

# **Pavement Quality Indicators Study**

## **Five Year Report**

By

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# Pavement Quality Indicators Study



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16. Abstract The Nebraska Department of Roads (NDOR) conducts annual examinations of the Nebraska's interstate and federal highway pavements. During these examinations, numerous indicators of pavement quality are measured directly or are compiled from parameters recorded by a vehicle passing over the pavement section. Parameters are documented and analyzed for each one-tenth mile segment. A number of pavement sections where innovative features have been incorporated were selected by the NDOR for comparison to nearby conventional pavement sections. This study used data recorded by the NDOR as well as field observations to develop a comparison between two pavement sections, one with innovative features incorporated and a second of more conventional design .  Pavement quality indicators measured and compared included Nebraska Serviceability Index, International Roughness Index, Present Serviceability Index, cracking index, rutting, faulting, and longitudinal and transverse cracking. Pavement sections where innovative features were incorporated generally performed better than pavement sections where only more conventional features were used.			
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This study was funded by the Nebraska Department of Roads (NDOR) under a research project titled Pavement Quality Indicators. The first five years of this project were completed under the direction of Dr. Wayne Jensen, with the assistance of three different undergraduate research technicians. This report was prepared primarily by Cody Kluver, who served as the 2006-2007 and 2007-2008 undergraduate research technician.

The authors wish to thank Dave Medinger from the NDOR for providing information concerning various pavement quality indicators from the appropriate databases at the NDOR. Many other individuals from the NDOR's Materials and Research Division made significant contributions to this research including Mick Syslo, Moe Jamshidi, Amy Starr, Jodi Gibson, and Lieska Halsey.



Several innovative pavement technologies have been introduced into the Nebraska highway system by the Nebraska Department of Roads during the past decade. These technologies include retrofitting dowel bars into pavement transverse joints, continuous "daylighting" of granular subbase material for drainage, lime and flyash modified subgrades, longitudinal tining of concrete pavement, Portland cement concrete overlays of asphalt pavement, crumb rubber overlays and others. The Pavement Quality Indicators (PQI) study was initiated in 2003 with the objective of analyzing the performance of pavement sections with innovative technologies and comparing their performance with that exhibited by more conventional pavement sections.

A specific number of pavement sections where innovative technologies have been incorporated were selected by the NDOR for comparison to nearby conventional pavement sections. Close geographic proximity was essential to maintain similar environmental conditions and similar traffic loads. Analysis of pavement included common indices such as cracking index, faulting index, International Roughness Index (IRI), degree of spalling at joints and other selected quality criteria. Since the project began, some of the conventional concrete pavement sections have been retrofitted with dowel bars. These sections remain in this study at least through this five year report. In the latter years, additional pavement sections have been added which examine such variables as asphalt pavement thickness and incorporation of recycled asphalt into pavement or subgrade for pavement.

This study sought to document the advantages and disadvantages of using various innovative technologies for concrete and asphalt pavement. At some point in the future, a cost/benefit analysis of various innovative technologies is recommended. The results of that research can be used to evaluate the cost versus expected benefits for construction of specific innovative pavement designs versus the cost versus expected benefits for more conventional pavement systems. The current research will allow only comparison of the effects of innovative technologies on expected pavement lifespan in relation to the lifespan of more conventional pavement systems.

The study utilizes information collected by the NDOR as part of their annual pavement evaluation studies and includes site visits to most pavement sections on an annual basis. Site visits were documented by measuring various physical parameters as well as by digital photography. Comparing the digital photography over time often highlights physical distresses suggested by analysis of quality data.



## How the NDOR Measures Pavement Quality

The Nebraska Department of Roads (NDOR) conducts annual examinations of the Nebraska's interstate and federal highway pavements. During these examinations, numerous indicators of pavement quality are measured directly or are compiled from parameters recorded by a vehicle passing over the pavement section. Parameters are documented and analyzed for each one-tenth mile segment. This study used data recorded by the NDOR as well as field observations to develop a standardized comparison between two similar pavement sections. Information about these quality indicators will be referenced throughout this report. The quality indicators measured and the conditions of each which relate to various levels of service are shown below.

**Nebraska Serviceability Index (NSI):** Overall surface condition of pavement rated on a subjective scale of 0-100.

Very good:	90 & Over
Good:	70—89
Fair:	50-69
Poor	30-49
Very Poor	0-29

**International Roughness Index (IRI):** Pavements smoothness is measured as vertical millimeters per lateral meter (mm/m).

Very smooth:	0.0—0.85
Smooth:	0.86—2.48
Moderately rough:	2.49—3.33
Rough	3.34—4.21
Very Rough	4.22 & Over

**Present Serviceability Index (PSI):** AASHTO index indicating the functional ability of the pavement to serve the public, based on roughness, with 5 being best and 0 worst.

Very Good:	4.1—5.0
Good:	3.1—4.0
Fair:	2.1—3.0
Poor	1.1—2.0
Very Poor	0.0—1.0

**Cracking Index:** Approximate percentage of bituminous surfacing (BIT) that is cracked or the percentage of PCC (Portland Cement Concrete) panels which are cracked.

Acceptable	0—30
Tolerable	30—50
Unacceptable	over 50

**Rutting:** Average rut depth for a bituminous surface expressed in millimeters (mm).

Acceptable	Less than 6
Tolerable	6—13
Unacceptable	Over 13

**Faulting:** The amount of displacement between two adjacent slabs measured at the common joint or structural crack in millimeters (mm). Pavement with faulting in excess of 6 mm is considered poor quality.

**Longitudinal Cracking:** Longitudinal cracking denotes cracks that run predominantly parallel to the centerline. These cracks may be in the wheel paths, between wheel paths and/or at lane joints such as near the centerline or shoulder.

**Transverse Cracking:** Cracks that run perpendicular to centerline, resulting in a panel that is broken into two or more pieces. Panels broken into two pieces are rated Class I and panels broken into more than two pieces are rated Class II.

## Dowelled Pavement

### Traditional Construction

Concrete shrinks slightly as it cures. Longitudinal and transverse joints are sawed at regular intervals to control the location and direction of cracking. The sawed joint is then sealed and maintained to prevent water infiltration. The control joint cracks during curing or when loaded by traffic. The crack will eventually propagate to the full depth of the slab. Over time, with repeated loads moving across the joint, the aggregate interlock and subbase are unable to maintain the adjoining concrete panels at the same horizontal level. The result is vertical displacement or 'faulting'.

Faulting creates an uncomfortable ride and is characterized by:

- Joint seals which tend to fail more frequently.
- Water and de-icing agents then infiltrate the joint.
- The top of the subbase is lowered as fines are removed by water moving downward through the joint.
- Removal of subbase material results in loss of support, cracking and failure along the pavement joint.



Dowel bars placed on chairs ready for paving.  
(Photo compliments of Lieska Halsey)

Faulting drastically decreases the lifespan of pavement. To prevent faulting, dowel bars are inserted between adjacent pavement sections in order to limit the amount of vertical displacement. Figure 1 at the bottom of this page shows how smooth dowel bars are inserted between the concrete pavement sections. The dowels allow the pavement to expand and contract horizontally but inhibit adjacent panels from moving vertically. The use of dowel bars significantly decreased the amount of faulting on new pavement and has now become a common feature on pavement designed for use throughout the state. The picture at the top right shows dowel bars sitting in chairs on top of a pavement subgrade.

## 1.5 inch Diameter Epoxy Coated Smooth Steel Bars for New Pavements

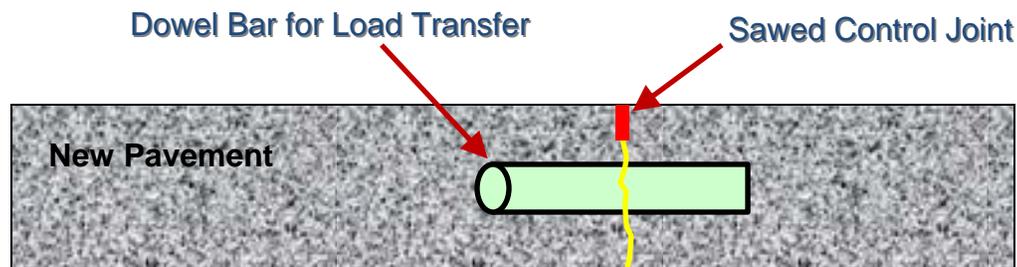


Fig. 1. Cross section of dowelled pavement. (Compliments of Lieska Halsey)



### Innovative Pavement Technologies

#### Dowel Bar Retrofit

Dowel bars have been very effective with regard to preventing faulting on new pavement sections. A process has also been developed to retrofit dowel bars into existing pavement sections.

The process of the retrofit starts by making saw cuts and chipping out the pavement where the dowel bars will be placed. The result of this process is illustrated in Picture 1.1 at the top right.

A foam chair is placed in the cut to hold the dowel bar in place. Spacers are placed around the dowel bar to allow for an expansion and contraction under changing temperature conditions. The dowel bar, foam chair and spacers are visible in Picture 1.2.

After all the components are in place, the cuts are filled with a high strength grout and the surface is finished (Picture 1.3).

Dowel bar retrofits projects have been performed successfully throughout the State. The PQI study examined multiple successful dowel bar retrofitted pavement sections including Nickerson South and Hebron to Belvidere. Retrofit projects have been as successful as new construction with respect to limiting faulting and adding lifespan to the pavement.

*(Information and photographs provided by Lieska Halsey)*



Picture 1.1: Removed pavement for new dowel bars.



Picture 1.2: Placement of dowel bar chairs, dowel bars, and expansion joint.



Picture 1.3: Placement of high strength grout.

## Innovative Pavement Technologies

### High Recycle Asphalt Pavement (RAP) Base

This process consists of milling the existing asphalt roadway and using only those millings (no other source) as RAP with hot mix asphalt (HMA) as a base material. New aggregate, in the form of crushed gravel and/or sand, is usually added as well.

The process of removing, recycling and placing the recycled asphalt pavement takes place in one day. The procession includes an incline conveyor, turbo double-barrel drum mixer, recycle bin, bag house, and several types of more standard construction equipment.

Benefits of a high RAP base construction include:

- No special equipment is needed.
- It can be used with a thinner wearing course.
- RAP is HMA rather than Cold In-Place Recycling (CIR), so it has better strength and density.
- It is competitive with CIR in cost.
- It doesn't produce the increase in height associated with CIR.
- There are no twenty-eight day liquidated damages to assess.

The PQI study is currently analyzing one of the first high RAP base projects in the state. The Plattsouth West and Louisville East sections both utilize a 3-3/4" high RAP base. This process offers many new construction and environmental benefits. The performance of these sections will be monitored in future years.

*(Photographs and information provided by Mick Syslo)*



Picture 2.1: Application of topping on Louisville East section.

The original pavement sections were selected by the NDOR to examine the performance, over a multiyear period, of several innovative versus conventional pavement designs. Waterloo NW versus Nickerson South examined dowelled versus non-dowelled pavements. Nebraska City South had a lime stabilized subgrade and drainable foundation course compared with a conventional subgrade on Nebraska City Interchange. Columbus East versus Columbus NW compared 10" doweled Portland cement concrete (PCC) to dowel bar retrofitted PCC pavement. Geneva NS compared doweled pavement with lime treated subgrade and drainable foundation course to a 10" dowel bar retrofitted section with a 4" foundation course at Hebron to Belvidere. Gibbon to Shelton examined crumb rubber versus conventional asphalt surface course at Minden to Gibbon. US-20 to N-59 is a rural section that compared SP1 asphalt concrete to a conventional asphalt wearing course. Berwyn to Ansley compared an 8" doweled concrete overlay of an asphalt base to a conventional PCC pavement section.

