



Date: April 29, 2009
To: Kevin Cox, P.E.
Mark Libby, P.E.
HDR Engineering, Inc.
From: Timothy J. Pfeiffer, P.E.
Subject: Foundation Report Amendment
Permanent Shaft Casing at Abutments
Project: Interstate 5/SR 501 Interchange Replacement



EXPIRES: 11-13-09
Project 2062005

In our final Foundation Report dated March 10, 2008, we presented design parameters for 3-foot diameter shafts at the abutments. The design included 3-foot diameter permanent casing in the upper ± 20 feet of the drilled shafts. At your request, we have prepared the following addendum to our Foundation Report to provide design parameters for 4-foot diameter shafts without permanent casing at the abutments.

FOUNDATION ANALYSIS AND DESIGN

Drilled Shaft Foundation

We understand the abutment (Bents 1 and 3) foundation will consist of eight, 4-foot diameter drilled shafts.

Shaft Type, Construction and Material Specifications. Our analysis assumes the drilled shafts will be constructed using reinforced concrete with a minimum compressive strength of 4,000 psi. Our design assumes no permanent casing will remain after construction. However, we anticipate construction of the drilled shafts will require temporary casing within the upper ± 20 feet to reduce caving. It is the contractors responsible for installing temporary casing, providing confirmation that the sides of the drilled shaft do not cave, and the bottom of the shaft remains free of loose and deleterious soil. We anticipate casing and/or drilling slurry will be required to maintain sidewall stability. To reduce caving of the sidewalls into the shaft during temporary casing removal, we recommend the tip of the casing be maintained at least ± 10 feet below the level of the concrete at all times during the removal process.

Nominal and Factored Axial Shaft Resistance. The nominal axial resistance versus embedment depth for the drilled shafts was calculated using analytical methods outlined in the FHWA publication IF-99-025; "Drilled Shafts: Construction Procedures and Design Methods" (1999). The calculated nominal axial resistance, factored axial resistance, and nominal uplift resistance versus elevation are summarized on Figure 1 (attached) for the abutments. The fill and the upper ± 15 feet of the soil profile was not included in the shaft resistance.

The nominal axial resistance of 4-foot diameter drilled shafts assumes the axial resistance will be developed by a combination of shaft friction and end-bearing resistance. Factored axial resistance was calculated by applying the appropriate

resistance factor to the side and end resistance based on O'Neill and Reese (1999) and as outlined in AASHTO LRFD (2008).

Table 1. Shaft Design Parameters

Shaft Resistance	Abutments (4-foot Diameter)
Nominal Axial Resistance ⁽¹⁾	±1358 kips
Factored Axial Resistance ⁽²⁾	±705 kips
Nominal Shaft Resistance ⁽³⁾	±876 kips
Nominal End Bearing	±483 kips
Existing Ground Surface Elevation	±El. 280
Top of Shaft Elevation	±El. 290
Shaft Tip Elevation	±El. 214
Shaft Length	±76 feet

Footnotes

(1) Nominal axial resistance for a 4-foot diameter shaft.

(2) Factored axial resistance is based on the nominal resistance and LRFD (AASHTO, 2008) resistance factors.

(3) Nominal shaft resistance does not include contribution above ±El. 265.

Shaft Tip Elevation. The recommended shaft tip elevation is based on the calculated depth to develop a factored resistance of ±705 kips. The recommended shaft design and resistances assumes a representative from the design team will be on-site during construction to confirm the shaft construction methods, tip elevation, clean out, and testing.

Lateral Resistance. Recommendations for the LPILE soil parameters and lateral analysis from our March 10, 2008 final Foundation Report may be used for the 4-foot diameter abutment shafts.

Uplift Resistance. The nominal uplift resistance of the drilled shafts was calculated using the nominal shaft resistance and appropriate LRFD factors. The values for the nominal shaft side resistance are shown on Figure 1 (attached) for the abutments. The dead weight of the shaft is not included. Table 1 presents the calculated nominal shaft resistances. A resistance factor of 0.45 should be applied to strength state uplift loading conditions and a resistance factor of 0.8 should be applied to the nominal shaft resistance for extreme event uplift loading conditions.

Settlement. The empirical equations used in the calculation of the nominal shaft and end resistances are based on vertical settlement of up to 5% of the shaft diameter (2.4 inches for a 4-foot diameter shaft). Under the factored load condition, the load is less than the calculated nominal shaft resistance. Therefore, we estimate the shaft settlement for the factored (Strength 1) loading conditions are based on mobilization of the shaft resistance. We calculated 0.2 inches of deflection, plus the compression of the shaft would be required to mobilize the shaft resistance at the abutments.

Downdrag. Approximately ½ inch of settlement around a shaft is required to induce downdrag loads following installation. We understand approach embankments will

require additional embankment fill near the abutments. The construction of the approach embankments could result in settlement that would mobilize downdrag within the foundations. If the construction takes place during the summer months, saturated soil is not anticipated and the embankment settlement should occur as the embankment is constructed. Therefore, we recommend constructing the embankment up to the elevation of the top of shaft before construction of the shafts. The shafts should be constructed through the fill and materials detrimental to the construction of the shafts should not be used in the embankment construction.

CONSTRUCTION RECOMMENDATIONS

Construction recommendations referred to in our March 10, 2008, final Foundation Report should be used for construction of the 4-foot diameter abutment shafts, with the exception of the requirement for permanent casing at the abutments.

