THURBER ENGINEERING LTD.

MEMORANDUM

To: Priscilla Tsang, P.Eng.
Associated Engineering Ltd.

Date: February 3, 2023

From: Christopher Clarke, P.Eng.
(Reviewed by David Tara, P.Eng.)

File: 26141

PROFESSIONAL PROVINCE OF C. J. W. CLARKE # 46202 BRITISH COLUMBIA ENGINEER 2023-02-03

HIGHWAY 1 - 216 STREET TO 264 STREET WIDENING
232ND STREET TEST PILE RESULTS

Thurber was retained by Associated Engineering Ltd. (AE) to provide geotechnical design input for Functional and Advanced Works Design of the BC Ministry of Transportation and Infrastructure's (the Ministry) Highway 1 - 216 Street to 264 Street Widening project. As part of this scope, the Ministry has elected to complete a test pile, along with an adjacent seismic cone penetration test (SCPT) to assess the amount of pile setup that is expected to occur following pile installation to help reduce the risk of needing to drive more piles than necessary during construction. This memo provides the SCPT results, summarizes the results of the dynamic load testing (DLT) and provides an estimate of the final axial resistance of the pile.

It is a condition of this memo that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

1. BACKGROUND GEOTECHNICAL INFORMATION

1.1 Functional Design Geotechnical Investigation

Thurber coordinated the completion of four CPTs to 50 m depth (CPT19-05 to -08), two CPTs adjacent to the north abutment of the 232nd Street Underpass and two adjacent to the south, through the outside shoulder of Highway 1 or in gravel pullouts as the final configuration of the interchange had not yet been confirmed at the time of our investigation. Solid stem auger test holes were completed to approximately 6 m depth adjacent to each CPT. The test holes were completed by Southlands Drilling Co. and the CPTs were completed by Schwartz Soil Tech Inc. using a CPT ramset that was mounted to Southland's drill rig.

The CPTs encountered silt and clay that extended to approximately 25 m depth. Sand layers of variable thickness interbedded with silt and clay layers were encountered below 25 m depth in most locations. However, CPT19-07 encountered predominately silt and clay to 50 m depth, with only thin sand layers encountered below 25 m depth. The CPTs suggest the silt and clay is relatively softer at 232nd Street than at Glover Road or the CP Rail locations. Further information including the CPT and test hole logs can be found in our April 27, 2020 Factual Report and our July 28, 2020 100% Functional Geotechnical Design Report.

1.2 Advanced Works Design Geotechnical Investigation

Two supplementary test holes were completed near the proposed north and south abutments of the 232nd Street Flyover, TH20-01 and TH20-02, on October 6 and 7, 2020. SCPT20-01 was completed adjacent to TH20-01. The test holes and SCPT were completed by Mud Bay Drilling Co Ltd.

The purpose of the test holes was to collect relatively undisturbed, thin-walled tube samples for oedometer testing and to complete vane shear testing. The test holes and SCPT encountered similar ground conditions as the CPTs described above that were completed as part of Functional Design. Further information including the SCPT and test hole logs can be found in our February 5, 2021 Advanced Works Geotechnical Report.

2. GEOTECHNICAL INVESTIGATION

A SCPT, SCPT21-01, was completed to approximately 64 m depth, about 10 m away from the test pile following pile installation. The purpose of the SCPT was to confirm soil conditions in relatively close proximity to the test pile location. The SCPT was completed by On-Track Drilling Inc. on May 6, 2021. The SCPT encountered silt and clay to 30 m depth. Interlayered sand and silt were encountered between approximately 30 m and 40 m depth. Material comprised predominately of silt and clay was encountered below 40 m depth until CPT refusal in sand at 64 m depth.

Artesian pressures are apparent in the sandy layers encountered between 30 m and 40 m depth, with an estimated pressure head of about 40 m. There also appears to be artesian pressure in the silt and clay between 15 m and 30 m depth, as well as possible artesian pressure in the deep silt and clay below 40 m depth.

3. PILE INSTALLATION

The test pile comprised a 914 mm diameter steel pipe with a wall thickness of 25.4mm. Pile installation was completed by Surespan Construction Ltd. between April 24 and April 28, 2021. A copy of the pile installation record is attached. As noted, the pile was installed by impact driving using a 48.9 kN (11 kip) drop hammer, typically using a 2.4 m drop height. Pertinent information from the installation record is shown on Figure 1 and is described below.

- The first 18 m pile segment was driven on April 24.
- The second 18 m pile segment was driven on April 26.
- The third 18 m pile segment was driven on April 27.
- The final 12 m pile segment was driven on April 28.

The soil plug was measured to be 4.4 m below ground elevation upon completion of pile installation. This suggests that the pile predominantly cored during pile installation.

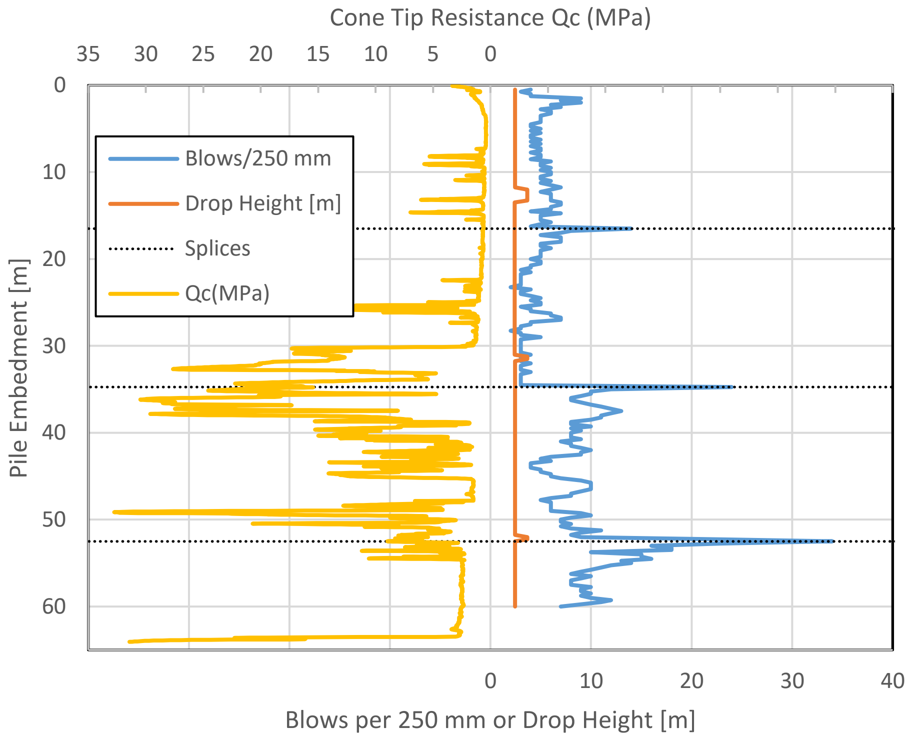

Figure 1 – Pile Installation Record and CPT Tip Resistance

4. DYNAMIC LOAD TEST RESULTS

Dynamic Load Tests (DLT) / Pile Driving Analyzer (PDA) tests were completed by the Ministry at End of Initial Drive (EOID) on April 28, 2021 using a 48.9 kN drop hammer. A 73.8 kN drop hammer was used for DLTs 3 days after EOID on May 1, 2021 and 14 days after EOID on May 12, 2021. The Ministry completed the final DLT on the test pile 40 days after EOID with the contractor again using the same 73.8 kN drop hammer. The Ministry provided Thurber with the draft results of the DLT test, finalized results were not provided. The results of the DLT tests provided to Thurber are summarized below in Table 1.

The Ministry drove the test pile approximately 3.2 m to within 300 mm of site grade, according to MoTI records, and completed an end of redrive DLT following the 40 days after EOID restrike. We understand that this was directed by the Detailed Design team to investigate if the CPT refusal was from a dense stratum. It should be noted that significant disturbance of the soil surrounding the pile occurred as a result of advancing the test pile an additional 3.2 m which could result in a significant reduction of the long-term unit shaft resistances compared to what was measured in the 40 day DLT.

Table 1 – DLT Test Result Summary

	Hammer Type	Drop Height (m)	Shaft Resistance (kN)	Toe Resistance (kN)	Total Mobilized Resistance (kN)
EOID	48.9 kN Drop Hammer	2.4	1460	400	1860
3 Days After EOID	73.8 kN Drop Hammer	2.4	3100	500	3600
14 Days After EOID	73.8 kN Drop Hammer	3.7	4420	580	5000
40 Days After EOID	73.8 kN Drop Hammer	3.7	5180	620	5800
End of redrive after remobilization of pile on Day 40	73.8 kN Drop Hammer	unknown	2400	450	2850

We have plotted the results of the DLTs completed to date on Figure 4.21 from Piling Engineering (Fleming et al., 2009) as we have done for several other projects in similar soils in Surrey and Langley. By inspection, the test results plot reasonably similar to existing test pile database in Piling Engineering with an assumed ultimate resistance of about 6100 kN (toe resistance of 600 kN and shaft resistance of 5500 kN). This assumes an equivalent diameter of the pile is 220 mm, less than the pile diameter due to the pile coring during installation. Accordingly, this suggests that the anticipated ultimate axial compressive resistance of the test pile should be in the range of 6100 kN, with the majority of the axial resistance being developed as shaft resistance.

The total mobilized axial resistance 40 days after EOID is less than expected based on our projected axial resistance following the 14 days after EOID DLT. It is likely that the intermediate DLTs resulted in a minor reduction of the unit shaft resistance compared to the situation where a DLT was completed on the test pile 40 days after EOID without intermediate testing. However, the ultimate purpose of the test pile was to provide DLT results shortly after EOID so that the design team could use those results to predict the long-term, axial resistance without the extended waiting period.

It should be noted that in the case where a DLT is completed weeks after EOID to allow for pile setup and the resultant axial resistance is shown to be insufficient, advancing the pile deeper to achieve more axial resistance could permanently reduce the unit shaft resistances due to remolding which might lead to the pile needing to be longer than if it were driven to the same embedment initially.

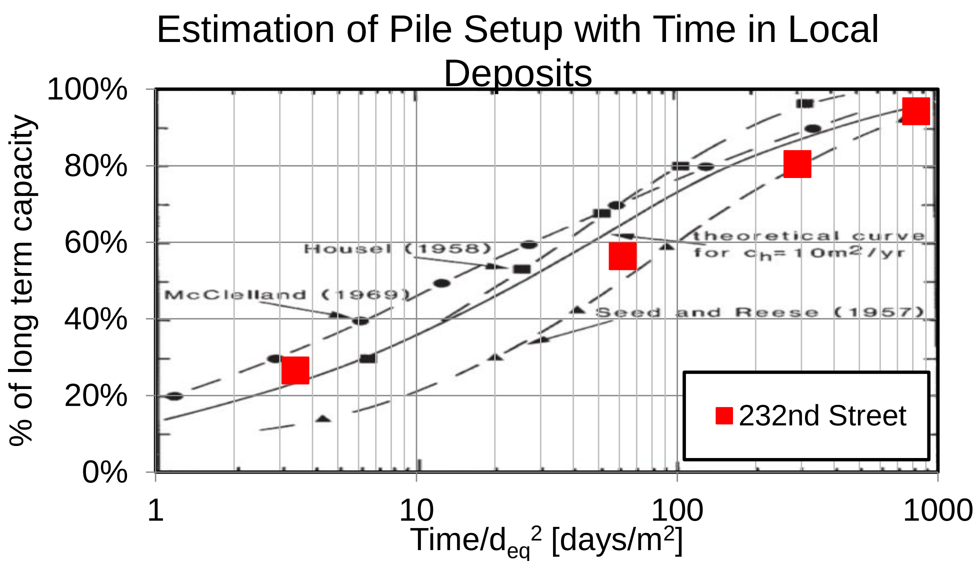

Figure 2 – Plot showing anticipate setup curve assuming 6100 kN ultimate resistance (excerpt from Piling Engineering).

The detailed design team may wish to rely on the 40-day DLT which mobilized an axial resistance of 5800 kN for detailed design, approximately 5% less than the long-term axial resistance estimate based on Figure 4.21.

After redriving the pile, we would expect significantly lower unit shaft resistances along the pile. The DLT test data from the end of redrive on Day 40 seems peculiar. While it does show a significant reduction of shaft resistance in the middle portion of the pile, it also shows much larger unit shaft resistance near the top of the pile compared to previously completed DLTs. Previous DLTs show very little to no axial resistance near the top of the pile and more resistance below.

