I-80 BCO soon after construction. A large percentage of the transverse cracks that had appeared in the I-80 BCO spalled severely. A patching contract for I-80 was awarded in November 1997 and was completed by October 1998. Table 2 contains the final full-depth and partial-depth patching quantities for the I-80 BCO. Full-depth patching involved the removal of the BCO along with the original pavement; partial-depth patching involved the removal of only the BCO. Both the full-depth and partial-depth patches extend across the entire width of the lane. The length of patches included in Table 2 is the total lineal feet (and meters) of patching completed in the lane indicated in the first column.

Table 2

Final Patching Quantities for I-80 Bonded Concrete Overlay

(Contract # 64059)

Direction (Driving Lane - DL Passing Lane - PL)	Length of Full-Depth Patches	Length of Partial-Depth Patches	Percent of Total Length Patched	Construction Dates
Eastbound - DL	684.12 ft (205.52 m)	0	7.75%	May 1998
Eastbound - PL	0	6.36 ft (1.94 m)	0.07%	October 1998
Westbound - DL	0	137.11 ft (41.79 m)	1.55%	July 1998
Westbound - PL	0	25.00 ft (7.62 m)	0.28%	October 1998

Traffic loading is one factor that has influenced the performance of the I-80 and I-88 overlays. Since the construction of the bonded concrete overlays, the cumulative equivalent single axle loads (ESALs) to date are over 2.5 times higher on the I-80 BCO than on the I-88 BCO. See Table 3 below for design traffic information and cumulative ESALs to date on the I-80 and I-88 overlays.

Table 3

Traffic Data on I-80 and I-88 Bonded Concrete Overlays

Route	Design Average Daily Traffic	Design Percent Multiple Unit Trucks	Design Traffic Factor	Cumulative ESALs (million)
I-80	21,100	14.0%	19.50	8.7
I-88	11,700	17.1%	13.13	3.2

PERFORMANCE

Visual Distress Surveys

Test sections for visual distress surveys were identified for the I-80 and I-88 BCO projects before construction. Typically, at least one test section was selected for each experimental section contained in the BCO projects. See the I-80 and I-88 project maps in Appendix A for clarification on the station limits of the experimental sections. Distress surveys were conducted in those test sections just before construction and annually after construction. A summary of the pre-construction distress surveys can be found in Tables 4 - 5 for I-80 (see pp. 12 - 13) and Table 6 for I-88 (see p. 14). Tables 7 - 9 (see pp. 15 - 17) contain summaries of the annual distress surveys after construction. Definitions of each distress included in Tables 4 - 9 are taken from the IDOT Pavement Distress Manual. Copies of those definitions are included in Appendix B.

The I-80 BCO contains six different experimental sections with replicates in each direction for a total of 12 experimental sections. Each section contains a 500-foot (152.4 m) test section for detailed monitoring. Therefore, a total length of 6000 feet (1828.8 m) has been surveyed annually on the I-80 BCO. For the I-88 BCO, one experimental section is located in the westbound lanes and the other is located in the eastbound lanes. The test sections for the I-88 distress surveys are 1000 feet (304.8 m) in length. A total of six test sections were selected for the I-88 annual distress surveys: three in the eastbound direction and three in the westbound direction. Therefore, a total length of 6000 feet (1828.8 m) has also been surveyed annually on the I-88 BCO.

The pre-construction surveys of I-80 indicate that the eastbound and westbound lanes appeared to be in about the same condition before the overlay was placed. However, I-80 post-construction distress surveys indicate that the eastbound lanes have deteriorated more rapidly than the westbound lanes. A large number of low severity cracks were found in the eastbound lanes within two years after construction of the

BCO. After three years, visible transverse cracking increased and several of the older cracks deteriorated to moderate and high severity. Naturally, fewer transverse cracks were found in the eastbound test sections after patching was completed in 1998. Since transverse cracking of continuously reinforced slabs is a normal occurrence, it is not in itself considered to be a distress [3]. However, open transverse cracks with spalling or faulting were included as distresses in the surveys.

Fewer transverse cracks were found in the westbound lanes of I-80. Furthermore, the severity of the transverse cracks remained low in the first few years after the BCO was constructed. However, by 1998, when the westbound lanes of the I-80 BCO were approximately three years old, a number of the transverse cracks in the westbound lanes had progressed to the moderate severity level.

See Tables 7 - 8 (see pp. 15 - 16) for a comparison of the distress quantities in the 500-foot (152.4 m) test sections of I-80. The '0% microsilica with no grout' section was the only test section found to contain longitudinal cracks in the eastbound lanes of I-80. This section was also the only test section in the eastbound lanes that contained longitudinal cracking in the original CRCP pavement. Attempts were made to prevent the longitudinal crack from reflecting through the BCO. Before construction of the BCO, a partial depth patch with #5 tie bars was placed over the crack. Concrete was then placed in the patch monolithically with the overlay [4]. However, the longitudinal crack eventually reflected through the BCO. Apparently this method was not effective.

By 1997 (year 3), the '0% microsilica with no grout' section in the eastbound lanes contained several low and moderate severity transverse cracks. However, no patches were placed within the test sections of the '0% microsilica with no grout' section and the '0% microsilica with grout' section in 1998. For this reason, one might notice in Table 7 that the quantities of distresses increased in those test sections but decreased in the other test sections in 1998 (year 4).

The '5% microsilica with no grout' test section in the eastbound lanes contained the most transverse cracks in the last three annual distress surveys. Furthermore, it also contained the greatest length of patching in 1998. While the '5% microsilica with grout' test section in the eastbound lanes contained the smallest number of transverse cracks by 1997, the cracks were moderate to high severity. Thus, in 1998, a relatively large number of patches were placed in that section as well.

In the westbound lanes, two test sections appear to be in very good condition: the '0% microsilica with no grout' section, and the '0% microsilica with grout' section. No transverse or longitudinal cracks were found in those sections during any of the annual surveys. The '3% microsilica with no grout' section is the only test section in the westbound lanes that contained longitudinal cracking. It also contained a relatively large number of transverse cracks by 1998. However, the '5% microsilica with no grout' section contained the largest number of transverse cracks by 1998. Since none of the patches in the westbound lanes of I-80 were placed within the test sections, no patching quantities are included in Table 8.

In both the eastbound and westbound lanes of the I-80 BCO, the majority of the test sections in which grout was not used contained more cracks than the corresponding test sections in which grout was used. The exceptions to that finding are the test sections in the eastbound lanes with 3% microsilica and the test sections in the westbound lanes with 0% microsilica. The 3% microsilica with no grout test section in the eastbound lanes contained fewer cracks than the corresponding 3% microsilica test section in which grout was used. As mentioned earlier, neither of the test sections containing 0% microsilica in the westbound lanes contained any cracks.

