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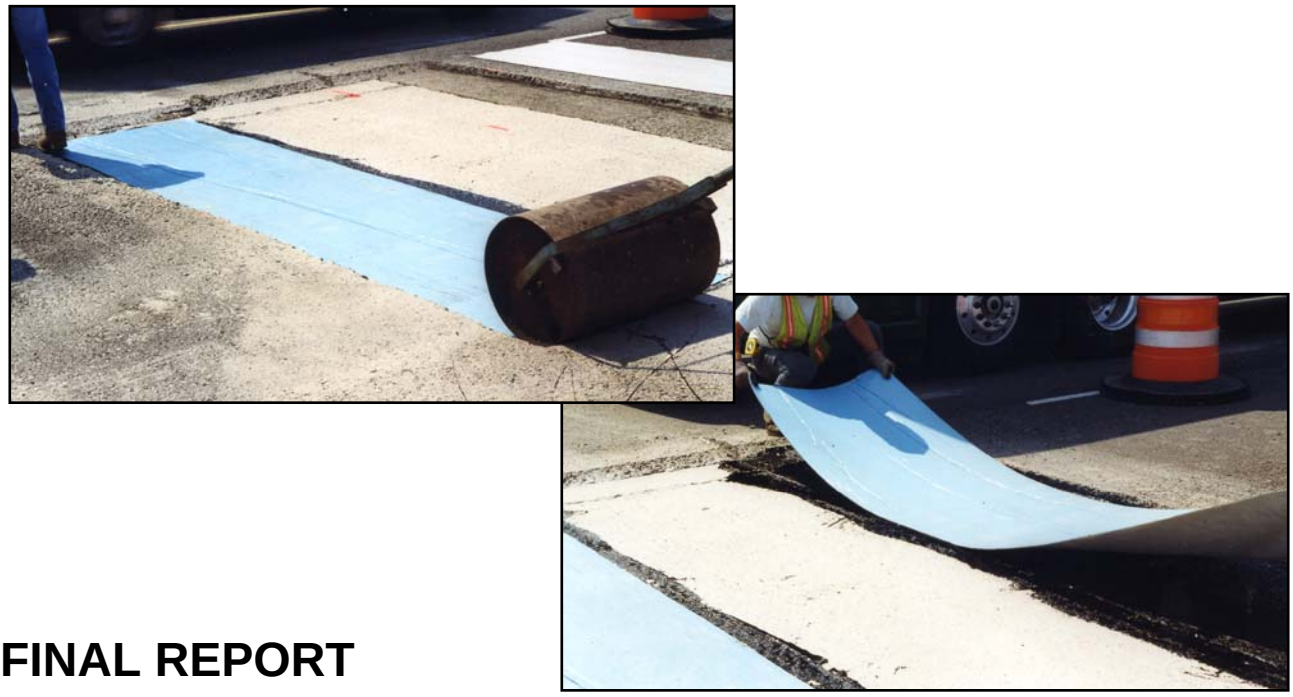
AN EVALUATION OF INTERLAYER STRESS ABSORBING COMPOSITE (ISAC) REFLECTIVE CRACK RELIEF SYSTEM



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16. Abstract

Reflective cracking of bituminous concrete overlays has long been a problem in pavement rehabilitation. Various types of interlayer systems and fabrics have been used to eliminate or slow the development of reflective cracks. These methods and products have had mixed results. In 1993, the University of Illinois completed research directed by the Illinois Department of Transportation on a prototype Interlayer Stress Absorbing Composite (ISAC). A prototype test section was placed on IL 38 near Rochelle, IL in 1993. Other ISAC test sections were placed on five asphalt concrete overlay (ACOL) projects between 1997 and 2000. Some of these ACOL sections contain other reflective crack control methods, such as Sand Anti-Fracture (SAF) layer, strip, and area-wide reflective crack control fabric.

ISAC consists of a three-layer system. The top layer is a high strength woven geotextile to resist stresses caused by underlying pavement movements. This layer has the ability to, due to its weaving, expand like a chain link fence. This movement dissipates the stress caused by the movement of the underlying pavement. Typically, this geotextile has a tensile strength greater than 4,000 lb. /in. (700 N/mm) at 5% strain (ASTM D 4595). High strength is needed to ensure that, when the geotextile is expanded to its full extent, the geotextile strength is greater than the strength of the bituminous concrete overlay. The bottom layer is a low strength, nonwoven, geotextile (meeting AASHTO M-288-92). The middle layer is a modified rubberized asphalt layer to absorb the strain energy and bond the two geotextiles together. The system bridges across the joint or crack and dissipates stresses resulting from opening or closing movements. ISAC is bonded to the existing pavement using a tack coat and then the overlay is placed.

The formation of reflective cracks and the subsequent deterioration of these cracks were delayed at ISAC treated joints and cracks. This statement was true for all five test sites. This delay ranged from over one year to close to three years when compared to the untreated and other crack control methods. Of special note, the ISAC areas consistently outperformed the System B products, PavePrep and Roadtac. When compared with SAF, the ISAC delayed reflective cracks by about two years. The two sections performed the same after the cracks were routed and sealed.

The cost analysis indicated that the higher the total cost of the asphalt concrete the higher the number of cracks and joints that could be treated with ISAC. The present cost of the ISAC strips, $10 - $14 per foot, limits the conditions under which it would be cost effective to use ISAC. If asphalt costs are high or the cost of ISAC were to decline, there would be more projects that could benefit from using ISAC.

Described herein are details of the various experimental field installations and a discussion of performance and results. Recommendations for the use of ISAC are included.

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Final Report

An Evaluation of Interlayer Stress Absorbing Composite (ISAC)
Reflective Crack Relief System

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DISCLAIMER

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INTRODUCTION

Reflective cracking of bituminous concrete overlays has long been a problem in pavement rehabilitation. Various types of interlayer systems and fabrics have been used to eliminate or slow the development of reflective cracks. These methods and products have had mixed results. In 1993, the University of Illinois completed research directed by the Illinois Department of Transportation on a prototype Interlayer Stress Absorbing Composite (ISAC). A prototype test section was placed on IL 38 near Rochelle, IL in 1993. Other ISAC test sections were placed on five asphalt concrete overlay (ACOL) projects between 1997 and 2000. Some of these ACOL sections contain other reflective crack control methods, such as Sand Anti-Fracture (SAF) layer, strip, and area-wide reflective crack control fabric. Described herein are details of the various experimental field installations and a discussion of performance and results.

DESCRIPTION

ISAC consists of a three-layer system (see figure 1). The top layer is a high strength woven geotextile to resist stresses caused by underlying pavement movements. This layer has the ability to, due to its weaving, expand like a chain link fence (see figure 2). This movement dissipates the stress caused by the movement of the underlying pavement. Typically, this geotextile has a tensile strength greater than 4,000 lb. /in. (700 N/mm) at 5% strain (ASTM D 4595). High strength is needed to ensure that, when the geotextile is expanded to its full extent, the geotextile strength is greater than the strength of the bituminous concrete overlay. The bottom layer is a low strength, nonwoven, geotextile (meeting AASHTO M-288-92). The middle layer is a modified rubberized asphalt layer to absorb the strain energy and bond the two geotextiles together. The system bridges across the joint or crack and dissipates stresses resulting from opening or closing movements. ISAC is bonded to the existing pavement using a tack coat and then the overlay is placed.