### Innovative Pavement Sections

- Waterloo Northwest
- Nebraska City South
- Columbus East
- Geneva North and South
- Gibbon to Shelton
- US-20 to N-59
- Berwyn to Ansley

### Conventional Pavement Sections

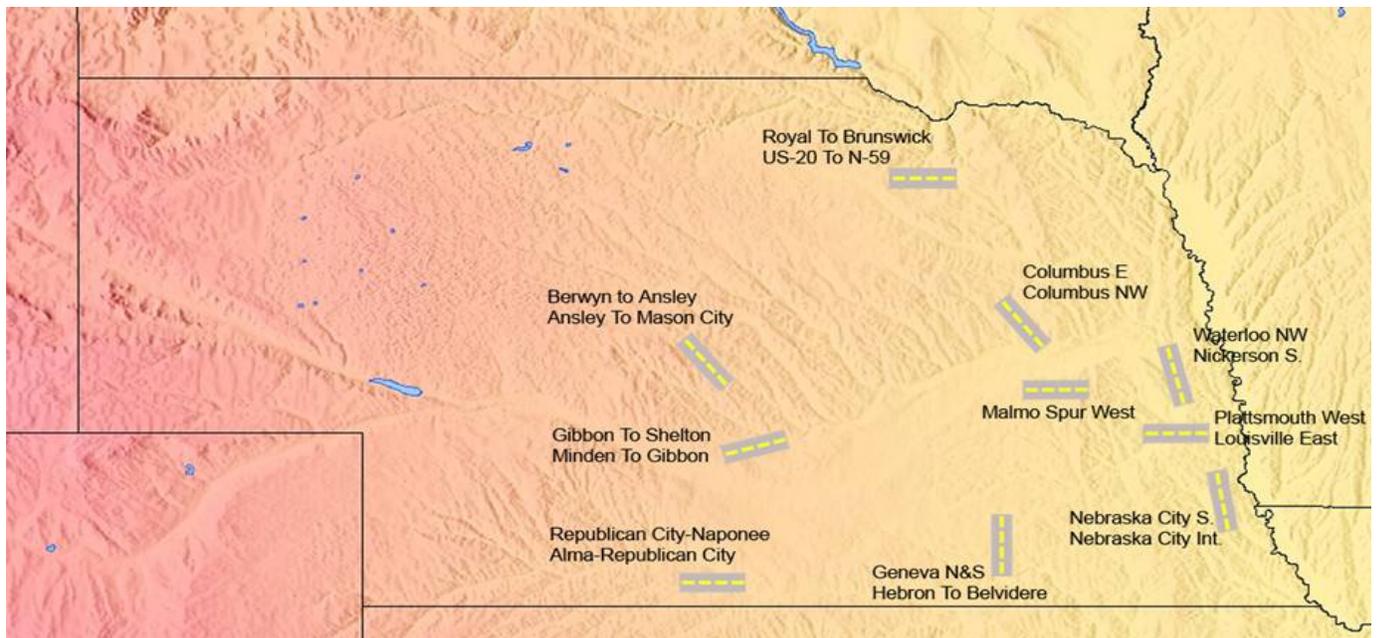
- Nickerson South
- Nebraska City Interchange
- Columbus Northwest
- Hebron to Belvidere
- Minden to Gibbon
- Royal to Brunswick
- Ansley to Mason City

### Innovative Pavement Sections Added Later

- Plattsmouth West
- Louisville East
- Malmo Spur West

### Conventional Pavement Sections

- Republican City—Naponee
- Alma—Republican City





## Innovative and Comparison Pavement Sections

EXPERIMENTAL SECTION	HWY. NO.	CTRL. #	INNOVATIVE TECHNOLOGIES	COMPARISON SECTION	HWY. NO.	CTRL. #
WATERLOO NORTHWEST	275	20796 A	30 FOOT TOP, DOWELED PAVEMENT GRANULAR SUBBASE	NICKERSON SOUTH **(Dowel Bar Retrofit)	77	21210C
NEBRASKA CITY SOUTH	75	10800	30 FOOT TOP, DOWELED PAVEMENT, DRAINABLE FOUNDATION COURSE, LIME TREATED SUBGRADE, LONGITUDINAL TINGING	NEBRASKA CITY INTERCHANGE	2	11972
COLUMBUS EAST	30	32031	30 FOOT TOP, DOWELED PAVEMENT, DRAINABLE FOUNDATION COURSE, FLY ASH TREATED SUBGRADE, LONGITUDINAL TINGING	COLUMBUS NORTHWEST **(Dowel Bar Retrofit)	81	30789
GENEVA NORTH AND SOUTH	81	41576	30 FOOT TOP, DOWELED PAVEMENT, DRAINABLE FOUNDATION COURSE, LIME TREATED SUBGRADE, LONGITUDINAL TINGING	HEBRON TO BELVIDERE **(Dowel Bar Retrofit)	81	41572
GIBBON TO SHELTON	80	42117	CRUMB RUBBER MODIFIED ASPHALT MIX	MINDEN TO GIBBON	80	42156
US-20 TO N-59	14	31582	CRUMB RUBBER MODIFIED ASPHALT MIX	ROYAL TO BRUNSWICK	20	31073A
BERWYN TO ANSLEY	2	60894	PCC OVERLAY OF EXISTING ASPHALT	ANSLEY TO MASON CITY	2	60792

Table 1. Original Study Sections



## Additional Study Sections

During the 2007-2008 study years, additional sections were added. The new sections included a variety of newer asphalt technologies including a high Recycle Asphalt Pavement (RAP) base and varying asphalt pavement thicknesses.

### **Plattsmouth West and Louisville East**

- 3-3/4" high RAP Base technology.
- Both sections have a 2" SP4 Asphaltic concrete wearing course.

### **Republican City to Naponee and Alma to Republican City**

- Rep. City to Naponee uses a 10" SP4 Asphaltic Concrete with subgrade preparation.
- Alma to Rep. City uses a 7" SP4 Asphaltic Concrete with a 4" foundation course.

### **Malmo Spur West**

- 4" Hydrated Lime Slurry Stabilization.
- 2-1/2" SP4 Asphalt Concrete wearing course.

<b>New Sections for 2007-2008</b>			
SECTION	HWY. NO.	CTRL. #	TECHNOLOGIES
Plattsmouth West	66	22225	3 ¾" High RAP Base
Louisville East	66	22204	3 ¾" High RAP Base
Republican City-Naponee	136	70591A	10" SP4 Asphaltic Concrete
Alma-Republican City	136	70591A	7" SP4 Asphaltic Concrete, 4" Foundation Course
Malmo Spur West	92	12819	4" Lime Slurry Stabilization 2 ½" SP4 Asphaltic Concrete

**Table 2: Additional Study Sections**

Section	Hwy. #	Ctrl. #	Innovative Technologies	Comparison Section	Hwy. #	Ctrl. #
WATERLOO NORTHWEST	275	20796A	30 FOOT TOP, DOWELED PAVEMENT GRANULAR SUBBASE	NICKERSON SOUTH  **Dowel Bar Retrofit)	77	21210C

## Waterloo Northwest (2002) Innovative PCC



- 10” Doweled pavement.
- Granular sub-base.
- 30 foot top.

## Nickerson South (1999) Conventional PCC Design Section



- 10” Non-doweled pavement.
- 4” Foundation course
- Subgrade preparation.
- 24 foot top.
- Milled lane #2.
- Dowel bar retrofit in lane #2.

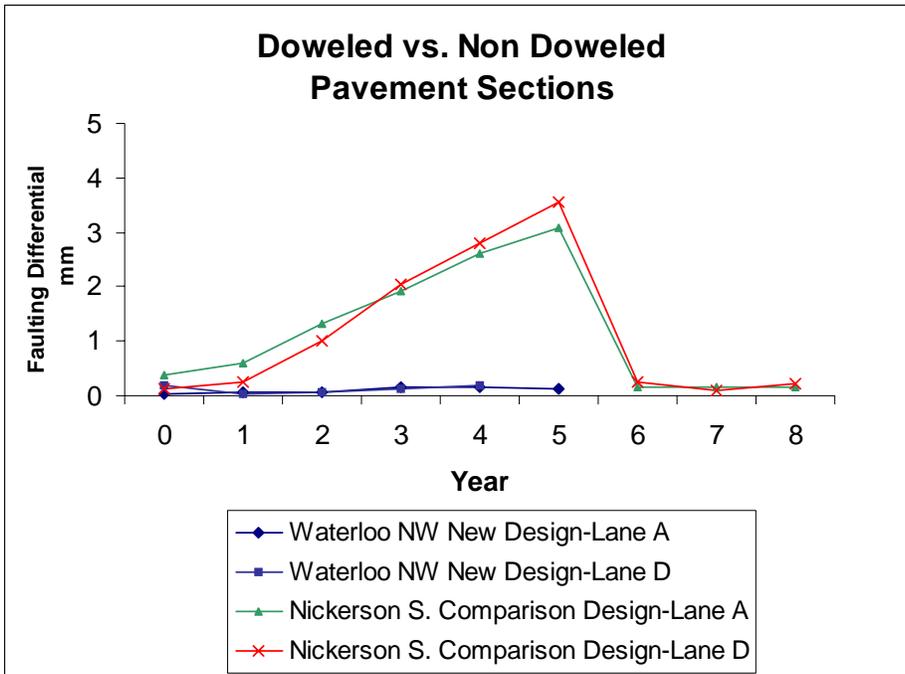


Figure 1.1: Faulting Differential, Waterloo NW and Nickerson South

This graph shows how the dowel bars used in the Waterloo NW section have limited the amount of faulting over the past five years.

The graph also shows the benefits of dowel bar retrofits. Nickerson South experienced a dowel bar retrofit in year 6 as is visible by the significant decrease in the level of faulting. Its important to notice the initial trend over the first five years (prior to the retrofit) as that trend shows a steady increase in faulting to nearly 3 mm (half the allowable maximum) by year five.

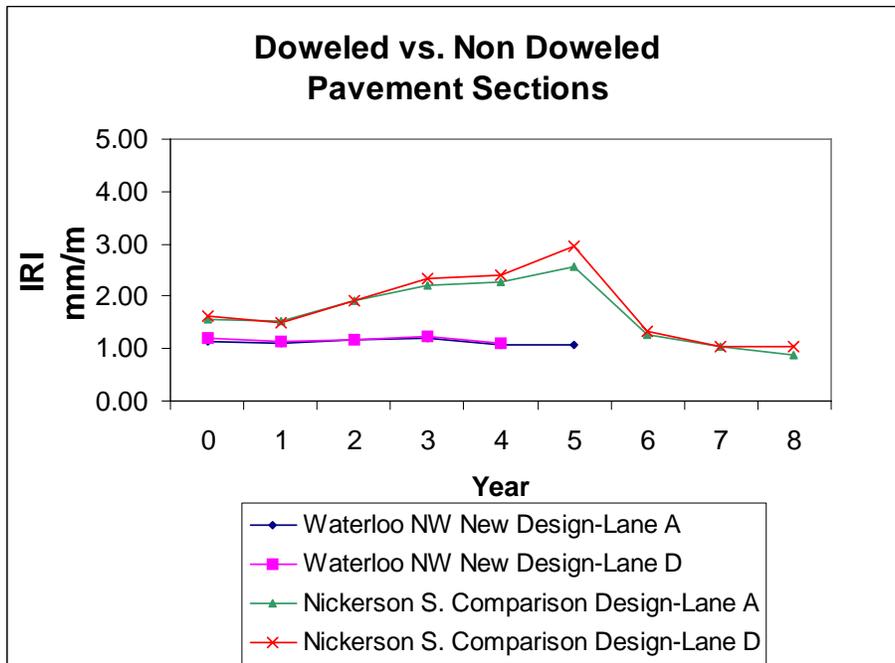


Figure 1.2: IRI, Waterloo NW and Nickerson South

Similar to the previous graph, the doweled Waterloo NW section is smoother than the traditional Nickerson South section.

