

To: Carolyn Carlson, P.E., Structures Project Manager
MRG *CEE*

From: Matthew Gardner, Geotechnical Engineer, via Callie Ewald, P.E., Senior Geotechnical Engineer

Date: December 9th, 2015

Subject: Wardsboro BRF 013-1(15) Wave Equation Analysis Review

The following summarizes our review of the wave equation analysis conducted for the piles proposed for the Wardsboro BRF 013-1(15) project. We received a copy of the wave equation analysis provided to Charlie Ezequelle of Renaud Brothers, Inc. conducted by Michael Deery of GZA GeoEnvironmental, Inc. (GZA) and Pile Driving & Equipment forms prepared by the contractor. Mr. Deery performed wave equation analyses for the pile and hammer to be used for Bridge No. 68 Abutments No. 1 and No. 2. The APE D19-42 single acting diesel hammer was requested for analysis with a maximum rated energy of 47,125 ft-lbs. This hammer was evaluated for the pile-soil system for the Wardsboro BRF 013-1(15) site only.

The characteristics of the proposed pile, hammer, and hammer cushion data were reviewed with the WEAP analysis to ensure the analysis was conducted per the contractor's submitted pile and driving equipment data form.

GZA modeled a variable capacity analysis which develops a driving resistance based on the most efficient hammer stroke with the APE D19-42 operating at a given fuel setting, as well as a constant capacity analysis which develops a driving resistance based on a varied hammer stroke. For both abutments, a shaft friction soil resistance profile and an end bearing resistance profile were modeled. The analyses were performed assuming the hammer was operating on fuel setting 3 to produce a driving criterion that met VTrans requirements. We are comfortable with the chosen analysis with respect to the information presented in the contract plans and on the pile and driving equipment data form.

Based on a review of the materials submitted, we agree with the recommendations provided by GZA in their report dated October 5, 2015. GZA recommends the preliminary driving criterion determined by the WEAP analyses to be 5 blows per inch for a minimum of 3 consecutive inches with the APE D19-42 operating on fuel setting 3 and providing an approximate 7.5-foot ram stroke. The project documents require that the piles be driven to a pile penetration of 30 feet below the bottom of the pile cap. At these blow counts, the stresses in the pile are expected to remain below 45 ksi per GZA's analysis. A saximeter is required to be on site to monitor the driving process at each substructure. We recommend a refusal criterion of 10 blows per half inch.

The 2011 VTrans Standard Specifications for Construction, Section 504.02(b), states the pile driving equipment must be capable of driving the pile to the required ultimate capacity at blow counts between 3 and 15 bpi. **Based upon this information and the WEAP analysis, the APE D19-42 hammer should be able to drive the steel HP 12x74 piles to the desired resistance and stay within the specifications.**

The serial number of the hammers should be recorded and kept in the pile driving records. Also, it is important to note that the thickness and condition of the prescribed Monocast MC904 blue nylon hammer cushion should be inspected prior to driving any piles. **If the thickness of the hammer cushion has decreased by 25%, then the cushion should be replaced, per Agency Specifications.** Generally, the best time to inspect the hammer cushion is when the hammer first arrives on the job, and is placed in the leads.

cc: Chad Greenwood, Resident Engineer