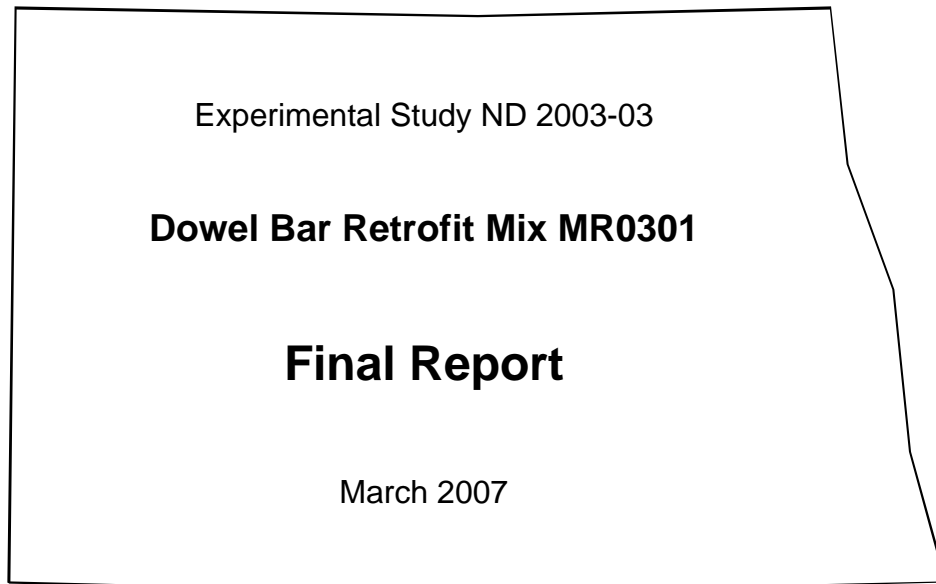


1. Report No. ND 2003-03	2. Report Date March 2007	3. Contract No. N/A	4. Project No. AC-IM-8-094(041)342
5. Title and Subtitle  Dowel Bar Retrofit Mix MR0301		6. Report Type  Work Plan <input type="checkbox"/> Construction <input type="checkbox"/> Evaluation <input type="checkbox"/> Final <input checked="" type="checkbox"/>	7. Project No. 8. Project No. 9. Project No. 10. Project No.
11. Author(s)/Principle Investigator(s) Bryon Fuchs			
12. Performing Organization Name and Address  NDDOT M+R <input checked="" type="checkbox"/> North Dakota DOT NDDOT OTHER* <input type="checkbox"/> Materials and Research Division NDSU <input type="checkbox"/> 300 Airport Road UND <input type="checkbox"/> Bismarck ND 58504-6005 UGPTI <input type="checkbox"/> OTHER* <input type="checkbox"/> *see supplementary notes		13. Sponsoring Agency Name and Address  North Dakota DOT Materials and Research Division 300 Airport Road Bismarck ND 58504-6005	
14. Supplementary Notes			
15. Abstract  <b><u>Purpose and Need</u></b>  The North Dakota Department of Transportation (NDDOT) has been constructing dowel bar retrofit projects since 1995 to restore load transfer across transfer joints in plain jointed concrete pavements. While this rehabilitation has worked to restore load transfer, the patch mix material used has durability problems. There are several commercially available patch mixes available on the market and the NDDOT has used a number of them. The mixes are expensive and suffer from durability problems such as; raveling, shrinkage cracks (leads to debonding and loss of load transfer), and spalling. These mixes also set up very quickly and can lead to little or no mix under the dowel bar which leads to the patch mix material breaking loose in the slot and load transfer is lost. There is a need for a low cost patch mix material using locally available materials.  <b><u>Objective</u></b>  The objective of this applied research will be to evaluate the patch mix developed at NDSU. This objective will be met by utilizing this patch mix in a dowel bar retrofit project and monitor the performance and effectiveness of this mix.  <b><u>Scope</u></b>  Project number AC-IM-8-094(041)342 in the Fargo District was identified. The project location is in the westbound lane, located at exit 342 on US Interstate 94. The project will be evaluated every year for five years or until failure of the patch mix. The items will be evaluated for visual durability and visual distresses in the patch mix as well as load transfer across the joints utilizing Falling Weight Deflectometer.  <b><u>Summary</u></b>  The production rates achieved during construction with the experimental mix will probably not allow the experimental mix to be competitive, (on a construction cost basis) with other proprietary mixes currently used. The long-term performance and continued load transfer of dowel bar retrofits relies on the performance of the concrete patch mix and dowel bar itself. Over the evaluation period, all sections experienced an increase in visible distresses. However, the experimental mix has also shown more distresses than control section 1 or control section 2. The load transfer efficiency is significantly lower in the experimental section and control section 2 compared with control section 1.			
16. Key Words  Dowel Bars Concrete Load Transfer	17. Distribution Statement No restrictions. This document is available to the public from:  North Dakota Department of Transportation Materials and Research Division: 300 Airport Road Bismarck ND 58504-6005 Office: (701) 328-6900		18. No. of Pages 60  19. File type/Size pdf/ 1.7 mb

**NORTH DAKOTA**  
**DEPARTMENT OF TRANSPORTATION**  
**MATERIALS AND RESEARCH**  
**DIVISION**



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## EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT	EXPERIMENTAL PROJECT NO.				CONSTRUCTION PROJ NO			LOCATION	
	1	STATE ND	YEAR 2003	NUMBER 03	SURF 8	AC-IM-8-094(041)342		Cass County 28	
SHORT TITLE	EVALUATION FUNDING							NEEP NO.	PROPRIETARY FEATURE?
	48	1 X	HP&R	3	DEMONSTRATION			Yes	
THIS FORM	DATE	MO.	YR.	REPORTING					
140	03	--	2007	1	INITIAL	2	ANNUAL	3 X FINAL	
KEY WORDS	KEY WORD 1				KEY WORD 2				
	145 Joints				167 Load Transfer				
	KEY WORD 3				KEY WORD 4				
	189 Dowels				211 Rehabilitation				
CHRONOLOGY	Date Work Plan Approved		Date Feature Constructed:		Evaluation Scheduled Until:		Evaluation Extended Until:		Date Evaluation Terminated:
	277 08-2003		281 08-2003		285 08-2008		289		293 04-2006
QUANTITY AND COST	QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS)			UNITS			UNIT COST (Dollars, Cents)		
	432			1 LIN. FT 2 SY 3 SY-IN 4 CY			5 TON 6 LBS 7 X EACH 8 LUMP SUM		
AVAILABLE EVALUATION REPORTS	CONSTRUCTION			PERFORMANCE			FINAL		
315	X			X			X		
EVALUATION	CONSTRUCTION PROBLEMS				PERFORMANCE				
	318	1 X	NONE	2	SLIGHT	3	EXCELLENT	4	GOOD
APPLICATION	1 ADOPTED AS PRIMARY STD.			4 PENDING			(Explain in remarks if 3, 4, 5, or 6 is checked)		
	2 PERMITTED ALTERNATIVE			5 X REJECTED					
320	3 ADOPTED CONDITIONALLY			6 NOT CONSTRUCTED					
REMARKS	321 It is recommended that the NDDOT continue using the proprietary mixes currently allowed in the standard specifications due to higher costs and poor performance of the experimental mix. It is also recommended that special attention is given to the location of coreboards after the dowel bar mix is placed. Coreboard failures can be reduced or eliminated if the coreboard remains in the joint and not allowed to move into the dowel bar slot.								
	700								

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Experimental Study ND 2003-03

**Dowel Bar Retrofit Mix MR0301**

**FINAL REPORT**

Project AC-IM-8-094(041)342

March 2007

Written by

Bryon Fuchs

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## **Disclaimer**

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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# Dowel Bar Retrofit Mix MR0301 ND 2003-03

## **Purpose and Need**

The North Dakota Department of Transportation (NDDOT) has been constructing dowel bar retrofit projects since 1995 to restore load transfer across transverse joints in plain jointed concrete pavements. While this rehabilitation has worked to restore load transfer, the patch mix material previously used has had caused durability problems.

There are several commercially available patch mixes on the market and the NDDOT had used a number of them. The mixes were considered expensive and suffered from durability problems such as; raveling, shrinkage cracks, and spalling. The mixes set up very quickly. This can lead to little or no mix under the dowel bar which has led to the patch mix material breaking loose in the slot and losing load transfer.

There was a need for a low cost patch mix material using locally available materials. North Dakota State University (NDSU), Civil Engineering Department, had developed a patch mix designed specifically for this purpose.

## **Objective**

The objective of this applied research was to evaluate the patch mix developed at NDSU.

## **Location**

NDDOT project number AC-IM-8-094(041)342 (westbound lane) near exit 342 was selected to incorporate this applied research. The project was located on Interstate 94 between the West Fargo Interchange and the Red River. Please refer to Figure 1 on the next page.

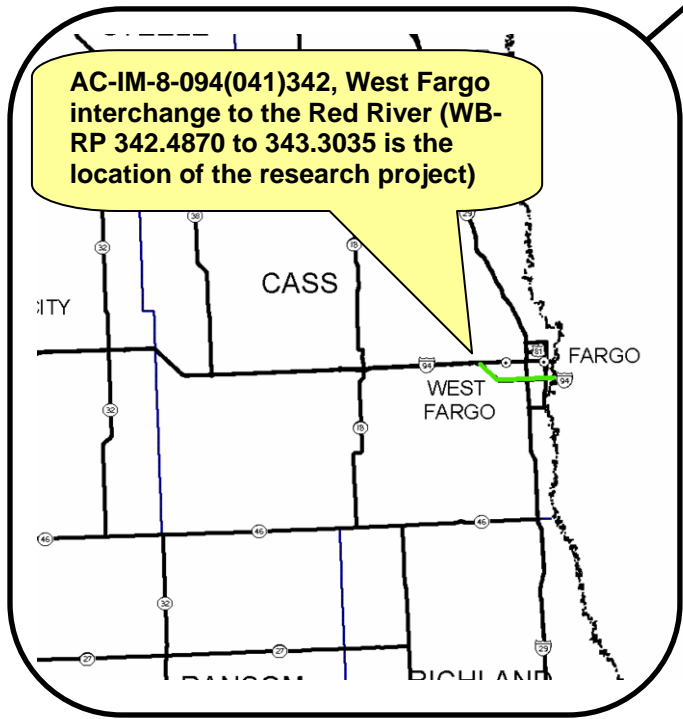
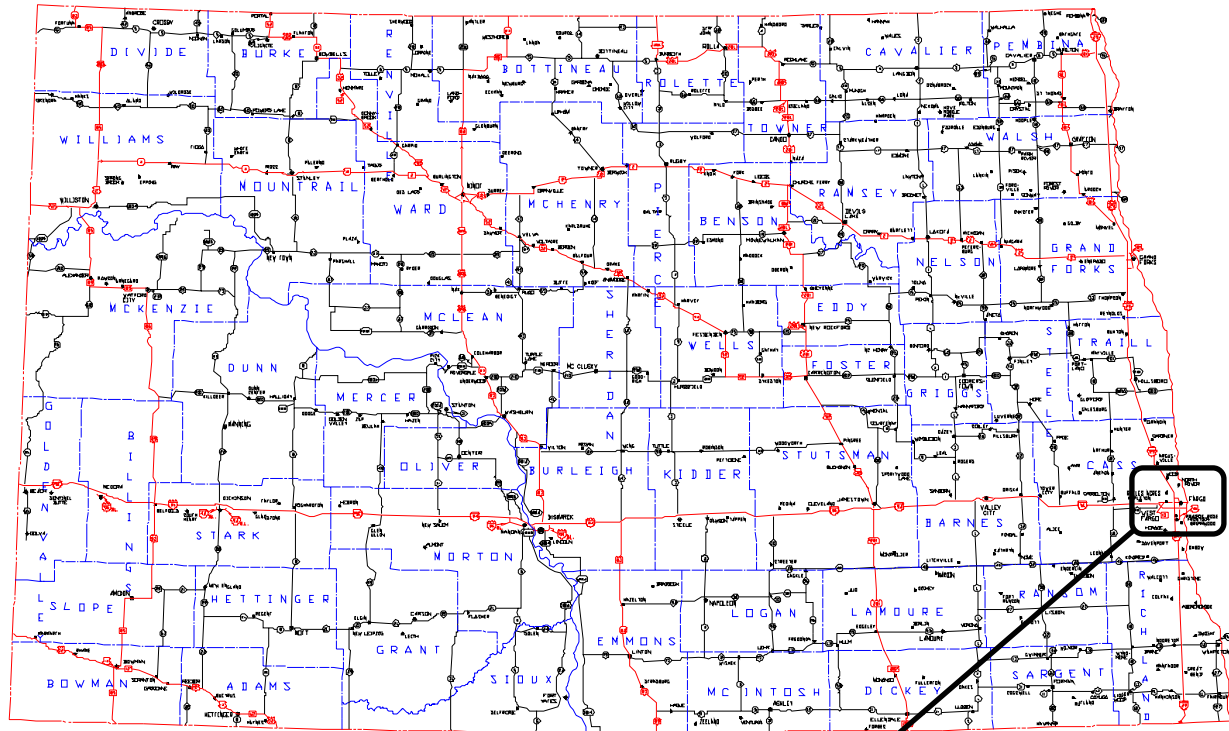


Figure 1 - Project Location.