At the end of five years the traditional section was rated as having moderate faulting using the International Roughness Index (IRI). Once retrofitted with dowels bars and milled, the pavement approached the doweled section in smoothness.

**Additional Graphs from Study are available in Appendix A**

## WATERLOO NORTHWEST



**Location:** MM 168.5

**Distresses Shown:**

- Placement of tie bars too close to pavement surface across longitudinal joint caused surface cracking shown in photo at left.



**Location:** MM 158

**Distresses Shown:**

- High structural cracking with visible displacement, caused by undermining of pavement for utilities.



**Location:** MM 165.5

**Distress Shown:**

- Longitudinal crack starting along edge of rumble strips.
- Crack extends four pavement panels in length.
- Located along a gentle curve.

## NICKERSON SOUTH

### \*\*Dowel Bar Retrofit



**Location:** MM 268

**Distresses Shown:**

- Saw cut patches showing disintegration of concrete.
- Grout patches from dowel bar retrofit are also visible.



**Location:** MM 253

**Distresses Shown:**

- Cracks forming where roadway was undermined during utility work.



**Location:** MM 296

**Distresses Shown:**

- Asphalt patching of shoulders.



The doweled PCC sections have been steadily outperforming the conventional ones in four of five Quality Indicators. The doweled sections performed better in faulting differential, IRI, PSI, NSI, but the data indicated a similar or an increased level of cracking was occurring in the innovative section. The dowel bar retrofit successfully increased the performance of the conventional section to the point where it was similar to doweled new construction.

Section	Hwy. #	Ctrl. #	Innovative Technologies	Comparison Section	Hwy. #	Ctrl. #
NEBRASKA CITY SOUTH	75	10800	30 FOOT TOP, DOWELED PAVEMENT, DRAINABLE FOUNDATION COURSE, LIME TREATED SUBGRADE, LONGITUDINAL TINING	NEBRASKA CITY INTERCHANGE	2	11972

## Nebraska City South (2003) Innovative PCC



- 30 ft wide PCC top.
- 10” doveled concrete pavement.
- 4” crushed concrete drainable foundation course.
- Lime stabilized subgrade.
- Longitudinal tining.

## Nebraska City Interchange (1997) Conventional PCC



- 10” Non-doweled PCC pavement.
- 4” foundation course.
- Subgrade preparation (mix, scarify, adjust moisture content, shape and compact).

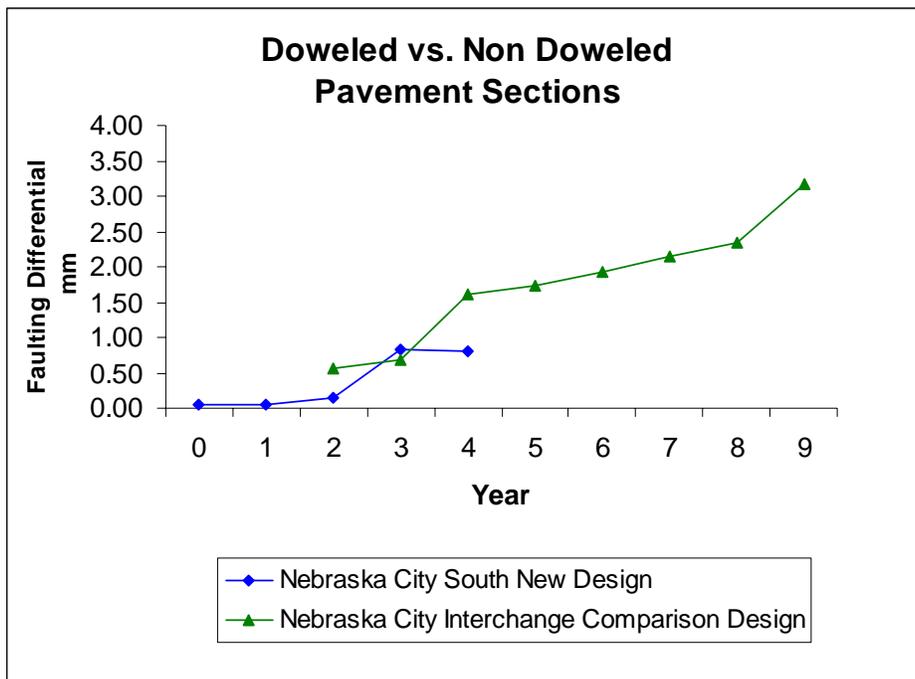


Figure 2.1: Faulting Differential, Neb. City South and Neb. City Int.

The doweled pavement (Nebraska City South) has outperformed the non-doweled section for most indicators.

At the end of year nine, the non-doweled pavement exhibits faulting of about 3 mm. The doweled pavement is experiencing less severe faulting, averaging about 1 mm after four years.

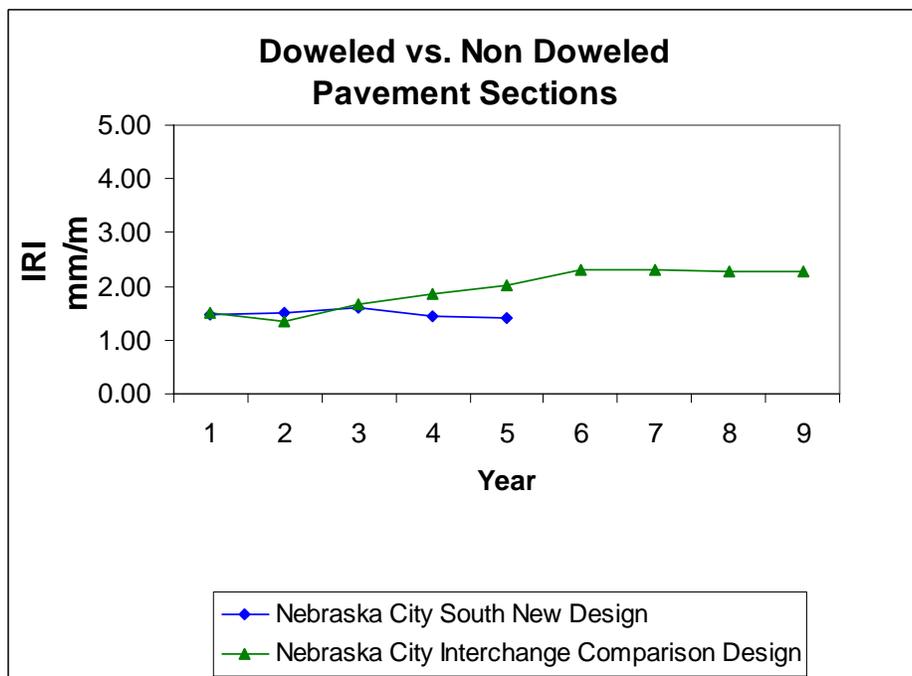
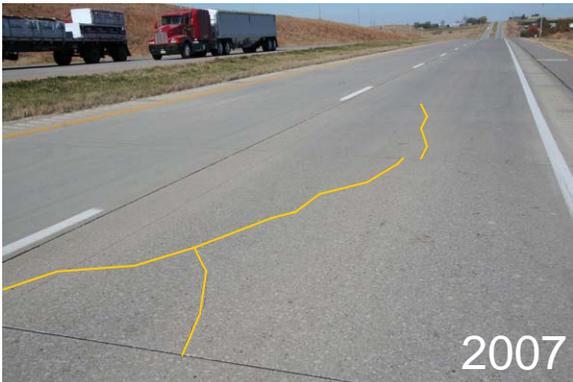


Figure 2.2: IRI, Neb. City South and Neb. City Int.

Over the past four years the doweled pavement has shown little increase in IRI while the conventional section showed a steady increase.

**Additional Graphs from Study are available in Appendix B**

## NEBRASKA CITY SOUTH



2007

**Location:** MM 43.8

### Distresses Shown:

- High slab cracking.
- Concave road surface for three sections.
- Standing water in shoulder joints.



2006

**Locations:** MM 44.9

### Distresses Shown:

- Perpendicular edge cracking along centerline.
- 2"– 8" transverse cracks approximately every four feet along centerline.
- High placement of tie bars across longitudinal joint caused surface cracking shown at left.



2007

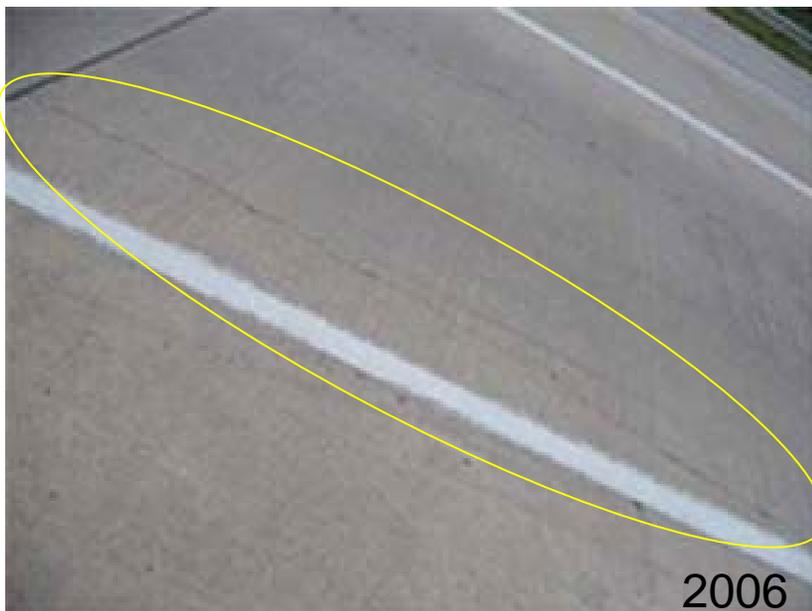
**NEBRASKA CITY INTERCHANGE**



**Location:** MM 58.01

**Distresses Shown:**

Faulting 6mm or greater.  
Severity of faulting varies with changes in temperature and soil moisture content.  
Image from 2005 shows more severe level of faulting.



**Location:** MM 59

**Distresses Shown:** Longitudinal crack shown is about 10 feet long .



The doweled PCC pavement outperformed the conventional non-doweled PCC pavement for all quality indicators measured in this study.

Section	Hwy. #	Ctrl. #	Innovative Technologies	Comparison Section	Hwy. #	Ctrl. #
COLUMBUS EAST	30	32031	30 FOOT TOP, DOWELED PAVEMENT, DRAINABLE FOUNDATION COURSE, FLY ASH TREATED SUBGRADE, LONGITUDINAL TINING	COLUMBUS NORTHWEST **(Dowel Bar Retrofit)	81	30789

## Columbus East (2002) Innovative PCC



- 30 foot PCC top.
- 10” doveled pavement.
- Drainable foundation course.
- Fly ash treated subgrade.
- Longitudinal tining.

## Columbus North West (1997) Conventional



- 24 foot top.
- 10” Non-doweled PCC pavement.
- 4” Foundation course.
- Subgrade preparation (mix, scarify, adjust moisture content, shape and compact).

