

MEMORANDUM

TO: Roger Weigel
Design Engineer

ATTN: Wayne Zacher
Design Division

FROM: /s/Ron Horner
Materials and Research Engineer
/s/Greg Wolter
Geotechnical Section

DATE: 10/7/2010

SUBJECT: Soils Report and Recommendation for Project SS-1-003(034)059

Attached is the Soils Report and Recommendation for project SS-1-003(034)059. If you have any questions please call me at 328-6907 or Jon Ketterling at 328-6908.

c: Office of Project Development
Bismarck District
Construction Services
FHWA
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Central File

LINEAR SOIL REPORT AND RECOMMENDATION

Project: SS-1-003(034)059

Project Description: Jct 34 N to I-94 Dawson

PCN: 17707

Project Length: 25.545 Miles

Project Limits: RP 59.566 to RP 85.111

Date: 10/7/2010

This document was
originally issued
and sealed by
Jonathan David Ketterling,
Registration Number
PE-4684,
on 10/7/2010 and the
original document
is stored at the North
Dakota Department
of Transportation.

Introduction: The proposed improvement for this project is a minor rehabilitation HBP overlay. The samples were taken at areas indicated as problems by maintenance personnel. The offset of the borings varied from 8 feet left to 8 feet right of the existing roadway centerline. The borings extended to depths of 5.0 feet below the existing pavement surface. A total of 14 samples were taken from 13 borings at the following locations:

Distress Area	Location (RP+Feet)	Number of Borings	Description of Distress
1	67+5040	4	Medium Severity Frost Heave (Signed)
2	78+3690 to 78+3800	3	Low Severity Frost Heave
3	80+1578	2	Low Severity Dip at Culvert
4	82+2410	2	Culvert Separation
5	82+3067	2	Low Severity Transverse Crack at Double Culvert

SOIL CLASSIFICATION AND COMMENTS

Quantity	AASHTO Classification	In-Place Moisture Range (%)	In-Place Moisture Average (%)	T-180 Optimum Moisture Average (%)
1	A-1-a	NA	6.5	7.5
4	A-1-b	6.0-13.3	9.2	8.3
1	A-2-4	NA	12.6	8.3
3	A-2-6	13.8-15.5	14.7	10.2
1	A-6	NA	14.7	12.2
4	A-7-6	18.2-38.6	28.3	15.7

ASHTO Classification	Plastic Limit Range (%)	Plastic Limit Average (%)	Plasticity Index Range (%)	Plasticity Index Average (%)	Liquid Limit Range (%)	Liquid Limit Average (%)
A-1-a	NA	NA	NA	NA	NA	NA
A-1-b	NA	NA	NA	NA	NA	NA
A-2-4	NA	NA	NA	NA	NA	NA
A-2-6	14-20	16	11-18	14	25-38	30
A-6	NA	16	NA	18	NA	34
A-7-6	18-25	21	23-31	27	43-56	48

Note: The non-plastic samples are not included in this table.

The Plasticity Index values ranged from 0 to 31 with an average of 12. The swell potential, based on the Plasticity Index (PI) results, is shown below:

Swell Potential		
Low (PI<25)	Marginal (25≤PI≤35)	High (PI>35)
79%	21%	None

Comparisons of In-Place Moisture Contents to Plastic Limits for the 2 to 5 foot depths are shown below:

Depth	Quantity	Below Plastic Limit	Plastic Limit to 5% Above	More than 5% Above Plastic Limit
2 Foot	7	57%	29%	14%
3 Foot	7	29%	29%	43%
4 Foot	7	29%	43%	29%
5 Foot	7	43%	14%	43%

Note: The non-plastic samples are not included in this table.

Note: Moisture Contents provided in this report have been obtained from samples taken on 5/26/09.

SOIL CLASSIFICATION AND COMMENTS (Cont.)