## Traffic

Two-way traffic is provided in the following table from RP 342.803 to 343.800.

Year	Passenger	Trucks	Total	30 <sup>th</sup> Max Hour	Two-way Rigid ESALs
2002	10,550	2,050	12,600	1,260	2,870
2004	12,300	1,800	14,100	1,410	2,520
2006	13,325	2,275	16,600	1,560	2,685

## Design

The design of the patch mix material was conducted by NDSU. Provided below is a summary of the information that was presented to the contractor in order to incorporate this experimental patch mix material onto the project. Refer to Appendix A for the entire submittal package.

## Description

This work shall consist of retrofitting approximately one-half lane mile of epoxy-coated dowel bars into existing concrete pavement using an experimental concrete mix. Section 570 of the 2002 edition of the NDDOT *Standard Specifications for Road and Bridge Construction* shall govern except where noted below.

## Material

1. Patching Material. "Concrete Patch Mix" shall be a mix prepared using the following mix design:

<u>Material</u>	<u>Per CY Quantities</u>
Cement ( <i>Type III – Lehigh</i> )	850 lbs
Water	255 lbs
Fine Aggregate ( <i>Section 816.01</i> )	1079 lbs
Coarse Aggregate ( <i>Section 816.02 – Granite</i> )	1526 lbs
Air-entraining Admixture ( <i>Master Builders – Pave Air</i> )	2.975 fl-oz
Accelerating Admixture ( <i>Master Builders – Pozzoloth NC 534</i> )	340 fl-oz
Water Reducer (Super Plasticizer) ( <i>Master Builders – Rheobuild 3000FC</i> )	102 fl-oz

- The Dowel Bar Retrofit Mix shall have the following properties:

Maximum Water to Cement (W/C) Ratio	0.30
Slump	9" ± 1"
Air	6% ± 1%

## **Construction**

The primary contractor for project number AC-IM-8-094(041)342 was Wanzek Construction, Inc located in Fargo, ND. The work related to the dowel bar retrofit was subcontracted to Highway Services / Penhall Company (Penhall) located in Rogers, MN.

The project engineer on this project was Joe Peyerl of the Fargo District, NDDOT. The inspectors on this project were Robin Bellmore and Larry Ostenson from the Fargo District.

The following personnel from Materials and Research Division were present on site for the construction of the experimental dowel bar mix; Bryon Fuchs, Mike Marquart, Steven Henrichs, Kyle Evert, and Tony Gross.

The experimental mix was change ordered onto this project at a cost of \$39.60 per dowel bar. The bid price using "Five Star" patch mix was \$25.00 per dowel bar. The bid price was for approximately 1,056 bars.

The construction of the experimental mix occurred on August 14, 2003. The contractor started placing the experimental mix in the dowel bar slots at 9:15 am. The weather on this day during construction had an average temperature of 86°F, average wind speed of 20 mph (gusts – 20 to 30 mph), 48% relative humidity and sunshine.

## **Testing**

Throughout construction of the experimental mix, tests were conducted. The tests were completed at the start of construction (set A), when approximately 25% (set B), 50% (set C) and 75% (set D) of the mix was placed.

The following table lists the averages for the four sets of tests conducted:

Test	Set A	Set B	Set C	Set D
Air (%)	5.1	5.5	4.3	5.1
Slump (in)	9.00	8.75	8.50	7.50
6-hr Comp Strength (psi)	5,060	5,610	5,390	5,110
7-day Comp Strength (psi)	8,820	9,180	9,990	9,280
28-day Comp Strength (psi)	10,260	10,370	11,370	11,280
28-day Flex Strength (psi)	980	1,100	1,090	1,190
Freeze/Thaw Durability-300 cycles (Factor)	93.1	89.8	98.9	96.9

### Post Construction Analysis

The experimental project site was visited on September 24, 2003 and again on October 8, 2003. Using an FWD, the load transfer across the transverse joints were tested on October 14, 2003.

Three different sections were evaluated for visual distresses and load transfer. Each section contains 72 transverse joints or 432 dowel bar slots. The following table identifies the differences in each section.

Section	Location	Description
Control Section 1	RP 343.2082 to 343.3035	Five Star Mix used on majority of project
Experimental Section	RP 343.1111 to 343.2067	MR0301 Mix
Control Section 2	RP 342.4870 to 343.0546	Five Star Mix using granite aggregate as used in the MR0301 Mix

Visual distresses were noted in each of the sections. The primary distress in each section was longitudinal shrinkage cracks between the patch mix and existing concrete. However, the experimental section had more longitudinal shrinkage cracks than the other two sections evaluated. The depth of the shrinkage cracks was unknown as cores were not taken.

Provided in the following table is a summary of the sections evaluated.

	Control Section 1	Experimental Section	Control Section 2
Date of Construction	6-27-03	8-14-03	8-15-03
Average (high) Temp (°F)	58 (68)	86 (90)	86 (91)
Average Wind Speed (gusts) (mph)	9 (N/A)	20 (23-30)	11 (N/A)
Humidity	78%	48%	64%
6-hour Comp Breaks (psi)	7,080	5,290	4,850
Load Transfer	97.1%	88.6%	84.6%
Production Rate	143 slots/hr	54 slots/hr	156 slots/hr
<b>Percentage of slots distressed</b>			
Percentage of slots distressed	1.4%	32.4%	3.5%

Based on the above table, there were several items that stood out and they are as follows:

- Environmental conditions
- Load transfer efficiency
- Production rate
- Longitudinal shrinkage cracks

Several of these items may have been caused by the same thing. The one item that is not tied to the others is the production rate. The production rates in the control sections were nearly three times the production rate than in the experimental section. This was attributed to the mixing time requirements. Fifteen minutes of mix time was substantially longer than the mixing time required for the current proprietary mixes (two – three minutes.) The use of admixtures required more mixing time in order for them to work as intended which slows production.

The increase in longitudinal shrinkage cracks in the experimental section may be the result of either the environmental conditions, the use of a water reducing admixture or both. The Portland Cement Association (PCA) publishes a book titled *Design and Control of Concrete Mixtures, 14<sup>th</sup> Edition* states that water reducing admixtures may cause an increase in drying shrinkage. The same publication also states that when using high-range water reducers (this project used a high-range water reducer), the drying shrinkage is comparable to concretes without high-range water reducers when

the water to cement ratios remains the same. Another publication, *Properties of Concrete, Fourth Edition* written by A. M. Neville states lignosulfonate-based water reducing admixtures (not used on this project) increase shrinkage, but other water reducing admixtures do not affect shrinkage. This same publication also states that super plasticizers (used on this project) do not influence shrinkage. Based on these two sources, the water reducing admixture used should not have caused an increase in longitudinal shrinkage in the experimental mix.

Based on the above information, environmental effects appear to have played a major role in the longitudinal shrinkage cracks. Based on Figure 13-8 in the publication *Design and Control of Concrete Mixtures, 14<sup>th</sup> Edition*, the rate of evaporation was calculated for the mixes on the day they were placed. The exact concrete temperature during placement was unknown in the two control sections and a reasonable temperature was assumed. Provided in the following table was the rate of evaporation calculated along with the input data.

Section	Air Temperature	Humidity	Concrete Temperature	Wind Speed	Rate of Evaporation
Control #1	58° F	78%	*60° F	9 mph	0.035 lb (ft <sup>2</sup> /hr)
Control #2	86° F	64%	*78° F	11 mph	0.04 lb (ft <sup>2</sup> /hr)
Experimental	86° F	48%	78° F	20 mph	0.18 lb (ft <sup>2</sup> /hr)

\*Assumed concrete temperature

As seen in the table above, the rate of evaporation in the experimental section far exceeded those in the control sections. The wind speed was the major factor in this. Even though curing compound was applied immediately, the wind will dry the pre-wetted slot prior to the placement of the grout and the experimental mix. The other factor that is not seen here is the temperature of the surrounding PCC Pavement. During summer months, when the air temperature is around 90°F, the PCC pavement can reach temperatures of 110°F plus. At these temperatures, the heat from the pavement may also have contributed to the evaporation of water.

Local PCC pavement temperature data (RWIS site at Red River Bridge, I-94) is not available for the immediate area on August 14 & 15, 2003, however data was available for June 27, 2003. The PCC pavement temperature stated on the previous page is from another site with very similar environmental conditions (sun, wind, etc) on these days (RWIS site west of Jamestown, ND, I-94).

Using RWIS data, the difference in pavement temperature ranged from approximately 20°F to 42°F lower in June compared to August. This temperature difference was important as it may indicate that the Experimental mix and Control Section #2 mix set up quicker than Control Section #1 mix, which may result in a slightly poorer bond to the existing concrete. The difference in the average ambient air temperature was 28°F lower in June compared to August.

## Evaluations

Materials and Research conducted the first evaluation of the dowel bar slots on September 28, 2004. The final evaluation was conducted on October 26, 2005. Control section 1, control section 2, and the experimental section were evaluated visually for distresses. Load transfers across the joints were performed on these sections with a FWD.

### Control Section 1

Photo 1 shows an overall view of control section 1.



**Photo 1 - Overall view of control section 1.**

Overall, control section 1 looks good. The number of visible distresses identified has nearly doubled but the load transfer efficiency has remained the same. Control section #1 is outperforming the other sections with lower visible distresses and higher load transfer efficiency.

Provided in the following table is the percent of slots (there is a total of 432 slots) with distresses in control section 1 and average load transfer efficiency within this section. The percentage of transverse cracks is slightly lower than one year ago but the amount of coreboard failures are up. The location of some transverse cracks suggests that they may be the initial stages of coreboard failures. Coreboard failures are a result of misalignment of the coreboard within the slot (coreboard does not remain in the joint).

Control Section 1				
Date	Distress / Load Transfer			
	Visible Long. Cracks	Transverse Crack	Coreboard Failure	Load Transfer
October 2003	1.4%	0.0%	0.0%	97.1%
September 2004	9.3%	2.1%	0.5%	93.9%
October 2005	16.9%	1.9%	1.9%	93.6%



Photo 2 - Typical joint in control section 1.