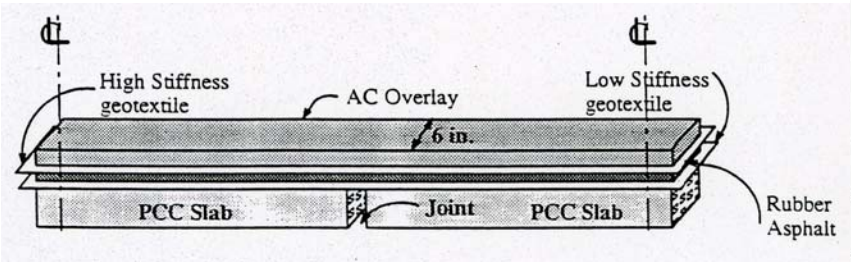

Figure 1. ISAC Lab Sample

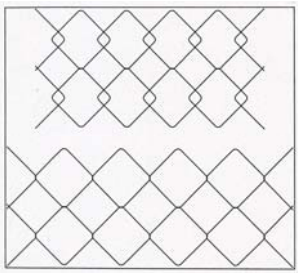

Figure 2

PROTOTYPE INSTALLATION

After ISAC was tested in the laboratory, a field test installation was performed by the Department on IL 38 between Ashton and Rochelle. This section was placed in July 1993. The results of this test installation were favorable. It was decided to place ISAC strips on additional projects to determine its effectiveness.

FIELD INSTALLATIONS

IL 29 Contract 88535: This project was located on IL 29 in Tazewell County, District 4, under the I-474 interchange. This section was a bare 10-inch jointed reinforced concrete pavement (JRCP) with a 50-foot joint spacing built in 1975. There were three through lanes with a left turn lane at the south end. The average daily traffic (ADT) of this section in 2003 was 28,900 vehicles. The average daily truck traffic (ADTT) was 850 trucks with 750 multiple units (MUs).

ISAC strips were placed over nine joints and cracks in the northbound median lane and two joints and cracks in the southbound median lane. PavePrep peel and stick, "System B" reflective crack control fabric, was placed over two joints and cracks in the northbound median lane and 11 joints and cracks in the southbound median lane. Area-wide fabric was used in the northbound and southbound outside lanes. Construction notes stated that reflective crack control was not used in the middle lanes of each direction. However, fabric was visible in some of the high severity transverse cracks in the middle lane, as noted on the pavement distress survey sheets. Formal control (untreated) sections were not established during the installation.

A rubberized asphalt tack coat (ASTM D 6690 Type II, old ASTM D 3405) was used and resulted in good ISAC adhesion to the original pavement. A 1.25 inch level binder was placed over the ISAC and the PavePrep. Some asphalt bleeding and material shrinkage occurred during paving. There was some cracking along the fabric edges. The lay down temperature of the binder was 310 ºF. A heavier than normal pneumatic roller was initially used, but shoving and pickup of the PavePrep resulted. Once this roller was replaced, the shoving and pickup problem was eliminated. There were no problems with the ISAC areas. A one inch surface lift was placed bringing the total ACOL thickness to 2.25 inches. The surface was completed in the Fall of 1997.

IL 267 (former US 67) Contract 76140: This project was located on IL 267 (former US 67) in Greene County, District 8, from TR 135 to the Morgan County line, 7.65 miles north. It was a two-lane, 30 foot jointed, 9-6½ -9 Portland Cement Concrete (PCC) pavement with two 3.00 inch ACOLs. This 20-foot wide pavement was built in 1939 and widened by one foot on each side with the 1970 overlay. The second overlay was placed in the early 1980's. The overlay for this study was placed in late October 1998. The 2003 ADT was 2400 vehicles. The ADTT was 500 trucks with 350 MUs.

The existing overlay was not milled. Full depth bituminous patches were placed at joints and cracks. These patches accounted for 2.8% of the pavement. The existing pavement was widened with this overlay to provide a safety shoulder. ISAC strips were placed over pre-designated joints, patch-joints, and cracks from TR 135 northerly for one mile. The ISAC strips extended from the centerline to the edge of the existing pavement. Many of the joints and cracks within this mile were not covered with ISAC. No other reflective crack control methods were used within this section. Formal control (untreated) sections were not established during the installation.

The 103 ISAC strips were installed in about seven hours. The strips were bonded to the pavement with rubberized asphalt. One crew placed the rubberized asphalt at 350 ºF from a Crafco kettle. The next crew peeled the backing from the ISAC and placed it onto the rubberized asphalt. One laborer rolled the strip with a steel roller and a crew placed sand over the ISAC to prevent the car tires from sticking to the fabric. The temperature

was cool during installation and the strips were left exposed overnight. There was no damage to the strips after one half day of traffic.

The total overlay thickness was 2.25". A 0.75" level binder was placed followed by a 1.50" Class D surface mix. The rubberized asphalt did not soften and the ISAC did not shadow (a slight visible indication of ISAC through the binder) after it was compacted. The pneumatic roller was not stopped or started on an ISAC strip.

US 136 @ I-155 Contract 72080: This project was located on US 136 east of San Jose and west of Interstate 155. The ISAC strips were added to this project which contained a SAF special provision. Contract # 72080 was let on January 15, 1999. The contract contained the following description of work: 12.13km (7.54mi) patch, surface removal, bituminous resurfacing, and bridge deck repairs on three structures on US 136 between San Jose and I-155. Installation of the SAF and ISAC started in early October 1999.

This section was a two-lane, 30 foot jointed, 9-6½ -9 PCC pavement with a 3.00 inch ACOL. This pavement was built in 1937 and overlaid in 1983. The existing ACOL was badly deteriorated, so the surface was milled. The depth of milling varied. There was minimal full depth bituminous patching and the roadway was not widened.

Petromat was placed in the westbound lane and a 3/4" level binder was placed over the Petromat. A 3/4" SAF layer was placed directly on the milled surface in the eastbound lane. A short section, 850 feet, of the westbound lane contains ISAC reflective crack control strips. There were 47 ISAC strips placed over cracks on the east end of the project in the westbound lane. PK nails were placed in the edge line at the ISAC locations. The 2003 ADT of this section was 2350 vehicles. The ADTT was 650 trucks with 500 MUs.

A rubberized AC-10 asphalt prime was used as a tack coat. The contractor installed the 47 ISAC strips in 1.5 hours. A distribution truck was used to apply the tack coat. One crew laid the ISAC strips into the tack coat and peeled the backing. One laborer rolled the ISAC with a steel roller. The air temperature was 75 ºF. This cooler temperature allowed for a faster curing of the asphalt tack coat and resulted in a good bond between the ISAC and the pavement. There was no shadowing of the ISAC after the binder was placed. Adhesion of the ISAC to the pavement was better than on the IL 29 project.

The binder was placed three hours after the ISAC installation. The ISAC strips were not exposed to traffic. The mix was produced at the Freesen drier drum plant in Peoria. There were no noted problems with the laydown of the SAF layer. The AC was supposed to be in the 8.5% range, but was out of specification at times.

Koch Materials requested that a polymer overlay surface, PG 70-22/28, be used as an alternate on a one or two mile section. Koch representatives claimed that a polymer modified asphalt surface would improve the reflective crack resistance. District 6 rejected this proposal, because it was too late to change to polymer modified asphalt. An AC-20 Type 2 D mixture with 12% RAP was used for the surface mix. The representatives claimed that this mix would not be flexible enough to work with the SAF layer.

I-55 (MP 23 - 26) Contract 96721: This project was located in the southbound lanes of Interstate 55 between mileposts 23 and 26. The pavement was a 100-foot jointed

reinforced concrete pavement (JRCP). It was built in 1956 as US 66 and was overlaid in 1976 with a 3.00 inch ACOL and in 1987 with a 3.25 inch ACOL. The 2003 ADT of this section was 26,500 vehicles and the ADTT was 7600 trucks with 6400 MUs.

This section was patched in the Fall of 1998 and overlaid with an asphalt concrete binder course. Traffic was allowed on the binder throughout the winter. Reflective cracks formed in the binder and needed repair before the surface was placed. The district wanted to use the ISAC strips at these locations to deter the reflective cracks. It should be noted that only the reflective cracks that were visible were repaired. There may have been other locations where the reflective cracks had begun, but had yet to reach the surface. Appendix C contains photos from this project. Formal control (untreated) sections were not established during the installation.