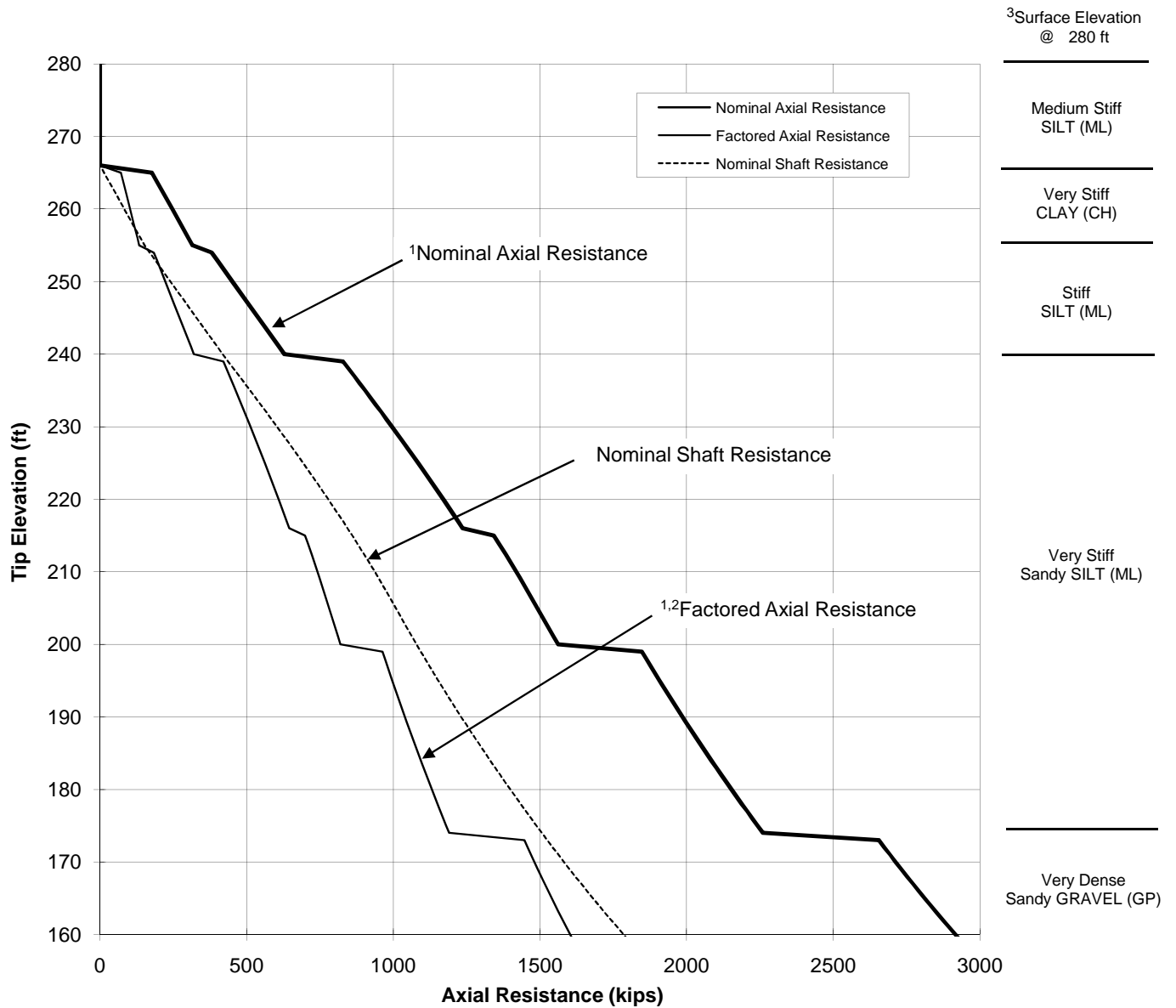
LIMITATIONS

Variation of Subsurface Conditions, Use of Report and Warranty

The analysis, conclusions, and recommendations contained herein are based on the assumption that the subsurface profiles encountered in the borings and test pits are representative of the overall site conditions. The above recommendations assume that we will have the opportunity to revise and review final drawings and be present during construction to confirm assumed foundation conditions and observe the installation of the drilled shafts. No changes in the enclosed recommendations should be made without our approval. FEI will assume no responsibility or liability for any engineering judgment, inspection, or testing performed by others.

This memorandum was prepared for the exclusive use of HDR Engineering, Inc. and other design consultants for the Interstate 5/SR 501 Interchange Replacement project in Ridgefield, Washington. Information contained herein should not be used for other sites or for unanticipated construction without our written consent. This report is intended for planning and design purposes. Contractors using this information to estimate construction quantities or costs do so at their own risk. FEI's services do not include any survey or assessment of potential surface contamination or contamination of the soil or ground water by hazardous or toxic materials. We assume that those services, if needed, have been completed by others.

Our work was done in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.



¹Based on shaft friction resistance and end bearing according to soil profiles BH-1 through BH-6

²Based on shaft friction and end bearing from the appropriate AASHTO LRFD factors.

³Existing Ground Surface at ±El. 280.

FIGURE 1. CALCULATED AXIAL DRILLED SHAFT RESISTANCE vs. ELEVATION

Interstate 5/SR 501 Interchange
 Abutments, 4-Foot Diameter
 Ridgefield, Washington
 FEI Project No.: 2062005