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Scientists

December 1, 2016
GEI Project No. 1414800

Ms. Kathy Evans
West Michigan Shoreline Regional Development Commission
316 Morris Avenue, Suite 340
Muskegon, MI 49443

RE: Report on Parallel Seismic Testing of Steel Sheet Pile, Veterans Memorial Park, Muskegon, Michigan.

Dear Ms. Evans:

The attached report presents the results of our analysis and interpretation of parallel seismic test data recorded on a steel sheet pile that forms part of the sheet pile wall at the Veterans Memorial Park in Muskegon, Michigan. A parallel seismic test result from one (1) sheet pile was recorded by a GEI Consultants, Inc. (GEI) technical specialist on November 11, 2016.

The sheet pile tested is identified by the number of the adjacent soil boring B-1, as shown in the attached report. The pile appears to be about 20 feet in length.

A copy of the test results for this pile is presented in this report. We appreciate this opportunity to be of service to you, and remain available to provide any other information that you may require concerning this project.

Sincerely,

GEI CONSULTANTS, INC.

Sean B. Brady
Senior Instrumentation Specialist

Bernard H. Hertlein, FACI, M.ASCE,
Senior Consultant

BHH:nls

c: Kelly Rice (GEI)

GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Analysis of Parallel Seismic Test, Veterans Memorial Park

Muskegon, Michigan

Submitted to:
West Michigan Shoreline Regional Development Commission
316 Morris Avenue, Suite 340
Muskegon, MI 49443

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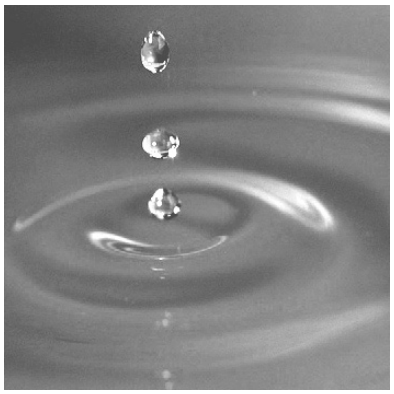
December 1, 2016

Project 1414800



Bernard H. Hertlein, M.ASCE, FACI
Senior Consultant

Table of Contents

1. Introduction

The West Michigan Shoreline Regional Development Commission (WMSRDC) is assessing the condition of a sheet pile retaining wall in Veterans Memorial Park, in Muskegon, Michigan, as part of an evaluation of hydrologic reconnection alternatives. As part of this assessment, WMSRDC engaged GEI Consultants, Inc. (GEI) to perform one geotechnical soil boring adjacent to the sheet pile wall and install a PVC pipe in the boring to facilitate measurement of the length of the sheet piles by the parallel seismic method.

GEI performed the parallel seismic test on November 10, 2016 in the borehole adjacent to the sheet pile identified in this report as B-1.

2. Test Method Description

Parallel Seismic Test

At the test location B-1, a borehole was drilled in the soil within approximately three feet of, and parallel to, the sheet pile to be tested. The borehole was lined with 2.0" ID PVC pipe, which was grouted in place and filled with water to provide acoustic coupling. The test equipment consisted of a hydrophone receiver and a hammer with an integral trigger device, connected to a data acquisition system.

The hydrophone was lowered down the borehole to the base, and the top of the sheet was struck with an instrumented hammer. A low-strain stress, or compression (P) wave was generated by the blow, and propagated down the sheet. The impact also started the data acquisition cycle. The hydrophone signal was recorded, allowing the time of arrival of the P wave at the hydrophone to be determined. The hydrophone was raised in uniform increments, and the test was repeated at each predetermined increment.

If the distance between the access tube and the foundation is assumed to be relatively constant, then the primary effect on wave transit time will be the length of the sheet through which the signal has passed. Since the depth of the transducer changes in uniform increments, so the transit time changes proportionately while the probe is alongside the foundation. The velocity of the wave in soil is considerably lower than through steel.

Where the wave encountered the end of the sheet pile, the path length through additional soil to the receiver caused a greater increase in transit time at that point.

To analyze the parallel seismic test data, the output of the test is plotted as a stacked graph of time against depth, in which each hydrophone trace is drawn in sequence. Where the wave has passed through a sound, continuous foundation, a line drawn on the graph to link first wave arrival points will show a uniform slope. This slope is determined by wave velocity. Because timber, concrete, and steel each have a characteristic range of velocity, it is possible to determine from the first arrival slope the nature of the material that the wave has traveled through.

Where transit time is increased by the additional soil below the base of the foundation, a separate line drawn to link the first arrival points intersects with the line linking first arrivals through the foundation. The intersection indicates the approximate depth of the foundation. Because the vertical axis is directly scaled in depth, a minimum of interpretation skill is required for the parallel seismic method.