Based on the visual distress surveys, I-88 appeared to be in very good condition both before and after construction of the BCO. As shown in Table 9, the post-construction surveys indicate that the test sections in the eastbound lanes (the 'cold milling with light shot blasting' experimental section) contained very few longitudinal or transverse cracks. The test sections in the westbound lanes (the 'shot blasting' experimental section) contained no longitudinal or transverse cracks.

International Roughness Index

Bar charts of the average International Roughness Index (IRI) values are presented in Figure 1 for I-80 (see p. 18) and Figure 2 for I-88 (see p. 19). Average IRI values are calculated from the IRI data stored in the Illinois Pavement Feedback System for a given segment of interstate in a given year. IRI state averages are also included in Figures 1 - 2.

The average IRI values decreased after construction of the I-80 and I-88 overlays, as expected. The I-80 average IRI values increased slightly between 1995 and 1997 but decreased significantly after sections of I-80 were patched in 1998. The I-88 average IRI values have not fluctuated significantly since the construction of the BCO.

With the exception of the average IRI value for I-80 westbound, the I-80 and I-88 average IRI values were significantly higher (i.e. rougher) than the state average before the construction of the overlays. The average IRI value for the westbound lanes of I-80 was lower (i.e. smoother) than the state average before the construction of the overlay. After the construction of the overlays, the I-80 average IRI values were slightly below the state average, while the I-88 average IRI values were well below the state average. By 1997, the I-80 average IRI values had increased and were equivalent to the state average but decreased to well below the state average after sections of the I-80 BCO were patched in 1998. The I-88 average IRI values have remained well below the state averages to date. Currently, the I-80 and I-88 overlays are smoother than the state average.

Condition Rating Surveys

IDOT conducts Condition Rating Surveys (CRS) to determine the overall condition of the state highway system. The CRS values range from 1.0 (failed) to 9.0 (new pavement). The condition of the highways is categorized according to the following scale [5].

CRS Range	Category
1.0 to 4.5	Poor
4.6 to 6.0	Fair
6.1 to 7.5	Good
7.6 to 9.0	Excellent

I-80 and I-88 CRS values are available for the even years and are presented in Figures 3 - 4 (see pp. 20 - 21). These figures include CRS values from the even year before construction of the BCO to 1998. Projects in the Annual Program (projects to be constructed or rehabilitated in the year of the CRS) are assigned a CRS value of 9.0 for that year. When BMPR recommended I-80 as a potential candidate for a BCO, the 1992 CRS value was not yet available but was estimated to be 6.5. At that point, the section of I-80 in consideration was not in the current IDOT 5-year improvement program. The 1992 CRS was eventually recorded to be 6.3, slightly lower than the estimated CRS for that year.

The 1992 CRS is the last available for I-80 that represents the condition of the pavement before the BCO. Since I-80 was planned for rehabilitation in 1994, it was assigned a CRS value of 9.0 in 1994. However, the actual 1994 CRS value of 9.0 does not accurately reflect the condition of the pavement just before the BCO was placed. As mentioned previously, the CRS assigned to I-80 in 1992 was a 6.3. By the time of the construction of the I-80 BCO in 1994 - 1995, the CRS value obviously decreased. With appropriate deduct values subtracted from the 1992 CRS value, an estimated CRS value for 1994 is 6.1. A CRS of 6.1 is at the bottom of the scale for a pavement considered to be in "good" condition.

At times, incipient distresses are not visible during a CRS but can deteriorate very quickly. As quickly as some of the cracking deteriorated in the I-80 BCO, it is very possible that the CRS value was even lower than the estimated 1994 CRS by the time the overlay was placed. Just a year after construction of the BCO, the CRS value for I-80 quickly dropped from 9.0 (an "excellent" rating) to 6.9 (a "good" rating). However, after patching was complete in 1998, the CRS value increased again to 7.7 (an "excellent" rating).

The CRS value of 7.8 assigned to I-88 in 1994 (before the BCO) indicates that the pavement was already in excellent condition. Like I-80, I-88 was assigned a 9.0 in 1996 (the year the BCO was constructed). With appropriate deduct values subtracted from the 1994 CRS value, an estimated CRS value for 1996 is 7.6 (an "excellent" rating). In 1998, two years after the construction of the overlay, I-88 was assigned a CRS value of 8.2 (an "excellent" rating).

SUMMARY

Significant differences have been observed in the performance of the I-80 and I-88 bonded concrete overlays. While the I-88 BCO has been performing very well, the I-80 BCO, particularly the overlay in the eastbound direction, was in need of rehabilitation only a few years after construction. Transverse cracking and other distresses had progressed from low severity to high severity in a short period of time. The I-80 average IRI values increased slightly between 1995 and 1997 (more so in the eastbound lanes). The I-80 CRS value was 6.9 in 1996, just two years after construction. After the I-80 BCO section was patched in 1998, the IRI values improved significantly and the CRS improved to 7.7.

No rehabilitation has been necessary on the I-88 BCO, even though it was constructed only one to two years after the I-80 BCO. Distresses on I-88 have been minimal and include mostly low severity transverse and longitudinal cracking. Average IRI values on the I-88 BCO have changed very little between 1996 and 1998; and in 1998, two years after construction of the BCO, I-88 was assigned a CRS of 8.2.

Traffic loading is one factor that has influenced the performance of the I-80 and I-88 overlays. Since the construction of the bonded concrete overlays, the cumulative equivalent single axle loads (ESALs) to date are 8.7 million on the I-80 BCO and 3.2 million on the I-88 BCO.

The original pavement of I-80 was in much worse condition than I-88 before the overlays were placed. However, when BMPR submitted potential BCO projects in 1992 - 1993, I-80 was not yet in the current IDOT 5-year improvement program. Furthermore, the most current CRS for I-80 at that time was an estimated value of 6.5 (a "good" rating). The CRS value for I-80 was eventually recorded as 6.3 for 1992. Between the time I-80 was selected as a BCO project and the time the BCO was constructed, the I-80 CRS is estimated to have decreased to 6.1.

When I-88 was selected as a BCO project, the latest CRS value of 7.8 indicated that the pavement was in excellent condition. By the time the I-88 BCO was actually constructed, the CRS value is estimated to be 7.6, which is still considered excellent.

This is an interim report. Performance will continue to be monitored for at least another year. A final report covering the constructability, cost, and performance of the I-80 and I-88 bonded concrete overlays is planned for completion by 2001. Conclusions and recommendations will also be included in the final report.