In-Place Moisture vs. Optimum Moisture

<u>Quantity</u>	<u>AASHTO Class.</u>	<u>Below Optimum</u>	<u>Optimum to Moderate</u> (0 to 6% over optimum)	<u>Moderate to High</u> (6 to 10% over optimum)	<u>High</u> (10 to 16% over optimum)	<u>Very High</u> (> 16% over optimum)
1	A-1-a	100%	NA	NA	NA	NA
4	A-1-b	50%	50%	NA	NA	NA
1	A-2-4	NA	100%	NA	NA	NA
3	A-2-6	NA	100%	NA	NA	NA
1	A-6	NA	100%	NA	NA	NA
4	A-7-6	NA	25%	NA	50%	25%

Moisture samples were taken at all boring locations. The results are as follows:

<u>Depth</u>	<u>Quantity</u>	<u>In-Place Moisture Range</u> (%)	<u>In-Place Moisture Average</u> (%)
2 Foot	13	4.8-34.7	12.7
3 Foot	13	5.8-36.8	16.7
4 Foot	13	6.3-39.8	17.0
5 Foot	13	6.7-43.0	19.1

Note: Moisture Contents provided in this report have been obtained from samples taken on 5/26/09.

Frost Susceptibility:

None of the samples were classified as F4 soils. The F4 designation indicates that under the right conditions these soils have a higher probability of heaving during freeze/thaw cycles.

Group Index:

All of the samples were classified as A-1-a, A-1-b, A-2-4, A-2-6, A-6, or A-7-6. The Group Indices from the samples ranged from a low of 0 to a high of 30 with an average of 6. A group index of 20 or greater indicates a “very poor” subgrade material.

Summary of Findings:

A detailed spreadsheet of the samples has been attached to the report.

- 86% of the samples had a group index of less than 20
- The samples were, on average, 5.2% above the T-180 optimum moisture contents.

SOIL DESCRIPTIONS

Granular Materials:

The **A-1-a** soils consists mainly of stone fragments or gravel, either with or without a well-graded soil binder. The **A-1-b** soils consists predominately of coarse sand with or without a nonplastic to slightly plastic soil binder. These soils generally serve very well as subgrade material.

The **A-2-4** soils consist primarily of granular materials containing 35 percent or less passing the No. 200 sieve. This includes such materials as gravel and coarse sand with silt contents or plasticity indexes in excess of the limitations of Group A-1. These soils function well as subgrade material.

The **A-2-6** soils are similar to A-2-4 soils, except they contain plastic clays. The A-2 soils are generally good as subgrade soils if they are protected from extreme moisture changes.

Silt-Clay Soils:

The **A-6** soils typically consist of plastic clays. They usually have high volume change between wet and dry states. These soils have dry strength but lose much of this strength upon absorbing water. The A-6 soils will compress when wet and shrink and swell with changes in moisture content. They do not drain readily and may absorb water by capillarity with resulting loss in strength. These soils can also be highly frost susceptible although they will perform well when moisture is kept near the optimum value.

The **A-7-6** soils possess many of the A-6 characteristics except that they have high liquid limits and may be elastic as well as subject to extremely high volume change. The plasticity index in these soils is high in relation to liquid limit.

EXISTING SECTION

The following table shows the history of the roadway through the project limits:

RP 59.566 to RP 84.366					
Year	Component	Depth (in)	Left Shoulder width (ft)	Roadway width (ft)	Right Shoulder Width (ft)
1956	Grade			32.0	
1958	Aggregate Base	3.5		30.0	
1958	Emulsified Base	3.5		28.0	
1958	Hot Bit Pavement	2.5		24.0	
1988	Contract Chip Seal			24.0	
1992	Int Cont Patch-1.25"			24.0	
1994	District Chip Seal			24.0	
2003	Int Cont Patch-1.5"			24.0	
2004	District Chip Seal			24.0	
Roadway widths are both lanes combined					

RP 84.366 to RP 84.766					
Year	Component	Depth (in)	Left Shoulder width (ft)	Roadway width (ft)	Right Shoulder Width (ft)
1935	Grade			28.0	
1935	Aggregate Base	4.0		26.0	
1935	Cold Bit Pavement	3.0		20.0	
1959	MTCE Shoulder Widening			32.0	
1959	Hot Bit Pavement	2.5		24.0	
1988	Contract Chip Seal			24.0	
2004	District Chip Seal			24.0	
Roadway widths are both lanes combined					

EXISTING SECTION (Cont.)

