

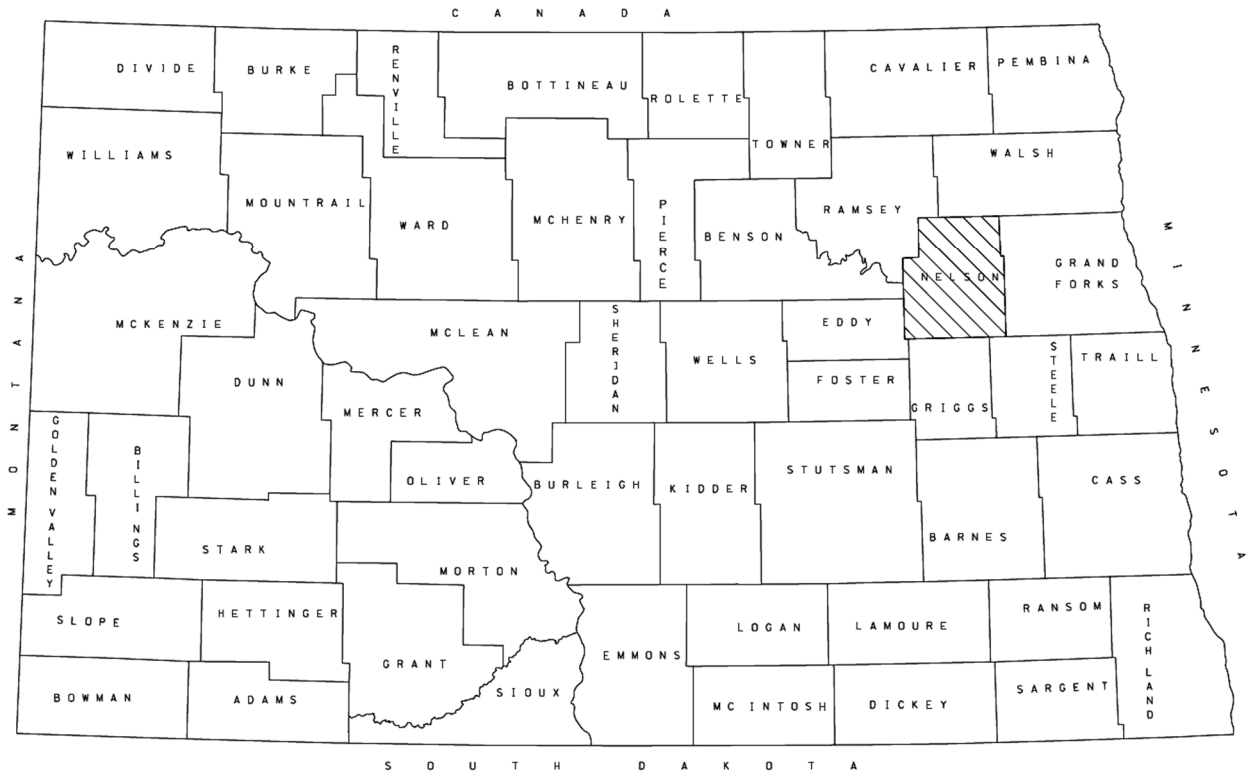
Deep Foundation Report and Analysis

PROJECT NO. BND-NH-6-002(134)313

PCN 22278

COUNTY Nelson

Bridge #: 0002-313.399L WB



PREPARED BY: Jared Loegering, PE

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION

October 2021

BND-NH-6-002(134)313

1 Mile East of ND 32 South
Bridge #0002-313.399L Westbound

CERTIFICATION

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly registered professional engineer under the laws of the State of North Dakota. This document was originally issued and sealed by Jared J. Loegering, Registration number PE-10931 on 10/25/2021 and the original document is stored at the North Dakota Department of Transportation.