TABLE 4. DISTRESS SURVEYS PRIOR TO PLACING THE OVERLAY*
I-80 EASTBOUND

SECTION	DISTRESS	SEVERITY	QUANTITY
0% Microsilica w/ No Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Low	475 ft (145 m)
		High	25 ft (8 m)
	Longitudinal Cracking	High	43 ft (13 m)
0% Microsilica w/ Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Low	500 ft (152 m)
3% Microsilica w/ No Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Edge Punchouts	High	13 ft (4 m)
	Centerline Distress	Low	383 ft (117 m)
		Medium	107 ft (33 m)
		High	10 ft (3 m)
3% Microsilica w/ Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Infrequent
	Centerline Distress	Low	122 ft (37 m)
		Medium	378 ft (115 m)
5% Microsilica w/ No Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Rare
	Centerline Distress	Low	500 ft (152 m)
5% Microsilica w/ Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Low	Frequent

* Data Source: L. Rowden, *Thin Bonded Concrete Overlay and Bonding Agents*, Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 123, June 1996, p. 10

TABLE 5. DISTRESS SURVEYS PRIOR TO PLACING THE OVERLAY*
I-80 WESTBOUND

SECTION	DISTRESS	SEVERITY	QUANTITY
0% Microsilica w/ No Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Low	495 ft (151 m)
		High	5 ft (2 m)
0% Microsilica w/ Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Infrequent
	Centerline Distress	Low	345 ft (105 m)
		Medium	130 ft (40 m)
		High	25 ft (8 m)
	Longitudinal Cracking	High	27 ft (8 m)
3% Microsilica w/ No Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Low	100 ft (30 m)
		High	400 ft (122 m)
3% Microsilica w/ Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Low	100 ft (76 m)
		Medium	180 ft (55 m)
		High	70 ft (21 m)
5% Microsilica w/ No Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Low	500 ft (152 m)
5% Microsilica w/ Grout	Transverse Cracking	Low	Frequent
		Medium	Infrequent
	Localized Areas of Distress	High	Very Infrequent
	Centerline Distress	Medium	225 ft (68 m)
		High	275 ft (84 m)

* Data Source: L. Rowden, *Thin Bonded Concrete Overlay and Bonding Agents*, Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 123, June 1996, p. 18

TABLE 6. DISTRESS SURVEYS PRIOR TO PLACING THE OVERLAY
I-88

SECTION	DISTRESS	SEVERITY	QUANTITY
Cold Milling with Light Shot Blasting (Eastbound)	Transverse Cracking	Low	Very Infrequent
		Medium	Very Infrequent
	Localized Areas of Distress	High	Very Infrequent
Shot Blasting (Westbound)	Transverse Cracking	Low	Very Infrequent
	Localized Areas of Distress	High	Very Infrequent

TABLE 7. SUMMARY OF VISUAL DISTRESS SURVEYS ON BONDED CONCRETE OVERLAY I-80 EASTBOUND

SECTION	DISTRESS	SEVERITY	UNITS[ab]	AGE OF PAVEMENT (YEARS) 1	2	3[c]	4
0% Microsilica w/ No Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	195.4	0.0	253.4
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Permanent Patch Deterioration	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	0.0	42.2	95.0
		Medium	Number/Mile	0.0	0.0	10.6	10.6
		High	Number/Mile	0.0	0.0	0.0	10.6
0% Microsilica w/ Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Permanent Patch Deterioration	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	10.6	0.0	100.3
		Medium	Number/Mile	0.0	0.0	0.0	5.3
		High	Number/Mile	0.0	0.0	0.0	0.0
3% Microsilica w/ No Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Permanent Patch Deterioration	Low	Lane Feet/Mile	0.0	0.0	0.0	26.4
	Transverse Cracking	Low	Number/Mile	0.0	42.2	21.1	31.7
		Medium	Number/Mile	0.0	0.0	10.6	0.0
		High	Number/Mile	0.0	0.0	10.6	0.0
3% Microsilica w/ Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Permanent Patch Deterioration	Low	Lane Feet/Mile	0.0	0.0	0.0	126.7
	Transverse Cracking	Low	Number/Mile	0.0	42.2	63.4	58.1
		Medium	Number/Mile	0.0	0.0	31.7	31.7
		High	Number/Mile	0.0	0.0	0.0	0.0
5% Microsilica w/ No Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Permanent Patch Deterioration	Low	Lane Feet/Mile	0.0	0.0	0.0	575.5
	Transverse Cracking	Low	Number/Mile	0.0	63.4	137.3	100.3
		Medium	Number/Mile	0.0	0.0	52.8	47.5
		High	Number/Mile	0.0	0.0	0.0	31.7
5% Microsilica w/ Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Permanent Patch Deterioration	Low	Lane Feet/Mile	0.0	0.0	0.0	116.2
	Transverse Cracking	Low	Number/Mile	0.0	21.1	0.0	10.6
		Medium	Number/Mile	0.0	0.0	31.7	0.0
		High	Number/Mile	0.0	0.0	10.6	0.0

[a] Miles are total one-lane miles of the test section at that age.

[b] Values are calculated by dividing the total quantities by the number of one-lane miles at that age (i.e. low severity longitudinal cracking at two years of age for the 0% microsilica w/ no grout section equals 195.4 feet per one-lane mile).

[c] Only the driving lane was included in the 3-year survey. The other surveys included both the driving lane and the passing lane.

Note:

To convert from lane feet per mile to lane meter per kilometer multiply by 0.1894

To convert from number per mile to number per kilometer multiply by 0.6214

TABLE 8. SUMMARY OF VISUAL DISTRESS SURVEYS ON BONDED CONCRETE OVERLAY
I-80 WESTBOUND

SECTION	DISTRESS	SEVERITY	UNITS[ab]	AGE OF PAVEMENT (YEARS) 1	2	3[c]	4
0% Microsilica w/ No Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	0.0	0.0	0.0
		Medium	Number/Mile	0.0	0.0	0.0	0.0
		High	Number/Mile	0.0	0.0	0.0	0.0
0% Microsilica w/ Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	0.0	0.0	0.0
		Medium	Number/Mile	0.0	0.0	0.0	0.0
		High	Number/Mile	0.0	0.0	0.0	0.0
3% Microsilica w/ No Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	26.4
		Medium	Lane Feet/Mile	0.0	0.0	0.0	79.2
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	10.6	21.1	26.4
		Medium	Number/Mile	0.0	0.0	0.0	15.8
		High	Number/Mile	0.0	0.0	0.0	0.0
3% Microsilica w/ Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	10.6	0.0	10.6
		Medium	Number/Mile	0.0	0.0	0.0	10.6
		High	Number/Mile	0.0	0.0	0.0	0.0
5% Microsilica w/ No Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	21.1	10.6	15.8
		Medium	Number/Mile	0.0	0.0	0.0	42.2
		High	Number/Mile	0.0	0.0	0.0	0.0
5% Microsilica w/ Grout	Length Surveyed	-	Miles	0.2	0.2	0.1	0.2
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	0.0	0.0	31.7
		Medium	Number/Mile	0.0	0.0	0.0	0.0
		High	Number/Mile	0.0	0.0	0.0	0.0

[a] Miles are total one-lane miles of the test section at that age.
[b] Values are calculated by dividing the total quantities by the number of one-lane miles at that age (i.e. low severity longitudinal cracking at two years of age for the 3% microsilica w/ no grout section equals 26.4 feet per one-lane mile).
[c] Only the driving lane was included in the 3-year survey. The other surveys included both the driving lane and the passing lane.