Photo 3 - Spalling at joint and dowel bar slot.



**Photo 4 - Coreboard failure in control section 1.**

### Control Section 2

Photo 5 shows an overall view of control section 2.



**Photo 5 - Overall view of control section 2.**

Overall, control section 2 looks OK. There has been a substantial increase in the number of visible distresses identified in the period of a year and load transfer efficiency has dropped. As the number and severity of the distresses increase, it is anticipated that the load transfer will continue to drop in this section.

Provided in the following table is the percent of slots (there is a total of 432 slots) with distresses in control section 2 and average load transfer efficiency within this

section. The location of some transverse cracks suggests that they may be the initial stages of coreboard failures. Coreboard failures are a result of misalignment of the coreboard within the slot (coreboard does not remain in the joint).

<b>Control Section 2</b>				
<b>Date</b>	<b>Distress / Load Transfer</b>			
	<b>Visible Long. Cracks</b>	<b>Transverse Crack</b>	<b>Coreboard Failure</b>	<b>Load Transfer</b>
<b>October 2003</b>	3.5%	0.2%	0.2%	84.6%
<b>September 2004</b>	18.3%	2.1%	0.2%	84.1%
<b>October 2005</b>	51.6%	33.3%	6.3%	80.5%



**Photo 6 - Typical joint in control section 2 - spall area is in the original PCC pavement.**

## Experimental Section

Photo 7 shows an overall view of the experimental section.



**Photo 7 - Overall view of the experimental section.**

Overall, the experimental section is experiencing the most visible distresses of the three sections evaluated. There has been an increase in the number of visible distresses identified with a decrease in load transfer efficiency. As the number and severity of the distresses increase, it is anticipated that the load transfer will continue to drop in this section.

Provided in the following table is the percent of slots (there is a total of 432 slots) with distresses in the experimental section and average load transfer efficiency within this section. The location of some transverse cracks suggests that they may be the initial stages of coreboard failures. Coreboard failures are a result of misalignment of the coreboard within the slot (coreboard does not remain in the joint).

<b>Experimental Section</b>				
<b>Date</b>	<b>Distress / Load Transfer</b>			
	<b>Visible Long. Cracks</b>	<b>Transverse Crack</b>	<b>Coreboard Failure</b>	<b>Load Transfer</b>
<b>October 2003</b>	32.4%	0.0%	0.7%	88.6%
<b>September 2004</b>	50.9%	1.2%	3.0%	83.1%
<b>October 2005</b>	79.6%	5.3%	4.6%	78.5%



Photo 8 - Typical joint in experimental section.



Photo 9 - Transverse crack location is likely the early signs of a coreboard failure.

## Summary

The production rates achieved during construction with the experimental mix will not allow the experimental mix to be competitive on a construction cost basis with other proprietary mixes currently used.

The long-term performance and continued load transfer of dowel bar retrofits relies on the performance of the concrete patch mix and dowel bar itself. Over the evaluation period, all sections experienced an increase in visible distresses. However, the experimental mix has also shown more distresses than control section 1 or control section 2. The load transfer efficiency is significantly lower in the experimental section and control section 2 compared with control section 1. Provided in the following table is a summary of the distress (in terms of percentage of slots) and load transfer efficiency observed or measured to date.

Distress	Control Section 1			Experimental Section			Control Section 2		
	Oct-03	Sep-04	Oct-05	Oct-03	Sep-04	Oct-05	Oct-03	Sep-04	Oct-05
<b>Visible crack-long.</b>	1.4%	9.3%	16.9%	32.4%	50.9%	79.6%	3.5%	18.3%	51.6%
<b>Transverse crack</b>	0.0%	2.1%	1.9%	0.0%	1.2%	5.3%	0.2%	2.1%	33.3%
<b>Coreboard</b>	0.0%	0.5%	1.9%	0.7%	3.0%	4.6%	0.2%	0.2%	6.3%
<b>Load Transfer</b>	97.1%	93.9%	93.6%	88.6%	83.1%	78.5%	84.6%	84.1%	80.5%

Where as the load transfer and distress in control section 1 is relatively stable, distress continues to increase and load transfer continues to decrease in the experimental section and control section 2.

It is believed that the environmental conditions at the time of construction are, in part, responsible for the distress noted initially and in subsequent evaluations. The ambient air temperature, wind speed, and temperature of the surrounding concrete have a dramatic affect on the rate of evaporation and rate of hydration of the concrete patch mix.

The decline in load transfer efficiency in the experimental section and in control section 2 appears to be related to the increased distress in the concrete patch mix for these sections. Distress in control section 1 although increasing, is relatively low and stable, and the load transfer efficiency for this section remains in the 90% plus range.

## **Recommendations**

It is recommended that the NDDOT continue using the proprietary mixes currently allowed in the standard specifications due to higher costs and poor performance of the experimental mix.

It is recommended that special attention is given to the location of coreboards after the dowel bar mix is placed. Coreboard failures can be reduced or eliminated if the coreboard remains in the joint and not allowed to move into the dowel bar slot when placing the concrete patch mix.

It is also recommended that tighter controls be placed on the allowable environmental conditions at the time that concrete patch mix is being placed. The effects of temperature, humidity, and wind speed can dramatically affect the rate of cure and final condition of the concrete patch mix. These factors have been shown to contribute to the formation of shrinkage cracks; as well as the development of bonding problems with the side walls of the existing concrete. Ambient air temperatures must be, at a minimum, within the manufacturer's recommendations at the time of placing the concrete patch mix. These concerns should be addressed in the Special Provisions for future Dowel Bar Retrofit projects.

## **Appendix A: Mix Design**

**North Dakota Department of Transportation  
Dowel Bar Retrofit Mix "MR0301"**

**Description**

This work shall consist of retrofitting approximately one-half lane mile of epoxy-coated dowel bars into existing concrete pavement using an experimental concrete mix. Section 570 of the 2002 edition of the NDDOT *Standard Specifications for Road and Bridge Construction* shall govern except where noted below.

**Material**

1. Patching Material. "Concrete Patch Mix " shall be a mix prepared using the following mix design:

<u>Material</u>	<u>Per CY Quantities</u>
Cement	850 lbs
Water	255 lbs
Fine Aggregate	1079 lbs
Coarse Aggregate	1526 lbs
Air-entraining Admixture	2.975 fl-oz
Accelerating Admixture	340 fl-oz
Water Reducer (Super Plasticizer)	102 fl-oz

- The cement shall be a Type III (Lehigh) meeting the requirements of Section 804.01.
- The fine aggregate shall meet the requirements of Section 816.01 and have the following gradation:

<u>Sieve Size</u>	<u>% Passing</u>
3/8"	100
#4	95-100
#8	45-65
#50	10-30
#100	0-10
#200 (Max)	3

- The coarse aggregate shall be granite obtained from Ortonville, MN. The owner of the pit is Aggregate Industries. The coarse aggregate shall meet the requirements of Section 816.02 and have the following gradation:

<u>Sieve Size</u>	<u>% Passing</u>
3/8"	100
#4	25-30
#8	10-20
#200 (Max)	1

- The concrete admixtures shall be the following:

Air-entraining	Master Builders – Pave-Air
Accelerator	Master Builders – Pozzolith NC534
Water Reducer (Super plasticizer)	Master Builders – Rheobuild 3000FC

- The Dowel Bar Retrofit Mix shall have the following properties:

Maximum Water to Cement (W/C) Ratio	0.30
Slump	9" ± 1"
Air	6% ± 1%

### **Construction Requirements**

1. A trial batch shall be conducted prior to placement in the slots in order to test the material properties. Minor adjustments may be required in order to meet the mix requirements as stated in Section 570 of the specifications and the changes indicated above.
2. A grout mix shall be applied to the dowel bar slot after pre-wetting the dowel bar slot and prior to placement of the MR0301 patch mix in the slot. The patch mix shall be placed in the slot prior to the grout mix drying. Drying of the grout mix will be considered when the grout mix starts to turn white. If the grout mix starts to dry, the grout shall be removed and cleaned according to Section 570.04 C.2.c.
3. The recommended mixing procedure is as follows:
  - a. Place the coarse aggregate into the mixer.
  - b. Combine the super plasticizer and water.
  - c. Add half the quantity of water with super plasticizer to the coarse aggregate and mix for two minutes before adding other components.
  - d. Add the fine aggregate (the air entraining admixture shall be added to the fine aggregate as it is being added to the mix).
  - e. Add the cement.
  - f. Add the remaining quantity of water with super plasticizer.
  - g. Add the accelerating admixture.
  - h. After the last component is added, mixing shall continue for additional five minutes and then stop the mixer for three minutes and then resume mixing for an additional two minutes.
4. The curing compound shall be applied immediately after the patch mix is finished.

### **Method of measurement and basis of Payment**

Installation of the Dowel Bars will be measured and paid for as "Dowel Bar Retrofit Type A" for each dowel installed and accepted by the Engineer. Payment shall be full compensation for all labor, equipment, and materials necessary to complete the work as specified.