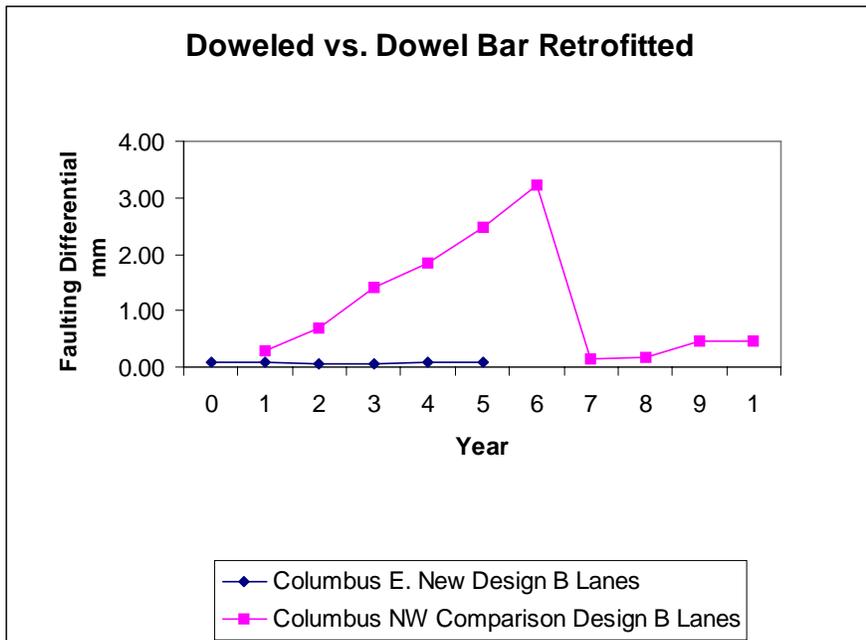


Figure 3.1: Faulting Differential, Columbus E. and Columbus NW.

Columbus NW, originally a non-doweled section, experienced a steady increase in the level of faulting to almost 3 mm after six years.

The level of faulting significantly decreased after a dowel bar retrofit was performed on the Columbus NW section in the seventh year. While Columbus NW has seen a slow increase in the level of faulting, faulting is now much less severe than prior to the dowel bar retrofit.

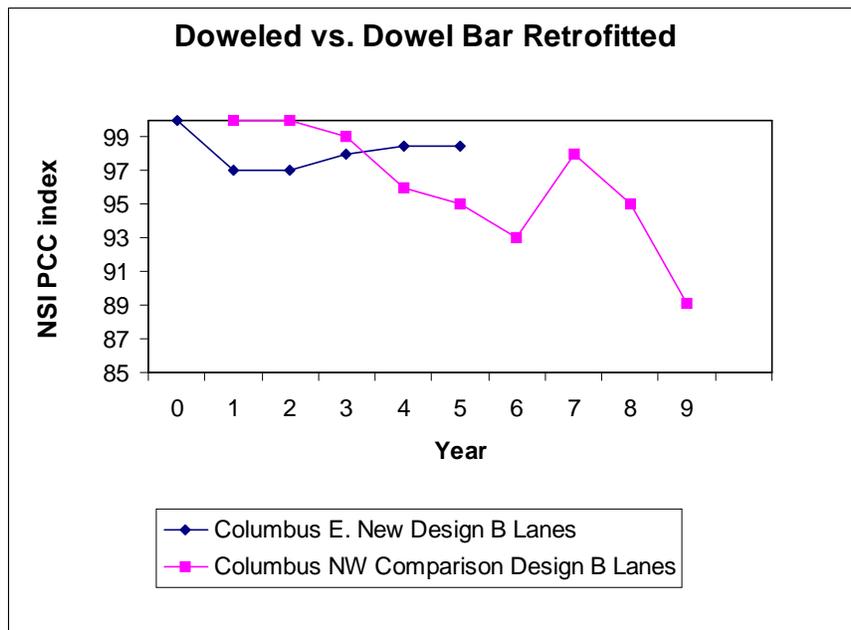


Figure 3.2: NSI PCC, Columbus E. and Columbus NW.

This graph shows how Columbus NW section reacted to a dowel bar retrofit in year seven. Since the retrofit, there has been a significant decrease in the Nebraska Serviceability Index (NSI). This decrease is caused by placing the retrofitted dowel bars too close to the shoulders, thereby causing cracking of pavement along the shoulders. This problem is visible in the pictures of the Columbus NW section.

**Additional Graphs from Study are available in Appendix C**

## COLUMBUS EAST



**Location:** MM 384.35

**Distresses Shown:**

- Transverse cracking near the end of the study section.
- Faulting greater than 3 mm.



Enlargement



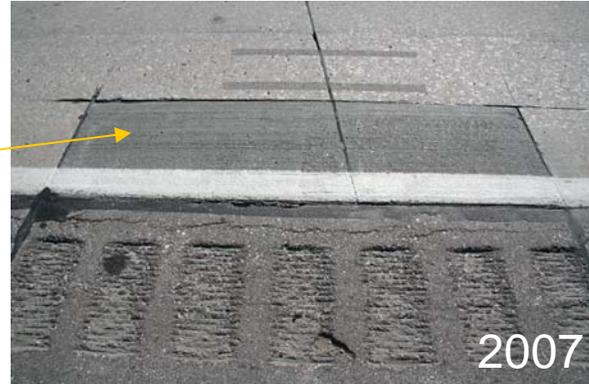
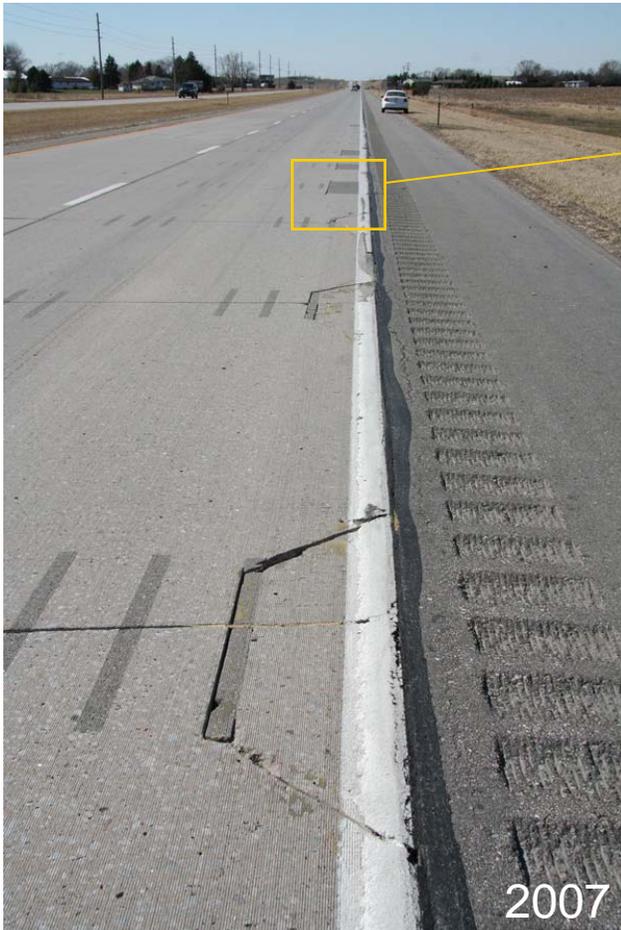
**Location:** MM 190.8

**Distress Shown:**

- Longitudinal cracking.
- Extends three panels i(~50 feet) in length.
- Longitudinal cracking is not typical of this section.

**COLUMBUS NORTHWEST**

**\*\* (Dowel Bar Retrofit)**



**Location:** MM 115.9

**Distresses Shown:**

- Cracking along shoulder where dowel bars were retrofitted is common throughout the study section.
- Euroteck foam was used to prevent additional settling and to raise cracked panels.
- Retrofitted dowel bars placed too close to edge of pavement caused the cracking.
- Retrofitted dowel bars are now placed 6” closer to the centerline to prevent cracking of this type.



The doweled PCC sections out-performed the non-doweled PCC sections for all five Quality Indicators prior to the dowel bar retrofit of the conventional sections. After the retrofit, both sections show similar levels of faulting. Problems with cracking where dowel bars were inserted near the shoulder were caused by placing retrofitted dowel bars too close to the outside edge of the pavement. This has been corrected on newer projects by placing the dowel bars nearest the shoulder six inches closer to the centerline. Increased cracking from dowel bar retrofit is illustrated by the decrease in NSI values for the Columbus NW section and is high-

Section	Hwy. #	Ctrl. #	Innovative Technologies	Comparison Section	Hwy. #	Ctrl. #
GENEVA NORTH AND SOUTH	81	41576	30 FOOT TOP, DOWELED PAVEMENT, DRAINABLE FOUNDATION COURSE, LIME TREATED SUB-GRADE, LONGITUDINAL TINING	HEBRON TO BELVIDERE  **(Dowel Bar	81	41572

## Geneva North South (2004) Innovative PCC Section

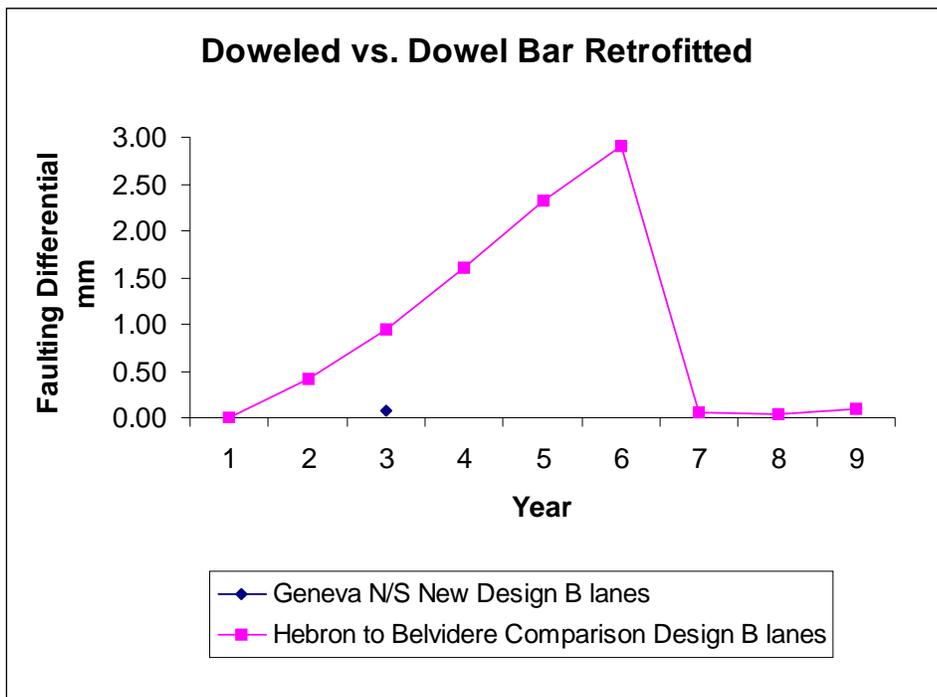


- 30 foot top.
- 10” Doweled pavement.
- 4” Drainable foundation course.
- Lime treated subgrade.
- Longitudinal tining.

## Hebron to Belvidere (1998) Conventional PCC Section



- 10” Non-doweled concrete.
- 4” Foundation course (Bituminous, Type A.)
- Subgrade preparation (scarify, mix, adjust moisture content, shape and compact).
- Dowel bar retrofit in driving lanes.

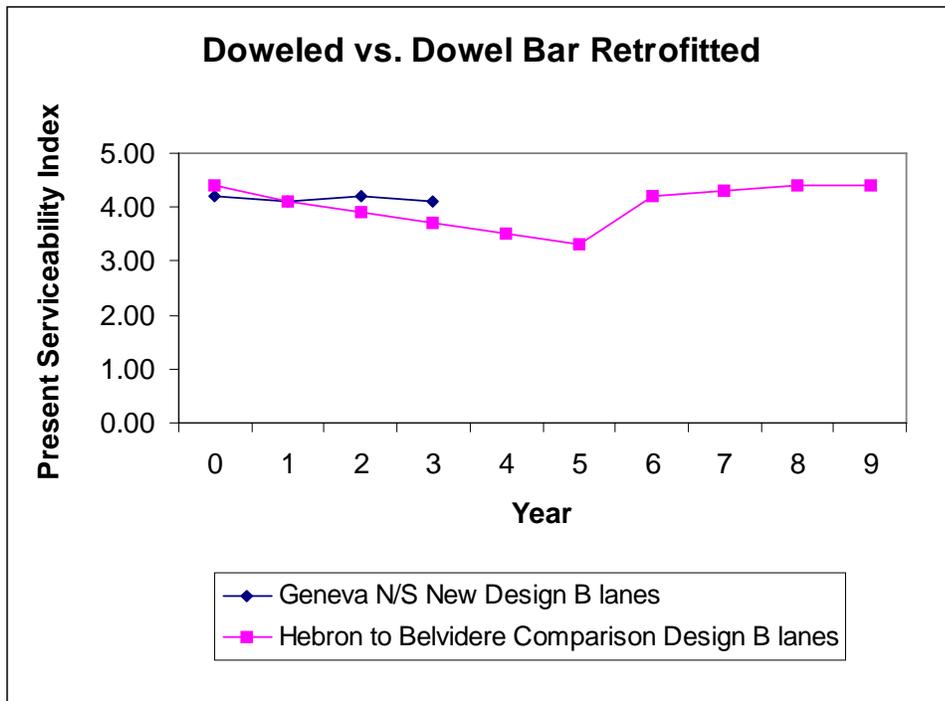


The doweled Geneva North and South section has outperformed the non-doweled conventional section with regard to most indicators.