Conversions to metric:
To convert from lane feet per mile to lane meter per kilometer multiply by 0.1894
To convert from number per mile to number per kilometer multiply by 0.6214

TABLE 9. SUMMARY OF VISUAL DISTRESS SURVEYS ON BONDED CONCRETE OVERLAY
I-88

SECTION	DISTRESS	SEVERITY	UNITS[ab]	AGE OF PAVEMENT (YEARS) 1	2
Cold Milling with Light Shot Blasting (Eastbound)	Length Surveyed	-	Miles	1.1	1.1
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	3.5
		Medium	Lane Feet/Mile	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0
	Transverse Cracking	Low	Number/Mile	1.8	5.3
		Medium	Number/Mile	0.0	0.0
		High	Number/Mile	0.0	0.0
Shot Blasting (Westbound)	Length Surveyed	-	Miles	1.1	1.1
	Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0
		Medium	Lane Feet/Mile	0.0	0.0
		High	Lane Feet/Mile	0.0	0.0
	Transverse Cracking	Low	Number/Mile	0.0	0.0
		Medium	Number/Mile	0.0	0.0
		High	Number/Mile	0.0	0.0

[a] Miles are total one-lane miles of the test section at that age.

[b] Values are calculated by dividing the total quantities by the number of one-lane miles at that age (i.e. low severity longitudinal cracking at two years of age in the eastbound lanes equals 3.5 feet per one-lane mile).

Conversions to metric:

To convert from lane feet per mile to lane meter per kilometer multiply by 0.1894