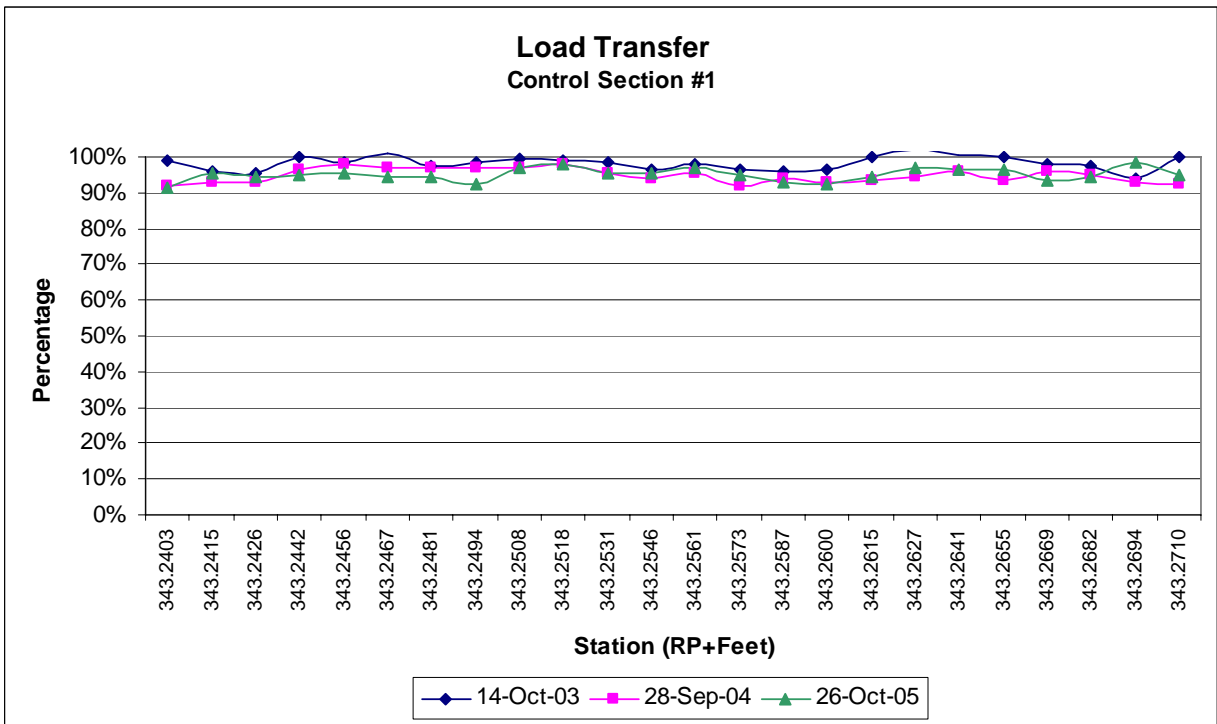
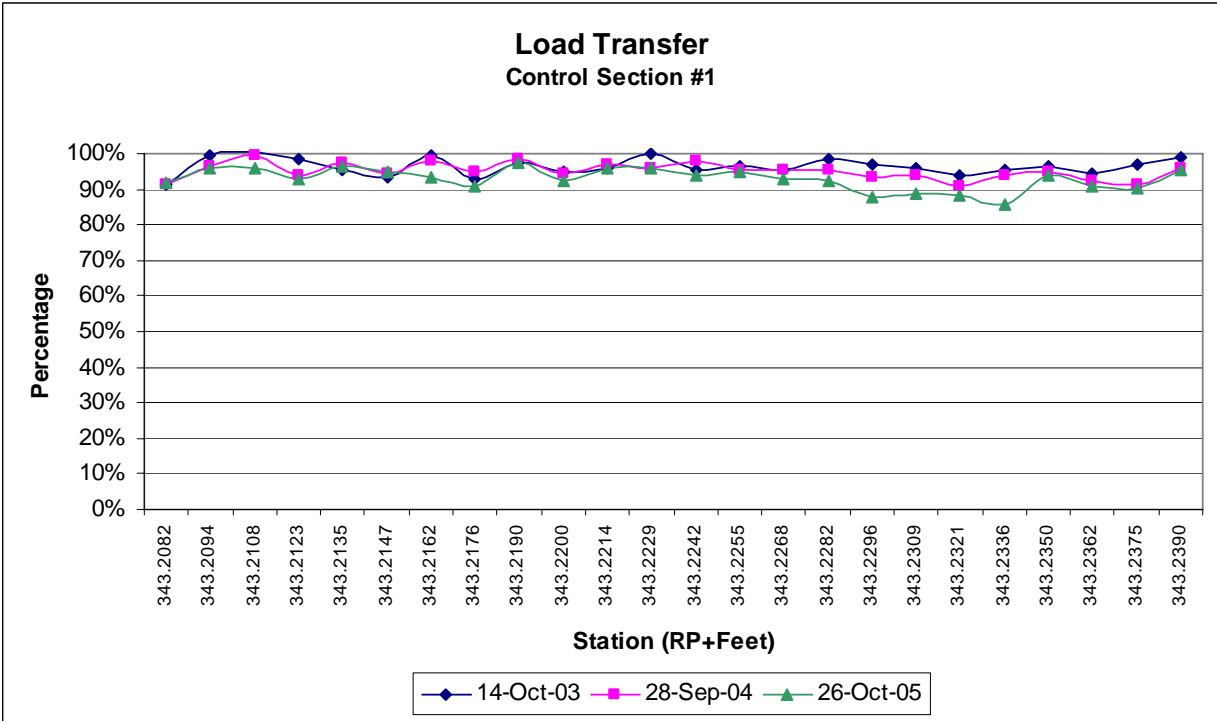
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## **Appendix B: Load Transfer**

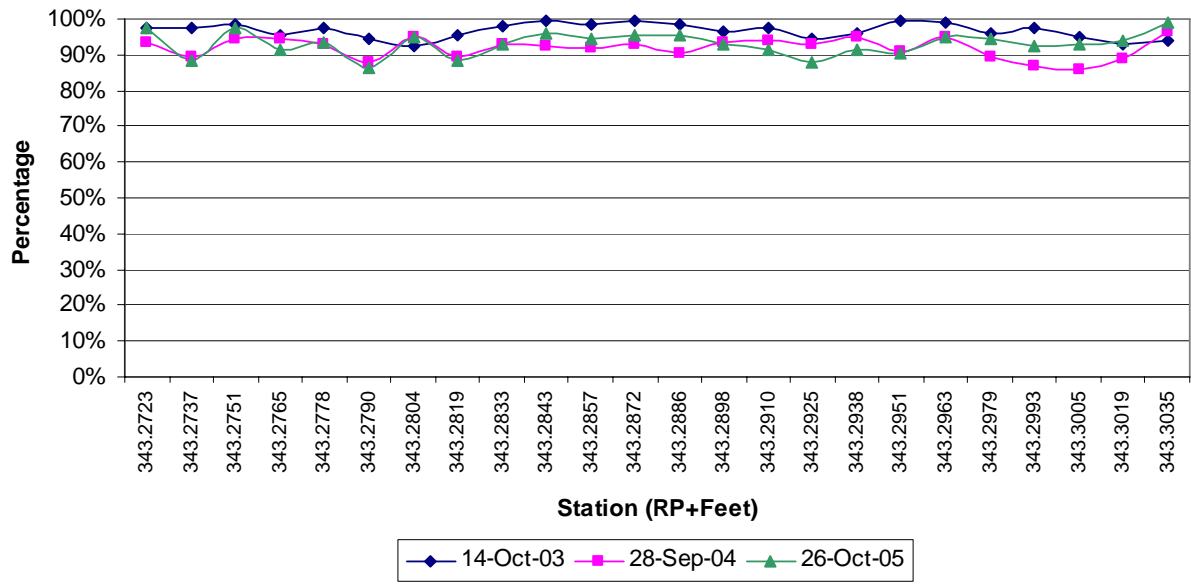
## Control Section #1

Station (mile.feet)	2003 Load Transfer	2004 Load Transfer	2005 Load Transfer
343.2082	91.4%	91.2%	91.9%
343.2094	99.6%	96.5%	95.9%
343.2107	100.3%	99.7%	95.8%
343.2123	98.6%	93.8%	92.7%
343.2136	95.6%	97.3%	96.2%
343.2148	93.5%	94.6%	94.8%
343.2162	99.4%	98.1%	93.2%
343.2176	92.8%	94.6%	90.9%
343.2190	97.2%	98.5%	97.2%
343.2201	94.9%	94.6%	92.6%
343.2214	96.1%	97.0%	95.8%
343.2229	99.8%	96.0%	95.8%
343.2243	95.3%	98.1%	93.8%
343.2254	96.3%	95.6%	95.0%
343.2268	95.6%	95.2%	92.9%
343.2282	98.4%	95.6%	92.5%
343.2297	96.7%	93.2%	87.8%
343.2308	95.7%	93.8%	88.7%
343.2321	93.6%	90.9%	88.1%
343.2337	95.4%	93.9%	85.8%
343.2350	96.3%	95.1%	93.9%
343.2362	94.6%	92.5%	90.6%
343.2375	96.8%	91.2%	90.2%
343.2390	98.9%	96.0%	95.5%
343.2403	99.1%	91.7%	91.5%
343.2415	96.2%	93.1%	95.3%
343.2426	95.4%	92.7%	94.2%
343.2442	99.8%	96.2%	94.9%
343.2456	98.7%	98.2%	95.5%
343.2467	100.9%	97.0%	94.4%
343.2481	97.5%	96.9%	94.5%
343.2494	98.7%	97.1%	92.6%
343.2508	99.7%	97.1%	96.8%
343.2521	99.1%	98.0%	98.0%
343.2533	98.7%	95.7%	95.6%
343.2547	96.7%	93.8%	95.7%
343.2561	97.9%	95.6%	96.7%
343.2573	96.4%	91.9%	94.8%
343.2587	95.8%	94.1%	93.0%
343.2601	96.6%	93.1%	92.4%
343.2615	100.2%	93.6%	94.3%
343.2628	102.1%	94.3%	96.8%

Station (mile.feet)	2003 Load Transfer	2004 Load Transfer	2005 Load Transfer
343.2641	100.6%	96.0%	96.4%
343.2655	99.8%	93.4%	96.5%
343.2670	98.2%	95.9%	93.4%
343.2681	97.3%	94.9%	94.5%
343.2695	94.1%	92.8%	98.5%
343.2710	100.2%	92.3%	94.9%
343.2723	97.7%	93.2%	97.7%
343.2736	97.5%	89.4%	88.4%
343.2750	98.6%	94.5%	97.3%
343.2765	95.3%	94.5%	91.6%
343.2779	97.4%	93.0%	93.3%
343.2791	94.2%	87.9%	86.5%
343.2804	92.6%	95.0%	95.1%
343.2819	95.5%	89.3%	88.4%
343.2833	97.9%	92.8%	92.7%
343.2845	99.4%	92.2%	95.8%
343.2858	98.3%	92.0%	94.2%
343.2873	99.5%	93.1%	95.2%
343.2887	98.6%	90.6%	95.4%
343.2898	96.6%	93.2%	92.7%
343.2910	97.4%	93.8%	91.6%
343.2926	94.7%	92.7%	88.0%
343.2939	96.1%	95.0%	91.2%
343.2952	99.3%	90.7%	90.3%
343.2964	99.0%	95.0%	95.0%
343.2979	96.1%	89.5%	94.7%
343.2995	97.4%	86.8%	92.2%
343.3005	95.1%	85.9%	93.0%
343.3019	93.1%	88.9%	94.0%
343.3035	94.1%	96.6%	98.8%