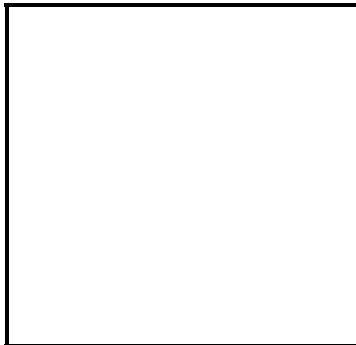


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Appendix A - Boring Logs
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Introduction

The purpose of the project is to address the existing deficiencies of the current structure by removing and replacing the bridge on a new alignment adjacent to the eastbound US 2 roadway.

This report will provide foundation, settlement and bridge end slope recommendations for the construction of the new structure.

Existing Structure Information

There is an existing bridge on US 2 that will be removed as part of the project. The information for this structure is below.

Bridge #0002-313.200 L

Main Structure Type: Steel Stringer

Length: 427'

Foundation Types: Abutments – Treated Timber Pile

Piers – Treated Timber Pile

Year Constructed: 1936

Soil Borings

A total of 2 borings were completed near the proposed structure. See the project location map for the boring locations.

Boring #1

Boring #1 has an elevation of approximately 1524 feet at the top of boring and is located near the proposed east abutment. This boring extends to a depth of 65 feet.

Boring #2

Boring #2 has an elevation of approximately 1519 feet at the top of boring and is located near the proposed west abutment. This boring extends to a depth of 62 feet.

Sampling and Testing Procedures:

Shelby tube sampling and split spoon sampling were used to extract the samples from a hollow stem auger.

Shelby tube sampling provides an “undisturbed” sample of fine-grained soils for laboratory testing via a thin wall tube that is slowly pushed into the soils to be sampled. Densities were calculated according to AASHTO test method T-296.

Split spoon samplers are utilized during advancement of the boring to perform the Standard Penetration Test (SPT). The samples are considered “disturbed”, due to the

driving nature in which they are obtained. The SPT results in an N-value, or number of blows required to drive the split spoon sampler 1 foot. This N-value is used to estimate the friction angle of non-cohesive soils and define the consistency of cohesive soils.

For cohesive soils, the shear strength values were determined from the Unconsolidated Undrained and Consolidated Undrained tests utilizing Shelby tubes samples.

The samples from the split spoon and Shelby tubes are submitted to the laboratory for determination of AASHTO classification, moisture content, dry density, sieve analysis, and Atterberg limits.

Test Results

A summary of the lab analysis has been included in the Appendix B.

Proposed Structure

Main Structure Type: 3 Span
Foundation Type: Steel H-Piles

Foundation Recommendation

Steel Piling

Pile recommendations are given as termination elevations. The pile sizes that have been analyzed are HP10x42, HP12x53 and HP14x102. See table 3 below for the recommended termination elevations.

The software "APile" was used in conjunction with engineering judgment and past experience in pile driving in these types of soils to estimate the pile lengths. The output from this analysis is available upon request from the NDDOT Geotechnical Section.

Below are simplified soil profiles for each boring that was used to predict the unfactored nominal geotechnical resistance in APile. A graphical representation of the unfactored nominal geotechnical resistance is also shown below in figures 1-2. The nominal geotechnical resistance is used to help predict the pile termination elevations which can be found in table 3 below.

Table 1 - Boring #1 Simplified Soil Profile-East Approach Slab, Abutment & Pier

Layer	Depth (feet)	Elevation (feet)	Cohesion (lb/ft ²)	Friction Angle	Effective Unit Weight (lb/ft ³)
Stiff Brown/Gray Clay	0.0-24.00	1524.0-1500.0	c'=141 psf c=3136 psf	φ=31.3°	61.7
Loose Sand	24.0-34.0	1500.0-1490.0	-	φ=28°	67.6
Hard Gray Clay	34.0-39.0	1490.0-1485.0	c=3887 psf	-	62.6
Hard Gray Silty Sand	39.0-44.0	1485.0-1480.0	-	φ=45°	67.6
Hard Gray Silty Clay	44.0-65.0	1480.0-1459.0	c=4000 psf	-	62.6