RP 84.766 to RP 84.966					
Year	Component	Depth (in)	Left Shoulder width (ft)	Roadway width (ft)	Right Shoulder Width (ft)
1935	Curb & Gutter Face-Face			40.0	
1935	Aggregate Base	4.0		40.0	
1935	Cold Bit Pavement	3.0		40.0	
1959	Aggregate Base	3.0		64.0	
1959	Hot Bit Pavement	2.5		64.0	
1988	Contract Chip Seal			24.0	
2004	District Chip Seal			24.0	
Roadway widths are both lanes combined					

RP 84.966 to RP 85.066					
Year	Component	Depth (in)	Left Shoulder width (ft)	Roadway width (ft)	Right Shoulder Width (ft)
1965	Curb & Gutter Face-Face			40.0	
1965	Aggregate Base	5.0		40.0	
1966	Hot Bit Pavement	4.0		40.0	
1966	Hot Bit Pavement	2.0		40.0	
1988	Contract Chip Seal			24.0	
2004	District Chip Seal			24.0	
Roadway widths are both lanes combined					

RP 85.066 to RP 85.111					
Year	Component	Depth (in)	Left Shoulder width (ft)	Roadway width (ft)	Right Shoulder Width (ft)
1965	Curb & Gutter Face-Face			38.0	
1965	Aggregate Base	5.0		36.0	
1966	Hot Bit Pavement	4.0		34.0	
1966	Hot Bit Pavement	2.0		24.0	
1988	Contract Chip Seal			24.0	
2004	District Chip Seal			24.0	
Roadway widths are both lanes combined					

EXISTING PAVEMENT SECTION

The soil borings were performed on 5/26/09 and obtained using a 6 inch solid flight auger. The asphalt thickness varied from 0.5 to 1.3 feet with an average of 0.8 feet. The thickness of the base varied from 0.4 to 4.5 feet with an average of 2.3 feet. The following table represents the pavement section as reported in the field log at the boring locations. All measurements are in feet.

Distress Area	RP+Feet	Offset	Asphalt	Agg. Base
1	67+5005	Lt 8 SB	0.8	0.8
	67+5040	Lt 8 SB	0.6	0.7
	67+5070	Lt 8 SB	0.8	3.7
	67+5125	Lt 8 SB	0.7	1.3
2	78+3615	Rt 8 NB	0.6	0.4
	78+3656	Rt 8 NB	0.6	0.4
	78+3704	Rt 8 NB	0.5	4.5
3	80+1574	Rt 8 NB	0.9	1.0
	80+1581	Lt 8 SB	1.3	3.7
4	82+2405	Rt 8 NB	1.2	3.5
	82+2414	Rt 8 NB	0.6	4.4
5	82+3063	Rt 8 NB	0.6	4.4
	82+3071	Lt 8 SB	0.6	4.4

Average asphalt thickness = 0.8 feet
 Average base thickness = 2.3 feet

MAINTENANCE

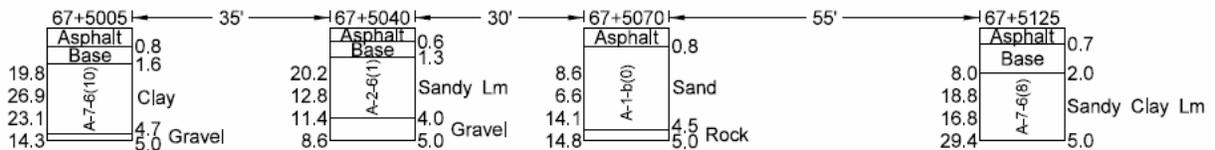
On 05/27/09, Jaime Naumann met with Marvin Lang, Napoleon Section, to review existing problem areas. The following are the areas that were discussed. Marvin sent Jamie a fax of the distress areas on 5/22/2009, and a copy of this fax has been attached to the report.

RP 67+5040 (Distress Area 1) Looking South



This area is indicated as a medium severity frost heave that is primarily in the SB lane. This area is seasonally signed. The group indices in this area are low, and swell potential for the soils in this area are low. The average moisture content of the soil samples in this area were 5.3% over their optimum moisture values. The differing soil types (shown below) are the most likely cause of the frost heave. The clay soil types heave in the winter, and the aggregate soil types do not heave. In a phone conversation with Marvin Lang on 6/22/2010, he mentioned that this bump gets so severe in the winter that local SB traffic moves into the other lane to avoid it. Plows have to raise the blade or else they will hit the road. Due to the severity of the distress in this section of the roadway, the Geotechnical Section recommends a subcut in this area.