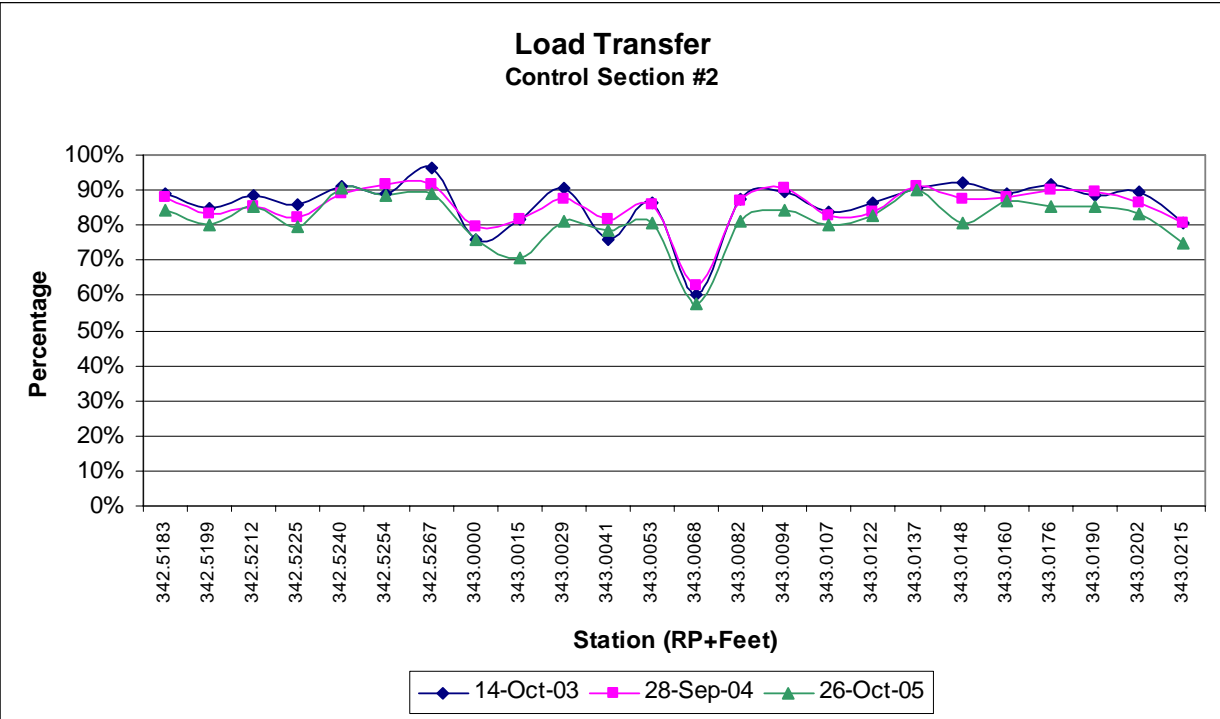
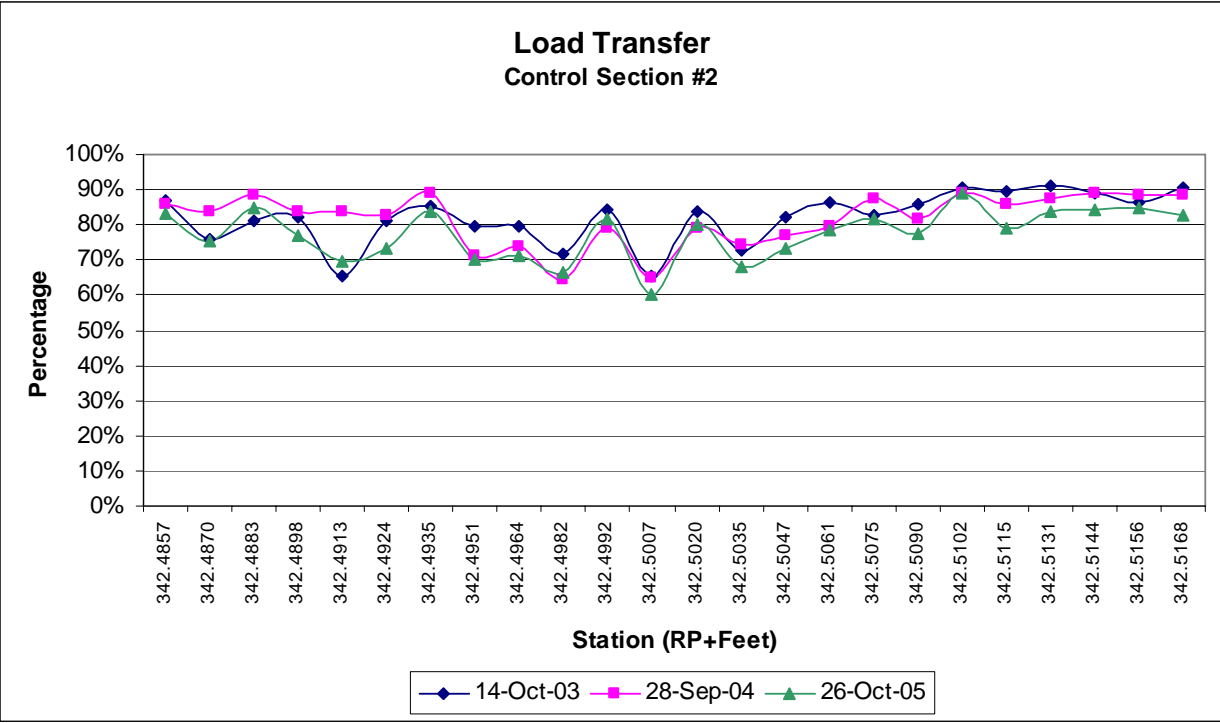
### Load Transfer Control Section #1



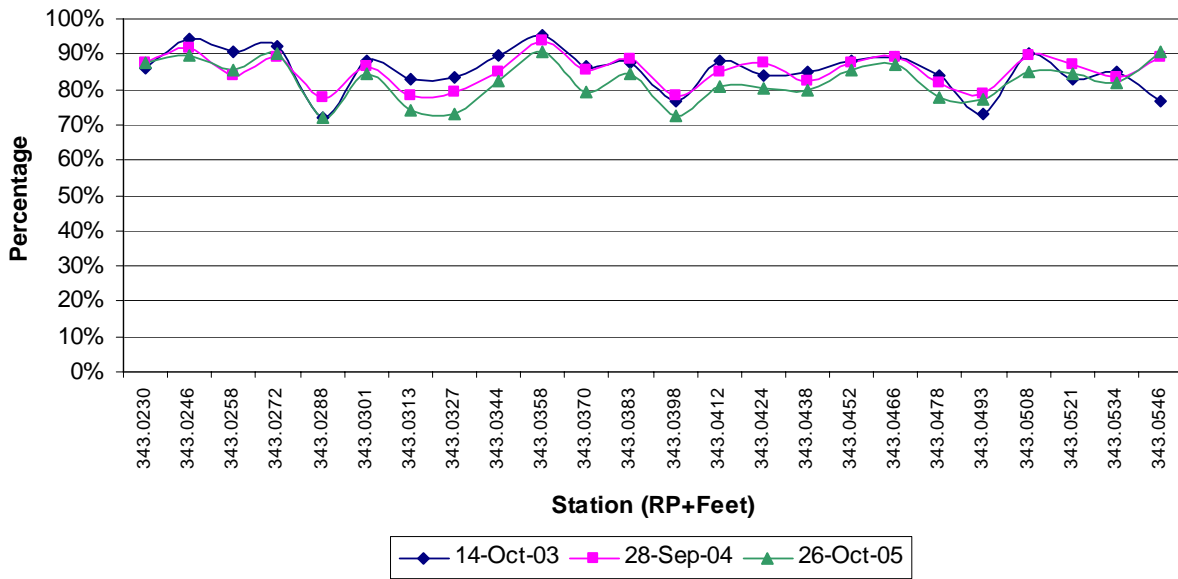
## Control Section #2

Station (mile.feet)	2003 Load Transfer	2004 Load Transfer	2005 Load Transfer
342.4857	87.0%	86.0%	83.4%
342.4870	76.1%	83.6%	75.6%
342.4883	81.3%	88.3%	85.1%
342.4898	82.4%	83.6%	77.2%
342.4913	65.5%	83.6%	69.6%
342.4924	80.9%	82.6%	73.4%
342.4935	85.2%	88.8%	84.0%
342.4951	79.8%	71.2%	70.1%
342.4964	79.5%	73.6%	71.4%
342.4982	71.8%	64.6%	66.7%
342.4993	84.1%	78.8%	81.6%
342.5007	65.3%	65.2%	60.0%
342.5021	83.7%	79.0%	79.9%
342.5035	72.9%	74.5%	67.9%
342.5048	82.4%	76.8%	73.1%
342.5061	86.6%	79.8%	78.5%
342.5075	82.6%	87.6%	81.9%
342.5090	86.1%	81.5%	77.7%
342.5102	90.5%	89.1%	88.8%
342.5115	89.3%	85.8%	79.0%
342.5131	91.1%	87.7%	84.0%
342.5144	88.9%	89.2%	84.2%
342.5157	86.3%	88.2%	84.7%
342.5169	90.4%	88.2%	82.9%
342.5183	89.2%	87.9%	84.3%
342.5199	84.9%	83.4%	80.3%
342.5211	88.7%	85.4%	85.4%
342.5225	86.1%	82.3%	79.8%
342.5240	91.2%	88.9%	90.7%
342.5253	89.2%	91.8%	88.4%
342.5267	96.3%	91.5%	89.2%
343.0000	76.0%	79.4%	75.9%
343.0015	81.9%	81.7%	70.9%
343.0029	90.4%	87.7%	81.0%
343.0041	75.8%	81.8%	78.4%
343.0055	86.2%	86.0%	80.8%
343.0069	60.5%	62.8%	57.7%
343.0082	87.3%	87.1%	81.4%
343.0095	89.8%	90.5%	84.4%
343.0108	83.7%	82.8%	80.2%
343.0122	86.6%	84.0%	82.6%
343.0137	90.3%	91.3%	89.8%

Station (mile.feet)	2003 Load Transfer	2004 Load Transfer	2005 Load Transfer
343.0149	92.1%	87.4%	80.9%
343.0162	89.3%	88.2%	87.1%
343.0177	91.4%	90.3%	85.4%
343.0190	88.2%	89.5%	85.4%
343.0203	89.7%	86.2%	83.0%
343.0216	80.8%	80.5%	74.7%
343.0230	86.0%	87.8%	87.6%
343.0246	94.1%	91.9%	89.7%
343.0258	90.5%	83.8%	85.5%
343.0272	92.1%	89.2%	90.3%
343.0287	72.0%	77.6%	71.8%
343.0301	88.2%	86.4%	84.4%
343.0314	82.7%	78.1%	74.3%
343.0327	83.2%	79.3%	73.2%
343.0342	89.8%	85.0%	82.6%
343.0357	95.6%	93.7%	90.9%
343.0370	86.5%	85.5%	79.1%
343.0383	87.6%	88.8%	84.4%
343.0398	76.9%	78.5%	72.5%
343.0411	88.1%	84.8%	80.9%
343.0424	84.2%	87.7%	80.5%
343.0437	85.0%	82.6%	79.7%
343.0453	88.3%	87.4%	85.3%
343.0467	89.2%	89.4%	87.0%
343.0478	83.7%	81.6%	77.9%
343.0493	73.2%	78.9%	77.2%
343.0507	90.3%	89.7%	85.1%
343.0520	83.0%	86.9%	84.5%
343.0534	85.2%	83.5%	82.0%
343.0546	76.9%	89.3%	90.7%