A dowel bar retrofit in year seven of the Hebron to Belvidere section has resulted in faulting almost identical to that found when dowel bars were inserted during pavement construction.

The doweled Geneva North and South section has shown little to no faulting after four years.

Figure 4.1: Faulting Differential, Geneva N/S and Hebron to Belvedere.



After five years, the Present Serviceability Index (PSI) dropped from a very good rating to a good rating. If that trend had continued, the PSI for Hebron to Belvidere would have decreased to a fair or poor rating within a few years.

The dowel bar retrofit in year seven increased the PSI to a level similar to that found in the innovative pavement section.

Figure 4.2: PSI, Geneva N/S and Hebron to Belvedere.

**Additional Graphs from Study are available in Appendix D**

**GENEVA NORTH AND SOUTH**



**Location:** MM 40

**Distresses Shown:**

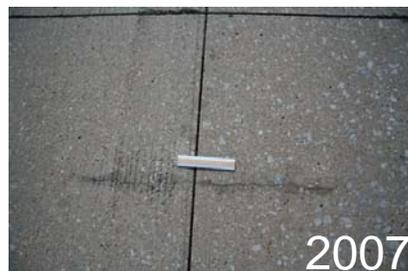
- Longitudinal cracking.
- Stitching with deformed bar to prevent further expansion of the cracks.



**Location:** MM 40.8

**Distresses Shown:**

- Surface cracking extending through 11 to 12 panels along longitudinal joint.
- 2'8" cracks above tie bars across longitudinal joints.



**HEBRON TO BELVIDERE**

**\*\* (Dowel Bar Retrofit)**



**Location:** MM 17

**Distresses Shown:**

- Shoulder drop off.



- Magnitude of drop off has not increased from previous years.



**Location:** MM 14.9

**Distresses Shown:**

- Pavement disintegration.
- Prominent crown between lanes.



**Location:** MM 15

**Distresses Shown:**

- Severe longitudinal cracking where highway was undermined for utilities work.



The innovative (doweled during construction) section had a lower NSI, equal IRI and more slab distress during the first year but outperformed the conventional section in the subsequent years. Prior to retrofit of Hebron to Belvidere, the doweled section had outperformed the conventional non-doweled section, especially in the area of faulting. After retrofit, both sections show similar levels of faulting.

Section	Hwy. #	Ctrl. #	Innovative Technologies	Comparison Section	Hwy. #	Ctrl. #
GIBBON TO SHELTON	80	42117	CRUMB RUBBER MODIFIED ASPHALT MIX	MINDEN TO GIBBON	80	42156

## Gibbon to Shelton (2003) Crumb Rubber Bituminous Section

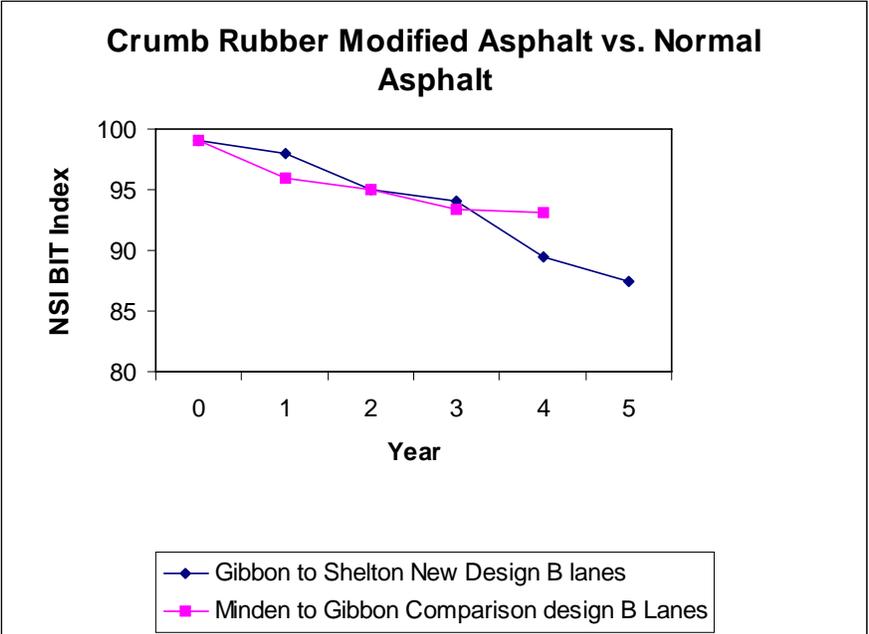


- 4" bituminous crumb rubber modified (CRM) asphalt.

## Minden to Gibbon (2002) Conventional Bituminous Section

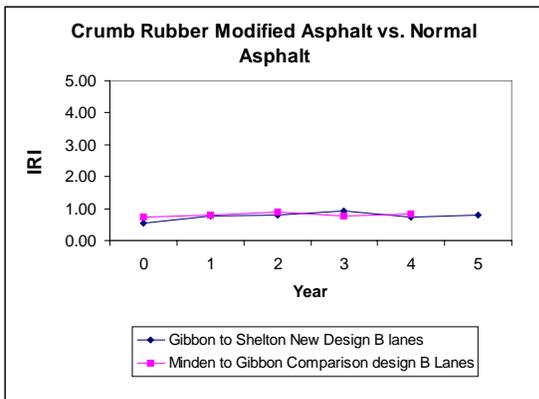


- 4" bituminous SP5 (Superpave) asphalt.



The crumb rubber modified asphalt from Minden to Gibbon has outperformed the conventional asphalt comparison section with regard to surface condition of the pavement as measured by the NSI bituminous index (see graph at left).

Figure 5.1: NSI Bit, Gibbon to Shelton and Minden to Gibbon.



These two sections behaved very similarly with respect to the International Roughness Index (IRI), Present Serviceability Index (PSI) and rut depth. The crumb rubber modified asphalt appears to perform marginally better only because it appears to maintain slightly better surface integrity over identical service life.

Figure 5.2: IRI, Gibbon to Shelton and Minden to Gibbon.

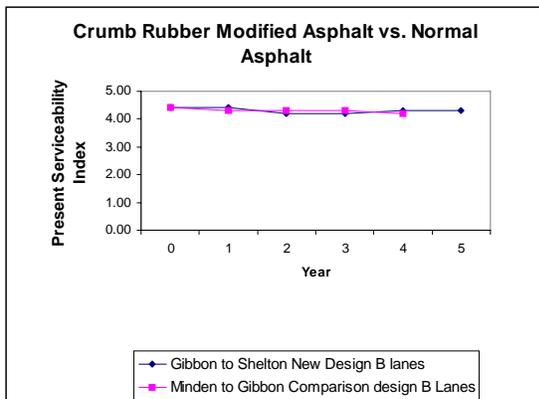


Figure 5.3: PSI, Gibbon to Shelton and Minden to Gibbon.

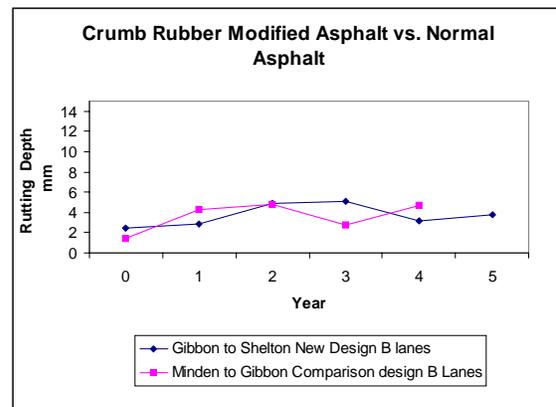


Figure 5.4: Rutting Depth, Gibbon to Shelton and Minden.

**Additional Graphs from Study are available in Appendix E**

**GIBBON TO SHELTON**



**Location:** MM 290.96

**Distresses Shown:**

- Surface distress near end of study section.
- Longitudinal and transverse cracking.

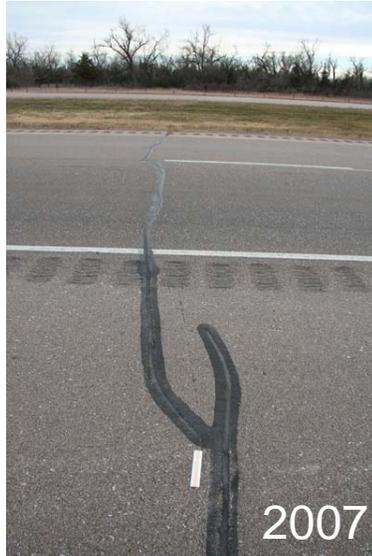


**Location:** MM 290.94

**Distresses Shown:**

- Transverse cracking is common throughout the study section.

**MINDEN TO GIBBON**



**Location:** MM 279.5

**Distresses Shown:**

- High severity transverse cracking.
- Cracking beginning outside of areas where cracks have been sealed.



**Location:** MM 282

**Distresses Shown:**

- High severity transverse cracking.
- High severity centerline cracking.



There was not much quantifiable difference found between the crumb rubber modified asphalt section and the conventional asphalt section. Both are showing wear in a similar manner. The crumb rubber asphalt appears to maintain slightly better surface integrity (reflected by the NSI bituminous index) than conventional asphalt.