Distress Area 1 Borings



Note: The moisture contents are displayed on the left column at the 2, 3, 4, and 5 foot depths.
 Note: The depths of the layers are displayed on the right column.

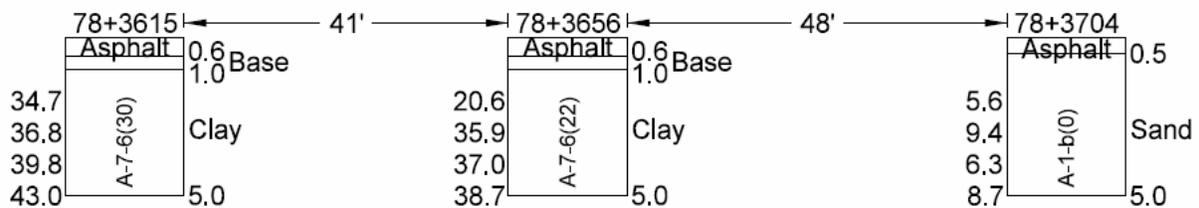
MAINTENANCE (Cont.)

RP 78+3690 to RP 78+3800 (Distress Area 2) Looking North



This area is indicated as a low severity frost heave that is primarily in the NB lane. **This area is not seasonally signed.** The group indices in this area ranged from 0 to 30, and swell potential for the soils in this area are low to moderate. The average moisture content of the soil samples in this area were 11.4% over their optimum moisture values. The differing soil types (shown below) are the most likely cause of the frost heave. The clay soil types heave in the winter, and the aggregate soil types do not heave. On 10/6/2010 Jon Ketterling, Jeff Jirava, and Greg Wolter conducted a site visit of the project. During the site visit no apparent pavement distress was found in this area. In a phone conversation with Marvin Lang on 10/7/2010, he mentioned that this heave is not a sharp heave in the winter, and the distress is minor. Due to the lack of severity of distress in this section of the roadway, the Geotechnical Section does not recommend a subcut in this area.

Distress Area 2 Borings



Note: The moisture contents are displayed on the left column at the 2, 3, 4, and 5 foot depths.
 Note: The depths of the layers are displayed on the right column.

MAINTENANCE (Cont.)

RP 79+0986 (void in inslope above cattle pass)



On 10/6/2010 Jon Ketterling, Jeff Jirava, and Greg Wolter conducted a site visit of the project. During the site visit, we investigated a cattle pass mentioned in a fax from Marvin Lang. In the embankment above the cattle pass there are voids. The Geotechnical Section recommends filling these voids.

RP 79+4431



During the site visit on 10/6/2010, the Geotechnical Section investigated a landslide. The landslide is not affecting the roadway at this time, and is considered a low risk. The slide begins five feet from the edge of the roadway. Marvin Lang mentioned that this slide has been here for the last 15 years. The Geotechnical Section recommends that this area be monitored.

MAINTENANCE (Cont.)

RP 80+1578 (Distress Area 3)



This area is indicated as a low severity dip at culvert. The pipe is 36" diameter corrugated steel. It is one of three that drain Lake Isabel. This area is not signed. The group indices and swell potential in this area are low. The average moisture content of the soil samples in this area were 1.2% over their optimum moisture values. Due to the lack of distress in this section of the roadway, the Geotechnical Section does not recommend a subcut in this area.

MAINTENANCE (Cont.)

RP 82+2410 (Distress Area 4)



This area is indicated as a low severity transverse crack at culvert. The pipe is 36" diameter RCP. This area is not signed. The group indices and swell potential in this area are low. The average moisture content of the soil samples in this area were 2.5% over their optimum moisture values. According to Marvin's fax, the pipe is separating. There are no pictures of the pipe separated, because the pipe is completely full of water. Since the remedy for the distress in this section of the roadway would require replacing/relaying the pipe, the Geotechnical Section does not recommend a subcut in this area, and would defer to the Hydraulics Section for further repair recommendations.