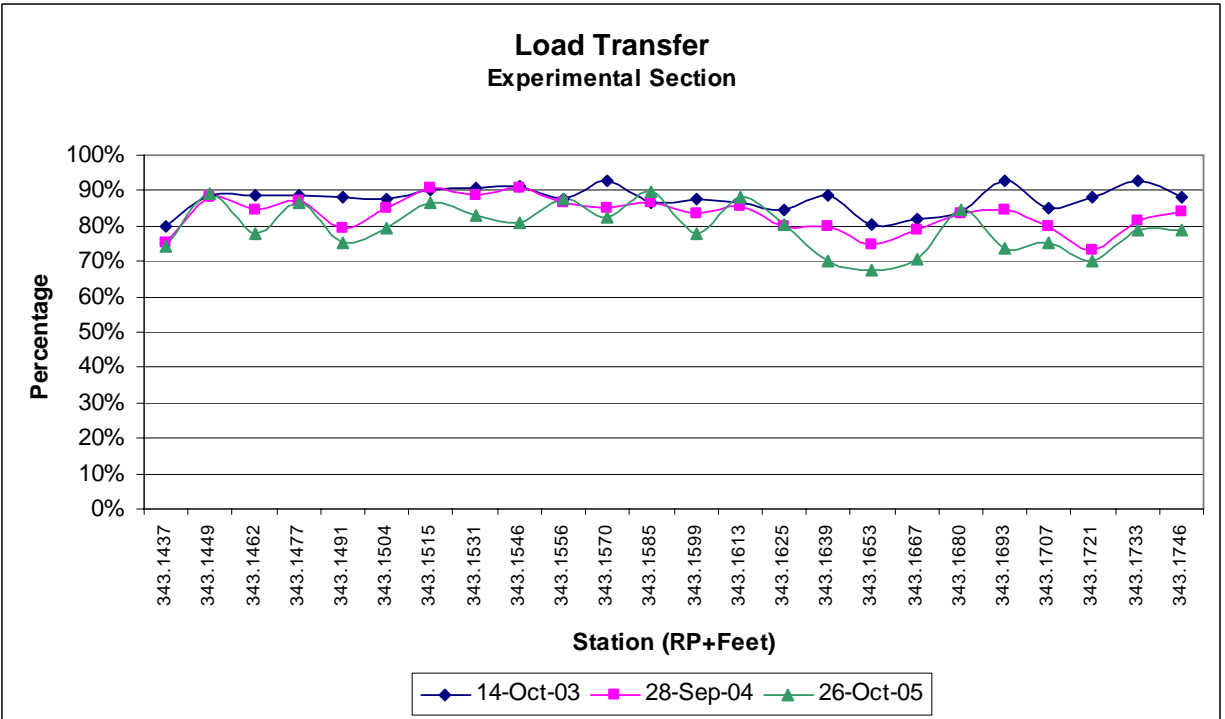
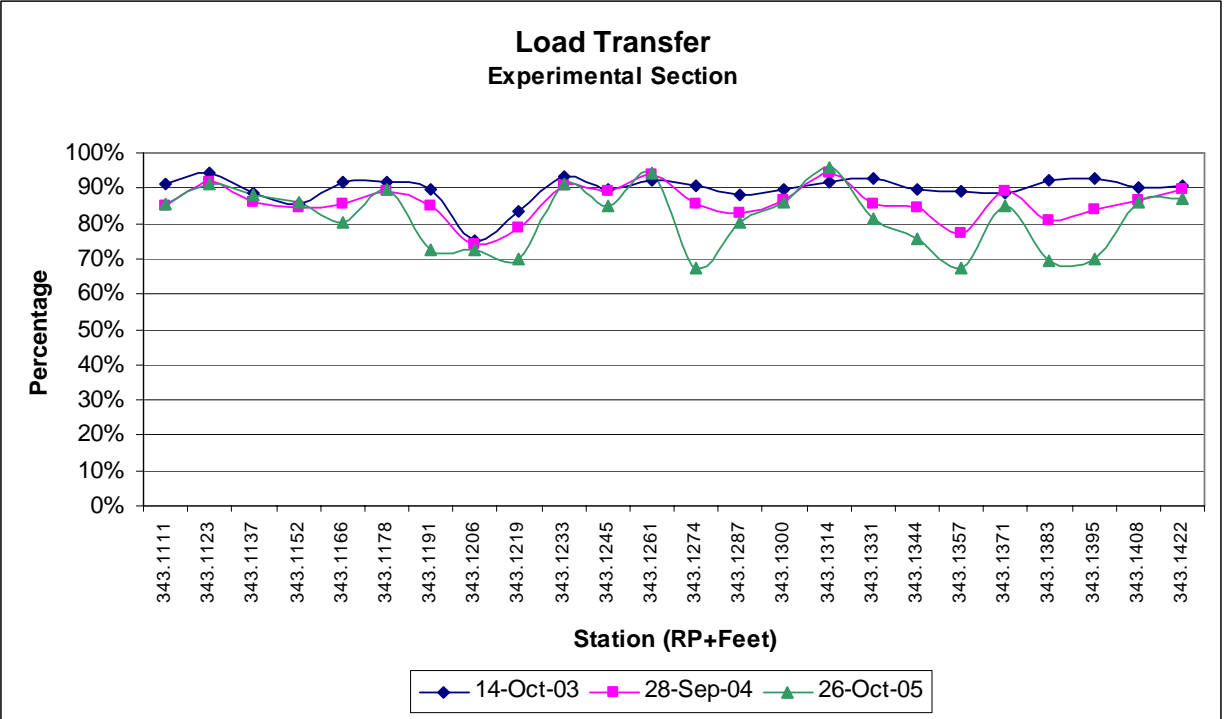
### Load Transfer Control Section #2



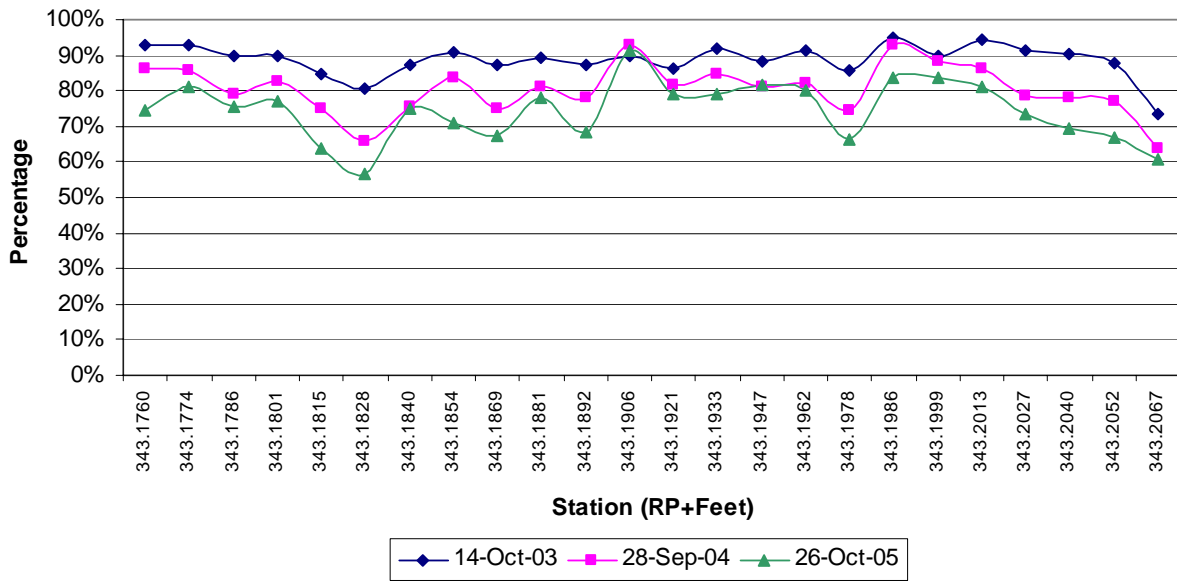
## Experimental Section

Station (mile.feet)	2003 Load Transfer	2004 Load Transfer	2005 Load Transfer
343.1111	91.1%	85.1%	85.6%
343.1123	94.1%	91.8%	91.3%
343.1136	88.5%	86.1%	88.2%
343.1152	85.5%	84.3%	86.0%
343.1165	91.8%	85.6%	80.5%
343.1178	91.8%	88.9%	89.4%
343.1191	89.6%	84.9%	72.8%
343.1205	75.2%	74.0%	72.5%
343.1220	83.4%	78.5%	69.8%
343.1232	93.3%	90.4%	91.2%
343.1245	89.6%	89.1%	84.9%
343.1260	92.3%	93.6%	94.1%
343.1273	90.6%	85.7%	67.5%
343.1287	87.8%	83.0%	80.3%
343.1300	89.6%	86.8%	86.0%
343.1314	91.5%	94.3%	95.7%
343.1330	92.5%	85.4%	81.5%
343.1343	89.6%	84.5%	75.7%
343.1357	89.4%	77.1%	67.6%
343.1371	88.8%	89.2%	85.2%
343.1384	92.1%	81.0%	69.4%
343.1396	92.5%	83.9%	70.0%
343.1408	90.3%	86.5%	86.0%
343.1422	90.6%	89.5%	87.3%
343.1437	80.0%	75.3%	74.0%
343.1449	88.9%	88.0%	89.1%
343.1462	88.5%	84.6%	77.9%
343.1477	88.5%	86.9%	86.7%
343.1491	87.9%	79.6%	75.1%
343.1504	87.4%	84.9%	79.4%
343.1517	90.1%	90.9%	86.8%
343.1531	90.8%	88.6%	83.1%
343.1546	91.3%	90.6%	81.0%
343.1557	87.6%	86.5%	87.8%
343.1570	92.9%	84.8%	82.5%
343.1585	86.6%	86.6%	89.6%
343.1599	87.7%	83.6%	77.7%
343.1613	86.8%	85.7%	88.4%
343.1625	84.3%	80.0%	80.4%
343.1640	88.7%	80.2%	70.3%
343.1654	80.3%	74.6%	67.5%
343.1666	82.1%	78.7%	70.5%

Station (mile.feet)	2003 Load Transfer	2004 Load Transfer	2005 Load Transfer
343.1679	84.1%	83.2%	84.5%
343.1694	92.9%	84.5%	73.8%
343.1707	85.2%	80.1%	75.3%
343.1720	88.1%	73.4%	69.9%
343.1733	93.0%	81.3%	78.8%
343.1747	88.1%	84.3%	78.8%
343.1762	93.0%	86.0%	74.6%
343.1774	93.0%	85.9%	81.3%
343.1785	89.6%	79.2%	75.4%
343.1801	89.8%	82.6%	77.0%
343.1815	84.5%	74.8%	63.9%
343.1828	80.5%	65.7%	56.7%
343.1839	87.1%	75.7%	75.2%
343.1854	90.9%	83.8%	71.0%
343.1869	87.3%	75.1%	67.6%
343.1881	89.3%	81.3%	78.0%
343.1893	87.4%	77.9%	68.3%
343.1908	89.6%	92.7%	91.2%
343.1922	86.0%	81.8%	78.9%
343.1934	91.7%	84.8%	79.0%
343.1948	88.2%	81.3%	81.8%
343.1963	91.4%	82.0%	80.0%
343.1978	86.0%	74.4%	66.1%
343.1987	94.7%	92.7%	83.4%
343.1999	89.9%	88.5%	83.9%
343.2014	94.2%	86.1%	81.1%
343.2028	91.4%	78.4%	73.5%
343.2040	90.4%	78.1%	69.6%
343.2053	87.8%	76.9%	66.9%
343.2067	73.4%	63.9%	60.7%



### Load Transfer Experimental Section



## **Appendix C: Compressive Strength**

# 6-Hour Compressive Break – Five Star

5011

PROJECT: ACIM-8-094 (041) 342

DATE: 6/30/3

REPORT TO: ND DEPARTMENT OF TRANSPORTATION COPIES WILLIE SHACHER  
 300 AIRPORT ROAD JOE PEYERL  
 BISMARCK, NORTH DAKOTA  
 ATTN: DENNIS BLASL

PROJECT # 03-3039.08

**FIELD DATA:**

TIME OF PLASTIC TEST:	12:10	CONCRETE 1	N.T.
TICKET NUMBER:	N.P.	SLUMP (inches)	N.T.
COUNTY:	CASS	AIR CONTENT	N.T.
DISTRICT:	FARGO	UNIT WEIGHT	N.T. - FRACTURE
CONTRACTOR:	HIGHWAY SERVICES		
PAVING STATION:	STA 1543+10 LT		
PART OF STRUCTURE:	WB CLOSURE DRIVE LANE SEG. A		

- |  |              |
|--|--------------|
|  | A - CONE     |
|  | B - CONE AN  |
|  | C - CONE ANI |
|  | D - SHEAR    |
|  | E - COLUMNAI |

SPECIFIED STRENGTH @ 28 DAYS:

**MIX DESIGN NUMBER:**

Mix Used Per Sack of Cement N.P.  
 Water / Sack of Cement (gals) N.P.  
 TTL Water / Sack of Cement ( N.P.)  
 Sacks per Cu Yd: N.P.  
 Source of Gravel: 1-139-46  
 Source of Sand: 1-139-46  
 Class of Concrete: 5 STAR

**CONCRETE FURNISHED BY:**

**COMPRESSIVE STRENGTH:**

SET NUMBER:	5011-A	5011-B
DATE CAST:	6/27/3	
DATE RECEIVED:	6/27/3	
DATE OF TEST:	6/27/3	6/27/3 <i>East</i>
LABORATORY #:	2715A	2715B
METHOD OF CURING:		
Days on Job & Enroute:	0	0
Days Lab Cured-ASTM C193:	0	0
AGE AT TEST (days):	0	0 <i>1</i>
LOAD AT FAILURE (lbs):	195,210	206,090
DIAMETER OF CYLINDER (in)	6.0	6.0
AREA OF CYLINDER (inches)	28.3	28.3
STRENGTH (psi):	6900	7250
TYPE OF FRACTURE:	D	D