Table 2 - Boring #2 Simplified Soil Profile-West Approach Slab, Abutment & Pier

Layer	Depth (feet)	Elevation (feet)	Cohesion (lb/ft ²)	Friction Angle	Effective Unit Weight (lb/ft ³)
Medium Stiff Brown/Gray Clay	0.0-26.0	1519.0-1493.0	c'=166 psf c=1575 psf	φ=29.5°	61.7
Loose Silty Sand	26.0-30.0	1493.0-1489.0	-	φ=28°	67.6
Hard Gray Silty Clay	30.0-39.0	1489.0-1480.0	c=3887 psf	-	62.6
Hard Gray Silty Sand	39.0-41.0	1480.0-1478.0	-	φ=45.0°	67.6
Hard Gray Clay	41.0-62.0	1478.0-1457.0	c=4000 psf	-	62.6

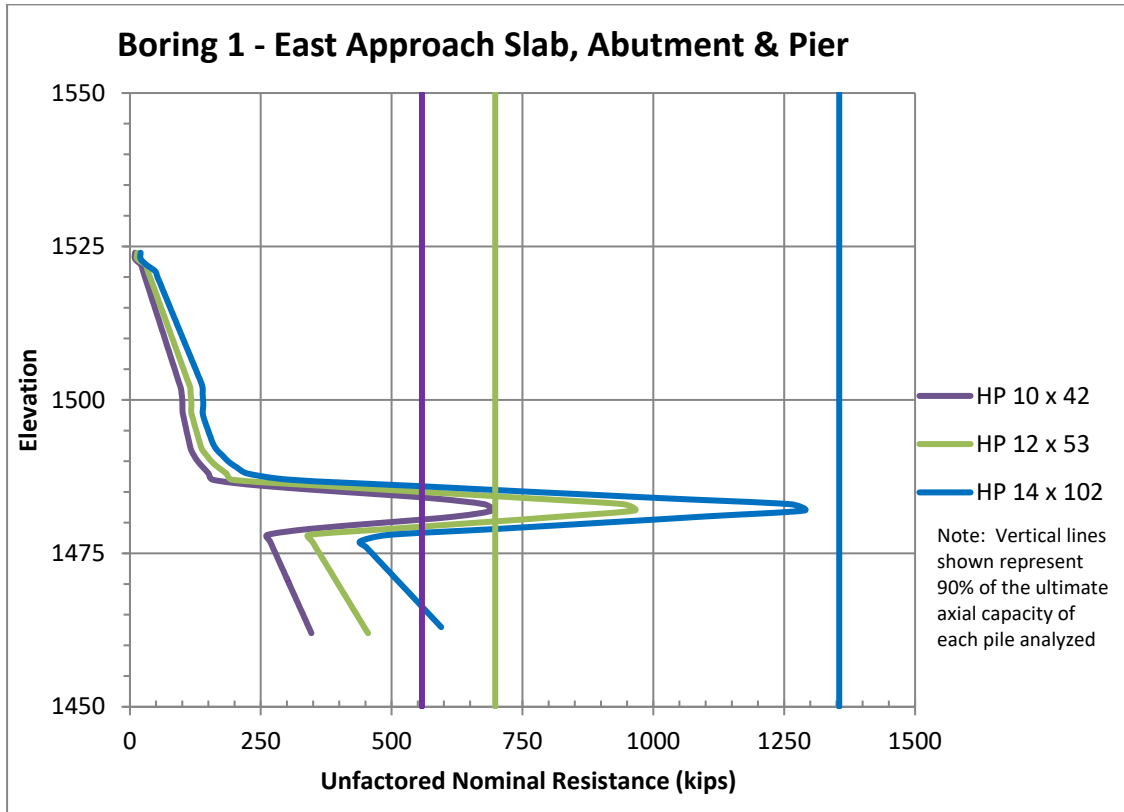


Figure 1: Nominal Resistance for Pile at East Approach Slab, Abutment & Pier

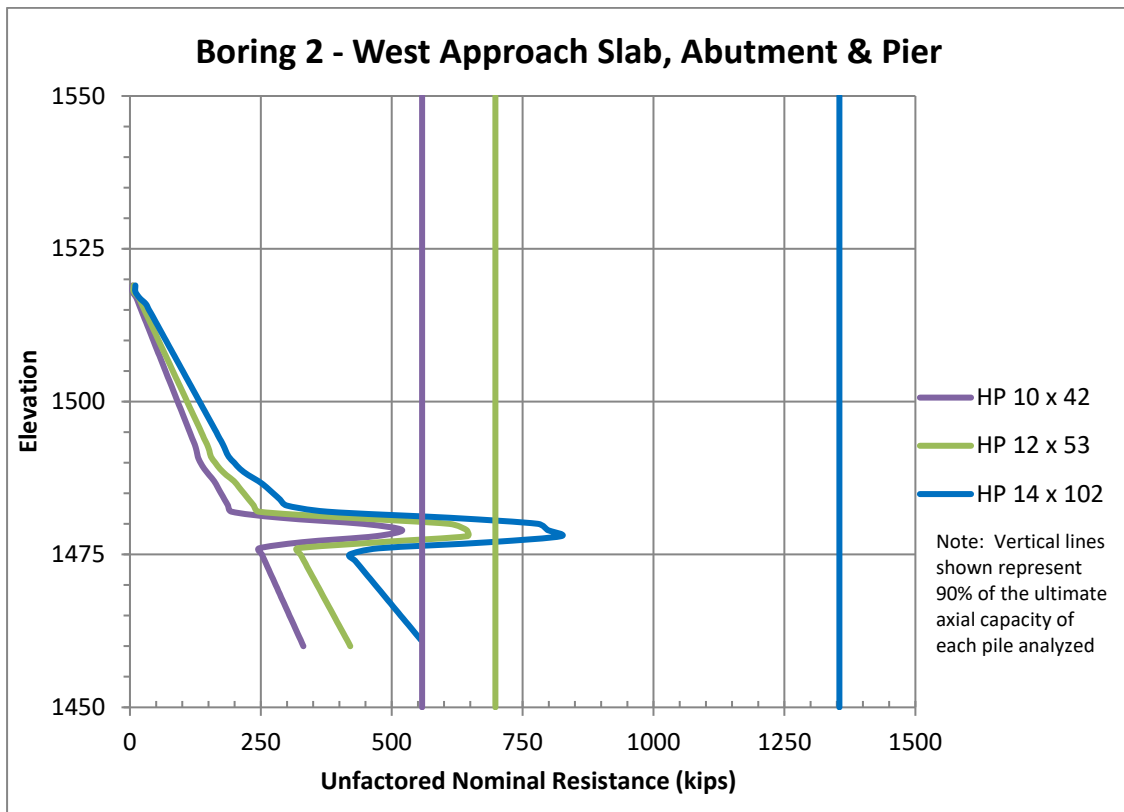


Figure 2: Nominal Resistance for Pile at West Approach Slab, Abutment & Pier

Based on the Apile information, past experience and engineering judgement the pile termination elevations were selected as shown in the table below.

Table 3 - Pile Length Information

Pile Type	90% Ultimate Axial Capacity	East Abutment/ Approach Slab	East Pier	West Pier	West Abutment/ Approach Slab
	kips	Termination Elevation	Termination Elevation	Termination Elevation	Termination Elevation
HP10x42	558	1463*	1463*	1463*	1463*
HP12x53	698	1463*	1463*	1463*	1463*
HP14x102	1355	1463*	1463*	1463*	1463*

*Based on engineering judgement/past experience

Pile Tips

It is not anticipated that pile tips will be required for this bridge.