5. COMPARISONS TO FUNCTIONAL DESIGN AXIAL RESISTANCE ESTIMATE

Our Functional Design Report provided an estimated factored axial pile compressive resistance of 2350 kN for a 50 m long, 914 mm diameter pipe pile. This factored axial resistance incorporated a resistance factor of 0.4 (ultimate axial resistance of 5875 kN). Using SCPT21-01 and the same methods used to estimate the axial resistance from Functional Design, we would have estimated that the ultimate axial resistance of the test pile to be approximately 7100 kN. This is about 16% higher than the projected ultimate axial resistance of 6100 kN from the PDA testing. Based on this, 50 m piles would be expected to have an unfactored axial resistance of approximately 4900 kN. It is worth noting that the estimated shaft resistance of a 914 mm diameter pile during Functional Design was about 18% greater and the toe resistance was about 65% greater than what was mobilized with the DLTs.

Attachments: Statement of Limitations and Conditions
SCPT Plots (11 Pages)
Ministry PDA Test Results (18 Pages)

Thurber Engineering Ltd.
Permit to Practice #1001319

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client, the BC Ministry of Transportation and Infrastructure (MoTI) and Authorized Users as defined in the MoTI Special Conditions Form H0461d. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Any use which an unauthorized third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any unauthorized third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

CONE PENETRATION TEST REPORT

Prepared for:

THURBER ENGINEERING LTD.

Site: Highway 1 & 232nd Street, Langley, BC
Date Drilled: May 6, 2021

Prepared by:

On Track Drilling
20626 Mufford Crescent
Langley, BC
V2Y 1N8

Phone: 604-523-1200
zach@ontrackdrilling.com
www.ontrackdrilling.com

ON TRACK
An earth DRILLING Company
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Cone Penetration Testing (CPT) Equipment & Calculated Geotechnical Parameters

On Track Drilling Inc. owns and operates a cone penetration test (CPT) system, supplied by Vertek – A Division of Applied Research and Associates. The Hogentogler electronic system is used with a 15 cm^2, 20 ton cone that records tip resistance, sleeve friction, pore pressure, inclination and temperature at desired intervals chosen by the operator. The cone penetrometers are designed with equal end area friction sleeves, a net end area ratio 0.8 and 60° apex angle on the tip. The cone consists of two strain gauge transducers, with the cone electronics packaged directly behind the transducers. The cone can be stopped at desired depths and dissipation tests can be completed to determine the groundwater pressures.

All testing is performed in accordance with the current ASTM D5778 standards.

The CPT calculations displayed on the plots are based on the measured tip resistance, sleeve friction and pore water pressure recorded at each specified data point. The recorded tip resistance (qc) is corrected for pore pressure effects (qt) and is used for all the calculations.

The following empirical correlations have been used to calculate the geotechnical parameters used in the CPT plots:

Corrected cone tip resistance:

$$q_t = q_c + (1-a) \bullet u2$$

where: q_c = the recorded tip resistance
a = net area ratio for cone (0.8)
u2 = the recorded dynamic pore pressure

Soil Behavior Type (Normalized): based on SBTn Robertson (1990) (Linear normalization)

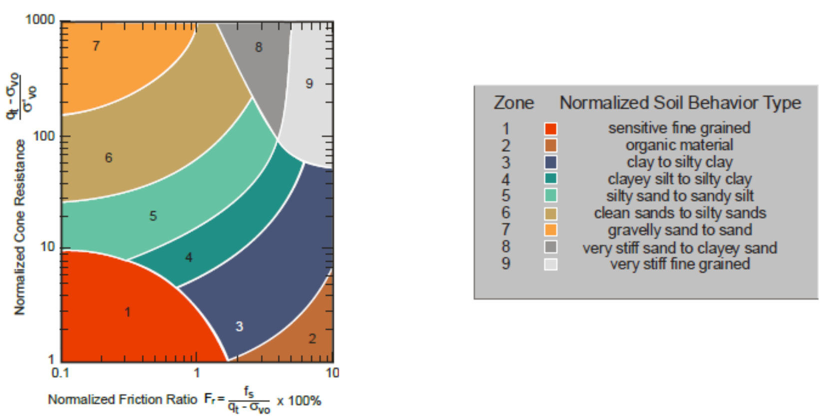

Figure 1: Normalized Soil Behavior Type (SBTn) Classification Chart

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Undrained Shear Strength (Su):

$$Su = \frac{(q_t - \sigma_v)}{N_{kt}}$$

where: q_t = the corrected tip resistance
σ_v = the effective overburden stress
N_{kt} = cone constant (user selectable)

Standard Penetration Test Correlation $N_{1(60)}$:

$$(N_1)_{60} = C_n N_{60}$$

The SPT N_{60} value corrected for overburden pressure (C_n)

Equivalent SPT N_{60}, (blows/30cm) Lunne et al. (1997) :

$$\frac{\left(\frac{q_t}{p_a}\right)}{N_{60}} = 8.5\left(1 - \frac{I_c}{4.6}\right)$$

Over Consolidation Ratio (OCR):

$$OCR = k_{OCR}\, Q_{t1}$$

Only SBTn 1, 2, 3, 4, & 9 (see Lunne et al., 1997)

Shear Wave Velocity (Vs) Testing:

Shear wave velocity measurements can be recorded at desired intervals in conjunction with the cone penetrometer test. The shear waves are typically generated by using a heavy hammer to horizontally strike a beam that is held in place on the ground by a normal force, in this case the outriggers of the drill rig. Two accelerometers mounted directly to the source are used as the contact triggers to initiate the recording of the seismic wave traces. The seismic source is oriented parallel to the axis of the active geophone being used.

The geophones are located 0.2 meters behind the cone tip and the source offset to the cone is recorded for each test.

The velocities of each interval are calculated by choosing a first arrival feature of each recorded wave set and taking the difference in ray path, divided by the time difference between subsequent first arrival times.

All testing is performed in accordance with the current ASTM D7400 standards.

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All calculations have been carried out automatically using the software program CPeT-IT v.3.0.3.2. supplied by Geologismiki. The parameters selected are based on current published CPT correlations and are subject to change to reflect the current state of practice. On Track Drilling does not warrant the correctness or the applicability of any of the calculations carried out by the software and does not assume liability for the use of the data in any design or review.

References:

ASTM D5778-12, 2012, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM International, West Conshohocken, PA. DOI: 10.1520/D5778-12.

ASTM D7400/D7400M-19, 2019, "Standard Test Methods for Downhole Seismic Testing", ASTM International, West Conshohocken, PA. DOI: 10.1520/D7400_D7400M-19.

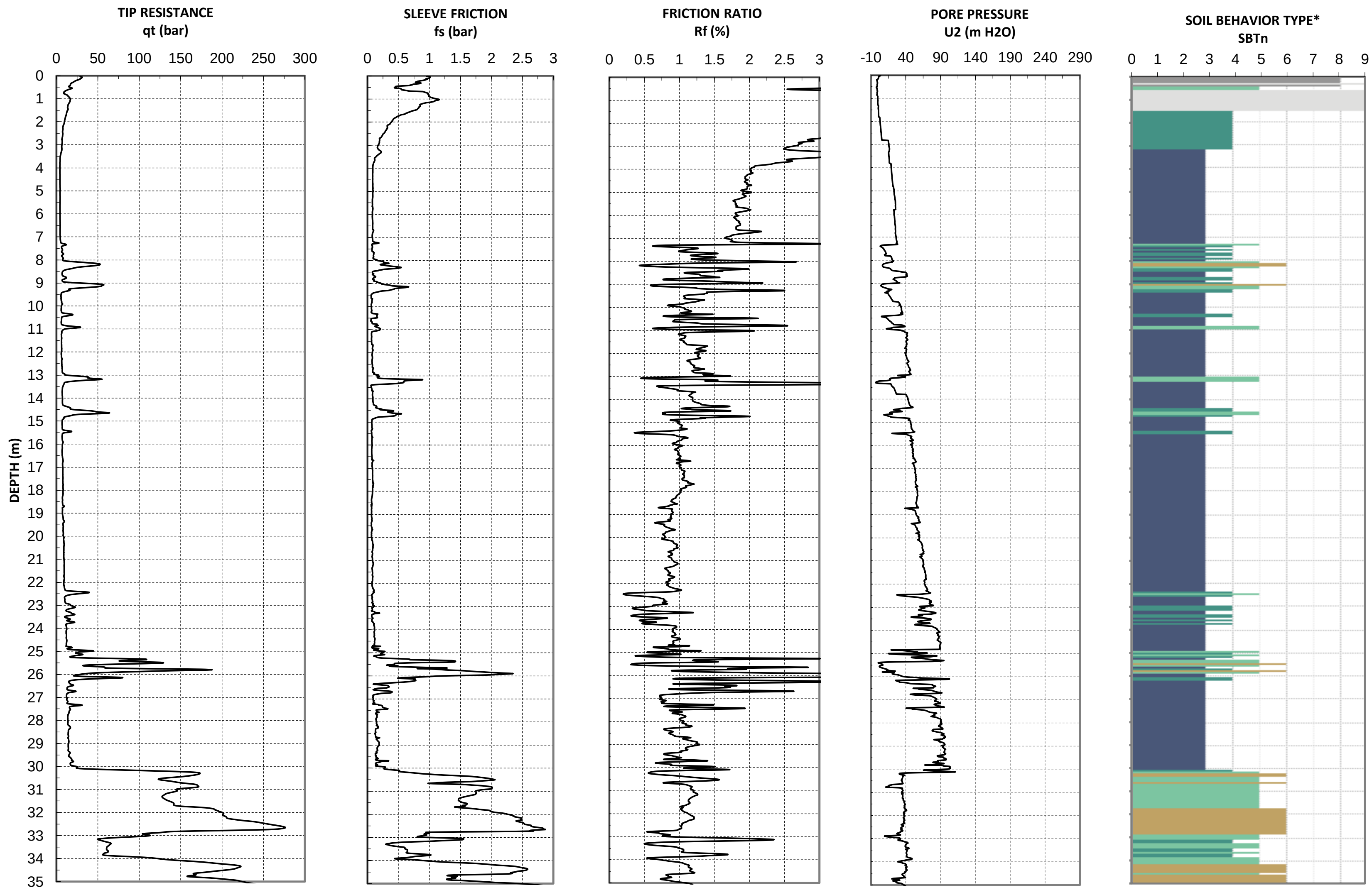
Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, “Cone Penetration Testing in Geotechnical Practice”, Blackie Academic and Professional.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, “Use of Piezometer Cone Data”, Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., 1990, “Soil Classification Using the Cone Penetration Test”, Canadian Geotechnical Journal, Volume 27: 151-158. DOI: 10.1139/T90-014.

On Track Drilling Inc.
20626 Mufford Crescent
Langley, BC, V2Y 1N8
Phone: 604 523 1200
Website: www.ontrackdrilling.com

Sounding: SCPT21-01	Client: Thurber Engineering Ltd.
06-May-2021	Site: Highway 1 & 232nd Street, Langley, BC