The binder around the reflective cracks was milled 2.5 inches to expose the concrete patch. A rubberized asphalt (D-6690 Type II) tack coat at 400 ºF was used to provide a bond between the fabric and the pavement. The plastic backing remained on the ISAC while a hand roller was used to seat the ISAC. A rubber-tired vehicle was used for final seating.

ISAC strips were placed on each joint at 14 patch locations. There was no difficulty placing the ISAC strips. The strips were not exposed to traffic. The binder layer was replaced at the ISAC locations and a 1.5 inch polymerized surface mix was then placed over the entire section. A “99” was stamped in the surface near the edge stripe at each ISAC location. The surface was completed in June 1999.

Mattis Avenue (Champaign): This project was located on Mattis Avenue in Champaign, IL between Springfield Avenue and Kirby Avenue. The original pavement was jointed concrete built in 1966. There were four through lanes with a four foot wide rumble strip median. The outside through-lanes were 14 feet wide and the inside through-lanes were 12 feet wide. The ADT of this section was 15,000 vehicles and the ADTT was 200 trucks. This was a City of Champaign project.

“System A” reflective crack control fabric was placed over the longitudinal joints. ISAC strips were placed over the transverse joints and cracks in both directions. Roadtac self-adhesive membrane strip reflective crack control fabric, “System B”, was placed in the two southbound lanes in the southern 3000 feet. “System A” reflective crack control fabric strips were placed over the transverse joints and cracks at the southern edge of the northbound lanes. The raised concrete curbs were painted with a white “T” at the joints and cracks that received ISAC or crack control treatment. Formal “control” (untreated) sections were not established during the installation.

A four man crew and truck driver placed the ISAC strips. An asphalt tack coat was sprayed over the crack or joint before the ISAC strip was placed. The asphalt tack coat was wider than the ISAC strip and the ISAC absorbed some of the tack coat. A Superpave asphalt concrete mix was placed in two lifts. The first lift was 1.5” and the surface lift was 1.625”. Traffic was diverted away from the work zone lanes and was not allowed directly on the ISAC strips. The overlay was completed in September 2000.

SUMMARY OF FIELD INSTALLATIONS

Each of the five locations where ISAC was installed to delay reflective cracking contained a wide variety of qualities and parameters that could affect the performance of the product. The original and existing pavement type and condition varied, as did the amount of patching and surface preparation. The heavy truck traffic ranged from low to very heavy. Some sections were rural and some sections were urban. The number of traffic lanes ranged from two to six. Table 1 summarizes the original pavement, overlays, lanes, surface preparations, and traffic data for each section.

ISAC – Section Information								
Location	Initial Pave.		Number of		Preparation		Traffic	
Route	Type	Built	ACOL	Lanes	Patch	Mill	ADT	ADTT
IL 29	JRCP	1975	Bare	6	No	No	28,900	850
IL 267	JPCP	1939	2	2	Bit.	No	2400	500
US 136	JPCP	1937	1	2	Bit.	Yes	2350	650
I-55	JRCP	1956	2	4	PCC	Yes	26,500	7600
Mattis Ave.	JPCP	1966	Bare	5	No	No	15,000	200

Table 1. Section Information.

Different tack coats, rollers, and methods were used to install the ISAC strips. Most of the ISAC strips were not exposed directly to traffic. IL 267 was the main exception. The asphalt binder and surface mixes and thicknesses that were placed over the ISAC also varied from project to project.

All of the sites had some form of listing of the location of the ISAC, System A, and System B strips. Since pre-overlay pavement distress surveys were not performed at any of the test locations, the potential for reflective cracking at a given location could not be determined. Formal “control” (untreated) sections were not established during the installation. Reflective cracks that formed at locations without crack control were categorized as “untreated.” The IL 267 and Interstate 55 projects had the greatest amount of untreated joints and cracks that could be compared with the ISAC locations.

Other reflective crack control systems were installed on three of the five projects. The Mattis Avenue project provided the best documentation of existing crack locations and the type of system that was installed. The US 136 project provided a side-by-side comparison of ISAC and SAF, but did not contain an untreated section. The existing cracks at the untreated location were not listed on the IL 29 project.

FIELD EVALUATION

Pavement distress surveys were performed for each section. Appendix A contains the Charts of the Field Installations and Appendix B contains the Tables of Pavement Distress Survey Summaries. Following is a detailed discussion of each project.

IL 29 - Contract 88535: There was no pre-overlay distress survey or listing of cracks. The metric station location of each ISAC or PavePrep strip was noted. Field inspections were performed in 1998 and 1999. Pavement distress surveys were performed annually from 2000-2004. Only the inner most lane in each direction was surveyed. The severity of cracks in the middle and outer lane was noted in the margin of the survey sheets

starting with the 2002 survey. Reflective cracks that formed at locations without crack control were categorized as "untreated." There were 49 untreated cracks as of 2004.

After three years, nine of the 13 (69%) PavePrep locations had reflective cracks, while only three of the 11 (27%) ISAC locations had reflective cracks. At this time, 28 of the 49 (57%) other reflective cracks at untreated locations had reflected through the overlay. All cracks were low severity. After seven years, 12 of the 13 (92%) PavePrep locations had reflective cracks with seven high severity cracks, while eight of the 11 (73%) ISAC locations had reflective cracks with one high severity crack. After this survey, eight of the 49 (16%) reflective cracks at untreated locations were high severity and 24 (49%) were medium severity.

Many of the PavePrep locations and some of the ISAC locations contained two or more cracks that were one to two feet apart. Some of these double cracks extended across the entire lane and sometimes the cracks formed "Y's". The cracks in the adjacent lanes were usually single cracks and much straighter. Crack control fabric was exposed in some of the high severity cracks in the outer and middle lanes.

Since there was no pre-overlay survey, the number of untreated cracks and joints is unknown. However, only five new cracks were recorded in the 2003 and 2004 surveys. The ISAC strips delayed the reflective crack by about two years (see Appendix A Figure 1). The crack severity progression was also delayed by about two years. The PavePrep locations had the quickest formation of reflective cracks and the highest severity progression.

IL 267 (former US 67) Contract 76140: A list of existing crack and patch locations was recorded in meters before the ISAC strips were placed. The locations of the ISAC strips were noted on the list. Pavement distress surveys were performed annually from 2000-2004. All of the surveys were performed using metric measurements. There were no stations stamped into the overlay. The lack of stations and landmarks made it difficult to correlate the initial crack listing with the cracks on the distress surveys. After the 2004 distress survey, enough cracks had reflected through the overlay to correlate them to the pre-overlay listing. Reflective cracks that formed at locations without ISAC crack control were categorized as "untreated." There were 131 untreated cracks as of 2004.

After three years, 14 of the 103 (14%) ISAC locations had reflective cracks. At this same time, 40 of the 131 (31%) untreated cracks had reflected through the overlay. After four years, 28 of 103 (27%) ISAC locations had reflective cracks. At this same time 70 of the 131 (53%) untreated cracks had reflected through the overlay. After five years, 41 of the 103 (40%) ISAC and 81 of the 131 (62%) untreated cracks had reflected through the overlay.

A large increase in reflective cracks at ISAC locations occurred between the 2003 and 2004 survey. The reflective cracks increased from 31 to 89. The reflective cracks at the untreated sections increased from 81 to 131. It was also between these surveys that the cracks were routed and sealed.

Before the cracks were sealed between the 2003 and 2004 surveys, there were 15 medium and high severity cracks at the untreated locations and only two medium severity reflective cracks at ISAC locations. The severity levels of the sealed cracks were rated at the previous severity level unless they had deteriorated further. The ISAC

strips delayed the reflective cracks between one and two years (see Appendix A Figure 2).