Downdrag

The structure requires approximately 33' of fill on the west and east abutments. Due to the proposed fill, a downdrag analysis was completed for the west and east abutment & approach slab piling. The unfactored down drag loads are shown in the table below.

Table 4 - Downdrag Loads

Location	Pile Size	Unfactored Downdrag Load (kips)
West Approach Slab Piling	HP10x42	160.5
West Abutment Piling	HP12x53	198.8
East Abutment Piling	HP12x53	178.8
East Approach Slab Piling	HP10x42	145.8

Scour

This is not a water crossing so scour is not applicable at this structure.

Compaction Recommendation

Compact roadway embankment material to at least 90 percent of the maximum dry density with moisture content no less than the optimum moisture and no more than 5.0 percentage points above the optimum moisture. The Engineer will determine the maximum dry density and optimum moisture content as specified in ND T 180.

Compact the aggregate transitions at the bridge ends according to section 714.04 A.7.

Slope Recommendation

A slope stability analysis was conducted with Slope/W developed by Geo-Slope International. The analysis was a two-dimensional limit equilibrium method. For the bridge end slopes the steepest slopes proposed were 2.5:1. The proposed slopes were analyzed, and an acceptable factor of safety was obtained. The stability analysis outputs can be found in Appendix C.

Drainage Recommendation

The drainage off the bridge should be controlled so that water does not drain directly off the bridge ends and cause erosion around the wing-wall. A combination of inlets, downdrains, and/or deckdrains should be used to control water runoff. Water should not be allowed to drain off the bridge as to allow the in slopes and end slopes to become saturated, which is a common cause of slope failure.

Settlement Analysis/Recommendation

Based on proposed cross section and profiles provided by the Design Division, the construction of the new bridge will require fills up to approximately 33 feet. Those locations are summarized in the table below:

Table 5 - Fill Locations

Location	Critical Station	Total Fill (feet)
West Abutment	457+01	33.0
East Abutment	460+21	32.0

A settlement analysis was completed based on one-dimensional consolidation tests performed on soil samples that were collected from the soil borings. Settlement calculations were completed using Settle 3D software. The table below shows the expected amount of settlement at the centerline of the roadway at each abutment:

Table 6 - Settlement Amounts

Location	Critical Station	Consolidation Settlement (in)
West Abutment	457+01	4.6
East Abutment	460+21	4.4

In order to remediate the expected settlement, it is recommended to place a 15' surcharge on the roadway on both the west and east side of the roadway, starting at the abutments and extending approximately 1000' on both the east and west side of the structure. It is expected that the surcharge will need to be in place for 9 months. The surcharge cannot be removed until directed by the NDDOT geotechnical section.

In order to ensure the stability of the embankment and existing ground during construction, the embankment needs to be built to the final roadway elevation and then left in place for a minimum of three weeks. This wait time will enable the increase of pore water pressures in the existing ground to dissipate. The proposed surcharge cannot be added to the embankment until directed by the NDDOT geotechnical section.

In order to monitor the amount of settlement, it is also recommended that settlement plates be placed at the locations shown in the table below:

Table 7 - Settlement Plate Locations

Station	Offset (feet)
456+00	22' Lt
456+75	6' Lt
456+75	22' Lt
460+50	6' Lt
460+50	22' Lt
462+00	22' Lt

Pre-Boring

Pre-Boring will be necessary for the piling at the east and west abutments and approach slabs. It is recommended to pre-bore through the proposed embankment and through the existing ground to the elevations shown in the table below:

Table 8 – Pre-boring Elevations

Location	Prebore Elevation
West Abutment/Approach Slab	1518
East Abutment/Approach Slab	1522

APPENDIX A

Boring Logs

APPENDIX B

Lab Results

APPENDIX C

Stability Analysis Outputs