REMARKS: Field data prepared by: NDDOT

BY: Keith Fraase

# 6-Hour Compressive Break – Five Star with Granite Aggregate



## COMPRESSION TESTS OF CONCRETE CYLINDERS

PROJECT: ACIM-8-094 (041) 342 DATE: 8/18/2003

REPORT TO: ND DEPARTMENT OF TRANSPORTATION  
300 AIRPORT ROAD  
BISMARCK, NORTH DAKOTA  
ATTN: DENNIS BLASL

COPIES TO: WILLIE SHACHER  
JOE PEYERL

PROJECT #: 03-3039.08

**FIELD DATA:**

TIME OF PLASTIC TEST:	11:00	CONCRETE TEMP:	N.T.
TICKET NUMBER:	N.P.	SLUMP (inches):	N.T.
COUNTY:	CASS	AIR CONTENT (%):	N.T.
DISTRICT:	FARGO	UNIT WEIGHT (pcf)	N.T.
CONTRACTOR:	HIGHWAY SERVICES		
PAVING STATION/	WB I-94 DRIVING LANE		
PART OF STRUCTURE:	SEG. A STA 1488+00 LT		

	TYPE OF FRACTURE
<input type="checkbox"/>	A - CONE
<input type="checkbox"/>	B - CONE AND SPLIT
<input type="checkbox"/>	C - CONE AND SHEAR
<input type="checkbox"/>	D - SHEAR
<input type="checkbox"/>	E - COLUMNAR

**SPECIFIED STRENGTH @ 28 DAYS:**

**MIX DESIGN NUMBER:**

M<sup>1</sup> and Per Sack of Cement: N.P.  
W. Sack of Cement (gals): N.P.  
TTL Water / Sack of Cement (gals): N.P.  
Sacks per Cu Yd: N.P.  
Source of Gravel: 1-139-46  
Source of Sand: 1-139-46  
Class of Concrete: 5 STAR

**CONCRETE FURNISHED BY:**  
**COMPRESSIVE STRENGTH:**

SET NUMBER:	5040-A	5040-B
DATE CAST:	8/15/2003	
DATE RECEIVED:	8/15/2003	
DATE OF TEST:	8/15/2003	8/15/2003
LABORATORY #:	3184A	3184B
METHOD OF CURING:		
Days on Job & Enroute:	0	0
Days Lab Cured-ASTM C193:	0	0
AGE AT TEST (days):	0	0
LOAD AT FAILURE (lbs):	140,000	134,320
DIAMETER OF CYLINDER (inches)	6.0	6.0
AREA OF CYLINDER (inches)	28.3	28.3
STRENGTH (psi):	4950	4750

**TYPE OF FRACTURE:**

REMARKS: Field data prepared by: NDDOT

BY: Keith Fraese

# 6-Hour Compressive Break – Mix MR0301-Set A

A

**PROJECT:** ACIM-8-094 (041) 342  
**REPORT TO:** ND DEPARTMENT OF TRANSPORTATION  
 300 AIRPORT ROAD  
 BISMARCK, NORTH DAKOTA  
 ATTN: DENNIS BLASL

**DATE:** 8/18/3  
**COPIES TO:** WILLIE ST  
 JOE PEYE

**PROJECT #:** 03-3039.08

**FIELD DATA:**

TIME OF PLASTIC TEST:	10:30	CONCRETE TEMP.:	N.T.
TICKET NUMBER:	N.P.	SLUMP (inches):	N.T.
COUNTY:	CASS	AIR CONTENT (%):	N.T.
DISTRICT:	FARGO	UNIT WEIGHT (pcf)	N.T.

**CONTRACTOR:** HIGHWAY SERVICES

**TYPE OF FRAC1**

**PAVING STATION/** I-94 WB W OF WEST FARGO  
**PART OF STRUCTURE:** INTERCHANGE DOWEL BAR RETROFIT

	A - CONE
	B - CONE
	C - CONE
	D - SHEAF
	E- COLUMN

**SPECIFIED STRENGTH @ 28 DAYS:**

**MIX DESIGN NUMBER:**

Mix Used Per Sack of Cement: N.P.  
 Water / Sack of Cement (gals): N.P.  
 TTL Water / Sack of Cement (gals): N.P.  
 Sacks per Cu Yd: N.P.  
 Source of Gravel: N.P.  
 Source of Sand: N.P.  
 Class of Concrete: TRIAL MIX

**CONCRETE FURNISHED BY:**

**COMPRESSIVE STRENGTH:**

	A-A	A-B
SET NUMBER:		
DATE CAST:	8/14/3	
DATE RECEIVED:	8/14/3	
DATE OF TEST:	8/14/3	8/14/3
LABORATORY #:	3164A	3164B
METHOD OF CURING:		
Days on Job & Enroute:	0	0
Days Lab Cured-ASTM C193:	0	0
AGE AT TEST (days):	0	0
LOAD AT FAILURE (lbs):	140,870	145,080
DIAMETER OF CYLINDER (in.)	6.0	6.0
AREA OF CYLINDER (In.)	28.3	28.3
STRENGTH (psi):	4980	5130
TYPE OF FRACTURE:	D	D

**REMARKS:** Field data prepared by: NDDOT

**BY:** Keith Fraase

# 6-Hour Compressive Break – Mix MR0301-Set B

B

**PROJECT:** ACIM-8-094 (041) 342  
**REPORT TO:** ND DEPARTMENT OF TRANSPORTATION  
 300 AIRPORT ROAD  
 BISMARCK, NORTH DAKOTA  
 ATTN: DENNIS BLASL

**DATE:** 8/18/3  
**COPIES TO:** WILLIE SH  
 JOE PEYE

**PROJECT #:** 03-3039.08

**FIELD DATA:**

TIME OF PLASTIC TEST:	12:30	CONCRETE TEMP:	N.T.
TICKET NUMBER:	N.P.	SLUMP (inches):	N.T.
COUNTY:	CASS	AIR CONTENT (%):	N.T.
DISTRICT:	FARGO	UNIT WEIGHT (pcf)	N.T.

**CONTRACTOR:** HIGHWAY SERVICES

**TYPE OF FRAC**

**PAVING STATION/** I-94 WB W OF WEST FARGO  
**PART OF STRUCTURE:** INTERCHANGE DOWEL BAR RETROFIT

	A - CONE
	B - CONE
	C - CONE
	D - SHEAF
	E - COLUM

**SPECIFIED STRENGTH @ 28 DAYS:**

**MIX DESIGN NUMBER:**

Mix Used Per Sack of Cement: N.P.  
 Water / Sack of Cement (gals): N.P.  
 TTL Water / Sack of Cement (gals): N.P.  
 Sacks per Cu Yd: N.P.  
 Source of Gravel: N.P.  
 Source of Sand: N.P.  
 Class of Concrete: TRIAL MIX

**CONCRETE FURNISHED BY:**

**COMPRESSIVE STRENGTH:**

	B-A	B-B
SET NUMBER:		
DATE CAST:	8/14/3	
DATE RECEIVED:	8/14/3	
DATE OF TEST:	8/14/3	8/14/3
LABORATORY #:	3170A	3170B
METHOD OF CURING:		
Days on Job & Enroute:	0	0
Days Lab Cured-ASTM C193:	0	0
AGE AT TEST (days):	0	0
LOAD AT FAILURE (lbs):	160,930	156,340
DIAMETER OF CYLINDER (In.)	6.0	6.0
AREA OF CYLINDER (In.)	28.3	28.3
STRENGTH (psi):	5690	5530
TYPE OF FRACTURE:	D	D

**REMARKS:** Field data prepared by: NDDOT

**BY:** Keith Fraase

# 6-Hour Compressive Break – Mix MR0301-Set C

C

**PROJECT:** ACIM-8-094 (041) 342  
**REPORT TO:** ND DEPARTMENT OF TRANSPORTATION  
 300 AIRPORT ROAD  
 BISMARCK, NORTH DAKOTA  
 ATTN: DENNIS BLASL

**DATE:** 8/18/3  
**COPIES TO:** WILLIE SF  
 JOE PEYE

**PROJECT #:** 03-3039.08

**FIELD DATA:**

TIME OF PLASTIC TEST:	3:30	CONCRETE TEMP:	N.T.
TICKET NUMBER:	N.P.	SLUMP (inches):	N.T.
COUNTY:	CASS	AIR CONTENT (%):	N.T.
DISTRICT:	FARGO	UNIT WEIGHT (pcf)	N.T.
CONTRACTOR:	HIGHWAY SERVICES	<b>TYPE OF FRAC</b>	
PAVING STATION:	I-94 WB W OF WEST FARGO		
PART OF STRUCTURE:	INTERCHANGE DOWEL BAR RETROFIT		

- |  |           |
|--|-----------|
|  | A - CONE  |
|  | B - CONE  |
|  | C - CONE  |
|  | D - SHEAF |
|  | E - COLUM |

**SPECIFIED STRENGTH @ 28 DAYS:**

**MIX DESIGN NUMBER:**  
 Mix Used Per Sack of Cement: N.P.  
 Water / Sack of Cement (gals): N.P.  
 TTL Water / Sack of Cement (gals): N.P.  
 Sacks per Cu Yd: N.P.  
 Source of Gravel: N.P.  
 Source of Sand: N.P.  
 Class of Concrete: TRIAL MIX

**CONCRETE FURNISHED BY:**

**COMPRESSIVE STRENGTH:**

	C-A	C-B
SET NUMBER:		
DATE CAST:	8/14/3	
DATE RECEIVED:	8/14/3	
DATE OF TEST:	8/14/3	8/14/3
LABORATORY #:	3175A	3175B
METHOD OF CURING:		
Days on Job & Enroute:	0	0
Days Lab Cured-ASTM C193:	0	0
AGE AT TEST (days):	0	0
LOAD AT FAILURE (lbs):	150,150	154,560
DIAMETER OF CYLINDER (in.)	6.0	6.0
AREA OF CYLINDER (in.)	28.3	28.3
STRENGTH (psi):	5310	5470
TYPE OF FRACTURE:	D	D

**REMARKS:** Field data prepared by: NDDOT

**BY:** Keith Fraase

# 6-Hour Compressive Break – Mix MR0301-Set D

D

**PROJECT:** ACIM-8-094 (041) 342 **DATE:** 8/18/3  
**REPORT TO:** ND DEPARTMENT OF TRANSPORTATION **COPIES TO:** WILLIE ST  
 300 AIRPORT ROAD JOE PEYE  
 BISMARCK, NORTH DAKOTA  
 ATTN: DENNIS BLASL

**PROJECT #:** 03-3039.08

**FIELD DATA:**

TIME OF PLASTIC TEST:	4:30	CONCRETE TEMP:	N.T.
TICKET NUMBER:	N.P.	SLUMP (inches):	N.T.
COUNTY:	CASS	AIR CONTENT (%):	N.T.
DISTRICT:	FARGO	UNIT WEIGHT (pcf)	N.T.