US 136 @ I-155 Contract 72080: Pavement distress surveys were performed annually from 2000-2004. There were two surveys performed in 2001. The first survey was performed using metric units. The correlation between the metric stations and the initial crack listing, performed using English stations, was uncertain. The survey on August 17, 2001 and all subsequent surveys were performed using English units. The PK nails marking the ISAC locations were located during this survey. The cracks in the previous surveys were correlated to the PK nails. Reflective cracks that formed at locations within the ISAC section, but not at an ISAC location, were categorized as "untreated."

The ISAC section was compared to the SAF section that was in the adjacent lane. The lengths of these sections were the same. The SAF section had 20 more reflective cracks, in the 2002 survey, than the ISAC section. Only one low severity crack in the ISAC section was not at an ISAC strip. Seams were forming at 18 of the 47 ISAC locations and four SAF locations. The ISAC strips were more effective at delaying the reflective cracks than the SAF layer. The formation of reflective cracks in the ISAC section was delayed about two years (See Appendix A Figures 3 and 4).

The cracks were routed and sealed a few days before the 2003 survey. The number of reflective cracks in the ISAC lane increased from 36 to 52 between 2002 and 2003. Of these 52 cracks, 43 were at ISAC locations and nine were at untreated locations. Forty-three (43) of the 47 (91%) ISAC locations had a reflective crack. After the cracks were sealed, the number and severity of the reflective cracks were almost identical between the two adjacent lanes.

The number of reflective cracks in the SAF section was lower in each survey than the number of reflective cracks in the area-wide section that was in the adjacent lane. The number of medium severity cracks in the area-wide section was three times greater than the SAF section in 2004. The number of medium severity cracks increased between 2003 and 2004 in all of the sections. This increased deterioration occurred despite the cracks being sealed in 2003.

I-55 (MP 23 -26) Contract 96721: There was no pre-overlay distress survey or crack listing for this section. A list of ISAC locations was recorded. Pavement distress surveys were performed annually from 2000-2004. The initial ISAC locations were listed in English units. Since metric stations were stamped into the overlay, the 2000, 2001, and 2002 distress surveys were performed using metric units. Reflective cracks that formed at locations without crack control were categorized as "untreated."

The correlation between the ISAC listing and metric surveys was not apparent despite the regular 100-foot reflective crack spacing. The correlation between the initial listing and the pavement distress surveys was made after the 2003 survey, which was performed using English units. It was during this survey that the "99" stamped into the overlay at the ISAC locations was confirmed. The inner southbound lane was also surveyed to provide a comparison with the outside lane, which contained the ISAC strips.

The percentage of reflective cracks at the ISAC locations after three years, 29%, was slightly less than the percentage at the untreated locations after one year, 34%. This

percentage was almost identical to the percentage of reflective cracks in the lane adjacent to the ISAC patches, 30%, after two years. There was a similar comparison of the ISAC locations after four years, 71%, to the untreated after three years, 69%, and with the adjacent lane after two years, 70% (See Appendix A Figure 5).

One patch was placed before the 2003 survey and two patches were placed before the 2004 survey in outer lane. The reflective cracks in the outer lane were rapidly deteriorating. There were 93 high severity cracks in 2004 and many of these cracks had been treated with spray injection patches. All of these cracks were at untreated locations. There were 17 low severity and three medium severity reflective cracks at the ISAC locations (See Appendix A Figure 6).

The formation of the reflective cracks was delayed two years when compared with the untreated locations in the same (outer) lane. Despite the greater heavy truck traffic in the outer lane, the reflective cracks were delayed by one year when compared with the reflective cracks in the adjacent inside lane. There were no high severity reflective cracks in the inside lane as of the 2004 survey and only 15 medium severity cracks.

Mattis Avenue (Champaign): There were two separate pre-overlay listings of ISAC and reflective crack control locations for this site. The stations differed slightly, but it was possible to correlate the ISAC locations with the reflective cracks recorded in the pavement distress survey using the white paint marks on the curb. Pavement distress surveys were performed annually from 2001-2004. All listings and distress surveys were performed using English units. The cracks were routed and sealed during the Fall of 2003.

After one year, nine of 455 (2%) ISAC locations had reflective cracks. At this same time, three of 12 (25%) System A (non-woven fabric), 32 of 84 (38%) System B (Roadtac), and 15 of 26 (58%) untreated locations had reflective cracks. After three years, 102 of 455 (22%) of the ISAC locations had reflective cracks. At this same time, six of 12 (50%) of System A (non-woven fabric), 58 of 85 (68%) System B (Roadtac), and 23 of 26 (88%) untreated locations had reflective cracks (See Appendix A Figure 7).

The greatest increase in reflective cracks at the ISAC locations, from 18 to 102, occurred between year two and three. There was an increase to 153 in year four. When compared with “System A”, the reflective cracks were delayed by about two years with ISAC. When compared with “System B”, the reflective cracks were delayed almost three years. When compared with the untreated locations, the reflective cracks were delayed over three years.

COST ANALYSIS

Asphalt surface and binder costs vary greatly by district and quantity purchased. The local Illinois distributor of ISAC stated that the typical installation costs of ISAC range from $10-14 per foot depending on the quantity purchased. The larger the quantity purchased, the lower the cost/foot of ISAC.

An equation to determine the number of cracks that could be treated with ISAC, N, was developed. It was assumed that the average overlay lasts ten years and that the use of ISAC would extend this life to twelve years. A one lane-mile section was used. It was also assumed that the cracks extended the entire lane width, so that the lane width and

ISAC length across the lane would be equal. The average yearly cost of the ten-year overlay and the average yearly cost of the twelve-year overlay with ISAC were set equal. The equation was solved for N, and is listed below. The variables used in the equation are listed in Table 2.

When the cost and thickness of the surface and binder and the ISAC cost are known, the following equation estimates the maximum number of cracks per mile that can be covered with ISAC to get an equal cost per year over the extended life of the overlay.

$$N = [(Ts \times Cs + Tb \times Cb) \times 6.57] / Ci$$

Ts	Thickness - surface	(inches)
Tb	Thickness - binder	(inches)
Cs	Cost - surface	($/Ton)
Cb	Cost - binder	($/Ton)
Ci	Cost - ISAC	($/Lineal Foot)
N	Number of cracks and joints to be covered with ISAC per lane mile	

Table 2. ISAC Cost Analysis Equation Variables

This equation shows that the higher the total cost of the asphalt concrete the higher the number of cracks that can be treated with ISAC. Also, the lower the ISAC cost, the higher the number of cracks that can be treated.

CONCLUSIONS

The formation of reflective cracks and the subsequent deterioration of these cracks were delayed at ISAC treated joints and cracks. This statement was true for all five test sites. This delay ranged from over one year to close to three years when compared to the untreated and other crack control methods. Of special note, the ISAC areas consistently outperformed the System B products, PavePrep and Roadtac. When compared with SAF, the ISAC delayed reflective cracks by about two years. The two sections performed the same after the cracks were routed and sealed.

The cost analysis indicated that the higher the total cost of the asphalt concrete the higher the number of cracks and joints that could be treated with ISAC. The present cost of the ISAC strips, $10 - $14 per foot, limits the conditions under which it would be cost effective to use ISAC. If asphalt costs are high or the cost of ISAC were to decline, there would be more projects that could benefit from using ISAC.

RECOMMENDATIONS

It is recommended that ISAC be approved for use in Illinois as a reflective crack control system. A cost/benefit analysis should be performed to determine if the extra cost of using the ISAC strips will result in a lower average cost/year over the extended life of the pavement.