To convert from number per mile to number per kilometer multiply by 0.6214

I-80 Average IRI

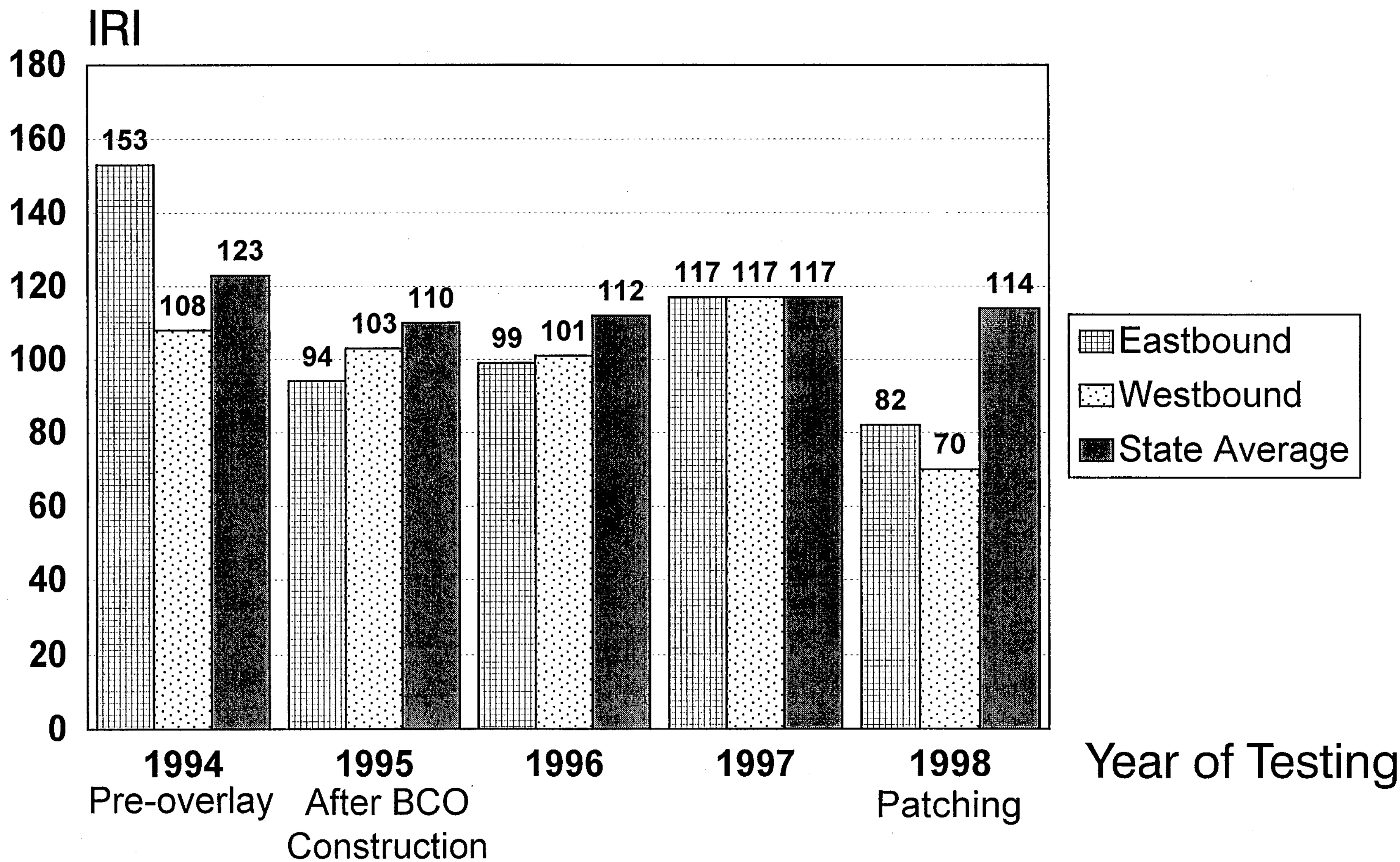


Figure 1

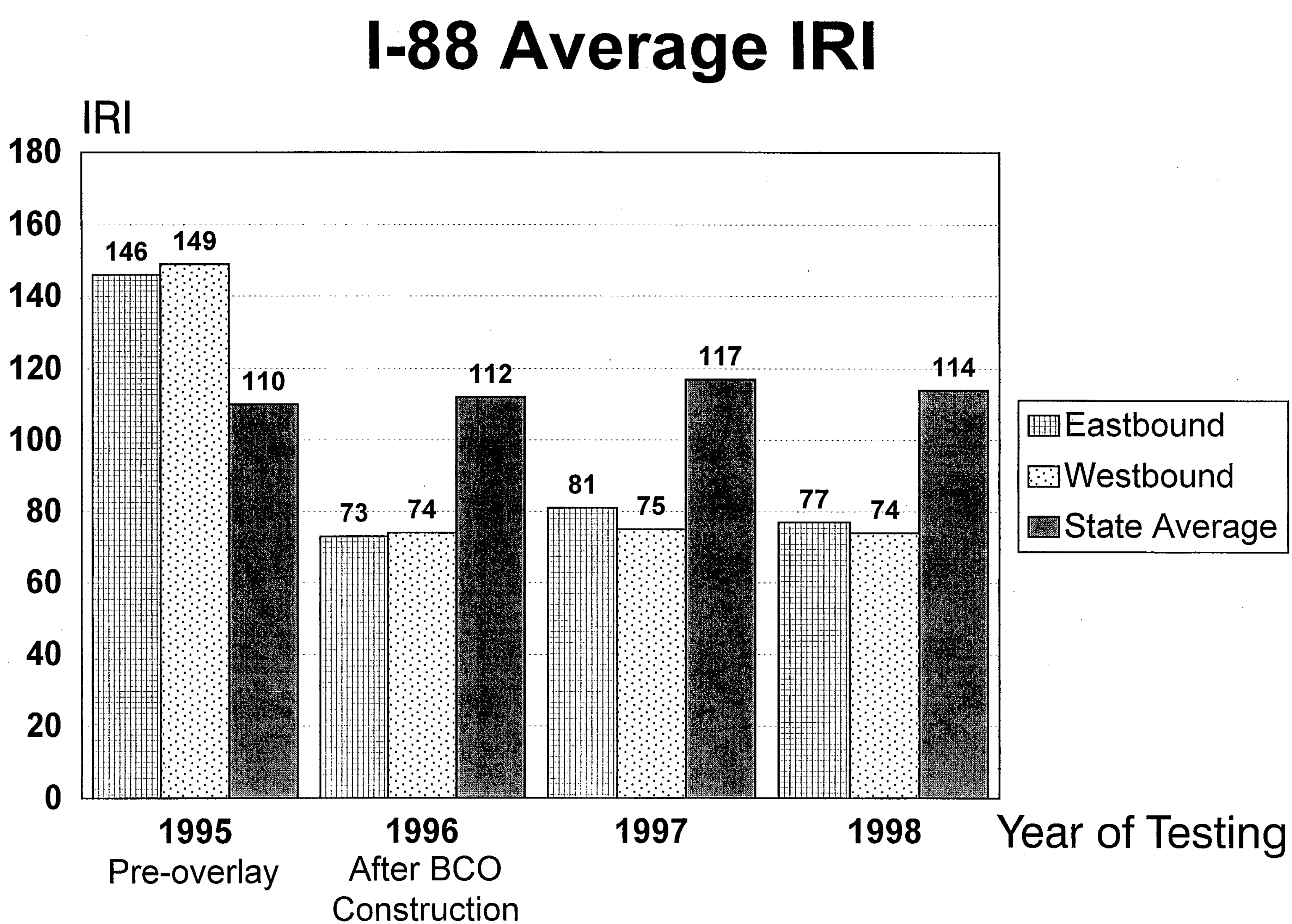

I-88 Average IRI
IRI
180
160
140
120
100
80
60
40
20
0
146
149
110
73
74
112
81
75
117
77
74
114
Eastbound
Westbound
State Average
1995
Pre-overlay
1996
After BCO
Construction
1997
1998
Year of Testing