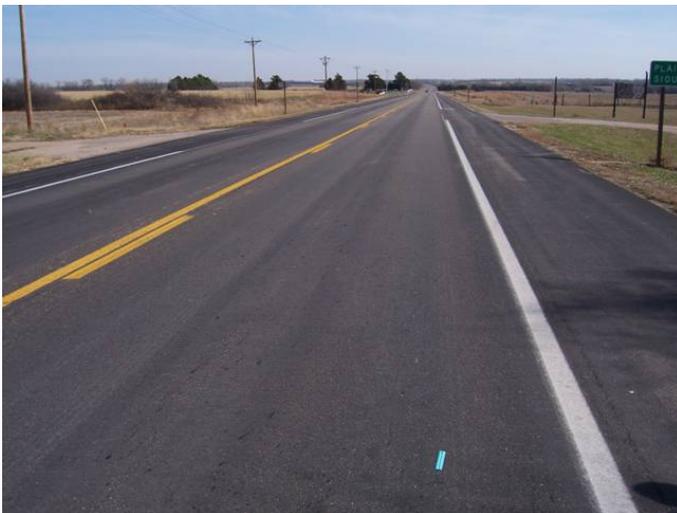
Section	Hwy. #	Ctrl. #	Innovative Technologies	Comparison Section	Hwy. #	Ctrl. #
US-20 TO N-59	14	31582	CRUMB RUBBER MODIFIED ASPHALT MIX	ROYAL TO BRUNSWICK	20	31073A

## US 20 to North 59 (2004) Innovative BIT Section

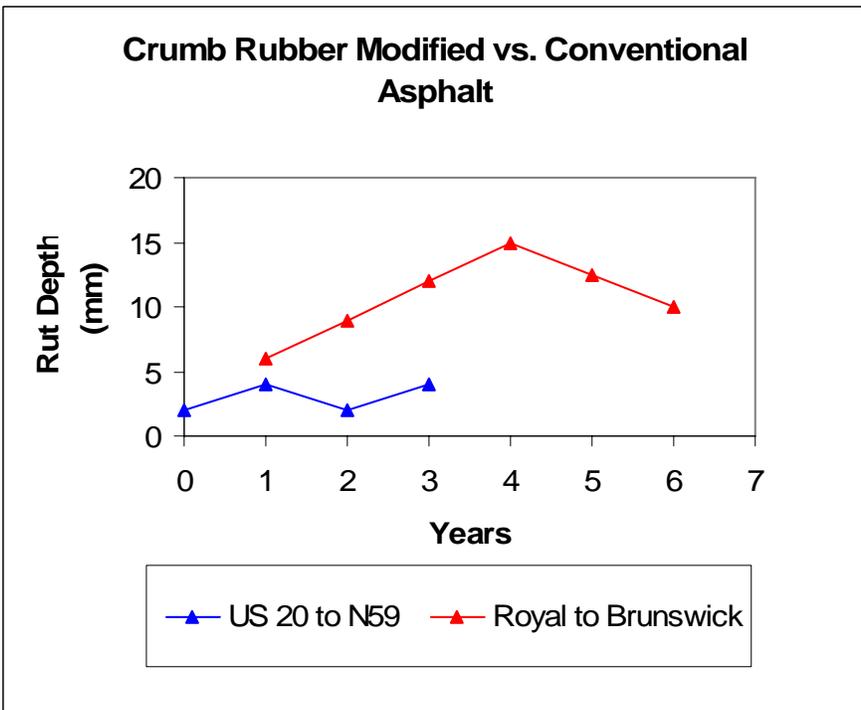


- 2" asphalt concrete, Type GGCRMLV.
- 1.5" asphalt concrete, Type SP1 over existing asphalt.

## US 20 Royal to Brunswick (2001) Conventional BIT Section

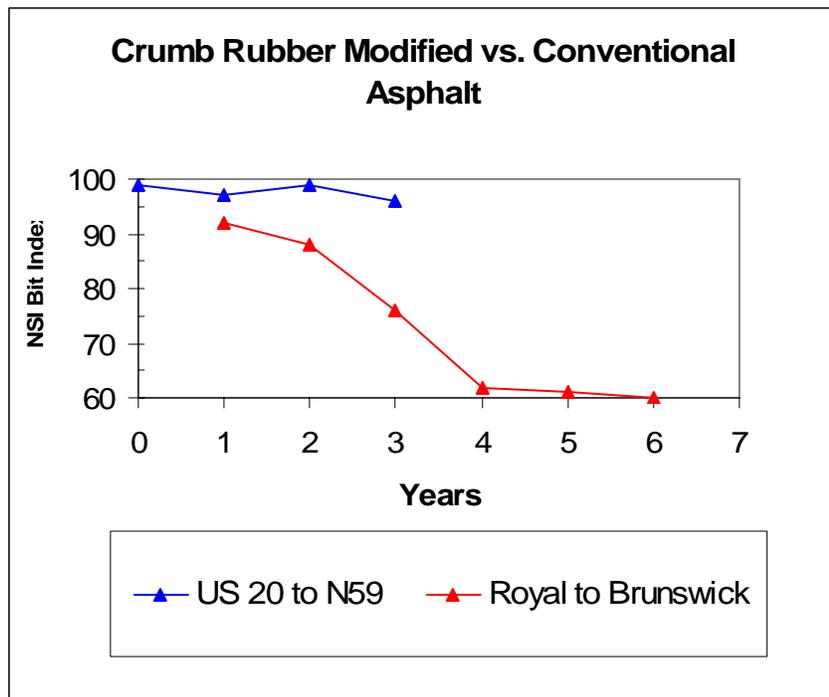


- 4" SP2 (Superpave) asphalt over existing asphalt.



The crumb rubber modified asphalt (US20 to N59) shows far less rutting than the conventional asphalt pavement section.

Figure 6.1: Rutting Depth, US20 to N59 and Royal to Brunswick.



The crumb rubber modified asphalt (US20 to N59) has consistently outperformed conventional asphalt with regard to surface condition of the pavement as reflected by the NSI bituminous index.

Figure 6.2: NSI Bituminous Index, US20 to N59 and Royal to Brunswick.

**Additional Graphs from Study are available in Appendix F**

**US-20 TO N-59**



**Location:** MM 171.3

**Distresses Shown:**

- Longitudinal crack ~ 100' in length.



**Location:** MM 172.6

**Distresses Shown:**

- Transverse cracking across both lanes and shoulder.



## ROYAL TO BRUNSWICK



**Location:** MM 341.9

**Note:**

- Pavement rehabilitation in 2006.
- Some surface wear was already visible in 2007.



**Location:** MM 337.58

**Note:**

- New wearing course in 2006.
- Minor surface distortion; some appearance of wear in 2007.



Crumb rubber modified asphalt outperformed conventional asphalt in all years for all Quality Indicators at this location.

Section	Hwy. #	Ctrl. #	Innovative Technologies	Comparison Section	Hwy. #	Ctrl. #
BERWYN TO ANSLEY	2	60894	PCC OVERLAY OF EXISTING ASPHALT	ANSLEY TO MASON CITY	2	60792

## Berwyn to Ansley (2003) Innovative PCC Section



- 8” Doweled concrete overlay.
- Portland cement concrete “whitetopping” over existing asphalt base.

## Ansley to Mason City



- 9” Portland cement concrete over conventional subgrade preparation (mix, scarify, adjust moisture content, shape and compact).

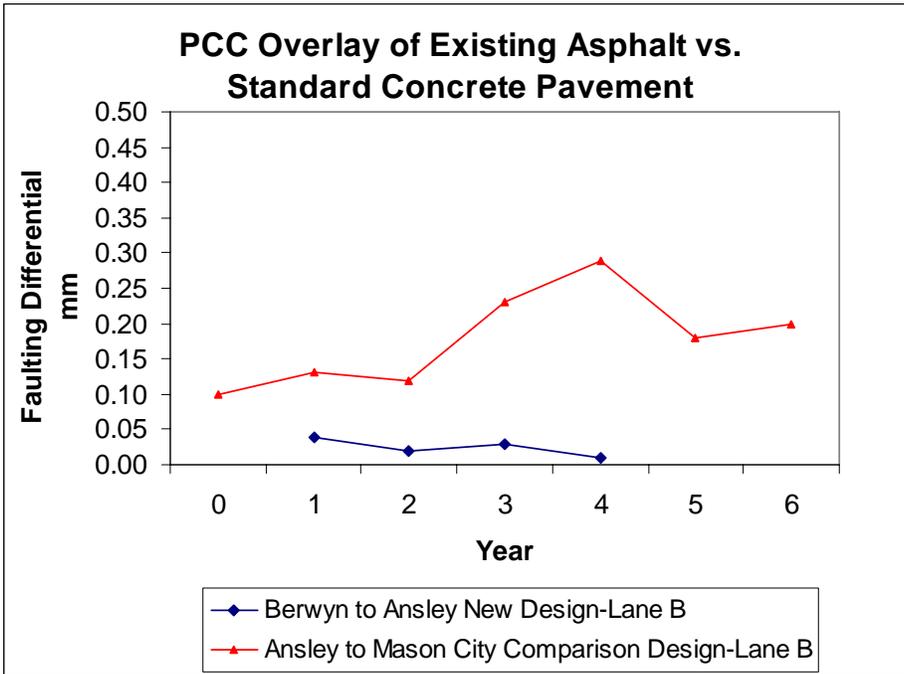


Figure 7.1: Faulting Differential, Berwyn to Ansley and Ansley to Mason City.

Dowelled pavement (Berwyn to Ansley) has outperformed the conventional PCC section for all parameters.

While the non-dowelled pavement has seen an increasing trend of faulting over the past six years, the dowelled pavement has shown little to no faulting over the four years of the study.

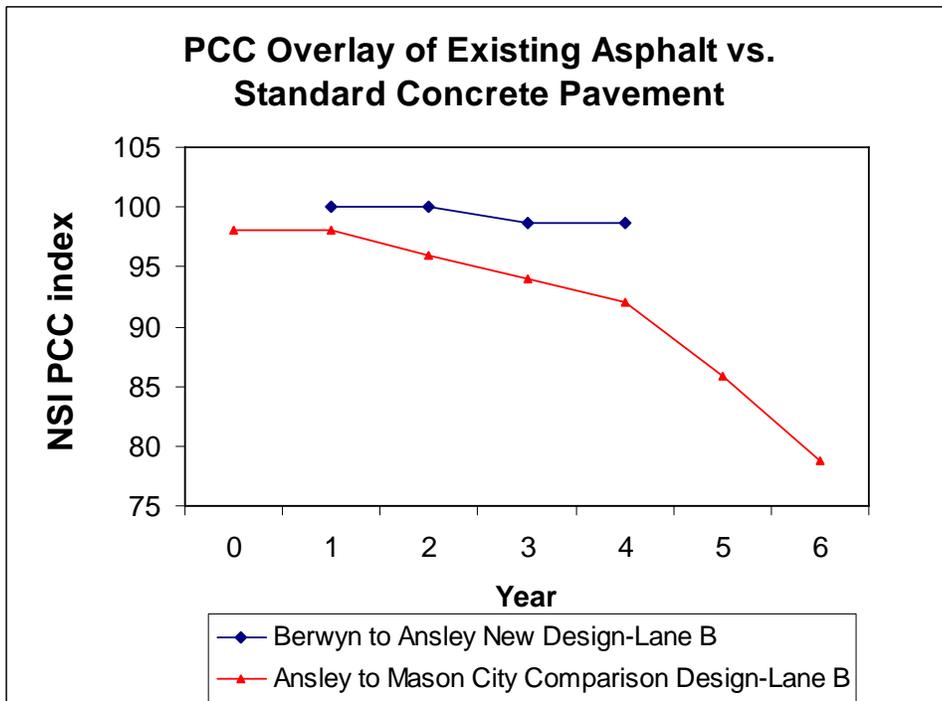


Figure 7.2: NSI PCC, Berwyn to Ansley and Ansley to Mason City.

The PCC overlay has outperformed the comparison section in relation to surface condition of the pavement.

The PCC overlay has maintained a high NSI while the conventional pavement has exhibited a decreasing trend in NSI.

**Additional Graphs from Study are available in Appendix G**

**BERWYN TO ANSLEY**



**Location:** MM 293.9

**Distress Shown:**

- 1.5' diagonal slab cracking.
- Between 2006 and 2007 hairline cracks advanced about six inches.



**Location:** MM 299.2

**Distresses Shown:**

- Edge cracking adjacent to shoulder.

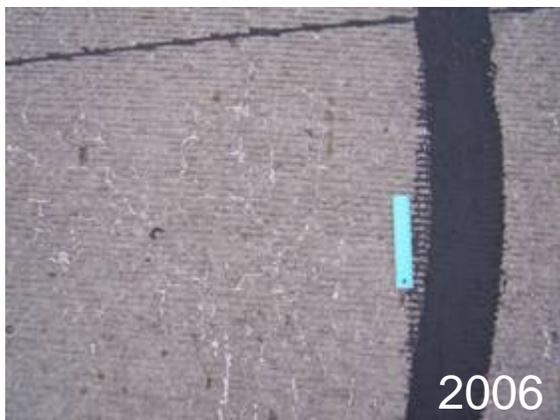
## ANSLEY TO MASON CITY



Location: MM 298.6

Distress shown:

- High severity longitudinal cracking.
- Low pavement wear in wheel paths.
- ASR cracking at joints and cracks was less visible in 2007 than in 2006.





The PCC overlay of existing asphalt has out-performed conventional concrete pavement sections over the five year study period for all Quality Indicators.



