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March 1, 2019

Brookings County Highway Department
422 Western Avenue
Brookings, South Dakota 57006

Attn: Jeff Anderson

Subj: Geotechnical Exploration
Proposed Bridge Replacement
Structure No. 06-280-116
Brookings County, South Dakota
GeoTek #18-437

Introduction

This correspondence is an addendum to our original report for the referenced project that was dated May 21, 2018. It has come to our attention that HP 12x53 piles may be used for support of the new bridge. We have provided recommendations and information for the HP 12x53 piles.

Driven Piles

Axial Compression Resistance

The piles will develop their resistance from a combination of end-bearing and side friction, but mostly side friction. Please refer to Table 1 that summarizes the estimated pile tip elevation, factored pile bearing resistance and nominal pile bearing resistance for the HP 12x53 piles. The factored pile bearing resistance is based on the particular pile section and Grade 50 steel (minimum yield strength of 50 ksi). A resistance factor of 0.40 was used for the nominal pile bearing resistance as we assume that field evaluation of the piles will be based on a pile driving formula.

Table 1. Estimated Pile Tip Elevation & Bearing Resistances – HP 12x53 Pile

Test Borings	Pile Tip Elevation, ft	Pile Size	Factored Pile Bearing Resistance, tons	Nominal Pile Bearing Resistance, tons
1 & 2	1,618.0	HP 12x53	100	250

Uplift Resistance

Please refer to Table 2 that summarizes the estimated pile tip elevation, factored pile uplift resistance and nominal pile uplift resistance for the HP 12x53 piles. The uplift resistance is based on a resistance factor of 0.25. The values provided in the table should only be used if the piles are installed to the pile tip elevation shown in the table.

Table 2. Estimated Pile Tip Elevation & Uplift Resistances – HP 12x53 Pile

Test Borings	Pile Tip Elevation, ft	Pile Size	Factored Pile Uplift Resistance, tons	Nominal Pile Uplift Resistance, tons
1 & 2	1,618.0	HP 12x53	56	224

Pile Driving

We recommend that pile tip reinforcement (rock tips for H-piles) be provided to prevent damage to the piles from driving through cobbles and boulders that may be encountered within the glacial fluvial soils, glacial outwash soils and glacial till soils. Additional pile and foundation review may be needed if the piles become obstructed at an abnormal depth due to cobbles or boulders. A large cobble/boulder (18 inches in diameter) was encountered within the glacial till soils at test boring 2 from 76 feet to 77 ½ feet.

We recommend using a pile driving formula, such as SDDOT's Pile Driving Equation for LRFD, to verify the nominal resistance and to establish the pile driving criteria. We also recommend that a geotechnical engineer or a geotechnical engineering technician working under the direct supervision of a geotechnical engineer monitor the installation of the production piles. Detailed driving records should be kept on all production piles.

Pile Driving Equipment

The use of a pile driving hammer that has a manufacturer's rated energy that is compatible to the pile type/size and the nominal resistance is vital for successful installation of the piles. If the pile driving hammer is either under-sized or over-sized, then it could be detrimental to the installation of the piles. With that said, we performed a drivability analysis using the GRLWEAP program. The GRLWEAP program is a one-dimensional wave equation analysis program that simulates pile response to pile driving equipment. Please refer to Table 3 that summarizes the results of the analysis. The analysis was based on various pile driving hammers (manufacturer's cushion recommendations) with HP 12x53 piles. If the contractor desires to use a pile driving hammer that is not listed in Table 3, then we recommend determining if the proposed pile driving hammer is acceptable.

Table 3. GRLWEAP Analysis Results – HP 12x53 Piles

Pile Hammer	HP 12x53 Piles Nominal Pile Bearing Resistance – 250 tons
APE D19-42	No
Delmag D 12-42	No
Delmag D 16-32	No
Delmag D 19-32	No
Delmag D 19-42	No
Delmag D 25-32	Yes (Maximum)
Delmag D 30-32	Yes (Maximum)
Delmag D 46-32	Yes (Second)
FEC 1500	No
ICE 180	No
ICE 42-S	No
MKT DE 35	No
MKT DE 42	No
MVE M-19	No
SPI D30-32	Yes (Maximum)

Notes: A "No" indicates that the hammer should not be used for the project. A "Yes" indicates that the hammer can be used for the project but may need to be operated at a lower fuel setting to prevent overstressing the pile during driving operations. The lower fuel setting is shown in the parentheses. The ranking of the fuel settings from lowest to highest is: lowest, second, third and maximum. The hammer should not be operated higher than the fuel setting shown in the parentheses. The fuel reductions should only be considered theoretical estimates. Actual fuel settings should be determined in the field during driving.

Pile Spacing

For the driven piles, we recommend that the center-to-center pile spacing be at least 2.5 pile diameters or 30 inches, whichever is greater. If a closer spacing is used, then we recommend evaluating the magnitude of the group effect to determine the extent to which the nominal resistances should be reduced.

Settlement

For the driven piles, we estimate total settlement to be less than ½ inch and the differential settlement to be approximately one-half of the estimated total settlement. Unknown soil conditions at the site that are different from those depicted at the test boring locations could increase the amount of expected settlement.

Remarks

The information/assumptions detailed in this report are important factors in our review and recommendations. If there are any corrections or additions to the information detailed in this

report, then it is important that you contact us so that we can review our recommendations with regards to the revised plans.

We trust this report provides you with the necessary information for the project. If you have any questions or require additional information, please contact our office.

GeoTek Engineering & Testing Services, Inc.

Jared Haskins, PE
Geotechnical Manager

Cc: Banner Associates, Inc., Attn: Colin Zwaschka, PE