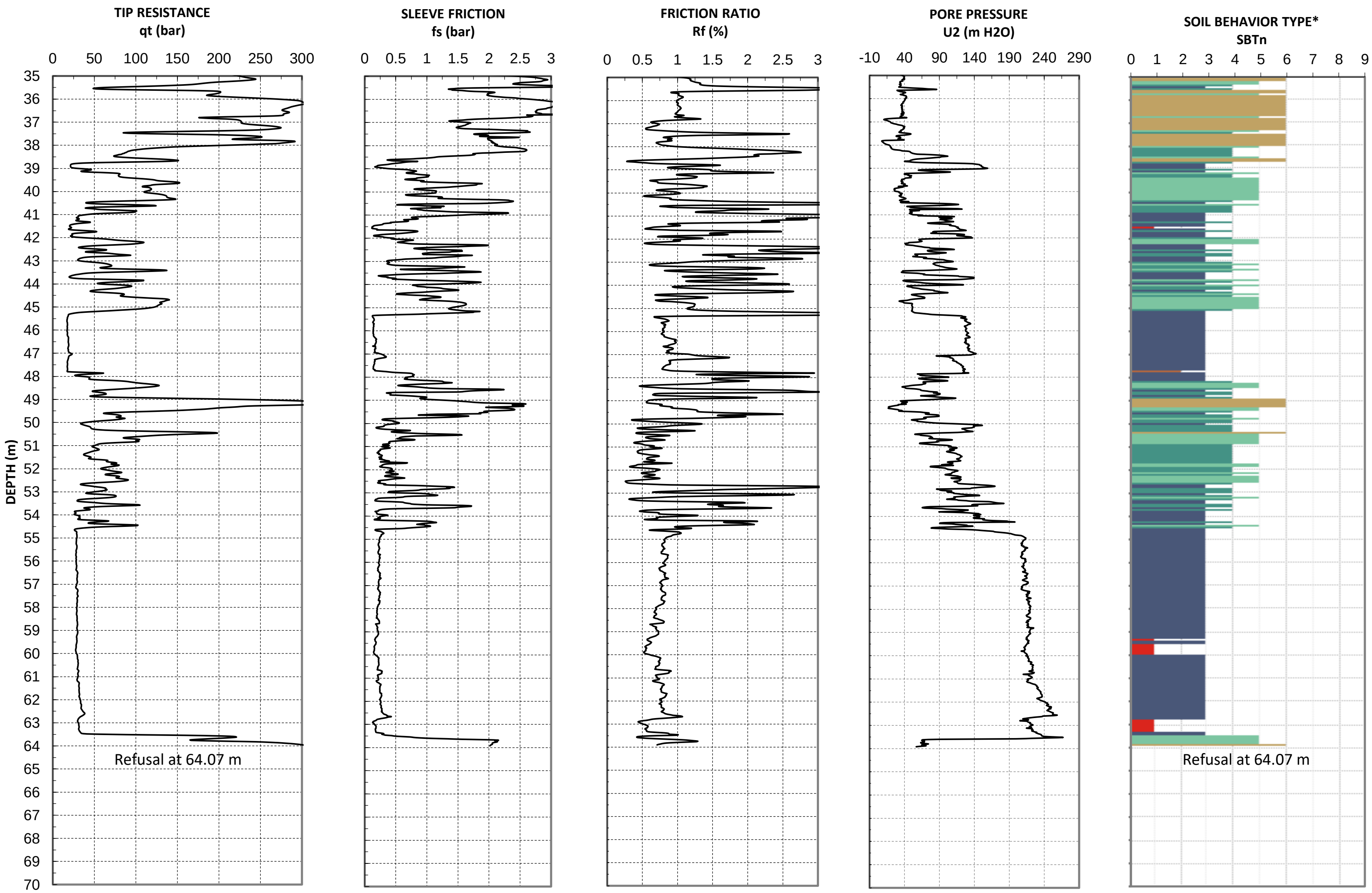
* Based on Robertson et. al 1990

1. Sensitive Fine Grained
2. Organic Material
3. Clay to Silty Clay
4. Clayey Silt to Silty Clay
5. Silty Sand to Sandy Silt
6. Clean Sand to Silty Sand
7. Gravely Sand to Sand
8. Very Stiff Sand to Clayey Sand
9. Very Stiff Fine Grained

Depth Increment: 0.02 m
Geodetic Elevation: N/A
Maximum Depth: 64.07 m

Cone ID: DPG1516
Operator: ZH

Sounding: SCPT21-01	Client: Thurber Engineering Ltd.
06-May-2021	Site: Highway 1 & 232nd Street, Langley, BC



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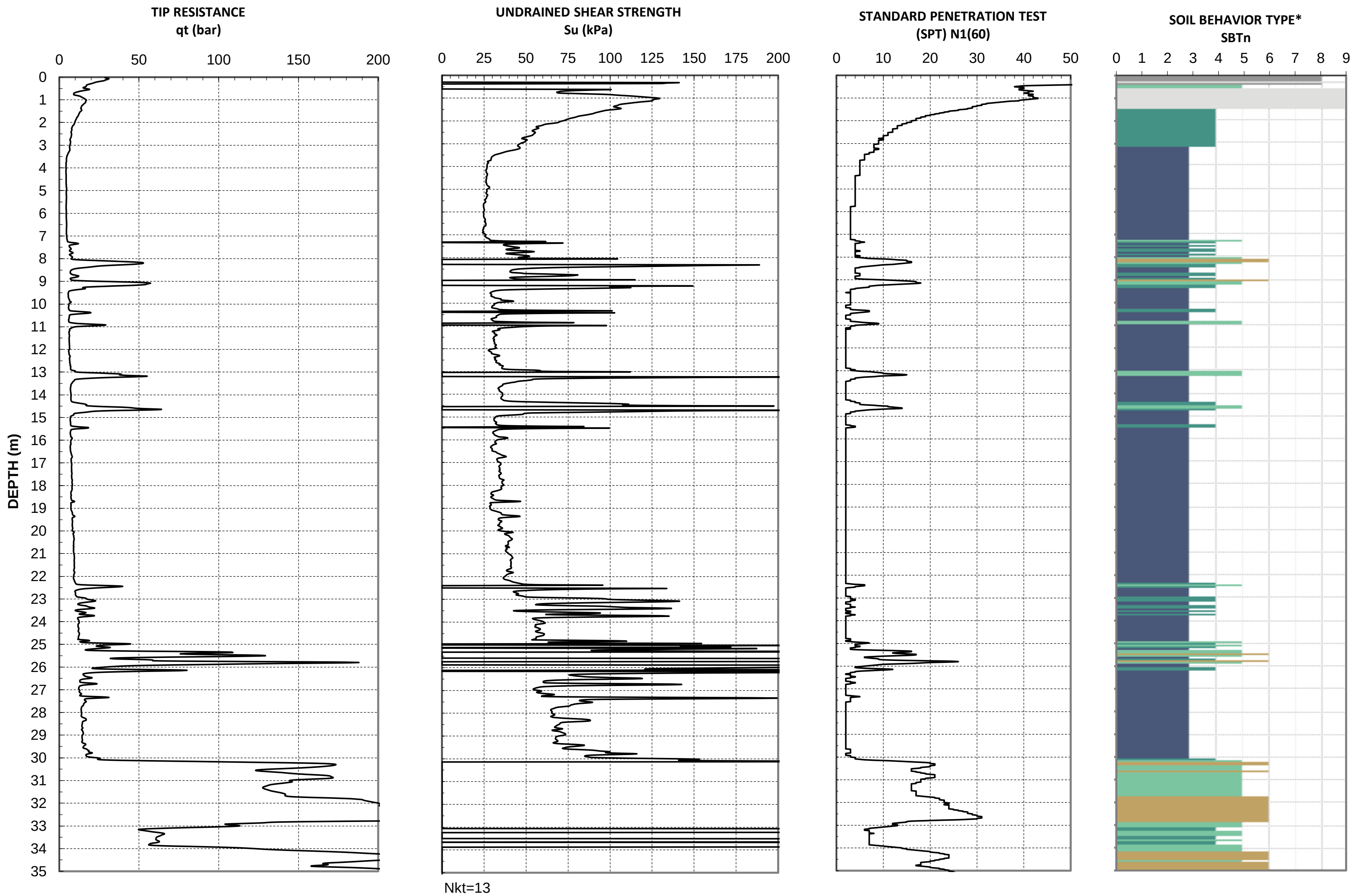

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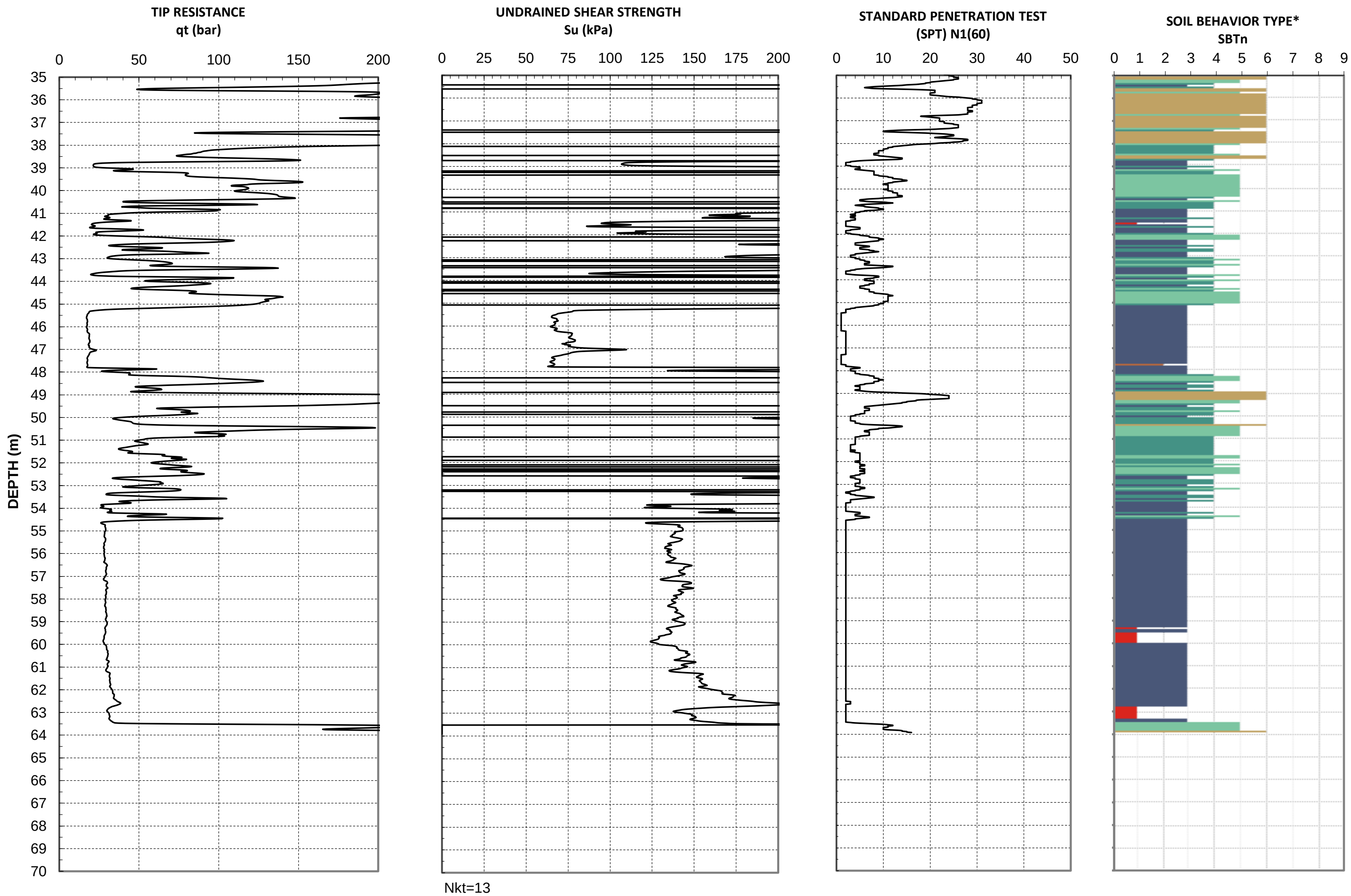
06-May-2021	Site: Highway 1 & 232nd Street, Langley, BC



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Sounding: SCPT21-01	Client: Thurber Engineering Ltd.
06-May-21	Site: Highway 1 & 232nd Street, Langley, BC

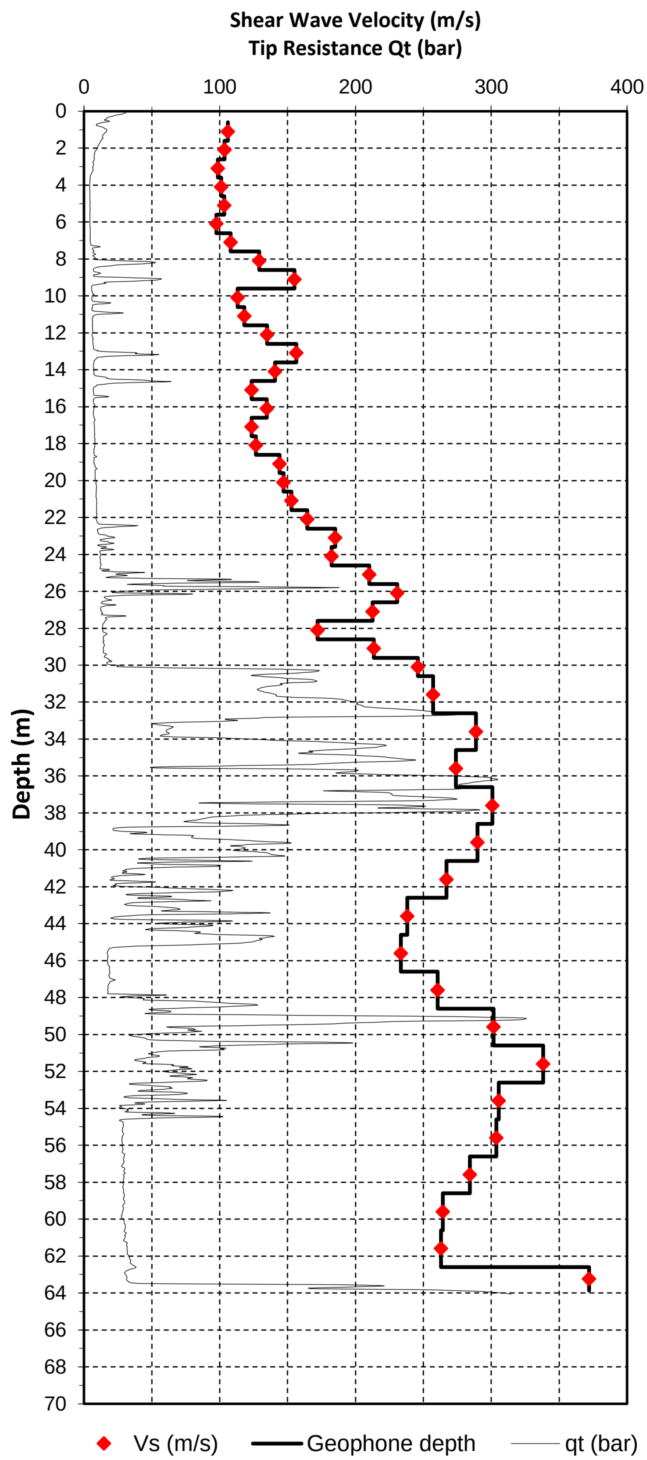
Seismic Source: Beam
Source to cone (m): 0.8