Recently Added  
Pavement Sections

# Pavement Quality Indicators Study



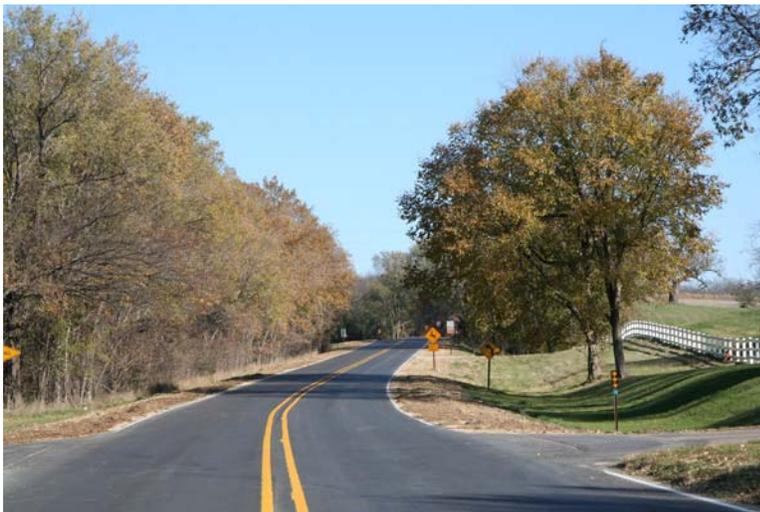
Section	Hwy. #	Ctrl. #	Technologies
Plattsmouth West	66	22225	3 ¾" High RAP Base
Louisville East	66	22204	3 ¾" High RAP Base

## Plattsmouth West (Let Dec. 2006)



- 3.75" high RAP base.
- 2" SP4 wearing course.

## Louisville East (Let Dec. 2006)



- 3.75" high RAP base.
- 2" SP4 wearing course.



- **These sections were completed near the end of 2007, so no data will be available until fall of 2008**



### Plattsmouth West



- Contractor was finishing construction during site visit in fall of 2007.
- Pictures show highway approaching a cable guard rail location.

### Louisville East



- Finish grading was being performed on the shoulders of study sections during site visit in fall of 2007.



Both projects were recently completed so evaluation of the pavement performance will begin next year. During site visits in the fall of 2007, both sections appeared to be in excellent condition.

# Pavement Quality Indicators Study



Section	Hwy. #	Ctrl. #	Technologies
Republican City-	136	70591A	10" SP4 Asphaltic Concrete
Alma-Republican City	136	70591A	7" SP4 Asphaltic Concrete, 4" Foundation Course

## Republican City-Naponee



- 4" SP4 Special.
- 10" fly ash stabilized bituminous.  
or
- 10" SP4 Special
- Subgrade preparation (mix, scarify, adjust moisture content, shape and compact).

## Alma-Republican City (2006)



- 7" SP4 Asphaltic concrete wearing course.
- 4" foundation course.



- **Republican City to Naponee was completed at end of 2007, no data will be available until fall of 2008. Data collected in 2007 Alma to Republican City is listed below.**

Alma to Republican City  
(Data from year one—2007)

Hwy: 136  
BRP: 29.51  
ERP: 37.57  
  
IRI: 0.83  
Rutting: 2.19  
PSI: 4.3  
NSI: 98.61

### Republican City-Naponee

- Study section is still under construction during the fall of 2007.



- Contractor was finishing construction during site visit in fall of 2007.
- Picture shows construction of wearing course.



- Completed portion of section with final grading on the shoulder.

**Alma-Republican City**



- The study section was in excellent condition during the fall of 2007.



- Only visible crack was in Republican City near end of the study section.



The Republican City to Naponee section was only recently constructed while the Alma to Republican City section has performed very well over the past few years. Little to no cracking was visible during site visits during the fall of 2007 on either section.

# Pavement Quality Indicators Study



Section	Hwy. #	Ctrl. #	Technologies
Malmo Spur West	92	12819	4" Lime Slurry Stabilization

## Malmo Spur West (Let Nov. 2006)



- 4" Hydrated lime slurry stabilized base.
- 2-1/2" SP4 Asphaltic concrete wearing course.



**No data has been collected for this pavement section as of Fall 2007.**

**Malmo Spur West**



**Location:** MM 442 +20

**Distress Shown:**

- Thin transverse cracking.
- Roadway appears in excellent condition, but it is possible to see thin transverse cracks when walking the section.
- Cracking is surprising because this section is less than one year old.



**Location:** MM 441 and 442+25

**Distress Shown:**

- Thin and short transverse cracking.



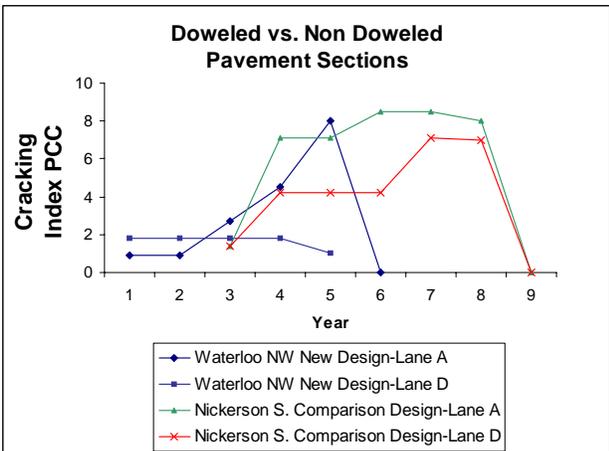
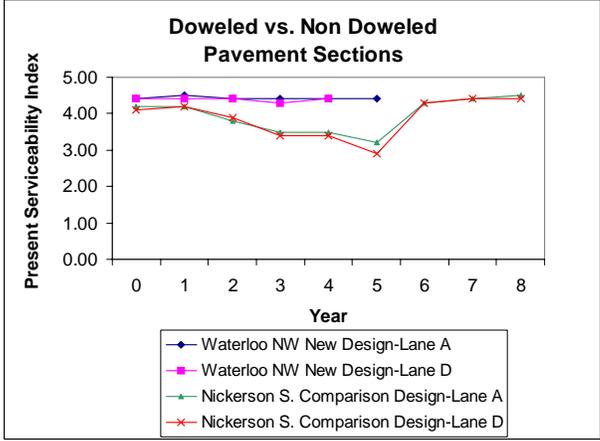
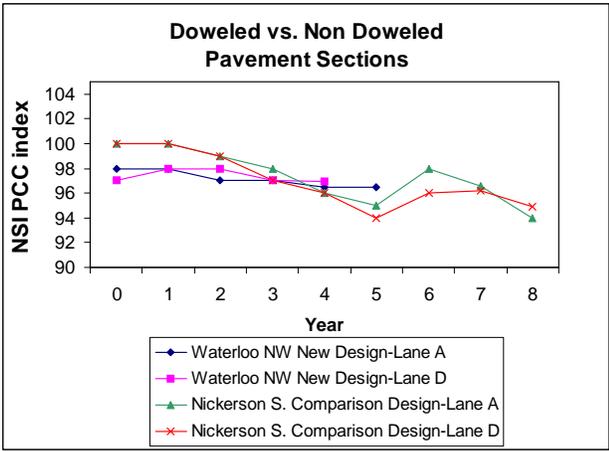
This section was recently completed (2007). The section appeared in excellent condition but it should be noted that thin transverse cracking was noticed upon close examination of the roadway. Long term effects of cracking on pavement quality will be evaluated in future years.



## Appendix A

### Additional Graphs

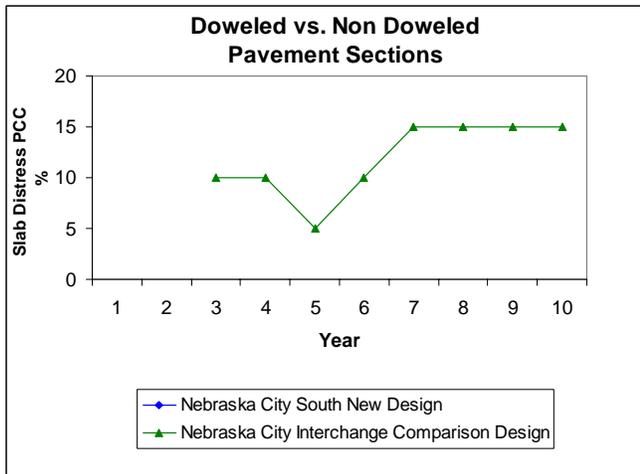
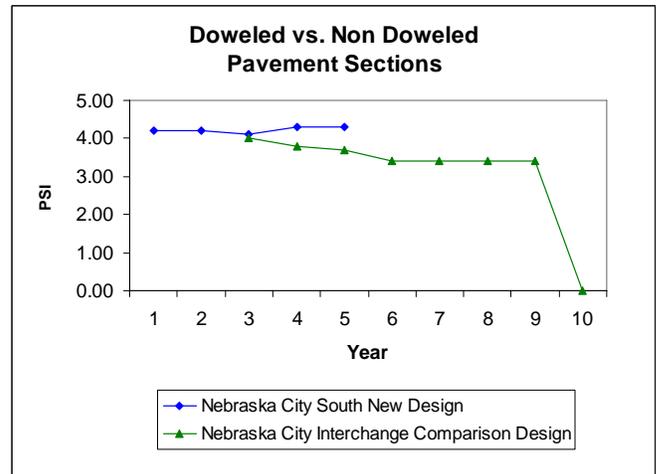
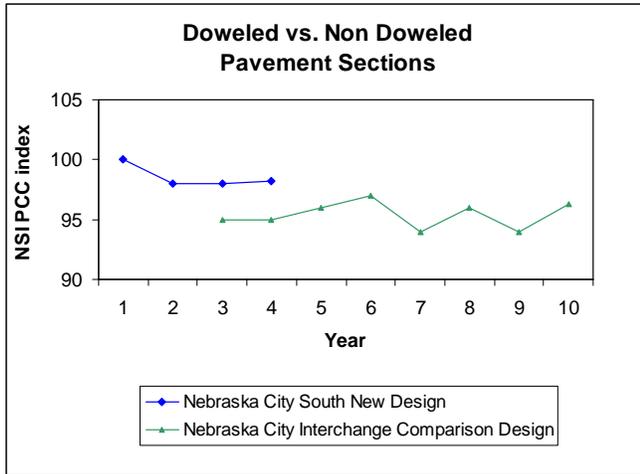
### Waterloo Northwest and Nickerson South