APPENDIX A

Charts of Field Installations

ISAC/Paveprep IL 29 – Creve Coeur

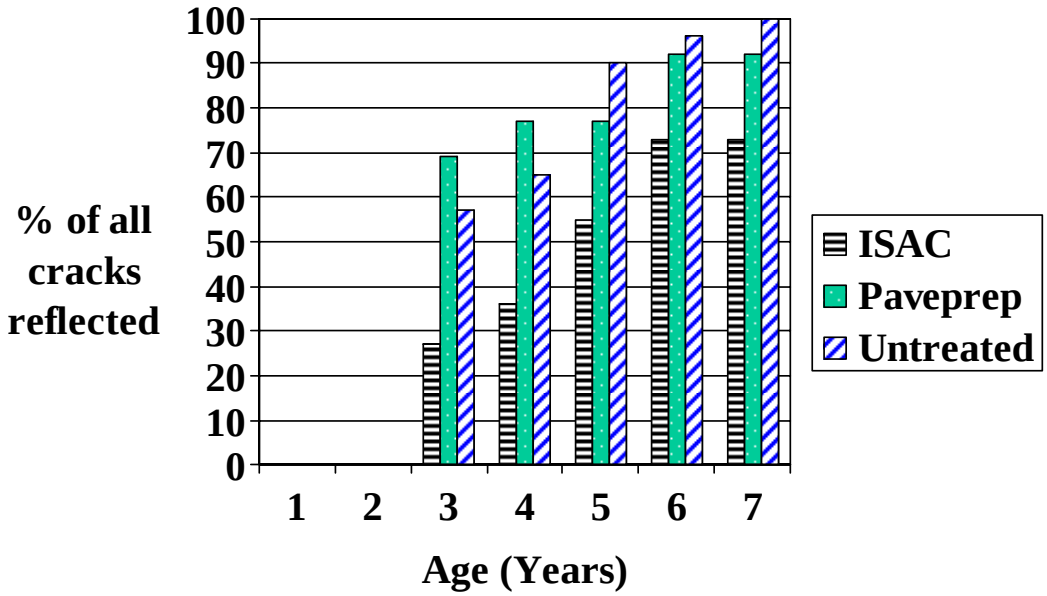

Figure 1

ISAC IL 267 – District 8

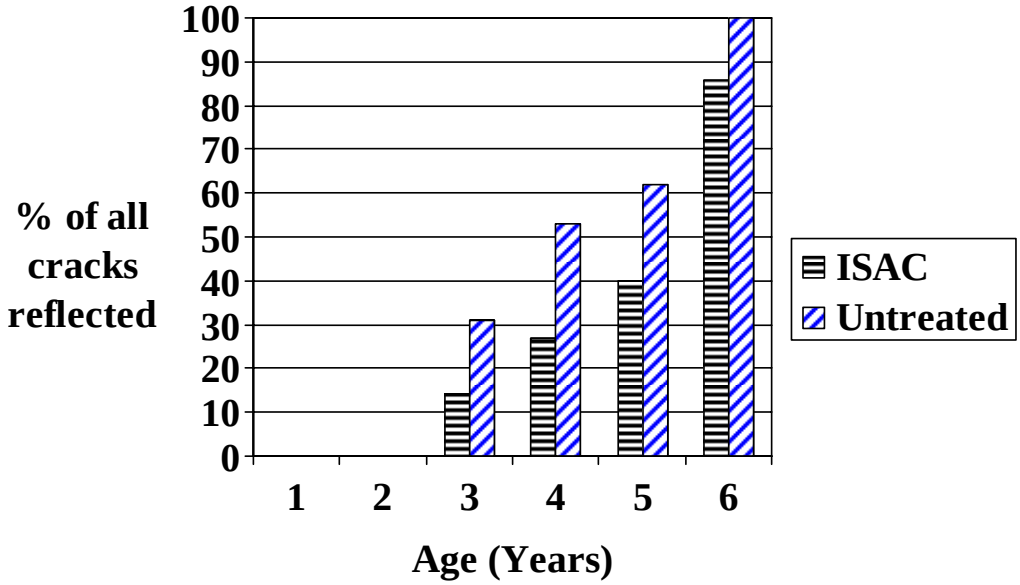

Figure 2

ISAC - US 136 – District 6

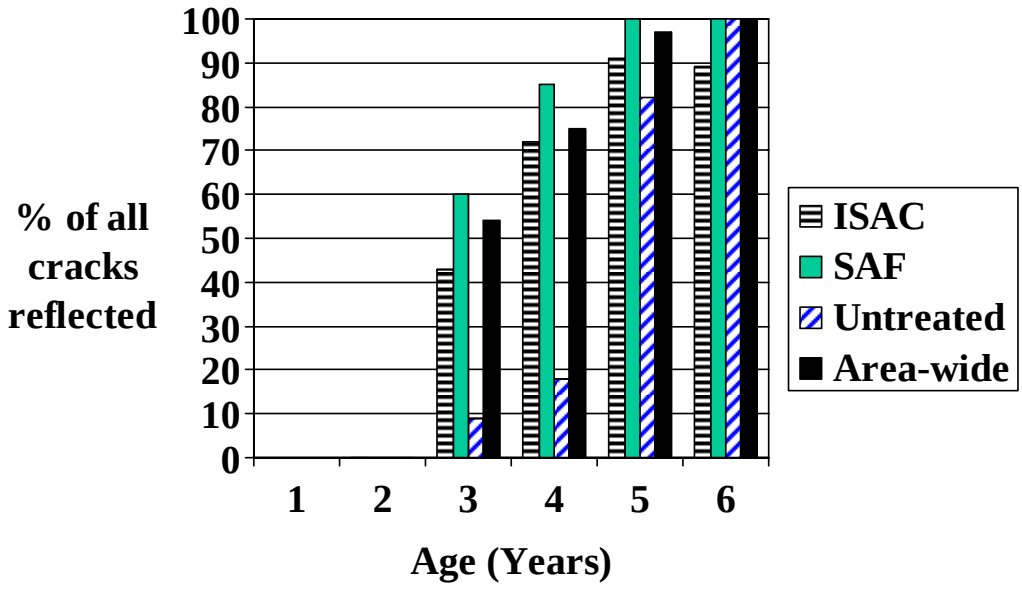

Figure 3

ISAC - US 136 – District 6

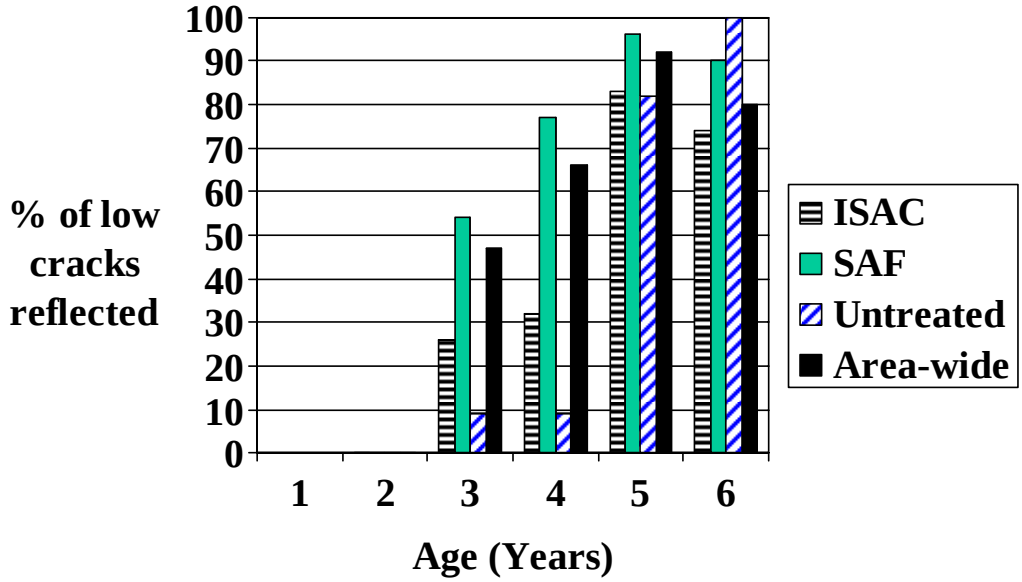

Figure 4

ISAC – I 55 (MP 23-26)