Geodetic Elevation: N/A
Cone ID: DPG1516
Operator: ZH

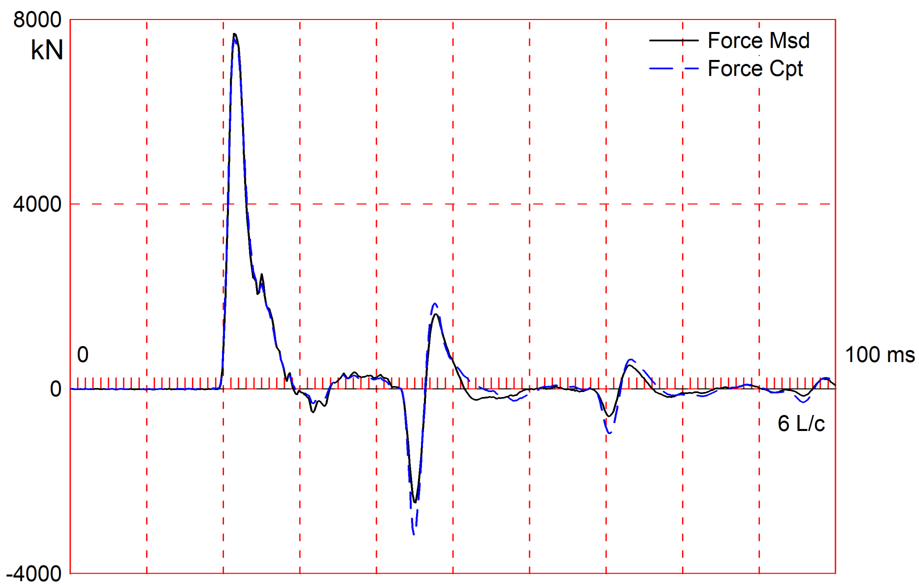
Shear Wave Velocity Data (Vs)

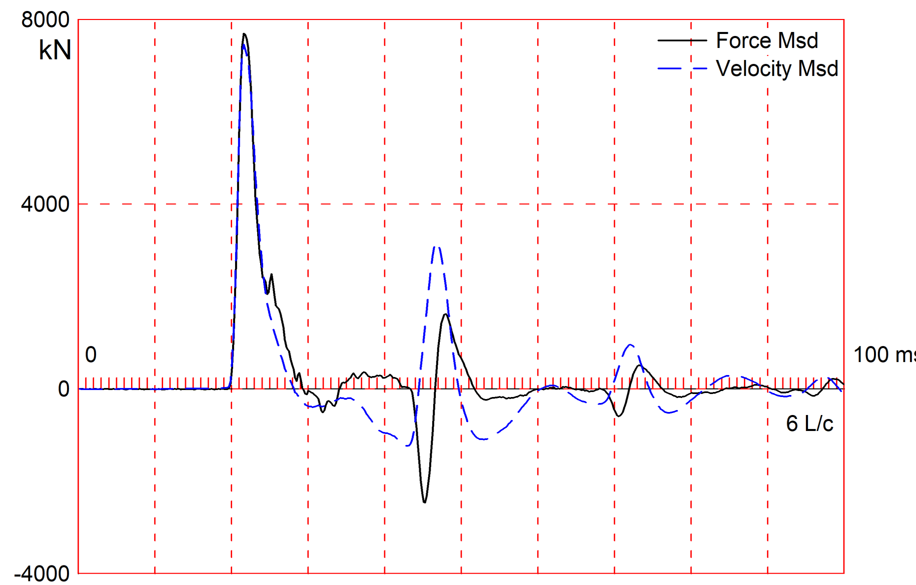
Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Time Difference (ms)	Shear Wave Velocity Vs (m/s)
0.80	0.60	1.00			
1.80	1.60	1.79	0.79	7.43	**106**
2.80	2.60	2.72	0.93	8.99	**104**
3.80	3.60	3.69	0.97	9.81	**99**
4.80	4.60	4.67	0.98	9.70	**101**
5.80	5.60	5.66	0.99	9.56	**103**
6.80	6.60	6.65	0.99	10.17	**97**
7.80	7.60	7.64	0.99	9.19	**108**
8.80	8.60	8.64	1.00	7.70	**129**
9.80	9.60	9.63	1.00	6.42	**155**
10.80	10.60	10.63	1.00	8.80	**113**
11.80	11.60	11.63	1.00	8.45	**118**
12.80	12.60	12.63	1.00	7.39	**135**
13.80	13.60	13.62	1.00	6.38	**156**
14.80	14.60	14.62	1.00	7.10	**141**
15.80	15.60	15.62	1.00	8.09	**123**
16.80	16.60	16.62	1.00	7.42	**135**
17.80	17.60	17.62	1.00	8.10	**123**
18.80	18.60	18.62	1.00	7.89	**127**
19.80	19.60	19.62	1.00	6.93	**144**
20.80	20.60	20.62	1.00	6.79	**147**
21.80	21.60	21.61	1.00	6.54	**153**
22.80	22.60	22.61	1.00	6.08	**164**
23.80	23.60	23.61	1.00	5.40	**185**
24.80	24.60	24.61	1.00	5.48	**182**
25.80	25.60	25.61	1.00	4.76	**210**
26.80	26.60	26.61	1.00	4.33	**231**
27.80	27.60	27.61	1.00	4.70	**213**
28.80	28.60	28.61	1.00	5.81	**172**
29.80	29.60	29.61	1.00	4.68	**213**
30.80	30.60	30.61	1.00	4.06	**246**
32.80	32.60	32.61	2.00	7.77	**257**

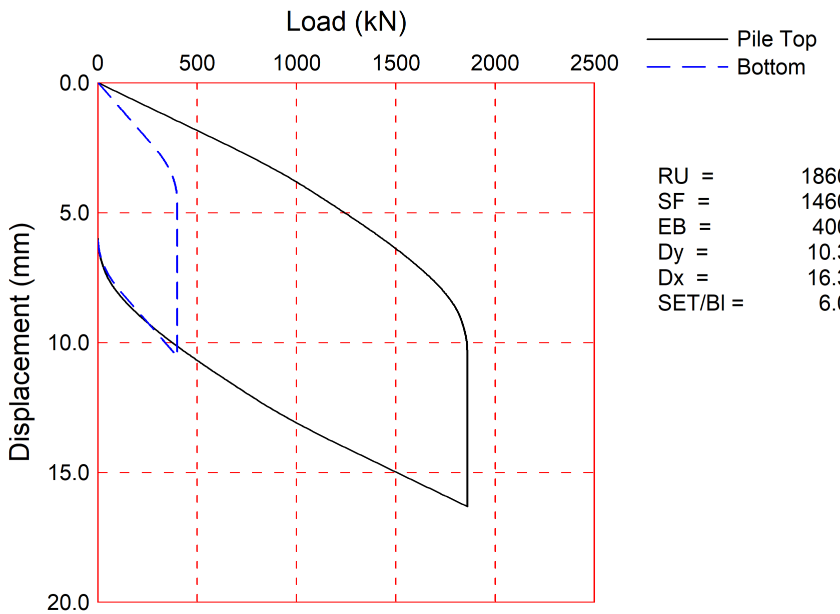
34.80	34.60	34.61	2.00	6.93	**289**
36.80	36.60	36.61	2.00	7.30	**274**
38.80	38.60	38.61	2.00	6.65	**301**
40.80	40.60	40.61	2.00	6.90	**290**
42.80	42.60	42.61	2.00	7.49	**267**
44.80	44.60	44.61	2.00	8.40	**238**
46.80	46.60	46.61	2.00	8.57	**233**
48.80	48.60	48.61	2.00	7.68	**260**
50.80	50.60	50.61	2.00	6.63	**302**
52.80	52.60	52.61	2.00	5.91	**338**
54.80	54.60	54.61	2.00	6.55	**305**
56.80	56.60	56.61	2.00	6.59	**304**
58.80	58.60	58.61	2.00	7.03	**284**
60.80	60.60	60.61	2.00	7.56	**264**
62.80	62.60	62.61	2.00	7.60	**263**
64.07	63.87	63.88	1.27	3.41	**372**



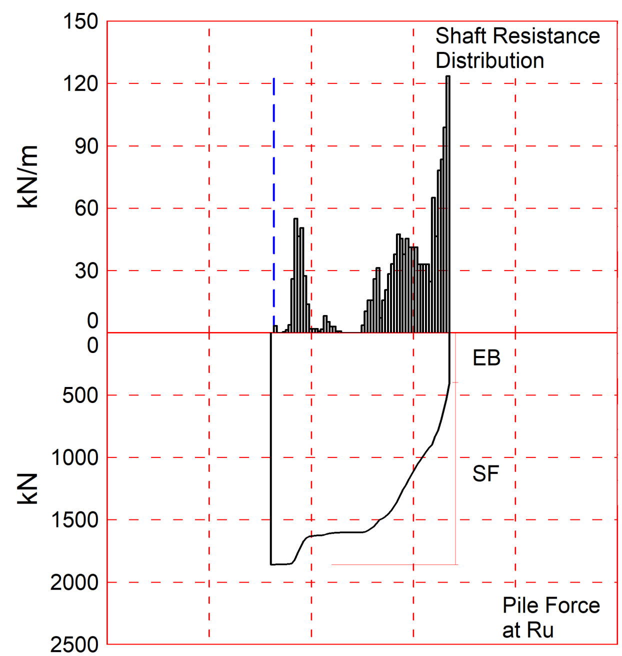
Shear Wave Velocity (m/s)
Tip Resistance Qt (bar)
0
100
200
300
400
Depth (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
70
Vs (m/s)
Geophone depth
qt (bar)







RU = 1860 kN
SF = 1460 kN
EB = 400 kN
Dy = 10.3 mm
Dx = 16.3 mm
SET/Bl = 6.0 mm



Length b. Sensors	61.2 m
Embedment	60.0 m
Top Area	709.4 cm^2
End Bearing Area	709.4 cm^2
Top Perimeter	2.87 m
Top E-Modulus	217222 MPa
Top Spec. Weight	77.3 kN/m^3
Top Wave Spd.	5250 m/s
Overall W.S.	5250 m/s
Match Quality	2.74
Top Compr. Stress	106.9 MPa
Max Compr. Stress	108.9 MPa
Max Tension Stress	-46.15 MPa
Avg. Shaft Quake	2.7 mm
Toe Quake	3.5 mm
Avg. Shaft Smith Dpg.	1.10 s/m
Toe Smith Damping	0.50 s/m

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

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CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal "match quality" (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