## Appendix B

### Additional Graphs

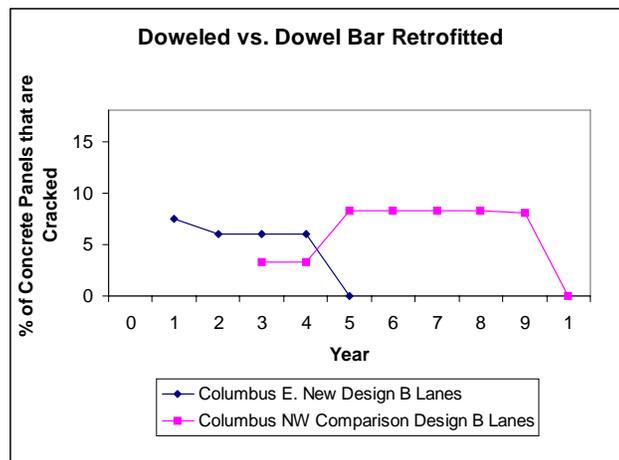
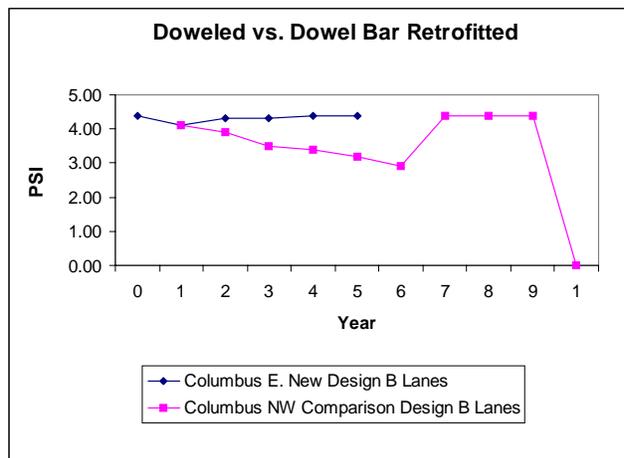
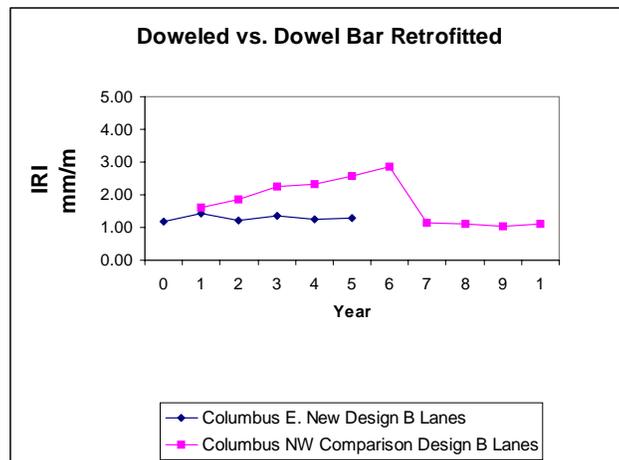
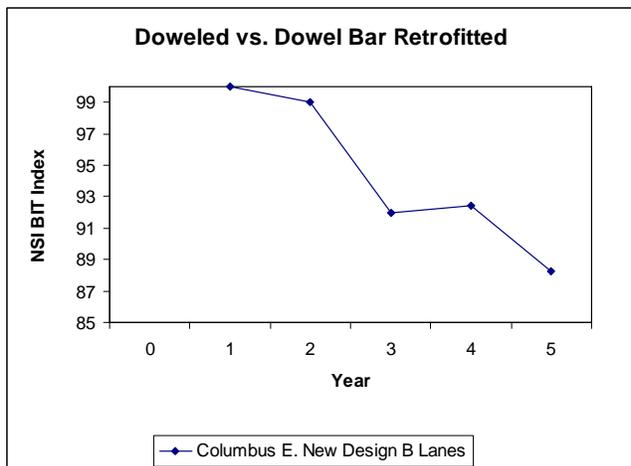
### Nebraska City South and Nebraska City Interchange



## Appendix C

### Additional Graphs

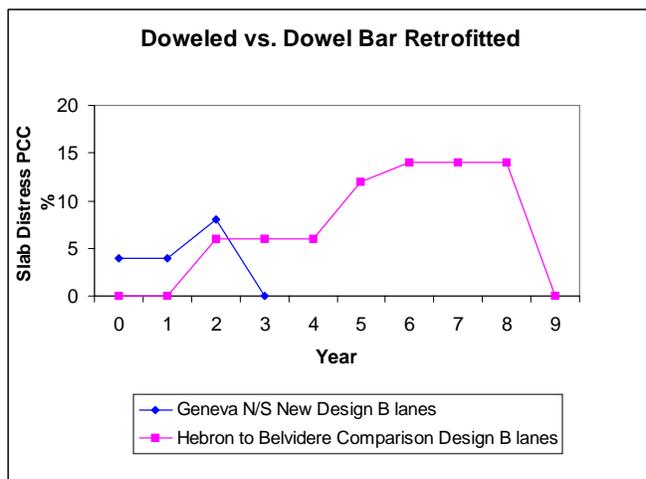
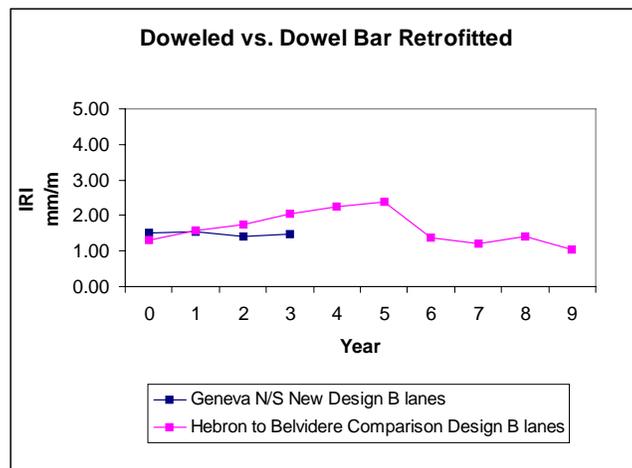
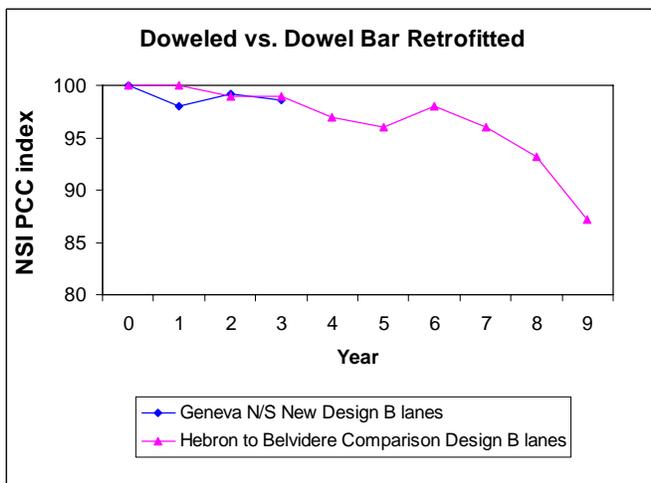
### Columbus East and Columbus North West



## Appendix D

### Additional Graphs

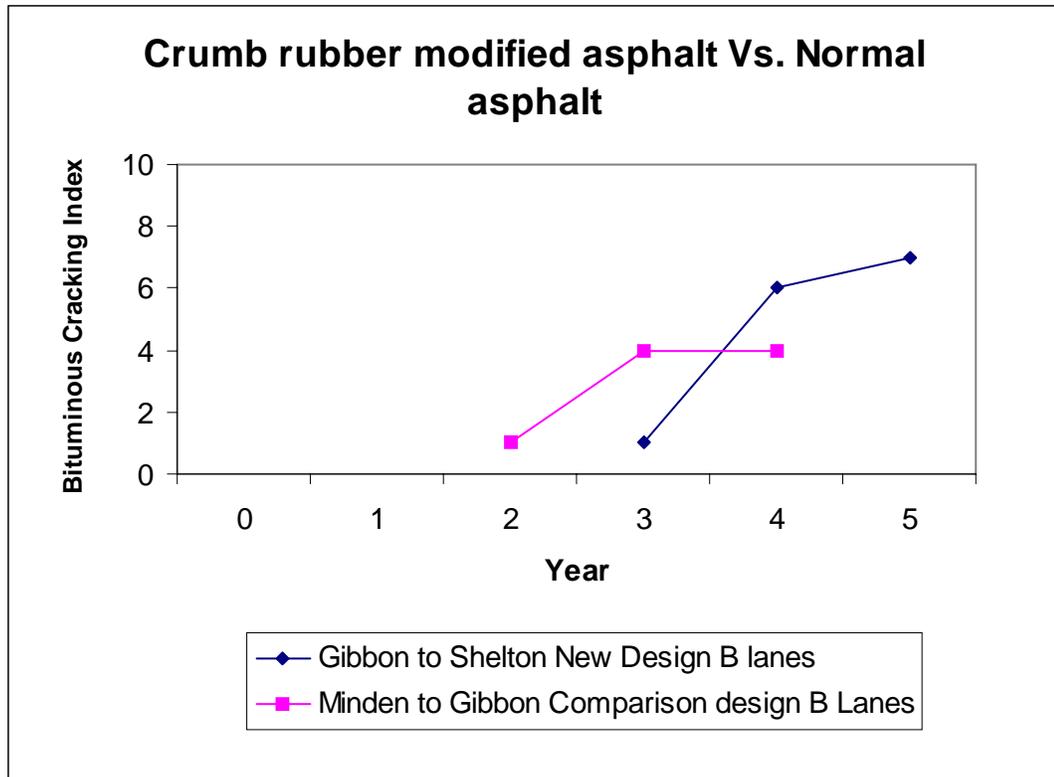
### Geneva North South and Hebron to Belvedere



## Appendix E

### Additional Graphs

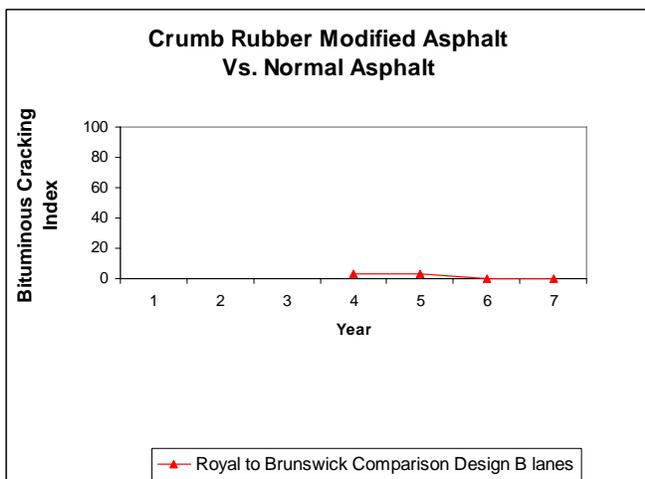
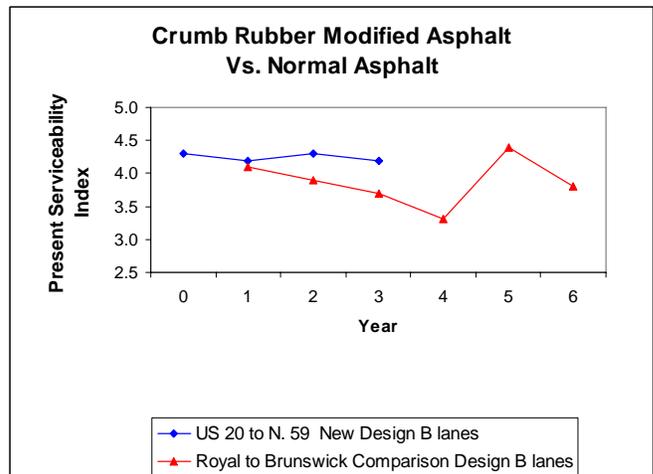
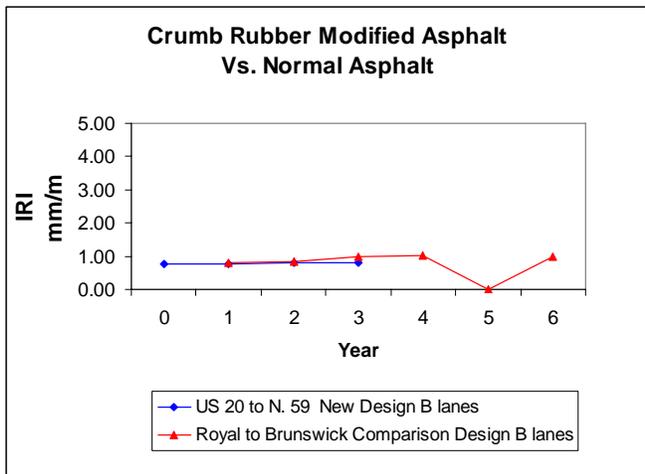
#### Gibbon to Shelton and Minden to Gibbon



## Appendix F

### Additional Graphs

### US 20 to N59 and Royal to Brunswick



## Appendix G

### Additional Graphs

### Berwyn to Ansley and Ansley to Mason City