MAINTENANCE (Cont.)

RP 82+3067 (Distress Area 5)



This area is indicated as a low severity transverse crack at culvert that appears patched. The pipe is 36" diameter RCP. This area is not signed. The group indices and swell potential in this area are low. The average moisture content of the soil samples in this area were 4.5% over their optimum moisture values. According to Marvin's fax, water flow is restricted in the culverts in this area. Marvin stated, "These two culverts as well as the 3 on the south end of Lake Isabelle need to have grates put over them and extended out several feet into the channels which would allow water to pass but keep public from trying to plug culvert with rocks, sand bags, etc." Due to the lack of subgrade distress in this section of the roadway, the Geotechnical Section does not recommend a subcut in this area.

DESIGN RECOMMENDATIONS

The analysis of the soils shows that most of the samples have a low group index and low swell potential. However, one area had high in-place moisture contents. This area has large differentials in moisture contents and material within the area. In Distress Area 1, there is a three foot differential in base thickness within this area. This area was listed by maintenance personnel as a frost heave and is seasonally signed. The Geotechnical Section recommends subcutting this area.

Subcut Recommendations:

<u>RP + Feet</u>	to	<u>RP + Feet</u>	<u>Remarks</u>
67+5005		67+5125	Subcut to a depth of 48" below the top of the existing pavement elevation at full width of the roadway embankment. Place reinforcement fabric (R1) at the bottom of the subcut excavation and backfill with Class 3 or Class 5 aggregate. Place 6 inches of aggregate on the fabric prior to compacting. Do not scarify the bottom of the subcut. Compaction of aggregate shall comply with 90% of the maximum dry density as determined by AASHTO T-180.

Total Subcut Length = **120 feet**

The recommendations in this report are based on the minor rehabilitation option. If the type of improvement changes or the vertical profile or horizontal alignment is changed, in either the conceptual phase or the design phase, Materials and Research must be notified as soon as possible to ensure that there is adequate geotechnical information addressing these areas.

Please contact me at 328-6907 or Jon Ketterling at 328-6908 if there are any questions or modifications to the plans for rehabilitation of this roadway.

SS-1-003(034)059

							GI < 20		Low Swell	Below Opt.	Below PL				
							GI > 20		Moderate Swell	6% to 10% Over Opt.	PL to 5% Above				
									High Swell	More than 16% Over Opt.	More Than 5% Above				
Distress Area	RP+Feet	Offset	Depth of Sample	Plastic Limit	AASHTO	Group Index	Optimum Moisture	Swell Potential (PI)	Average In-Place Moisture Content of Sample Depth	Plastic Limit vs. Moisture Content				F4 Soil	
										2 foot	3 foot	4 foot	5 foot		
1	67+5005	Lt 8 SB	1.6-4.7	20	A-7-6(10)	10	13.0	23	23.3	19.8	26.9	23.1	14.3		
	67+5040	Lt 8 SB	1.3-4.0	20	A-2-6(1)	1	10.6	18	14.8	20.2	12.8	11.4	8.6		
	67+5070	Lt 8 SB	1.2-4.5	0	A-1-b(0)	0	8.4	0	9.8	8.6	6.6	14.1	14.8		
	67+5125	Lt 8 SB	2.0-5.0	18	A-7-6(8)	8	13.0	25	18.2	8.0	18.8	16.8	29.4		
2	78+3615	Rt 8 NB	1.0-5.0	25	A-7-6(30)	30	19.1	31	38.6	34.7	36.8	39.8	43.0		
	78+3656	Rt 8 NB	1.0-5.0	22	A-7-6(22)	22	17.8	27	33.0	20.6	35.9	37.0	38.7		
	78+3704	Rt 8 NB	0.5-5.0	0	A-1-b(0)	0	8.0	0	7.5	5.6	9.4	6.3	8.7		
3	80+1574	Rt 8 NB	1.9-3.5	16	A-6(6)	6	12.2	18	14.7	10.1	19.2				
	80+1574	Rt 8 NB	3.5-5.0	14	A-2-6(0)	0	12.2	12	15.5			17.9	13.1		
	80+1581	Lt 8 SB	1.3-5.0	0	A-1-b(0)	0	8.1	0	6.0	4.9	6.4	6.3	6.7		
4	82+2405	Rt 8 NB	1.2-4.7	0	A-1-a(1)	1	7.5	0	6.5	4.8	5.8	8.9	18.8		
	82+2414	Rt 8 NB	0.6-5.0	14	A-2-6(0)	0	7.9	11	13.8	10.6	13.3	14.0	17.4		
5	82+3063	Rt 8 NB	0.6-5.0	0	A-2-4(0)	0	8.3	0	12.6	7.2	14.2	13.0	16.0		
	82+3071	Lt 8 SB	0.6-5.0	0	A-1-b(0)	0	8.6	0	13.3	9.4	11.6	12.8	19.2		