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The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 1860.1; along Shaft 1460.1; at Toe 400.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
				1860.1				
1	2.0	0.8	2.7	1857.4	2.7	3.35	1.17	1.10
2	3.0	1.8	0.0	1857.4	2.7	0.00	0.00	0.00
3	4.0	2.8	0.0	1857.4	2.7	0.00	0.00	0.00
4	5.0	3.8	0.5	1856.9	3.2	0.50	0.17	1.10
5	6.0	4.8	1.4	1855.5	4.6	1.40	0.49	1.10
6	7.0	5.8	3.8	1851.7	8.4	3.79	1.32	1.10
7	8.0	6.8	26.0	1825.7	34.4	25.92	9.02	1.10
8	9.0	7.8	55.2	1770.5	89.6	55.02	19.15	1.10
9	10.0	8.8	46.6	1723.9	136.2	46.45	16.17	1.10
10	11.0	9.8	50.6	1673.3	186.8	50.43	17.56	1.10
11	12.0	10.8	27.6	1645.7	214.4	27.51	9.58	1.10
12	13.0	11.8	13.8	1631.9	228.2	13.75	4.79	1.10
13	14.0	12.8	2.0	1629.9	230.2	1.99	0.69	1.10
14	15.0	13.8	2.0	1627.9	232.2	1.99	0.69	1.10
15	16.1	14.9	2.0	1625.9	234.2	1.99	0.69	1.10
16	17.1	15.9	0.9	1625.0	235.1	0.90	0.31	1.10
17	18.1	16.9	1.8	1623.2	236.9	1.79	0.62	1.10
18	19.1	17.9	8.3	1614.9	245.2	8.27	2.88	1.10
19	20.1	18.9	5.4	1609.5	250.6	5.38	1.87	1.10
20	21.1	19.9	3.1	1606.4	253.7	3.09	1.08	1.10
21	22.1	20.9	3.1	1603.3	256.8	3.09	1.08	1.10
22	23.1	21.9	0.8	1602.5	257.6	0.80	0.28	1.10
23	24.1	22.9	0.8	1601.7	258.4	0.80	0.28	1.10
24	25.1	23.9	0.0	1601.7	258.4	0.00	0.00	0.00
25	26.1	24.9	0.0	1601.7	258.4	0.00	0.00	0.00
26	27.1	25.9	0.0	1601.7	258.4	0.00	0.00	0.00
27	28.1	26.9	0.0	1601.7	258.4	0.00	0.00	0.00
28	29.1	27.9	0.0	1601.7	258.4	0.00	0.00	0.00
29	30.1	28.9	0.0	1601.7	258.4	0.00	0.00	0.00
30	31.1	29.9	0.0	1601.7	258.4	0.00	0.00	0.00
31	32.1	30.9	3.7	1598.0	262.1	3.69	1.28	1.10
32	33.1	31.9	10.5	1587.5	272.6	10.47	3.64	1.10
33	34.1	32.9	15.7	1571.8	288.3	15.65	5.45	1.10
34	35.1	33.9	15.7	1556.1	304.0	15.65	5.45	1.10
35	36.1	34.9	26.0	1530.1	330.0	25.92	9.02	1.10
36	37.1	35.9	31.3	1498.8	361.3	31.20	10.86	1.10
37	38.1	36.9	7.3	1491.5	368.6	7.28	2.53	1.10
38	39.1	37.9	15.8	1475.7	384.4	15.75	5.48	1.10
39	40.1	38.9	20.8	1454.9	405.2	20.73	7.22	1.10
40	41.1	39.9	28.5	1426.4	433.7	28.41	9.89	1.10

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 1860.1; along Shaft 1460.1; at Toe 400.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
41	42.1	40.9	33.3	1393.1	467.0	33.19	11.55	1.10
42	43.1	41.9	38.0	1355.1	505.0	37.88	13.18	1.10
43	44.1	42.9	47.6	1307.5	552.6	47.44	16.52	1.10
44	45.1	43.9	45.5	1262.0	598.1	45.35	15.79	1.10
45	46.2	45.0	38.0	1224.0	636.1	37.88	13.18	1.10
46	47.2	46.0	45.5	1178.5	681.6	45.35	15.79	1.10
47	48.2	47.0	41.3	1137.2	722.9	41.17	14.33	1.10
48	49.2	48.0	41.3	1095.9	764.2	41.17	14.33	1.10
49	50.2	49.0	41.3	1054.6	805.5	41.17	14.33	1.10
50	51.2	50.0	33.1	1021.5	838.6	32.99	11.48	1.10
51	52.2	51.0	33.1	988.4	871.7	32.99	11.48	1.10
52	53.2	52.0	33.1	955.3	904.8	32.99	11.48	1.10
53	54.2	53.0	33.1	922.2	937.9	32.99	11.48	1.10
54	55.2	54.0	24.8	897.4	962.7	24.72	8.60	1.10
55	56.2	55.0	65.3	832.1	1028.0	65.09	22.66	1.10
56	57.2	56.0	46.6	785.5	1074.6	46.45	16.17	1.10
57	58.2	57.0	78.5	707.0	1153.1	78.24	27.24	1.10
58	59.2	58.0	83.8	623.2	1236.9	83.53	29.08	1.10
59	60.2	59.0	99.2	524.0	1336.1	98.88	34.42	1.10
60	61.2	60.0	124.0	400.0	1460.1	123.59	43.02	1.10
Avg. Shaft			24.3			24.33	8.47	1.10
Toe			400.0				5638.65	0.50

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(mm)	2.7	3.5
Case Damping Factor		0.55	0.07
Damping Type		Viscous	Sm+Visc
Reloading Level	(% of Ru)	100	100
Soil Plug Weight	(kN)		3.000
Soil Support Dashpot		0.150	3.000
Soil Support Weight	(kN)	14.41	14.41

CAPWAP match quality = 2.74 (Wave Up Match) ; RSA = 0
Observed: Final Set = 6.0 mm; Blow Count = 167 b/m
Computed: Final Set = 6.0 mm; Blow Count = 168 b/m
Transducer F6 (0526) CAL: 149.0; RF: 1.00; F8 (0527) CAL: 149.9; RF: 1.00
A5 (56138) CAL: 930; RF: 1.00; A7 (56111) CAL: 955; RF: 1.00

max. Top Comp. Stress = 106.9 MPa (T= 21.8 ms, max= 1.019 x Top)
max. Comp. Stress = 108.9 MPa (Z= 8.0 m, T= 23.1 ms)
max. Tens. Stress = -46.15 MPa (Z= 1.0 m, T= 45.1 ms)
max. Energy (EMX) = 42.1 kJ; max. Measured Top Displ. (DMX)= 8.3 mm

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages m	max. Force kN	min. Force kN	max. Comp. Stress MPa	max. Tens. Stress MPa	max. Trnsfd. Energy kJ	max. Veloc. m/s	max. Displ. mm
1	1.0	7583.6	-3273.5	106.9	-46.15	42.1	2.58	8.4
2	2.0	7582.6	-3264.4	106.9	-46.02	42.0	2.58	8.3
5	5.0	7586.2	-3124.7	106.9	-44.05	42.0	2.57	8.1
8	8.0	7725.5	-3103.0	108.9	-43.74	41.8	2.51	8.0
11	11.0	7461.5	-2992.6	105.2	-42.19	39.3	2.45	8.0
14	14.0	7183.0	-2970.1	101.3	-41.87	37.5	2.44	7.9
17	17.1	7169.1	-2878.5	101.1	-40.58	37.3	2.43	7.9
20	20.1	7145.3	-2745.0	100.7	-38.69	37.0	2.42	7.8
23	23.1	7105.5	-2706.8	100.2	-38.16	36.8	2.42	7.8
26	26.1	7091.7	-2683.7	100.0	-37.83	36.7	2.42	7.9
29	29.1	7091.2	-2827.0	100.0	-39.85	36.6	2.41	8.0
32	32.1	7137.2	-2993.2	100.6	-42.19	36.5	2.40	8.0
35	35.1	7136.5	-3181.6	100.6	-44.85	35.8	2.36	8.0
38	38.1	6988.0	-3109.1	98.5	-43.83	34.4	2.33	8.1
41	41.1	6998.3	-3118.9	98.7	-43.97	33.6	2.28	8.3
44	44.1	6881.1	-3035.7	97.0	-42.79	31.9	2.21	8.5
47	47.2	6668.9	-2728.8	94.0	-38.47	29.8	2.15	8.7
50	50.2	6448.8	-2273.3	90.9	-32.05	27.4	2.10	8.8
53	53.2	6284.9	-1994.4	88.6	-28.11	25.1	2.05	9.0
56	56.2	6244.3	-1453.8	88.0	-20.49	21.6	2.07	9.0
59	59.2	4558.8	-500.3	64.3	-7.05	15.2	3.02	9.0
61	61.2	1479.1	-138.5	20.9	-1.95	6.0	3.25	9.0
Absolute	8.0			108.9			(T =	23.1 ms)
	1.0				-46.15		(T =	45.1 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	5971	5046	4121	3195	2270	1345	420	0	0	0
RX	5971	5046	4121	3195	2270	1345	1173	1117	1075	1061
RU	6340	5452	4563	3675	2786	1898	1010	121	0	0

RAU = 1058 (kN); RA2 = 1608 (kN)

Current CAPWAP Ru = 1860 (kN); Corresponding J(RP)= 0.44; J(RX) = 0.44

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
m/s	ms	kN	kN	kN	mm	mm	mm	kJ	kN	kN/mm
2.55	21.59	7487	7736	7736	8.3	6.0	6.0	42.8	5968	114

PILE PROFILE AND PILE MODEL

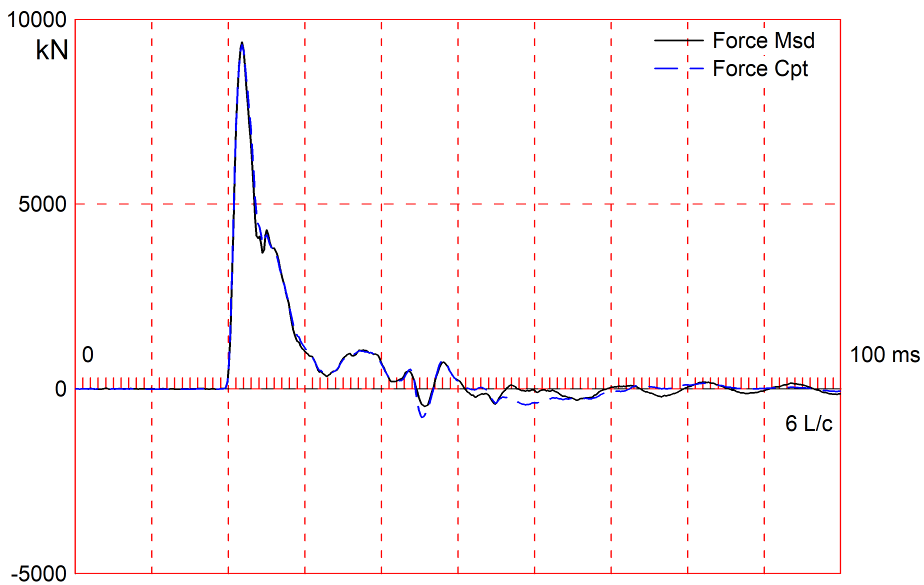
Depth	Area	E-Modulus	Spec. Weight	Perim.
m	cm^2	MPa	kN/m^3	m
0.0	709.4	217222.3	77.287	2.87
61.2	709.4	217222.3	77.287	2.87

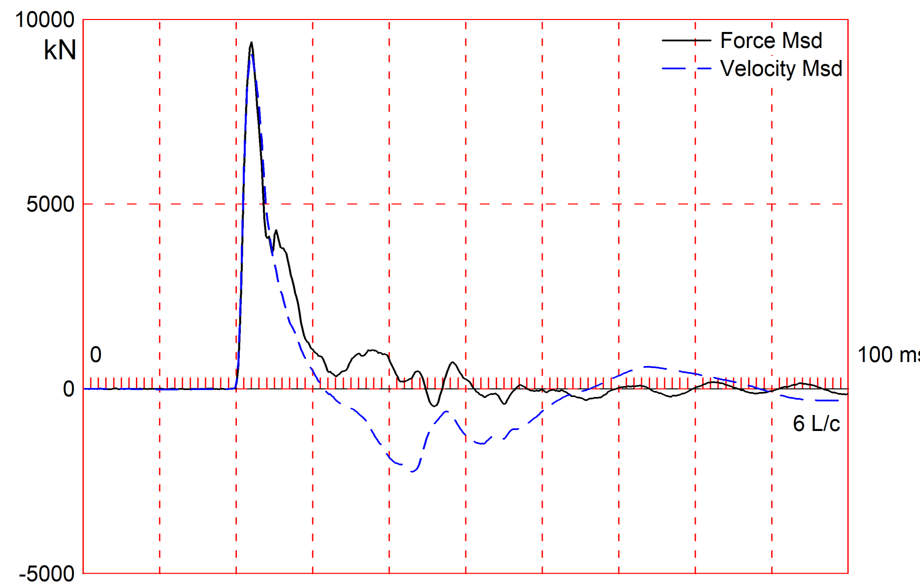
Toe Area 709.4 cm^2

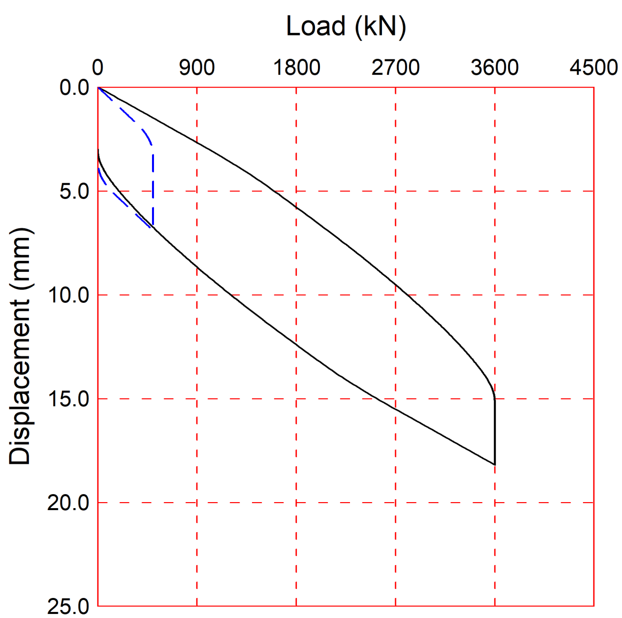
Top Segment Length 1.00 m, Top Impedance 2935 kN/m/s