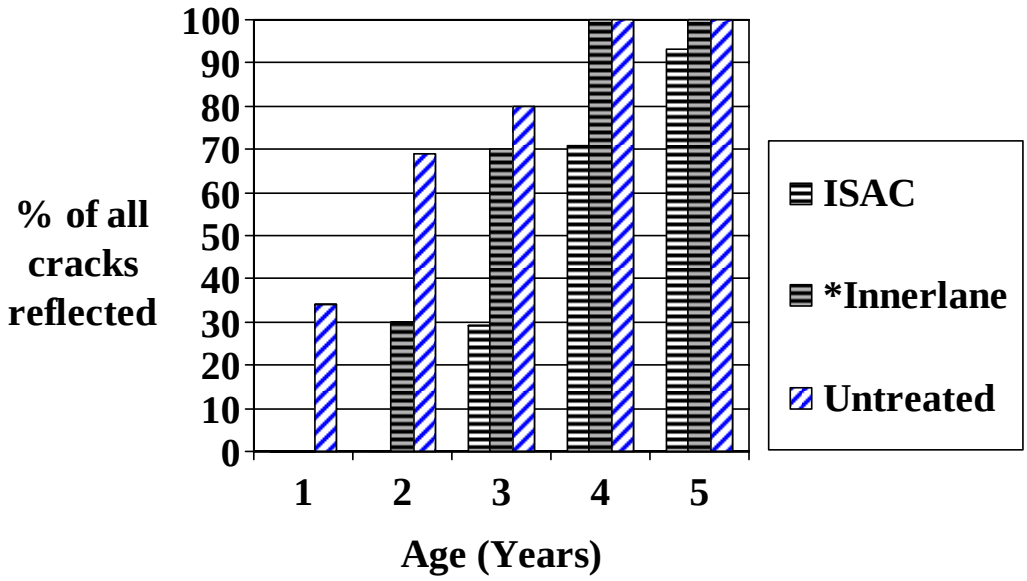

Figure 5

*Untreated inner lane locations with ISAC located in adjacent patch in outer lane

ISAC – I 55 (MP 23-26)

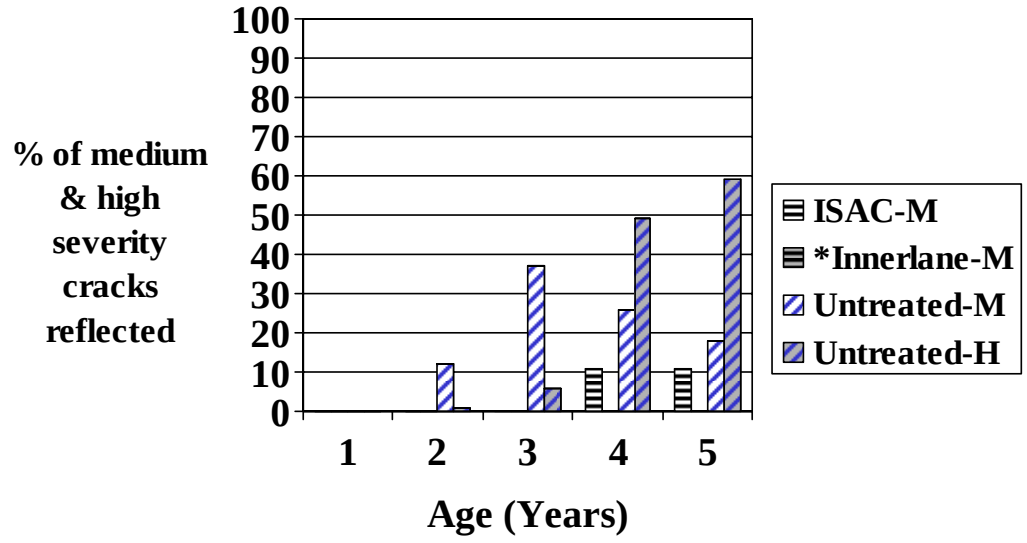

Figure 6

*Untreated inner lane locations with ISAC located in adjacent patch in outer lane

ISAC – Mattis Ave, Champaign, IL

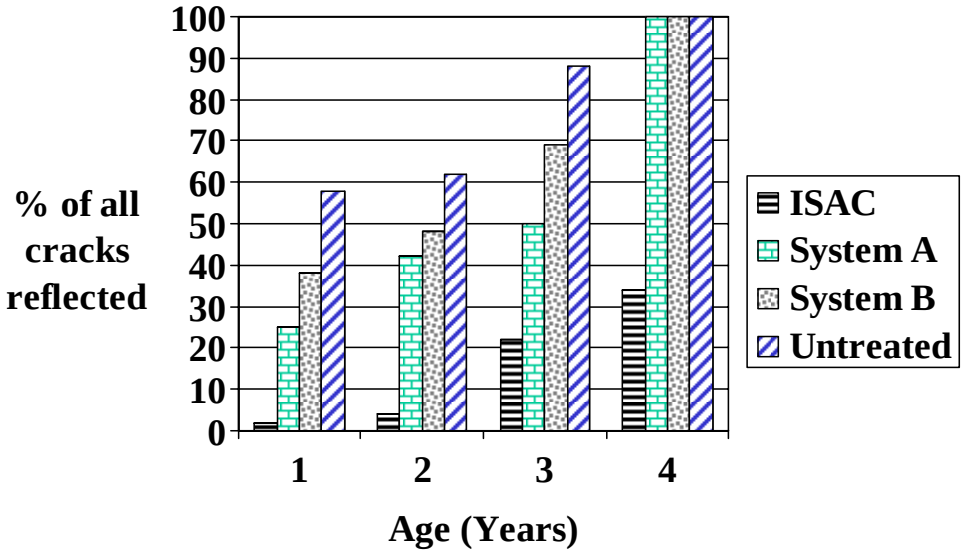

Figure 7

APPENDIX B

Tables of Pavement Distress Survey Summaries

Table B1 – ISAC/Paveprep – IL 29 Creve Coeur District 4

NB	Seam			Low			Medium			High			Total		
Date	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing
6/1/2000	0	0	0	2	2	19	0	0	0	0	0	0	2	2	19
3/27/2001	0	0	0	2	2	13	0	0	2	0	0	2	2	2	17
7/24/2002	1	0	0	3	0	10	0	2	9	0	0	2	4	2	21
10/8/2003	0	0	0	3	0	5	3	2	12	0	0	4	6	2	21
8/10/2004	0	0	2	3	0	4	3	2	10	0	0	7	6	2	23

Table B1a. NB IL 29 ISAC (9 Locations) Paveprep (2 Locations) Nothing (Untreated)

SB	Seam			Low			Medium			High			Total		
Date	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing
6/1/2000	0	0	0	1	7	9	0	0	0	0	0	0	1	7	9
3/27/2001	0	0	0	2	5	15	0	3	0	0	0	0	2	8	15
7/24/2002	0	0	1	1	0	15	1	6	6	0	2	1	2	8	23
10/8/2003	0	0	0	0	2	16	1	1	9	1	7	1	2	10	26
8/10/2004	0	0	0	0	2	11	1	1	14	1	7	1	2	10	26

Table B1b. SB IL 29 ISAC (2 Locations) Paveprep (11 Locations) Nothing (Untreated)

NB+SB	Seam			Low			Medium			High			Total		
Date	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing
6/1/2000	0	0	0	3	9	28	0	0	0	0	0	0	3	9	28
3/27/2001	0	0	0	4	7	28	0	3	2	0	0	2	4	10	32
7/24/2002	1	0	1	4	0	25	1	8	15	0	2	3	6	10	44
10/8/2003	0	0	0	3	2	21	4	3	21	1	7	5	8	12	47
8/10/2004	0	0	2	3	2	15	4	3	24	1	7	8	8	12	49

Table B1c. NB & SB (Total) IL 29 ISAC (11 Locations) Paveprep (13 Locations) Nothing (Untreated)

NB+SB	Seam (%)			Low (%)			Medium (%)			High (%)			Total (%)		
Date	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing	ISAC	Ppre p	Nothing
6/1/2000	0	0	0	27	69	57	0	0	0	0	0	0	27	69	57
3/27/2001	0	0	0	36	54	57	0	23	4	0	0	4	36	77	65
7/24/2002	9	0	2	36	0	51	9	62	31	0	15	6	55	77	90
10/8/2003	0	0	0	27	15	43	36	23	43	9	54	10	73	92	96
8/10/2004	0	0	4	27	15	31	36	23	49	9	54	16	73	92	100

Table B1d. NB & SB (Percent) IL 29 ISAC (11 Locations) Paveprep (13 Locations) Nothing (Untreated)

Note: Section completed Fall 1997.