ATT: Jamie

Hwy 3 – Junction 34 to I-94.

3660 ft. N of mm 74 - also 47th St. S. E.

East side of road approach - 2 24 in. pipes rusted out , road collapsed in center in 1997.

Pipes were rusted out and also squashed and have to be replaced.

Kidder County commissioners and landowner said we need to increase the capacity to 36 in. culverts . County road is constantly getting washed out.

3725 ft N of mm 78

Also 43rd St. S. E.

Frost boil - north bound lane is very bad in the winter time. South bound lane is fair.

Currently frost boil is healed out completely. Frost boil starts south end of the approach past the north end of the approach.

986 ft North of mm 79

Cattle pass fitted into square box culvert. Internal separation which needs to be addressed.

2567 ft. mm 79 - North of mm 79 . 1997 large box culvert fitted into large concrete culvert – bad separation internally - 1997 west end washed out and collapsed to edge of roadway. East end of pipe washed out in separation , shoulder collapsed up to asphalt.

Contractor was hired to put pipes back in place, highway was not dug up. Contractor drove in large metal sheeting on both inlet and outlet to prevent water from undermining. This whole area is all fine sand. You may want to get some pictures and check it out to see what the internal joints look like after 10 years.

Mm 79 - 4431 ft. N - west side of road – large slide area. Have been fighting this area for the last 15 years. Shoulder area slides away within 3-4 ft. of asphalt. Area is sliding into the lake. This area is several hundred feet long and is in poor condition at this time.

Just a bit north of the slide area are 6 large trees too close to road and should be removed. South side.

Mile .80 - regarding 3 drainage pipes on SW corner of Lake Isabelle. – outlet of all 3 pipes is eroding and needs ripwrap with concrete slurry added to hold rocks in place.

Main pipe in channel (the west pipe) was leaking water between the pipe and the road in 1997 – contractor was hired and did not dig up roadway but was able to stop seepage with betonite. (same stuff used on oil wells)

Mile .81 – main drive into Lake Isabelle Recreation area – east side – culvert buried.

2402 ft. N of mm .82 - pipe under highway completely plugged – water backing up – it was working last year fine. This pipe has a separation for sure in the north bound lane – in 1997 this collapsed leaving hole in lane 5 feet across. It was fixed temporarily and has never been addressed. Concrete pipes have wide separation – sheet of tin laid over separation , filled hole with asphalt. This must be addressed.





3057 ft. N of mm 82 - culvert has numerous rocks inside and unable to get out . water flow is restricted. May have to address this issue soon . These two culverts as well as the 3 on the south end of Lake Isabelle need to have grates put over them and extended out several feet into the channels which would allow water to pass but keep public from trying to plug culvert with rocks, sand bags, etc. Grates should be hinged for clean out purposes. This has been an ongoing issue that even as of today we have been fighting for the last 30 years since this recreation area was established.

✓ 757 ft. to 1506 ft north of mm 84 – no drainage – silted in - west side of road through Dawson. Narrow ditch is full of silt – water should run south but cannot , so after backing up and setting on roadway it starts to run north. Close to railroad and then goes west.

North of railroad drainage problem on both sides. Water sets on pavement and cannot drain properly.

IN ADDITION – Missed one

Bad frost boil – southbound lane (Very bad) north bound (fair) - this is south side of approach 200 ft. – south of mm 68. This frost boil is totally healed out.

Hopes this helps you.

Marvin

Tele: 527-3660

Can go with you next week if you need to actually see these spots.