Wave Speed: Pile Top 5250.0, Elastic 5250.0, Overall 5250.0 m/s
Pile Damping 1.00 %, Time Incr 0.191 ms, 2L/c 23.3 ms
Total volume: 4.341 m^3; Volume ratio considering added impedance: 1.000

Livingstone Rd UP; Pile: Test Pile_5; 3 day resrike; Blow: 5 (Test: 01-May-2021 10:52:) 07-May-2021
BC Ministry of Transportation (BC MOTI) CAPWAP(R) 2014-3







RU	=	3600 kN
SF	=	3100 kN
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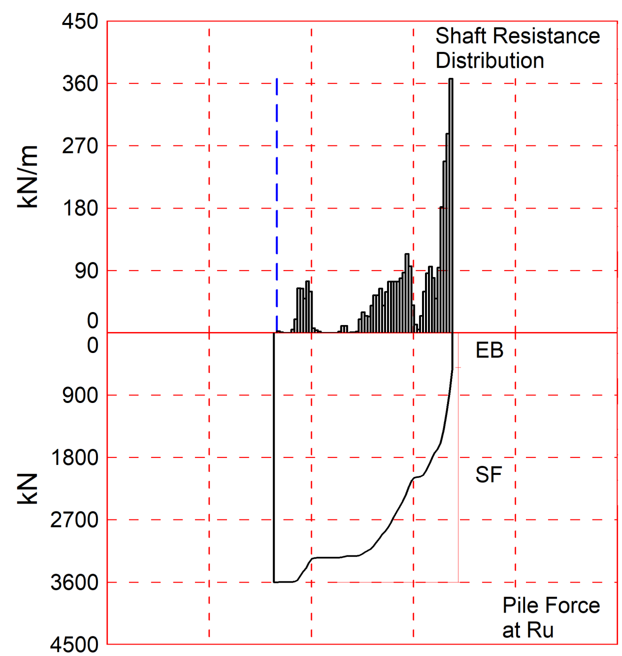
Dy	=	15.2 mm
Dx	=	18.2 mm
SET/Bl	=	3.0 mm



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Max Compr. Stress	135.9 MPa
Max Tension Stress	-14.45 MPa
Avg. Shaft Quake	3.0 mm
Toe Quake	2.5 mm
Avg. Shaft Smith Dpg.	1.20 s/m
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CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 3600.0; along Shaft 3100.0; at Toe 500.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
				3600.0				
1	2.0	0.8	2.0	3598.0	2.0	2.42	0.84	1.20
2	3.0	1.8	1.0	3597.0	3.0	1.00	0.35	1.20
3	4.0	2.8	0.0	3597.0	3.0	0.00	0.00	0.00
4	5.0	3.8	0.0	3597.0	3.0	0.00	0.00	0.00
5	6.0	4.8	0.0	3597.0	3.0	0.00	0.00	0.00
6	7.0	5.8	4.9	3592.1	7.9	4.89	1.70	1.20
7	8.0	6.8	20.0	3572.1	27.9	19.94	6.94	1.20
8	9.0	7.8	64.7	3507.4	92.6	64.51	22.46	1.20
9	10.0	8.8	64.3	3443.1	156.9	64.11	22.32	1.20
10	11.0	9.9	49.6	3393.5	206.5	49.45	17.22	1.20
11	12.0	10.9	74.7	3318.8	281.2	74.48	25.93	1.20
12	13.0	11.9	59.8	3259.0	341.0	59.62	20.76	1.20
13	14.0	12.9	7.0	3252.0	348.0	6.98	2.43	1.20
14	15.0	13.9	4.0	3248.0	352.0	3.99	1.39	1.20
15	16.0	14.9	2.0	3246.0	354.0	1.99	0.69	1.20
16	17.1	15.9	0.0	3246.0	354.0	0.00	0.00	0.00
17	18.1	16.9	0.0	3246.0	354.0	0.00	0.00	0.00
18	19.1	17.9	0.0	3246.0	354.0	0.00	0.00	0.00
19	20.1	18.9	0.0	3246.0	354.0	0.00	0.00	0.00
20	21.1	19.9	0.0	3246.0	354.0	0.00	0.00	0.00
21	22.1	20.9	0.0	3246.0	354.0	0.00	0.00	0.00
22	23.1	21.9	2.0	3244.0	356.0	1.99	0.69	1.20
23	24.1	22.9	10.0	3234.0	366.0	9.97	3.47	1.20
24	25.1	23.9	10.0	3224.0	376.0	9.97	3.47	1.20
25	26.1	24.9	0.0	3224.0	376.0	0.00	0.00	0.00
26	27.1	25.9	1.1	3222.9	377.1	1.10	0.38	1.20
27	28.1	26.9	1.1	3221.8	378.2	1.10	0.38	1.20
28	29.1	27.9	1.9	3219.9	380.1	1.89	0.66	1.20
29	30.1	28.9	20.0	3199.9	400.1	19.94	6.94	1.20
30	31.1	29.9	29.8	3170.1	429.9	29.71	10.34	1.20
31	32.1	30.9	24.8	3145.3	454.7	24.73	8.61	1.20
32	33.1	31.9	23.7	3121.6	478.4	23.63	8.23	1.20
33	34.1	32.9	39.6	3082.0	518.0	39.48	13.74	1.20
34	35.1	33.9	54.4	3027.6	572.4	54.24	18.88	1.20
35	36.1	34.9	54.4	2973.2	626.8	54.24	18.88	1.20
36	37.1	35.9	64.3	2908.9	691.1	64.11	22.32	1.20
37	38.1	36.9	39.6	2869.3	730.7	39.48	13.74	1.20
38	39.1	37.9	59.5	2809.8	790.2	59.32	20.65	1.20
39	40.1	38.9	74.4	2735.4	864.6	74.18	25.82	1.20
40	41.1	39.9	74.4	2661.0	939.0	74.18	25.82	1.20

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 3600.0; along Shaft 3100.0; at Toe 500.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
41	42.1	40.9	74.4	2586.6	1013.4	74.18	25.82	1.20
42	43.1	41.9	74.4	2512.2	1087.8	74.18	25.82	1.20
43	44.1	42.9	79.2	2433.0	1167.0	78.97	27.49	1.20
44	45.1	44.0	87.5	2345.5	1254.5	87.24	30.37	1.20
45	46.1	45.0	114.4	2231.1	1368.9	114.06	39.71	1.20
46	47.1	46.0	96.4	2134.7	1465.3	96.12	33.46	1.20
47	48.1	47.0	39.9	2094.8	1505.2	39.78	13.85	1.20
48	49.1	48.0	12.0	2082.8	1517.2	11.96	4.17	1.20
49	50.1	49.0	4.9	2077.9	1522.1	4.89	1.70	1.20
50	51.2	50.0	24.9	2053.0	1547.0	24.83	8.64	1.20
51	52.2	51.0	59.7	1993.3	1606.7	59.52	20.72	1.20
52	53.2	52.0	86.4	1906.9	1693.1	86.15	29.99	1.20
53	54.2	53.0	96.0	1810.9	1789.1	95.72	33.32	1.20
54	55.2	54.0	79.6	1731.3	1868.7	79.37	27.63	1.20
55	56.2	55.0	49.7	1681.6	1918.4	49.55	17.25	1.20
56	57.2	56.0	94.4	1587.2	2012.8	94.12	32.76	1.20
57	58.2	57.0	182.5	1404.7	2195.3	181.96	63.34	1.20
58	59.2	58.0	248.5	1156.2	2443.8	247.77	86.25	1.20
59	60.2	59.0	288.3	867.9	2732.1	287.45	100.06	1.20
60	61.2	60.0	367.9	500.0	3100.0	366.82	127.69	1.20
Avg. Shaft			51.7			51.67	17.99	1.20
Toe			500.0				7048.31	0.40

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(mm)	3.0	2.5
Case Damping Factor		1.27	0.07
Damping Type		Viscous	Sm+Visc
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	20	
Soil Plug Weight	(kN)	6.000	2.000

CAPWAP match quality = 2.20 (Wave Up Match) ; RSA = 0
Observed: Final Set = 3.0 mm; Blow Count = 333 b/m
Computed: Final Set = 3.2 mm; Blow Count = 313 b/m
Transducer F6 (0526) CAL: 149.0; RF: 1.00; F8 (0527) CAL: 149.9; RF: 1.00
A5 (56138) CAL: 930; RF: 1.00; A7 (56111) CAL: 955; RF: 1.00

max. Top Comp. Stress = 131.5 MPa (T= 22.2 ms, max= 1.034 x Top)
max. Comp. Stress = 135.9 MPa (Z= 9.0 m, T= 23.7 ms)
max. Tens. Stress = -14.45 MPa (Z= 7.0 m, T= 44.1 ms)
max. Energy (EMX) = 75.8 kJ; max. Measured Top Displ. (DMX)= 12.8 mm

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages m	max. Force kN	min. Force kN	max. Comp. Stress MPa	max. Tens. Stress MPa	max. Trnsfd. Energy kJ	max. Veloc. m/s	max. Displ. mm
1	1.0	9326.1	-772.4	131.5	-10.89	75.8	3.12	12.4
2	2.0	9325.6	-745.9	131.5	-10.51	75.8	3.12	12.4
5	5.0	9349.1	-897.9	131.8	-12.66	75.6	3.10	12.2
8	8.0	9604.7	-1007.2	135.4	-14.20	75.3	3.00	12.1
11	11.0	9279.3	-856.1	130.8	-12.07	69.8	2.89	11.9
14	14.0	8573.0	-786.5	120.8	-11.09	63.3	2.85	11.7
17	17.1	8511.0	-813.4	120.0	-11.47	62.6	2.85	11.4
20	20.1	8501.8	-827.8	119.8	-11.67	62.4	2.84	11.1
23	23.1	8520.0	-850.8	120.1	-11.99	62.0	2.83	10.7
26	26.1	8432.4	-828.3	118.9	-11.68	60.8	2.82	10.3
29	29.1	8531.1	-876.3	120.3	-12.35	60.1	2.78	9.8
32	32.1	8523.3	-933.0	120.1	-13.15	57.9	2.71	9.3
35	35.1	8468.8	-955.8	119.4	-13.47	55.0	2.61	8.9
38	38.1	8135.3	-888.4	114.7	-12.52	50.2	2.50	8.4
41	41.1	7885.1	-921.6	111.2	-12.99	45.9	2.37	8.2
44	44.1	7534.1	-908.2	106.2	-12.80	41.3	2.22	8.1
47	47.1	6851.9	-730.5	96.6	-10.30	35.8	2.14	8.0
50	50.1	6550.3	-702.4	92.3	-9.90	32.9	2.08	7.8
53	53.2	6610.9	-620.6	93.2	-8.75	31.2	1.97	7.6
56	56.2	6324.8	-519.8	89.2	-7.33	26.5	1.81	7.4
59	59.2	4664.8	-433.7	65.8	-6.11	20.8	2.27	7.1
61	61.2	2088.8	-185.5	29.4	-2.61	4.5	2.38	7.0
Absolute	9.0			135.9			(T =	23.7 ms)
	7.0				-14.45		(T =	44.1 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	9608	8714	7820	6926	6032	5138	4244	3350	2456	1562
RX	9608	8714	7820	6926	6032	5138	4244	3350	2456	1826
RU	10258	9429	8600	7771	6942	6113	5284	4455	3626	2797

RAU = 1139 (kN); RA2 = 1927 (kN)

Current CAPWAP Ru = 3600 (kN); Corresponding J(RP)= 0.67; J(RX) = 0.67

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
m/s	ms	kN	kN	kN	mm	mm	mm	kJ	kN	kN/mm
3.11	21.97	9139	9409	9409	12.8	3.0	3.0	76.0	9599	200