Table B2 – ISAC – IL 267, District 8

NB	Seam		Low		Medium		High		Total (51)	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
2/16/2000	0	0	0	0	0	0	0	0	0	0
3/27/2001	0	2	4	10	0	2	0	0	4	14
7/5/2002	3	7	7	17	0	5	0	0	10	29
4/23/2003	8	3	6	20	1	8	0	1	15	32
6/4/2004	5	4	35	32	1	9	0	1	41	46

Table B2a. NB IL 267 ISAC (51 Locations) Nothing (46 Untreated)

SB	Seam		Low		Medium		High		Total (52)	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
2/16/2000	0	0	0	0	0	0	0	0	0	0
3/27/2001	1	1	9	24	0	1	0	0	10	26
7/5/2002	1	3	17	35	0	3	0	0	18	41
4/23/2003	2	4	23	39	1	5	0	1	26	49
6/4/2004	2	1	45	78	1	5	0	1	48	85

Table B2b. SB IL 267 ISAC (52 Locations) Nothing (85 Untreated)

NB+SB	Seam		Low		Medium		High		Total (103)	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
2/16/2000	0	0	0	0	0	0	0	0	0	0
3/27/2001	1	3	13	34	0	3	0	0	14	40
7/5/2002	4	10	24	52	0	8	0	0	28	70
4/23/2003	10	7	29	59	2	13	0	2	41	81
6/4/2004	7	5	80	110	2	14	0	2	89	131

Table B2c. NB & SB (Total) IL 267 ISAC (103 Locations) Nothing (131 Untreated)

NB+SB	Seam (%)		Low (%)		Medium (%)		High (%)		Total (%)	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
2/16/2000	0	0	0	0	0	0	0	0	0	0
3/27/2001	1	2	13	26	0	2	0	0	14	31
7/5/2002	4	8	23	40	0	6	0	0	27	53
4/23/2003	10	5	28	45	2	10	0	2	40	62
6/4/2004	7	4	78	84	2	11	0	2	86	100

Table B2d. NB & SB (Percent) IL 267 ISAC (103 Locations) Nothing (131 Untreated)

Note: Section completed 10/1/1998
Note: Cracks were routed and sealed in the Fall of 2003.

Table B3 – ISAC – US 136, District 6 San Jose

Sand Anti-Fracture (EB) vs. Area-wide (WB)										
1150 ft	Seam		Low		Medium		High		Total	
Date	Sand	Area	Sand	Area	Sand	Area	Sand	Area	Sand	Area
6/1/2000	0	0	0	0	0	0	0	0	0	0
3/26/2001	3	2	34	39	0	0	0	0	37	41
8/17/2001	2	6	35	43	1	0	0	0	38	49
7/24/2002	2	5	43	60	4	3	0	0	49	68
4/16/2003	1	1	66	84	4	3	0	0	71	88
6/2/2004	1	0	67	73	6	18	0	0	74	91

Table B3a. US 136 – SAF (74 Locations) Area-wide (91 Locations)

Westbound ISAC (47 locations)										
WB-813 ft	Seam		Low		Medium		High		Total	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
6/1/2000	0	0	0	0	0	0	0	0	0	0
3/26/2001	5	0	12	1	0	0	0	0	17	1
8/17/2001	8	0	12	1	0	0	0	0	20	1
7/24/2002	18	1	15	1	1	0	0	0	34	2
4/16/2003	3	0	39	9	1	0	0	0	43	9
6/2/2004	2	0	35	11	5	0	0	0	42	11

Table B3b. US 136 – ISAC (47 Locations) Nothing (11 Untreated Locations)

Sand Anti-Fracture vs. ISAC Section										
813 ft	Seam		Low		Medium		High		Total	
Date	Sand	ISAC	Sand	ISAC	Sand	ISAC	Sand	ISAC	Sand	ISAC
6/1/2000	0	0	0	0	0	0	0	0	0	0
3/26/2001	1	5	30	13	0	0	0	0	31	18
8/17/2001	3	8	26	13	0	0	0	0	29	21
7/24/2002	4	19	37	16	0	1	0	0	41	36
4/16/2003	1	3	46	48	1	1	0	0	48	52
6/2/2004	0	2	43	46	5	5	0	0	48	53

Table B3c. US 136 – SAF vs. ISAC section (total includes the Untreated locations)

Sand Anti-Fracture (EB) vs. Area-wide (WB)										
1150 ft	Seam (%)		Low (%)		Medium (%)		High (%)		Total (%)	
Date	Sand	Area	Sand	Area	Sand	Area	Sand	Area	Sand	Area
6/1/2000	0	0	0	0	0	0	0	0	0	0
3/26/2001	4	2	46	43	0	0	0	0	50	45
8/17/2001	3	7	47	47	1	0	0	0	51	54
7/24/2002	3	5	58	66	5	3	0	0	66	75
4/16/2003	1	1	89	92	5	3	0	0	96	97
6/2/2004	1	0	91	80	8	20	0	0	100	100

Table B3d. US 136 – SAF vs. Area-wide (percent of total cracks)

Westbound ISAC (47 locations)										
WB-813 ft	Seam (%)		Low (%)		Medium (%)		High (%)		Total (%)	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
6/1/2000	0	0	0	0	0	0	0	0	0	0
3/26/2001	11	0	26	9	0	0	0	0	36	9
8/17/2001	17	0	26	9	0	0	0	0	43	9
7/24/2002	38	9	32	9	2	0	0	0	72	18
4/16/2003	6	0	83	82	2	0	0	0	91	82
6/2/2004	4	0	74	100	11	0	0	0	89	100

Table B3e. US 136 – ISAC section (percent of total cracks)

Sand Anti-Fracture vs. ISAC Section										
813 ft	Seam (%)		Low (%)		Medium (%)		High (%)		Total (%)	
Date	Sand	ISAC	Sand	ISAC	Sand	ISAC	Sand	ISAC	Sand	ISAC
6/1/2000	0	0	0	0	0	0	0	0	0	0
3/26/2001	2	9	63	25	0	0	0	0	65	34
8/17/2001	6	15	54	25	0	0	0	0	60	40
7/24/2002	8	36	77	30	0	2	0	0	85	68
4/16/2003	2	6	96	91	2	2	0	0	100	98
6/2/2004	0	4	90	87	10	9	0	0	100	100

Table B3f. US 136 – SAF vs. ISAC section (percent of total cracks)

Note: Section completed 1999.
Note: Cracks were routed and sealed days before the 4/16/2003 survey.
Note: Three cracks (two ISAC locations) were overlaid as part a taper of an adjacent overlay before the 6/2/2004 survey.