Figure 2

I-80 CRS

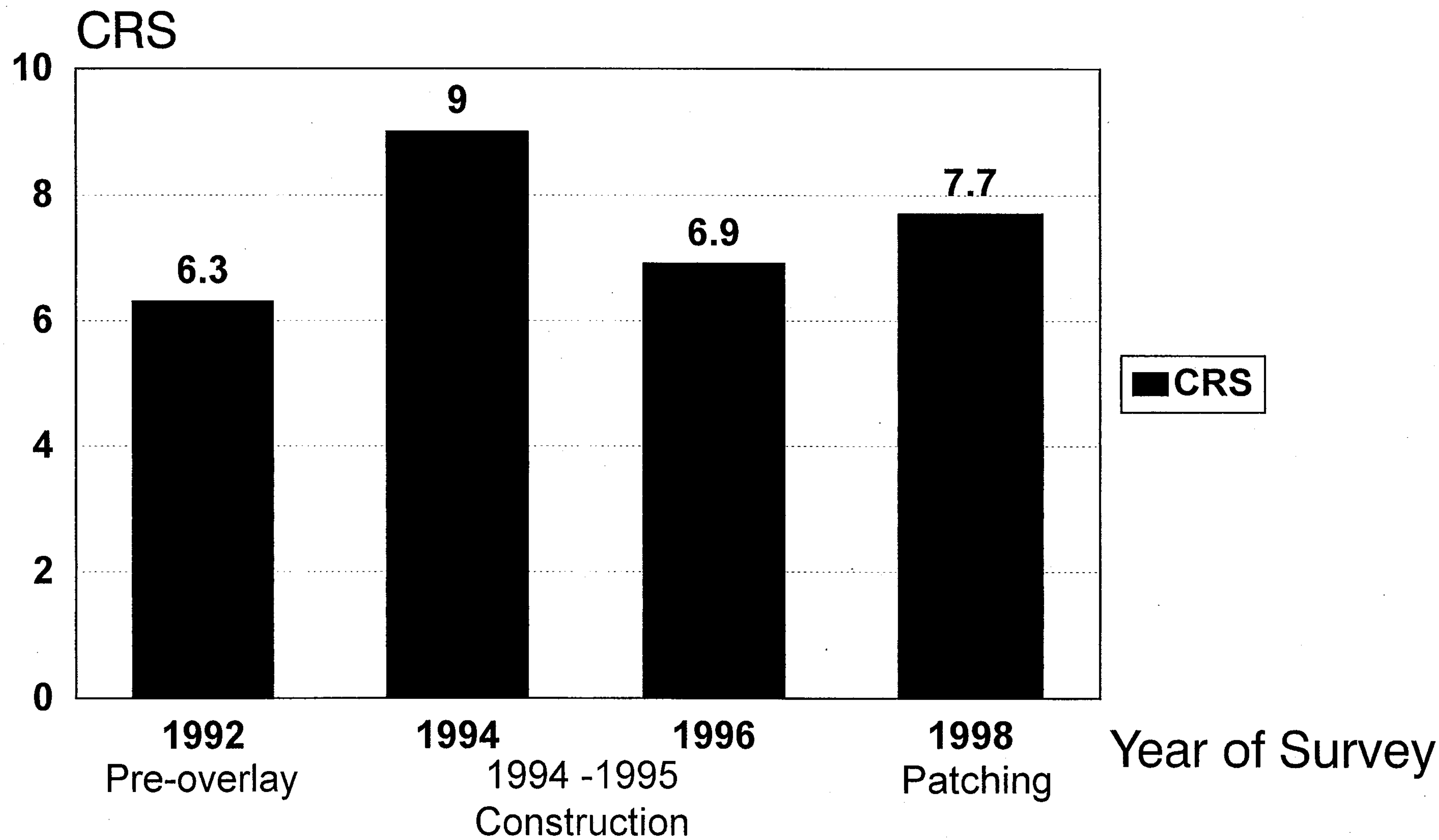


Figure 3

I-88 CRS

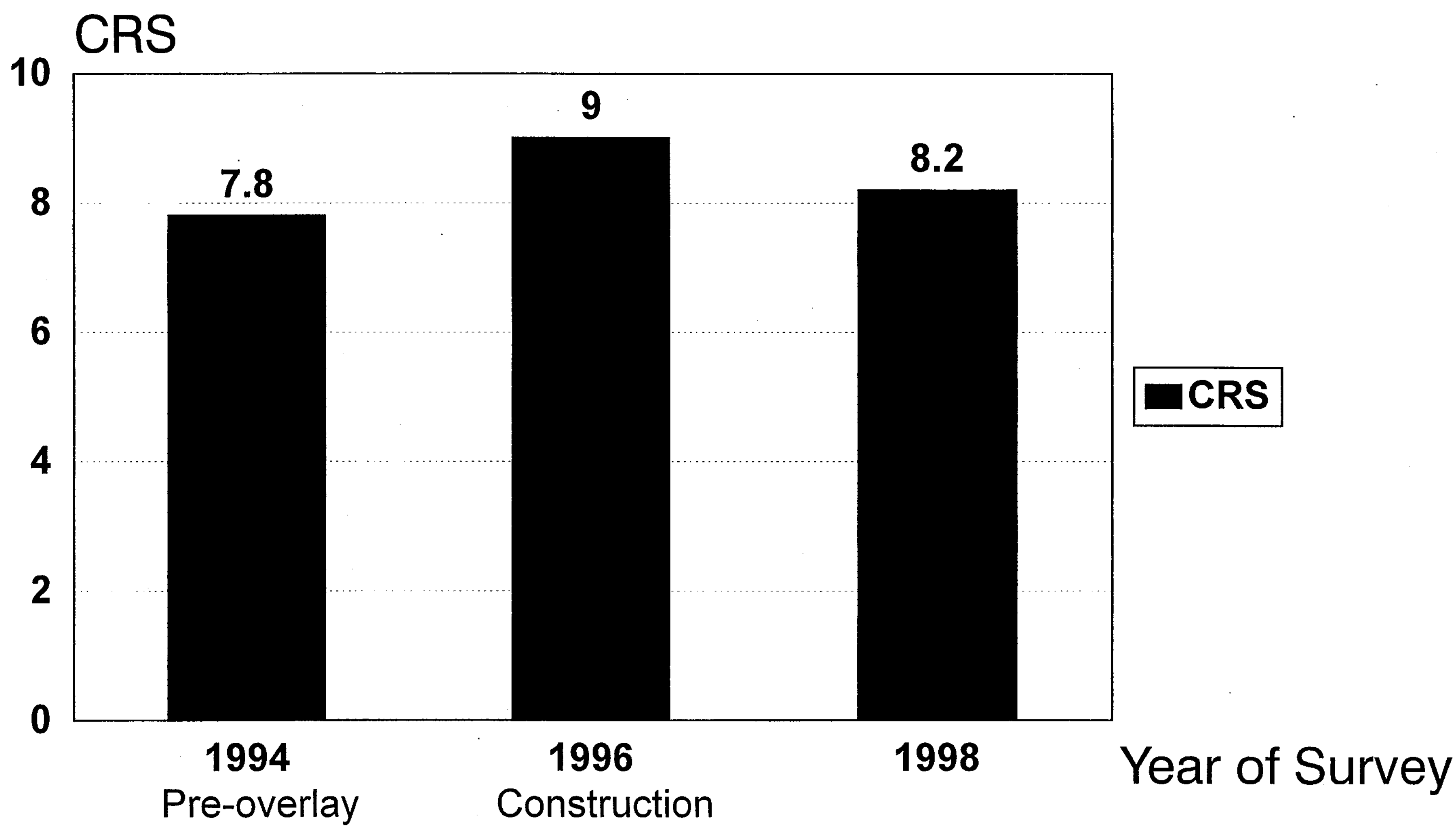


Figure 4

REFERENCES

1. L. Rowden, *Thin Bonded Concrete Overlay and Bonding Agents,* Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 123, June 1996, p. 1.

2. L. Rowden, *Thin Bonded Concrete Overlay and Bonding Agents,* Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 123, June 1996, p. 3.

3. L. Rowden, *Thin Bonded Concrete Overlay and Bonding Agents,* Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 123, June 1996, p. 11.