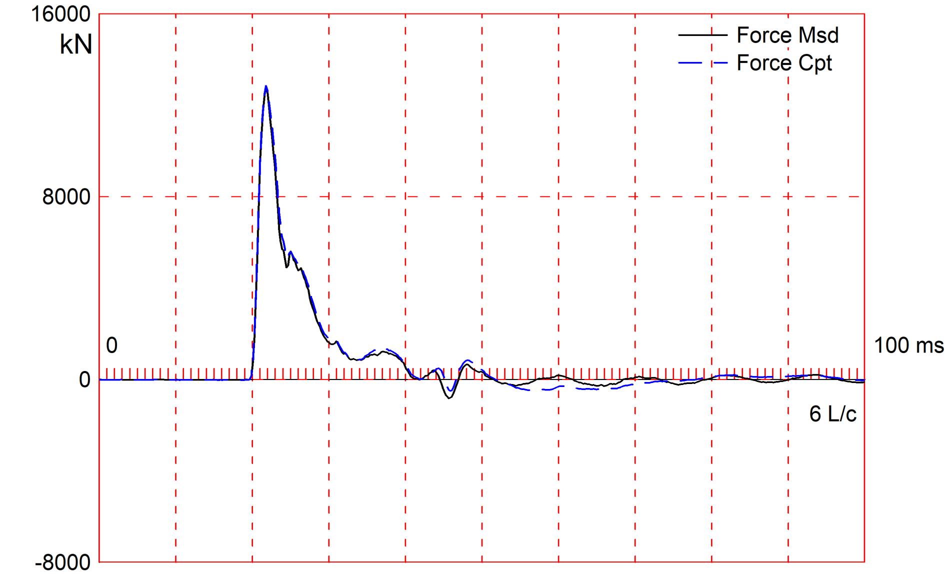
PILE PROFILE AND PILE MODEL

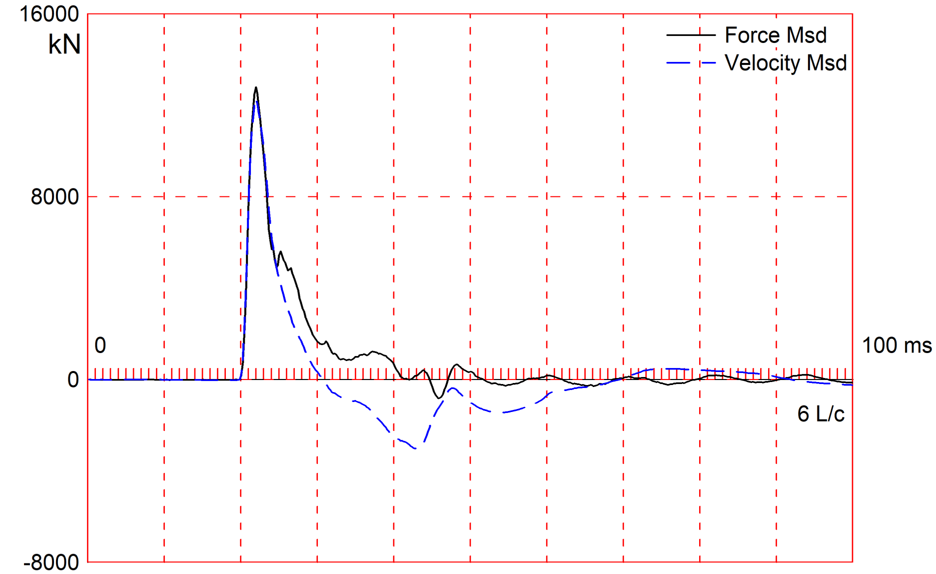
Depth	Area	E-Modulus	Spec. Weight	Perim.
m	cm^2	MPa	kN/m^3	m
0.0	709.4	217222.3	77.287	2.87
61.2	709.4	217222.3	77.287	2.87

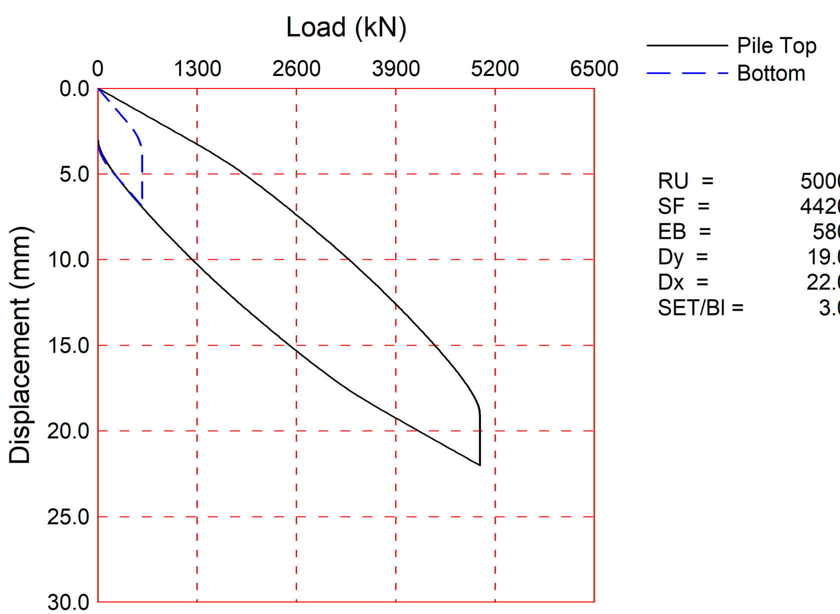
Toe Area 709.4 cm^2

Segmnt Number	Dist. B.G.	Impedance	Imped. Change	Tension Slack	Tension Eff.	Compression Slack	Compression Eff.	Perim.	Wave Speed	Soil Plug
	m	kN/m/s	%	mm		mm		m	m/s	kN
1	1.0	2935.2	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.000
2	2.0	2935.2	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.100
61	61.2	2935.2	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.100

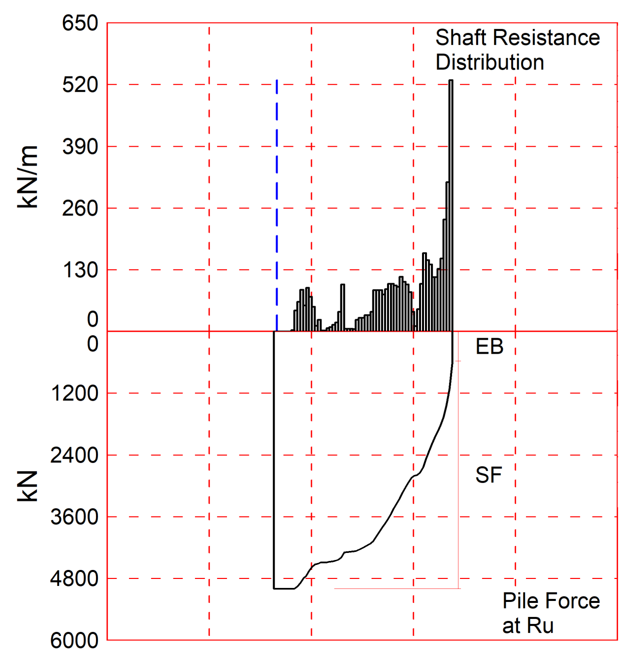
Wave Speed: Pile Top 5250.0, Elastic 5250.0, Overall 5250.0 m/s
Pile Damping 1.00 %, Time Incr 0.191 ms, 2L/c 23.3 ms
Total volume: 4.340 m^3; Volume ratio considering added impedance: 1.000







RU =	5000 kN
SF =	4420 kN
EB =	580 kN
Dy =	19.0 mm
Dx =	22.0 mm
SET/Bl =	3.0 mm



Length b. Sensors	61.2 m
Embedment	60.0 m
Top Area	709.4 cm^2
End Bearing Area	709.4 cm^2
Top Perimeter	2.87 m
Top E-Modulus	217222 MPa
Top Spec. Weight	77.3 kN/m^3
Top Wave Spd.	5250 m/s
Overall W.S.	5250 m/s
Match Quality	2.90
Top Compr. Stress	181.9 MPa
Max Compr. Stress	188.1 MPa
Max Tension Stress	-14.29 MPa
Avg. Shaft Quake	3.0 mm
Toe Quake	3.0 mm
Avg. Shaft Smith Dpg.	1.25 s/m
Toe Smith Damping	0.50 s/m

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal “match quality” (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 5000.4; along Shaft 4420.4; at Toe 580.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
				5000.4				
1	1.0	-0.2	0.5	4999.9	0.5	0.50	0.17	1.25
2	2.0	0.8	0.0	4999.9	0.5	0.00	0.00	0.00
3	3.0	1.8	0.0	4999.9	0.5	0.00	0.00	0.00
4	4.0	2.8	0.0	4999.9	0.5	0.00	0.00	0.00
5	5.0	3.8	0.0	4999.9	0.5	0.00	0.00	0.00
6	6.0	4.8	0.0	4999.9	0.5	0.00	0.00	0.00
7	7.0	5.8	3.0	4996.9	3.5	2.99	1.04	1.25
8	8.0	6.8	44.8	4952.1	48.3	44.67	15.55	1.25
9	9.0	7.8	62.8	4889.3	111.1	62.62	21.80	1.25
10	10.0	8.8	88.5	4800.8	199.6	88.24	30.72	1.25
11	11.0	9.9	55.1	4745.7	254.7	54.94	19.12	1.25
12	12.0	10.9	92.6	4653.1	347.3	92.33	32.14	1.25
13	13.0	11.9	73.4	4579.7	420.7	73.18	25.48	1.25
14	14.0	12.9	52.4	4527.3	473.1	52.25	18.19	1.25
15	15.0	13.9	12.6	4514.7	485.7	12.56	4.37	1.25
16	16.0	14.9	25.1	4489.6	510.8	25.03	8.71	1.25
17	17.1	15.9	2.4	4487.2	513.2	2.39	0.83	1.25
18	18.1	16.9	2.4	4484.8	515.6	2.39	0.83	1.25
19	19.1	17.9	7.2	4477.6	522.8	7.18	2.50	1.25
20	20.1	18.9	9.6	4468.0	532.4	9.57	3.33	1.25
21	21.1	19.9	14.5	4453.5	546.9	14.46	5.03	1.25
22	22.1	20.9	19.4	4434.1	566.3	19.34	6.73	1.25
23	23.1	21.9	42.0	4392.1	608.3	41.88	14.58	1.25
24	24.1	22.9	99.5	4292.6	707.8	99.21	34.53	1.25
25	25.1	23.9	6.3	4286.3	714.1	6.28	2.19	1.25
26	26.1	24.9	6.3	4280.0	720.4	6.28	2.19	1.25
27	27.1	25.9	6.3	4273.7	726.7	6.28	2.19	1.25
28	28.1	26.9	5.2	4268.5	731.9	5.18	1.80	1.25
29	29.1	27.9	25.1	4243.4	757.0	25.03	8.71	1.25
30	30.1	28.9	29.5	4213.9	786.5	29.41	10.24	1.25
31	31.1	29.9	29.5	4184.4	816.0	29.41	10.24	1.25
32	32.1	30.9	34.7	4149.7	850.7	34.60	12.04	1.25
33	33.1	31.9	34.7	4115.0	885.4	34.60	12.04	1.25
34	34.1	32.9	42.1	4072.9	927.5	41.98	14.61	1.25
35	35.1	33.9	87.9	3985.0	1015.4	87.64	30.51	1.25
36	36.1	34.9	87.9	3897.1	1103.3	87.64	30.51	1.25
37	37.1	35.9	87.9	3809.2	1191.2	87.64	30.51	1.25
38	38.1	36.9	78.6	3730.6	1269.8	78.37	27.28	1.25
39	39.1	37.9	89.8	3640.8	1359.6	89.54	31.17	1.25
40	40.1	38.9	101.1	3539.7	1460.7	100.80	35.09	1.25

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 5000.4; along Shaft 4420.4; at Toe 580.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
41	41.1	39.9	101.1	3438.6	1561.8	100.80	35.09	1.25
42	42.1	40.9	97.8	3340.8	1659.6	97.51	33.94	1.25
43	43.1	41.9	94.7	3246.1	1754.3	94.42	32.87	1.25
44	44.1	42.9	115.7	3130.4	1870.0	115.36	40.16	1.25
45	45.1	44.0	104.9	3025.5	1974.9	104.59	36.41	1.25
46	46.1	45.0	99.6	2925.9	2074.5	99.31	34.57	1.25
47	47.1	46.0	83.8	2842.1	2158.3	83.55	29.09	1.25
48	48.1	47.0	42.0	2800.1	2200.3	41.88	14.58	1.25
49	49.1	48.0	11.5	2788.6	2211.8	11.47	3.99	1.25
50	50.1	49.0	47.4	2741.2	2259.2	47.26	16.45	1.25
51	51.2	50.0	101.1	2640.1	2360.3	100.80	35.09	1.25
52	52.2	51.0	165.8	2474.3	2526.1	165.31	57.55	1.25
53	53.2	52.0	151.0	2323.3	2677.1	150.56	52.41	1.25
54	54.2	53.0	141.5	2181.8	2818.6	141.08	49.11	1.25
55	55.2	54.0	115.3	2066.5	2933.9	114.96	40.02	1.25
56	56.2	55.0	115.3	1951.2	3049.2	114.96	40.02	1.25
57	57.2	56.0	132.6	1818.6	3181.8	132.21	46.02	1.25
58	58.2	57.0	154.8	1663.8	3336.6	154.34	53.73	1.25
59	59.2	58.0	237.0	1426.8	3573.6	236.30	82.26	1.25
60	60.2	59.0	315.9	1110.9	3889.5	314.97	109.64	1.25
61	61.2	60.0	530.9	580.0	4420.4	529.34	184.27	1.25
Avg. Shaft			72.5			73.67	25.22	1.25
Toe			580.0				8176.04	0.50

*Guide friction or other non-soil resistance.