Table B4 – ISAC I-55 (MP 23-26) Edwardsville, IL

SB-Inner	Seam		Low		Medium		High		Total	
Date	*Inner	Nothing	*Inner	Nothing	*Inner	Nothing	*Inner	Nothing	*Inner	Nothing
6/20/2000	0	0	0	5	0	5	0	0	0	10
3/20/2001	1	0	5	63	0	0	0	0	6	63
7/16/2002	1	1	13	74	0	1	0	0	14	76
11/21/2003	0	0	20	101	0	8	0	0	20	109
10/7/2004	0	3	20	94	0	17	0	0	20	114

Table B4a. I-55 *Inner (ISAC located in 14 adjacent patches in outer lane)

SB-Outer	Seam		Low		Medium		High		Total	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
6/20/2000	0	0	0	54	0	0	0	0	0	54
3/20/2001	0	6	0	82	0	19	0	1	0	108
7/16/2002	2	6	6	52	0	58	0	10	8	126
11/21/2003	0	8	17	31	3	41	0	77	20	157
10/7/2004	6	6	17	26	3	28	0	93	26	153

Table B4b. I-55 SB outer – ISAC (28 strips at 14 patches) Nothing (untreated 157)
Note: Four untreated cracks were patched in March 2004 decreasing the total to 153.

SB-Inner	Seam (%)		Low (%)		Medium (%)		High (%)		Total (%)	
Date	*Inner	Nothing	*Inner	Nothing	*Inner	Nothing	*Inner	Nothing	*Inner	Nothing
6/20/2000	0	0	0	4	0	4	0	0	0	9
3/20/2001	5	0	25	55	0	0	0	0	30	55
7/16/2002	5	1	65	65	0	1	0	0	70	67
11/21/2003	0	0	100	89	0	7	0	0	100	96
10/7/2004	0	3	100	82	0	15	0	0	100	100

Table B4c. I-55 *Inner percent (ISAC located in 14 adjacent patches in outer lane)

SB-Outer	Seam (%)		Low (%)		Medium (%)		High (%)		Total (%)	
Date	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing	ISAC	Nothing
6/20/2000	0	0	0	34	0	0	0	0	0	34
3/20/2001	0	4	0	52	0	12	0	1	0	69
7/16/2002	7	4	21	33	0	37	0	6	29	80
11/21/2003	0	5	61	20	11	26	0	49	71	100
10/7/2004	21	4	61	17	11	18	0	59	93	100

Table B4d. I-55 ISAC percent (28 strips at 14 patches in outer lane)

SB	Seam (%)		Low (%)		Medium (%)		High (%)		Total (%)	
Date	ISAC	* Inner	ISAC	* Inner	ISAC	* Inner	ISAC	* Inner	ISAC	* Inner
6/20/2000	0	0	0	0	0	0	0	0	0	0
3/20/2001	0	5	0	25	0	0	0	0	0	30
7/16/2002	7	5	21	65	0	0	0	0	29	70
11/21/2003	0	0	61	100	11	0	0	0	71	100
10/7/2004	21	0	61	100	11	0	0	0	93	100

Table B4e. I-55 ISAC percent vs. *Inner percent

Note: Binder placed fall 1998. ISAC placed over patch joints and surface placed 1999.

Table B5 – ISAC – Mattis Avenue, Champaign, IL

NB-Inner	Seam			Low			Medium			High			Total (ISAC 162)		
Date	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing
3/20/2001	3	0	0	0	1	2	0	0	2	0	0	0	3	1	4
7/6/2001	4	0	0	0	1	1	0	0	3	0	0	0	4	1	4
7/3/2002	3	1	0	5	1	2	0	0	3	0	0	0	8	2	5
5/5/2003	12	0	3	22	3	2	0	0	3	0	0	0	34	3	8
5/5/2003	3	1	1	42	5	5	0	0	3	0	0	0	45	6	9

Table B5a. Mattis Ave. NB Inner Lane – ISAC (162 locations)

NB-Outer	Seam			Low			Medium			High			Total (ISAC 170)		
Date	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing	ISAC	Sys. A	Nothing
3/20/2001	1	2	0	3	0	3	0	0	2	0	0	0	4	2	5
7/6/2001	1	2	0	3	0	2	0	0	3	0	0	0	4	2	5
7/3/2002	1	0	0	5	3	2	0	0	3	0	0	0	6	3	5
5/5/2003	14	0	2	15	3	2	1	0	3	0	0	0	30	3	7
4/30/2004	7	2	1	35	4	4	2	0	3	0	0	0	44	6	8

Table B5b. Mattis Ave. NB Outer Lane – ISAC (170 locations)

SB-Inner	Seam			Low			Medium			High			Total (ISAC 57)		
Date	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing
3/20/2001	0	5	0	0	7	3	0	1	0	0	0	0	0	13	3
7/6/2001	0	4	0	0	7	3	0	2	0	0	0	0	0	13	3
7/3/2002	0	4	0	2	10	0	0	4	3	0	0	0	2	18	3
5/5/2003	9	3	1	10	16	1	2	8	2	0	1	1	21	28	5
4/30/2004	5	4	0	25	32	3	2	8	2	0	1	1	32	45	6

Table B5c. Mattis Ave. SB Inner Lane – ISAC (57 locations)

SB-Outer	Seam			Low			Medium			High			Total (ISAC 66)		
Date	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing	ISAC	Sys. B	Nothing
3/20/2001	0	5	0	1	12	3	0	2	0	0	0	0	1	19	3
7/6/2001	0	4	0	1	12	3	0	3	0	0	0	0	1	19	3
7/3/2002	1	5	0	0	9	0	1	8	3	0	0	0	2	22	3
5/5/2003	9	5	0	7	11	0	1	13	3	0	1	0	17	30	3
4/30/2004	14	5	0	15	19	0	3	14	3	0	1	0	32	39	3

Table B5d. Mattis Ave. SB Outer Lane – ISAC (66 locations)

All Lanes	Seam				Low				Medium				High				Total			
Date	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing
3/20/2001	4	2	10	0	4	1	19	11	0	0	3	4	0	0	0	0	8	3	32	15
7/6/2001	5	2	8	0	4	1	19	9	0	0	5	6	0	0	0	0	9	3	32	15
7/3/2002	5	1	9	0	12	4	19	4	1	0	12	12	0	0	0	0	18	5	40	16
5/5/2003	44	0	8	6	54	6	27	5	4	0	21	11	0	0	2	1	102	6	58	23
4/30/2004	29	3	9	2	117	9	51	12	7	0	22	11	0	0	2	1	153	12	84	26

Table B5e. Mattis Ave. All Lanes – Total Cracks

All Lanes	Seam (%)				Low (%)				Medium (%)				High (%)				Total (%)			
Date	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing	ISAC	Sys.A	Sys. B	Nothing
3/20/2001	1	17	12	0	1	8	23	42	0	0	4	15	0	0	0	0	2	25	38	58
7/6/2001	1	17	10	0	1	8	23	35	0	0	6	23	0	0	0	0	2	25	38	58
7/3/2002	1	8	11	0	3	33	23	15	0	0	14	46	0	0	0	0	4	42	48	62
5/5/2003	10	0	10	23	12	50	32	19	1	0	25	42	0	0	2	4	22	50	69	88
4/30/2004	6	25	11	8	26	75	61	46	2	0	26	42	0	0	2	4	34	100	100	100

Table B5f. Mattis Ave. All Lanes – Percent of Total Cracks

Note: Section completed 9/10/2000
Note: ISAC located in all lanes (455 total).
Note: System A, non-woven fabric, located in the NB lanes (12 total).
Note: System B, Roadtac self adhesive membrane, in SB lanes (84 total).
Note: Nothing (Untreated) located in all lanes (26 total).

APPENDIX C

Pictures from Interstate 55 Installation Project

Interstate 55 reflective cracks in binder layer June 1999.

Binder layer removed June 1999.

Placement of tack coat.

Rolling the ISAC.

ISAC in place, blue backing film will be removed.

10/07/04 ISAC treated patch in bottom lane (“99” stamped near the edge stripe).
All reflective cracks are low severity.

10/07/04 untreated patches. Low severity reflective cracks in top lane.
High severity reflective cracks in the bottom lane.