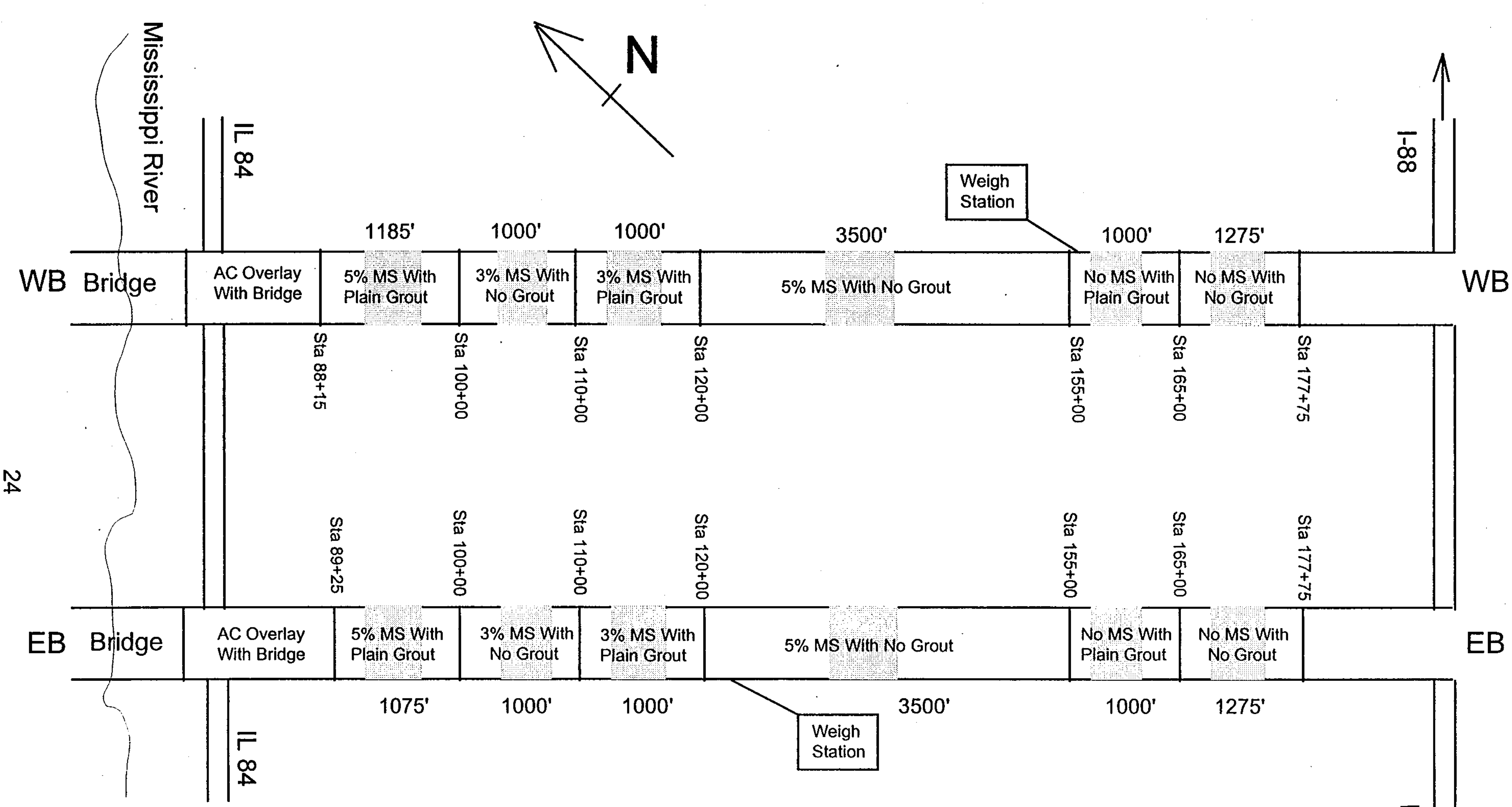
4. L. Rowden, *Thin Bonded Concrete Overlay and Bonding Agents,* Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 123, June 1996, p. 13.

5. *1997 Illinois Condition Rating Survey*, Illinois Department of Transportation, Springfield , Illinois, pp. 1 - 2.

APPENDIX A

Project Maps

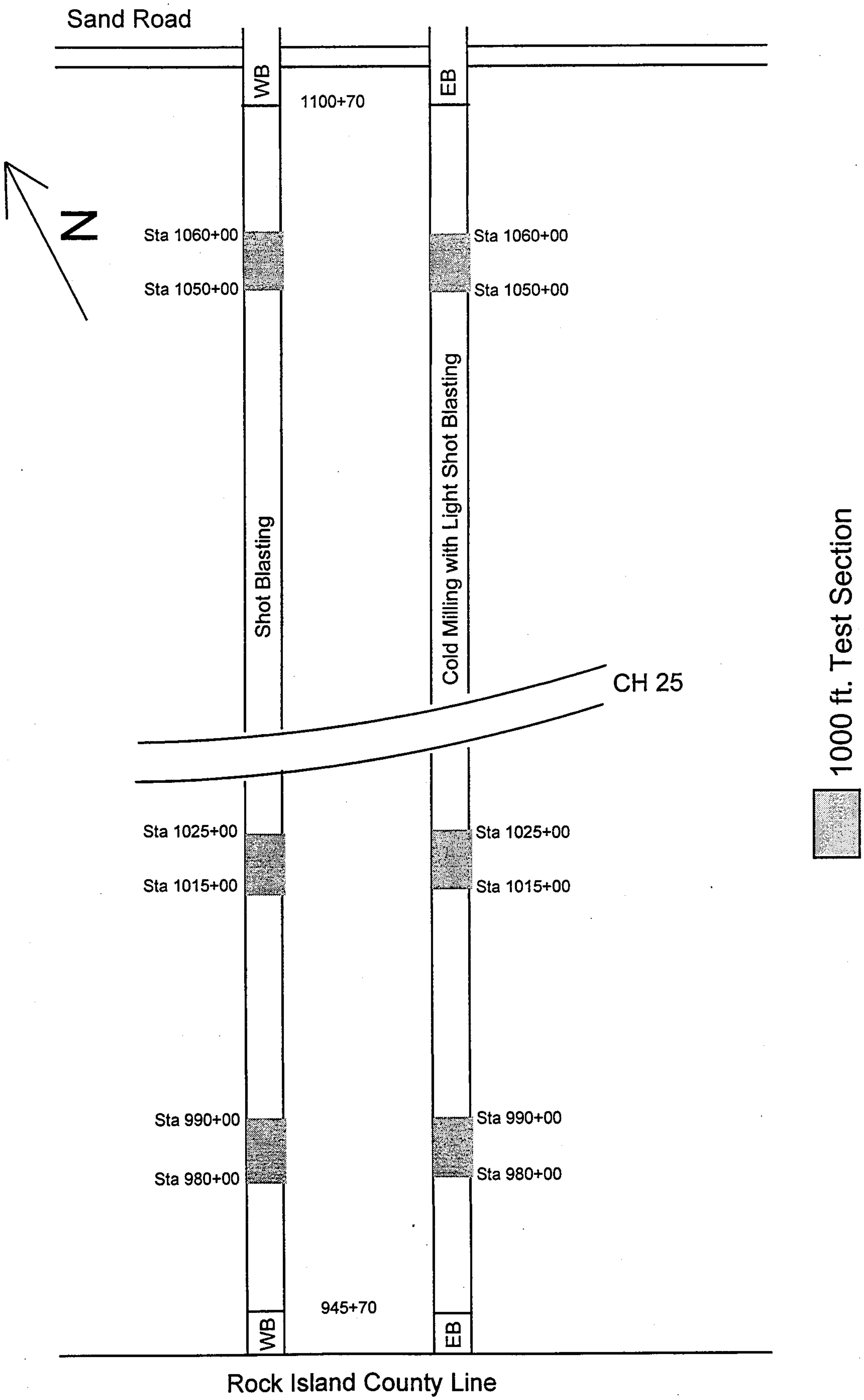
BONDED OVERLAY TEST SECTIONS FOR I-80



Note:
MS = Microsilica
WB weigh station overlay is no microsilica with no grout
EB weigh station overlay is 5% microsilica with no grout
500 ft. Test Sections