**CONTRACTOR:** HIGHWAY SERVICES **TYPE OF FRAC**

**PAVING STATION/** I-94 WB W OF WEST FARGO

**PART OF STRUCTURE:** INTERCHANGE DOWEL BAR RETROFIT

	A - CONE
	B - CONE
	C - CONE
	D - SHEAF
	E - COLUMN

**SPECIFIED STRENGTH @ 28 DAYS:**

**MIX DESIGN NUMBER:**

Mix Used Per Sack of Cement: N.P.  
 Water / Sack of Cement (gals): N.P.  
 TTL Water / Sack of Cement (gals): N.P.  
 Sacks per Cu Yd: N.P.  
 Source of Gravel: N.P.  
 Source of Sand: N.P.  
 Class of Concrete: TRIAL MIX

**CONCRETE FURNISHED BY:**

**COMPRESSIVE STRENGTH:**

	D-A	D-B
SET NUMBER:		
DATE CAST:	8/14/3	
DATE RECEIVED:	8/14/3	
DATE OF TEST:	8/14/3	8/14/3
LABORATORY #:	3176A	3176B
METHOD OF CURING:		
Days on Job & Enroute:	0	0
Days Lab Cured-ASTM C193:	0	0
AGE AT TEST (Days):	0	0
LOAD AT FAILURE (lbs):	145,690	143,370
DIAMETER OF CYLINDER (in.)	6.0	6.0
AREA OF CYLINDER (in.)	28.3	28.3
STRENGTH (psi):	5150	5070
TYPE OF FRACTURE:	D	D

**REMARKS:** Field data prepared by: NDDOT

**BY:** Keith Fraase

# 7-Day Compressive Break – Mix MR0301-Set A

AUG 22 2003

***GEO SERV, INC.*** Testing - Exploration - Engineering  
 Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling

**TO:** Mr. Dennis Blasl  
 NDDOT  
 Materials & Research Division  
 300 Airport Road  
 Bismarck, ND 58504-6005

**DATE:** 8-21-03  
**PROJECT NO:** GEO-080319

**COPY TO:**

**PROJECT:** PSPR 001 0025 01 02  
 Cass County

## COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	A7 - 335	A7 - 336
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	7	7
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#	
Water	255#	
Admixture	Air 2.975 oz.	
	W/R 102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27947-1	ND27947-2
* Date Received	8-21-03	8-21-03
* Method of Curing:		
Days on Job & Enroute	7	7
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	7	7
* Load at Failure, pounds	251,000	247,250
* Strength, psi	8,880	8,750
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)

*Mark Schmitt*  
 GEOSERV, INC.

3100 EAST BROADWAY AVENUE • BISMARCK, ND 58501  
 P.O. BOX 3159 • BISMARCK, ND 58502-3159

PHONE 701-223-6149  
 FAX 701-223-2372  
 geoservinc@quest.net

## 7-Day Compressive Break – Mix MR0301-Set B

***GEOSERV, INC.***    *Testing - Exploration - Engineering*  
*Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling*

**TO:** Mr. Dennis Blasl  
 NDDOT  
 Materials & Research Division  
 300 Airport Road  
 Bismarck, ND 58504-6005

**DATE:** 8-21-03  
**PROJECT NO:** GEO-080319

**COPY TO:**

**PROJECT:** PSPR 001 0025 01 02  
 Cass County

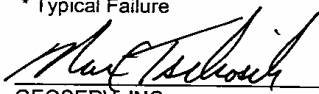
### COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	B7 - 337	B7 - 338
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	7	7
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#	
Water	255#	
Admixture	Air        2.975 oz.	
	W/R        102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27948-1	ND27948-2
* Date Received	8-21-03	8-21-03
* Method of Curing:		
Days on Job & Enroute	7	7
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	7	7
* Load at Failure, pounds	256,750	261,750
* Strength, psi	9,090	9,260
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)



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# 7-Day Compressive Break – Mix MR0301-Set C

***GEOSERV, INC.***    *Testing - Exploration - Engineering*  
*Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling*

**TO:**            Mr. Dennis Blasl  
                   NDDOT  
                   Materials & Research Division  
                   300 Airport Road  
                   Bismarck, ND 58504-6005

**DATE:**            8-21-03  
**PROJECT NO:**    GEO-080319

**COPY TO:**

**PROJECT:** PSPR 001 0025 01 02  
                   Cass County

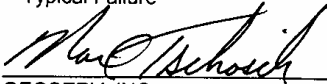
### COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	C7 - 339	C7 - 340
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	7	7
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#	
Water	255#	
Admixture	Air            2.975 oz.	
	W/R            102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27949-1	ND27949-2
* Date Received	8-21-03	8-21-03
* Method of Curing:		
Days on Job & Enroute	7	7
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	7	7
* Load at Failure, pounds	277,750	287,000
* Strength, psi	9,830	10,155
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)



**GEOSERV, INC.**

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 FAX 701-223-2372  
 geoservinc@quest.net

# 7-Day Compressive Break – Mix MR0301-Set D

***GEOSERV, INC.***    *Testing - Exploration - Engineering*  
*Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling*

**TO:**            Mr. Dennis Blasl  
                   NDDOT  
                   Materials & Research Division  
                   300 Airport Road  
                   Bismarck, ND 58504-6005

**DATE:**            8-21-03  
**PROJECT NO:**    GEO-080319

**COPY TO:**

**PROJECT:**    PSPR 001 0025 01 02  
                   Cass County

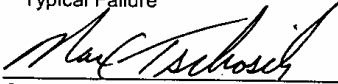
## COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	D7 - 341	D7 - 342
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	7	7
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#	
Water	255#	
Admixture	Air            2.975 oz.	
	W/R            102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27950-1	ND27950-2
* Date Received	8-21-03	8-21-03
* Method of Curing:		
Days on Job & Enroute	7	7
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	7	7
* Load at Failure, pounds	260,500	263,750
* Strength, psi	9,220	9,330
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)



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## 28-Day Compressive Break – Mix MR0301-Set A

**GEOSERV, INC.**    *Testing - Exploration - Engineering*  
*Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling*

**TO:** Mr. Dennis Blasl  
 NDDOT  
 Materials & Research Division  
 300 Airport Road  
 Bismarck, ND 58504-6005

**DATE:** 9-11-03  
**PROJECT NO:** GEO-080319

**COPY TO:**

SEP 16 2003

**PROJECT:** PSPR 001 0025 01 02  
 Cass County

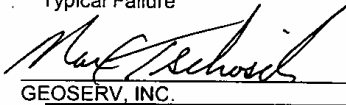
### COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	A28 - 343	A28 - 344
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	28	28
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#.	
Water	255#	
Admixture	Air        2.975 oz.	
	W/R        102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27967-1	ND27967-2
* Date Received	9-11-03	9-11-03
* Method of Curing:		
Days on Job & Enroute	28	28
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	28	28
* Load at Failure, pounds	298,250	281,750
* Strength, psi	10,555	9,970
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)

  
 GEOSERV, INC.

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## 28-Day Compressive Break – Mix MR0301-Set B

***GEO SERV, INC.*** Testing - Exploration - Engineering  
 Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling

**TO:** Mr. Dennis Blasl  
 NDDOT  
 Materials & Research Division  
 300 Airport Road  
 Bismarck, ND 58504-6005

**DATE:** 9-11-03  
**PROJECT NO:** GEO-080319

**COPY TO:**

**PROJECT:** PSPR 001 0025 01 02  
 Cass County

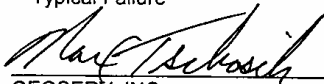
### COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	B28 - 345	B28 - 346
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	28	28
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#	
Water	255#	
Admixture	Air 2.975 oz.	
	W/R 102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27968-1	ND27968-2
* Date Received	9-11-03	9-11-03
* Method of Curing:		
Days on Job & Enroute	28	28
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	28	28
* Load at Failure, pounds	295,000	291,250
* Strength, psi	10,440	10,305
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)



GEO SERV, INC.

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## 28-Day Compressive Break – Mix MR0301-Set C

**GEOSERV, INC.**    *Testing - Exploration - Engineering*  
*Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling*

**TO:**            Mr. Dennis Blasl  
                   NDDOT  
                   Materials & Research Division  
                   300 Airport Road  
                   Bismarck, ND 58504-6005

**DATE:**            9-11-03  
**PROJECT NO:**    GEO-080319

**COPY TO:**

**PROJECT:**    PSPR 001 0025 01 02  
                   Cass County

### COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	C28 - 347	C28 - 348
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	28	28
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#.	
Water	255#	
Admixture	Air        2.975 oz.	
	W/R      102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27969-1	ND27969-2
* Date Received	9-11-03	9-11-03
* Method of Curing:		
Days on Job & Enroute	28	28
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	28	28
* Load at Failure, pounds	322,750	320,000
* Strength, psi	11,420	11,325
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)

*Mark Tschosch*  
 \_\_\_\_\_

GEOSERV, INC.

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 geoservinc@quest.net

## 28-Day Compressive Break – Mix MR0301-Set D

***GEOSERV, INC.***    *Testing - Exploration - Engineering*  
*Construction Materials Testing, Geotechnical, Geosynthetics, Geoenvironmental, Drilling*

**TO:**            Mr. Dennis Blasl  
                   NDDOT  
                   Materials & Research Division  
                   300 Airport Road  
                   Bismarck, ND 58504-6005

**DATE:**            9-11-03  
**PROJECT NO:**    GEO-080319

**COPY TO:**

**PROJECT:**    PSPR 001 0025 01 02  
                   Cass County

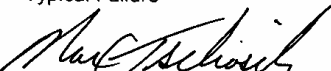
### COMPRESSION TESTS OF CYLINDERS

**FIELD DATA:**

* Job Identification	D28 - 349	D28 - 350
* Date Cast	8-14-03	8-14-03
* Age to be Tested, Days	28	28
* Slump (inches)	N/A	N/A
* Air Content (%)	N/A	N/A
* Location of Placement	N/A	
* Specified Strength @ 28 Days	N/A	
* Mix Proportions		
Cement	850#	
Fine Aggregate	1079#	
Coarse Aggregate	1526#.	
Water	255#	
Admixture	Air        2.975 oz.	
	W/R      102.0 oz.	
	Accelerator 340.0 oz.	
* Concrete Furnished by	N/A	

**COMPRESSIVE STRENGTH:** Test Method-ASTM:C39, 6"x12" Cylinder, Area 28.26 Sq. In.

* Laboratory Number	ND27970-1	ND27970-2
* Date Received	9-11-03	9-11-03
* Method of Curing:		
Days on Job & Enroute	28	28
Days Lab. Cured-ASTM:C192	0	0
* Age at Test, days	28	28
* Load at Failure, pounds	338,250	299,200
* Strength, psi	11,970	10,590
* Typical Failure	Shear	Shear
	(Long Plane)	(Long Plane)

  
 GEOSERV, INC.

3100 EAST BROADWAY AVENUE • BISMARCK, ND 58501  
 P.O. BOX 3159 • BISMARCK, ND 58502-3159

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 FAX 701-223-2372  
 geoservinc@quest.net

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## **Appendix D: Flexural Strength**

## 28-Day Flexural Strength

Set A = 982 psi

Set B = 1,099 psi

Set C = 1,093 psi

Set D = 1,188 psi

## **Appendix E: Freeze/Thaw**

**MEMORANDUM**

**TO:** BYRON FUCHS

**FROM:** CEMENT AND CONCRETE SECTION 

**DATE:** 12-18-03

**SUBJECT:** DOWEL BAR RETROFIT MIX "MR0301"  
PROJECT # PSPR 001 0025 01 02 CASS COUNTY

---

Freeze/thaw bars molded at the Fargo experimental site were subjected to 300 freeze/thaw cycles from 9-3-2003 to 11-3-2003.

The results are listed below:

	<u>Durability Factor</u>	<u>Weight Change(%)</u>	<u>Length Change(%)</u>
Bars set A	93.1	+ .16	-.002
Bars set B	89.8	+ .17	0
Bars set C	98.9	+ .04	-.001
Bars set D	96.9	0	-.002

None of the bars showed any signs of flaking, scaling, or cracking. Irregular projections along some edges, resulting from less-than-perfect molding, did not break off. This would not have been the case with "regular" concrete.

From all appearances, the mortar mix appears to be very durable.