3. Parallel Seismic Test Results

The pile was tested on November 10, 2016 and was designated as B-1 as shown in Figure 1 below:

Figure 1: Aerial Photograph of Veterans Memorial Park

A copy of the parallel seismic test results are presented graphically on the following page of this report. Please note that each horizontal line of test data shown in the compiled profile on the left side of the page was analyzed individually in an enlarged format graph as shown in the example wave-form on the right side of the page. The hydrophone signals recorded at B-1 provided data that was difficult to interpret, because the waveform breaks indicating the likely first wave arrivals were subtle, and partially obscured by random geo-noise.

However, the lines linking interpreted first wave arrivals intersect at a depth of approximately 20 to 21 feet below the top of the sheet pile wall, as shown in Figure 2. Please note that the equipment used was manufactured in the UK, and the depth scale on the graph is in metres.

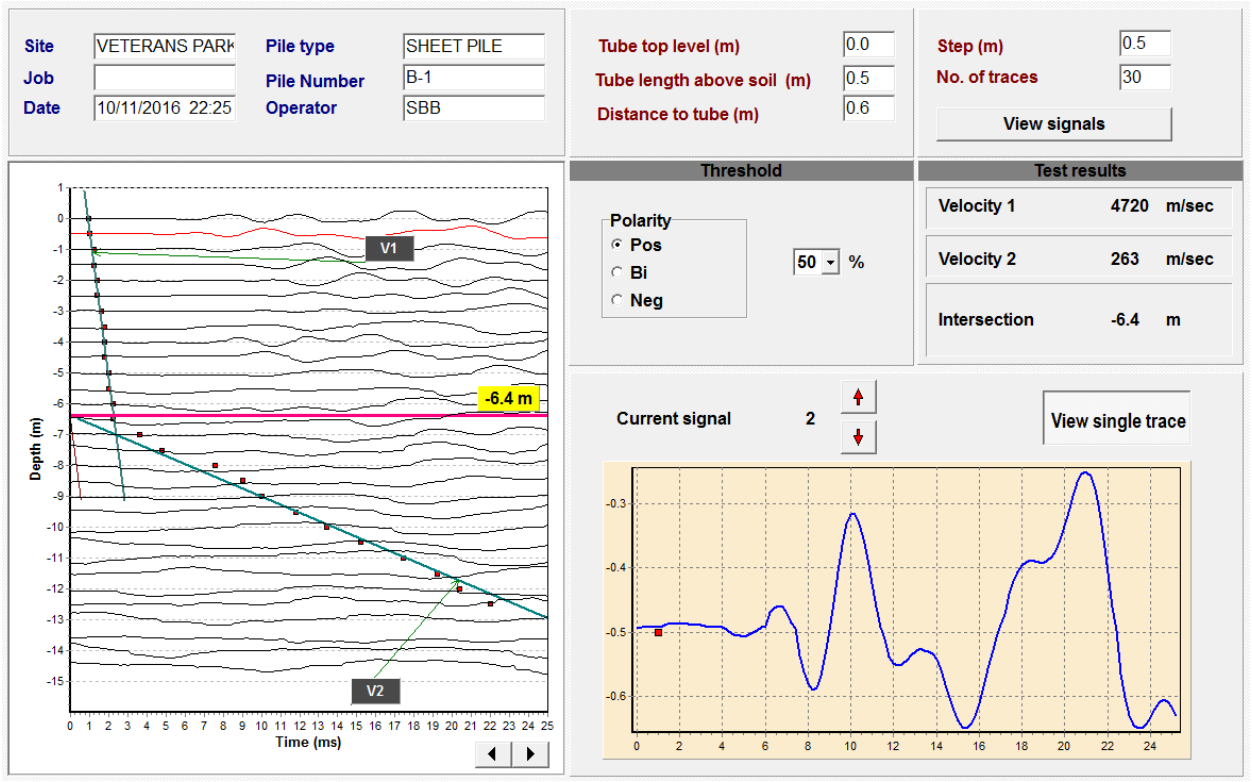


Figure 2: Parallel Seismic Test Result for Boring B-1. Depth indicated approx. 20 feet

Parallel Seismic Test Setup at test location B-1

Parallel Seismic Test Setup at test location B-1

4. Conclusions

The parallel seismic tests performed in soil boring B-1 were difficult to interpret, but the lines linking the interpreted first wave arrivals in the compiled data graph intersect at a depth of approximately 20 feet. We therefore conclude that the adjacent sheet piles probably extend to a depth of approximately 20 feet below the top of the sheet pile wall.