BONDED OVERLAY TEST SECTIONS FOR I-88

3" Overlay -- No Grout



APPENDIX B

Definitions of Distresses

LONGITUDINAL CRACKING

Description:

Longitudinal cracks occur generally parallel to the centerline of the pavement. They are often caused by a combination of heavy load repetition, loss of foundation support and thermal and moisture gradient stresses.

Severity Levels:

L - Hairline (tight) crack with no spalling or faulting, or a well sealed crack with no visible faulting or spalling.

M - Working crack with a moderate or less severity spalling and/or faulting less than 1/2 inch.

H - A crack with width greater than 1 inch; a crack with a high severity level of spalling; or a crack faulted 1/2 inch or more.

How to Measure:

Cracks are measured in linear feet for each level of distress. The length and average severity of each crack should be identified and recorded.

PERMANENT PATCH DETERIORATION

Description:

A patch is an area where a portion or all of the original concrete slab has been removed and replaced with a permanent type of material (e.g., concrete, epoxy, hot mix asphalt/aggregate mixture). Only permanent patches should be considered.

Severity Levels:

L - Patch has little or no deterioration. Cracks and edge joints are tight. Low severity spalling or raveling may exist. No faulting or settlement has occurred. Patch is rated low severity even if it is in excellent condition.

M - Patch is somewhat deteriorated. Settlement less than 1/2 inch, cracking, rutting, or shoving- has occurred in an asphalt patch; concrete patch may exhibit spalling and/or faulting up to 1/2 inch around the edges and/or cracks.

H - Patch is badly deteriorated either by cracking, faulting, spalling, rutting or shoving to a condition which requires replacement. Patch may present tire damage potential.

How to Measure:

The area of patches at each severity level within the sample unit are recorded. Patching is measured in square feet of area.

POTHOLES AND LOCALIZED DISTRESS

Description:

A localized distress is an area where the concrete has broken up into pieces, spalled or scaled. The localized distress takes many shapes and forms. Many times it occurs within an area between intersecting, Y-shaped or closely spaced cracks. A localized distress can occur anywhere on the slab surface, but is frequently located in the wheelpaths. Inadequate consolidation of concrete is often a primary cause of localized distress. This is primarily considered to be caused by a construction deficiency, whereas the Edge Punchout is primarily load associated.

Severity Levels:

Area (ft^2)	Less than 1	1-3	Greater than 3
Depth (in)			
Less than 1	L	L	M
1-2	M	M	H
Greater than 2	M	H	H

Localized distresses that have been filled or partially filled by maintenance forces should be rated the same as an unfilled localized distress, i.e., a filled localized distress (2 ft^2) with a remaining depth of 1.5" would be rated "M".

How to Measure:

The number of localized distress areas are counted and recorded at each severity level in the uniform section.

PUNCHOUTS

Description:

A punchout is first characterized by a loss of aggregate interlock at one or two closely spaced cracks (i.e., usually less than 48 inches apart) near the edge joint. The crack or cracks begin to fault and spall slightly which causes the portion of the slab between the closely spaced cracks to act essentially as a cantilever beam. As heavy truck load applications continue, a short longitudinal crack forms between the two transverse cracks about 24-60 inches from the pavement edge. Eventually the transverse cracks break down further, the steel ruptures and the pieces of concrete punch downward under load into the subbase and subgrade. There is generally evidence of pumping near edge punchouts, and sometimes extensive pumping. The distressed area will expand in size to adjoining cracks and develop into a very large area if not repaired. The edge punchout is the major structural distress of CRCP.

Severity Levels:

L - A longitudinal crack develops between two closely spaced transverse cracks. The longitudinal and transverse cracks are fairly tight and only slight faulting or spalling is present.

M - The transverse and/or longitudinal cracks have begun to widen and spall with faulting or punching down of the concrete less than 1/2 inch.

H - The concrete within the boundary of the punchout is breaking up, has been punched down into the subbase more than 1/2 inch and/or has an asphalt patch on top. If the area has been patched with asphalt, it is still considered a punchout and not an asphalt patch since this is only a temporary patch.

How to Measure:

The number of punchouts and their level of severity are recorded for each sample unit.

TRANSVERSE CRACKING

Description:

Transverse cracking of continuously reinforced slabs is a normal occurrence and is not in itself considered to be a distress. As soon as the slab is placed and begins to harden, drying shrinkage of the concrete occurs. Reinforcement in the slab and subbase friction oppose the shrinkage and cracks soon form. After about 2-4 years, the crack spacing becomes constant. The purpose of the steel is to hold these random spaced transverse cracks tightly together so that load transfer across the crack will be obtained through aggregate interlock. If the steel ruptures or shears, load transfer across the crack is lost and the crack becomes a potential location for major distress. When deicing salts and water infiltrate through a wide crack, the reinforcing steel is subjected to corrosion and the effective diameter t of the steel begins to decrease. When the stresses due to temperature chances and loading are greater than the strength of the steel, the reinforcing bar ruptures. Indicators of sheared or decreased diameter reinforcing bars are faulted and/or widened spalled cracks. Some cracks may have widened substantially after steel rupture. (Note: Sometimes the transverse cracks run diagonally across the pavement and intersect. Hairline cracks that are less than 6 feet long are not rated.)

Severity Levels:

Severity levels of transverse cracking are determined by crack spalling and faulting.

L - Tight (hairline) cracks with no faulting, steel rupture, or spalling.

M - A crack with no steel rupture, faulting less than or equal to 0.2 inch and/or low severity spalling.

H - Faulting greater than 0.2 inch, or steel rupture, or medium to high severity spalling.

How to Measure:

Low severity cracks are counted for the first 100 feet and multiplied by 5 to approximate the number in the entire unit.

Medium and high severity cracks are counted individually for the entire unit.