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(mm)	3.0	3.0
Case Damping Factor		1.88	0.10
Damping Type		Viscous	Sm+Visc
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	15	
Soil Plug Weight	(kN)	20.807	2.079

CAPWAP match quality = 2.90 (Wave Up Match) ; RSA = 0
Observed: Final Set = 3.0 mm; Blow Count = 333 b/m
Computed: Final Set = 3.1 mm; Blow Count = 323 b/m
Transducer F6 (O526) CAL: 149.0; RF: 1.00; F8 (O527) CAL: 149.9; RF: 1.00
A5 (56138) CAL: 930; RF: 1.00; A7 (56111) CAL: 955; RF: 1.00

max. Top Comp. Stress = 181.9 MPa (T= 22.2 ms, max= 1.034 x Top)
max. Comp. Stress = 188.1 MPa (Z= 8.0 m, T= 23.7 ms)
max. Tens. Stress = -14.29 MPa (Z= 8.0 m, T= 44.7 ms)
max. Energy (EMX) = 135.8 kJ; max. Measured Top Displ. (DMX)= 16.6 mm

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages m	max. Force kN	min. Force kN	max. Comp. Stress MPa	max. Tens. Stress MPa	max. Trnsfd. Energy kJ	max. Veloc. m/s	max. Displ. mm
1	1.0	12905.7	-610.9	181.9	-8.61	135.8	4.15	15.7
2	2.0	12900.3	-636.0	181.9	-8.96	135.7	4.15	15.6
5	5.0	12938.5	-684.8	182.4	-9.65	135.2	4.12	15.2
8	8.0	13344.9	-1013.7	188.1	-14.29	134.6	3.96	14.8
11	11.0	12810.5	-847.7	180.6	-11.95	123.1	3.75	14.5
14	14.0	11842.1	-751.3	166.9	-10.59	110.7	3.66	14.1
17	17.1	11406.6	-751.8	160.8	-10.60	105.5	3.64	13.7
20	20.1	11462.9	-775.9	161.6	-10.94	104.2	3.59	13.2
23	23.1	11508.1	-784.6	162.2	-11.06	101.1	3.48	12.7
26	26.1	10828.4	-733.9	152.6	-10.35	93.2	3.44	12.0
29	29.1	10941.2	-770.4	154.2	-10.86	91.1	3.38	11.3
32	32.1	10813.6	-808.2	152.4	-11.39	86.4	3.28	10.7
35	35.1	10777.5	-832.9	151.9	-11.74	81.2	3.10	10.0
38	38.1	10145.5	-772.0	143.0	-10.88	71.4	2.91	9.3
41	41.1	9574.3	-786.1	135.0	-11.08	62.4	2.71	8.6
44	44.1	8938.1	-756.0	126.0	-10.66	54.3	2.51	8.2
47	47.1	8026.1	-655.4	113.1	-9.24	46.8	2.40	8.0
50	50.1	7980.9	-577.8	112.5	-8.14	43.6	2.25	7.7
53	53.2	7545.2	-480.0	106.4	-6.77	37.4	2.05	7.3
56	56.2	6929.8	-376.9	97.7	-5.31	30.2	1.86	7.0
59	59.2	5231.5	-290.1	73.7	-4.09	23.3	2.20	6.7
61	61.2	2696.5	-154.7	38.0	-2.18	4.9	2.32	6.5
Absolute	8.0			188.1			(T =	23.7 ms)
	8.0				-14.29		(T =	44.7 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	13100	11893	10685	9477	8270	7062	5855	4647	3439	2232
RX	13100	11893	10685	9477	8270	7062	5855	4647	3439	2232
RU	13974	12853	11733	10613	9492	8372	7252	6131	5011	3891

RAU = 1140 (kN); RA2 = 2861 (kN)

Current CAPWAP Ru = 5000 (kN); Corresponding J(RP)= 0.67; J(RX) = 0.67

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
m/s	ms	kN	kN	kN	mm	mm	mm	kJ	kN	kN/mm
4.21	21.97	12350	12826	12868	16.6	3.0	3.0	136.9	13967	193

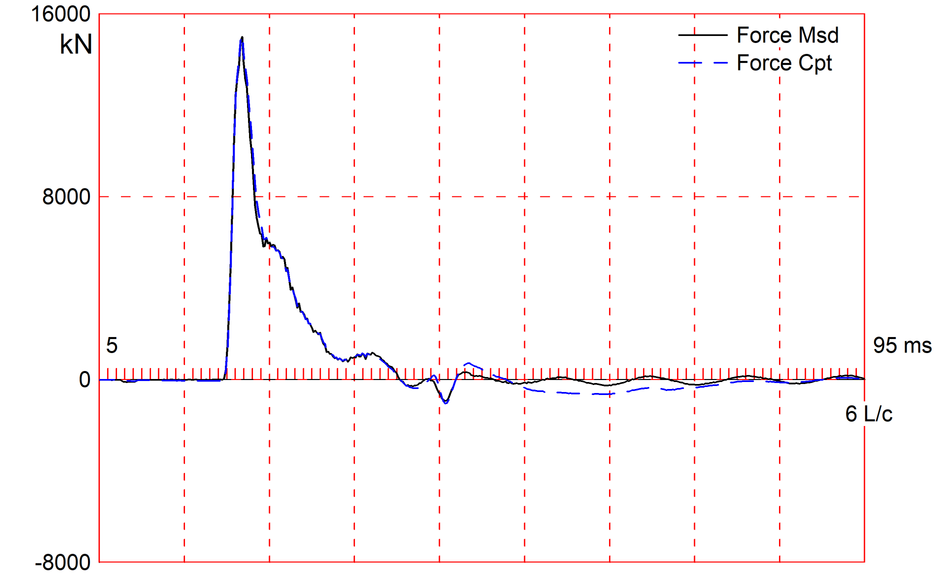
PILE PROFILE AND PILE MODEL

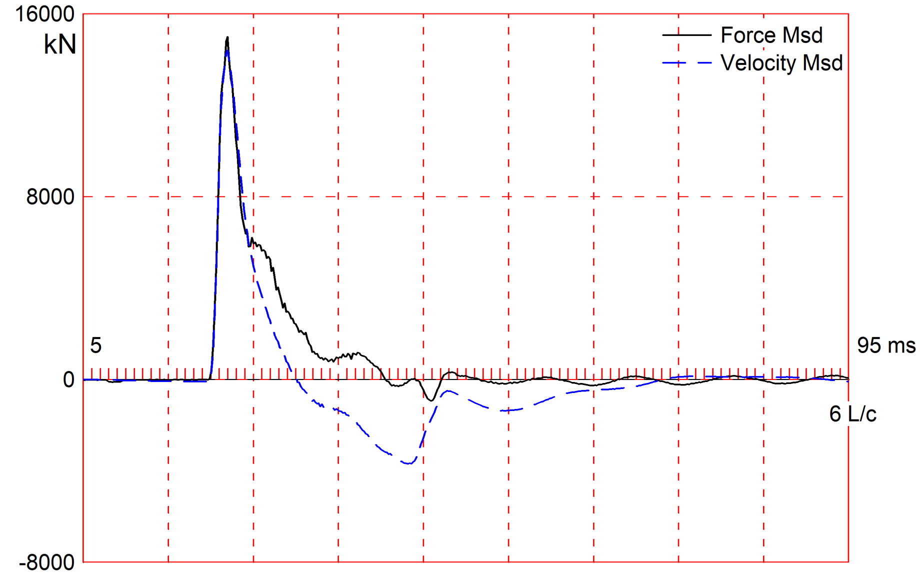
Depth	Area	E-Modulus	Spec. Weight	Perim.
m	cm^2	MPa	kN/m^3	m
0.0	709.4	217222.3	77.287	2.87
61.2	709.4	217222.3	77.287	2.87

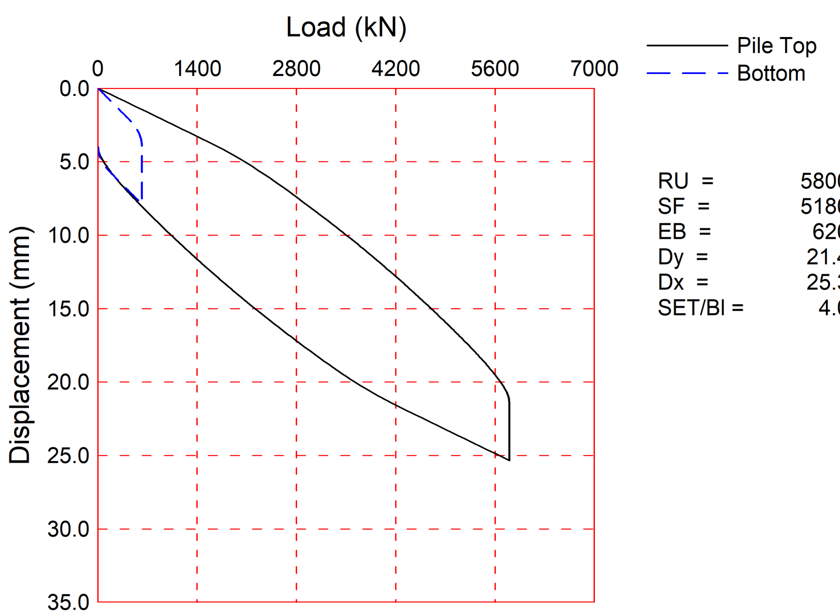
Toe Area 709.4 cm^2

Segmnt Number	Dist. B.G.	Impedance	Imped. Change	Tension Slack	Tension Eff.	Compression Slack	Compression Eff.	Perim.	Wave Speed	Soil Plug
	m	kN/m/s	%	mm		mm		m	m/s	kN
1	1.0	2935.2	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.000
2	2.0	2935.2	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.350
3	3.0	2935.2	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.347
61	61.2	2935.2	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.347

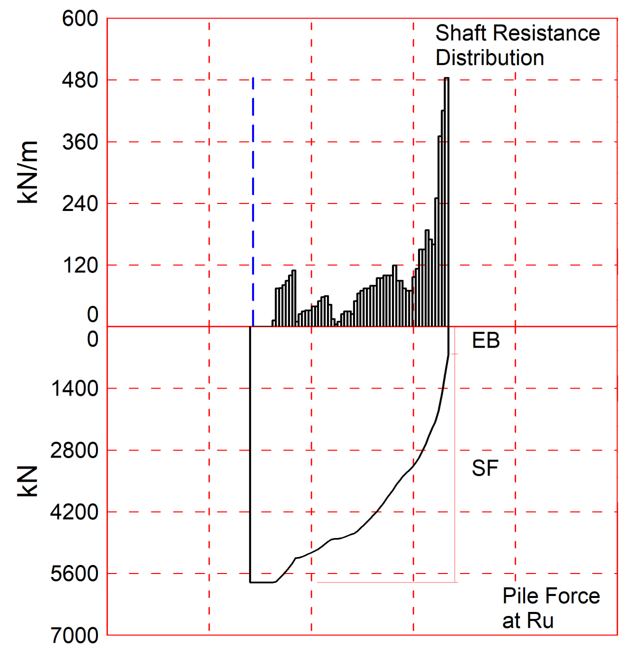
Wave Speed: Pile Top 5250.0, Elastic 5250.0, Overall 5250.0 m/s
Pile Damping 1.00 %, Time Incr 0.191 ms, 2L/c 23.3 ms
Total volume: 4.340 m^3; Volume ratio considering added impedance: 1.000







RU	=	5800 kN
SF	=	5180 kN
EB	=	620 kN
Dy	=	21.4 mm
Dx	=	25.3 mm
SET/Bl	=	4.0 mm



Length b. Sensors	61.2 m
Embedment	60.0 m
Top Area	709.1 cm^2
End Bearing Area	709.1 cm^2
Top Perimeter	2.87 m
Top E-Modulus	217222 MPa
Top Spec. Weight	77.3 kN/m^3
Top Wave Spd.	5250 m/s
Overall W.S.	5250 m/s
Match Quality	2.85
Top Compr. Stress	212.4 MPa
Max Compr. Stress	220.5 MPa
Max Tension Stress	-24.46 MPa
Avg. Shaft Quake	3.0 mm
Toe Quake	3.0 mm
Avg. Shaft Smith Dpg.	0.90 s/m
Toe Smith Damping	0.50 s/m

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal “match quality” (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 5799.8; along Shaft 5179.8; at Toe 620.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
				5799.8				
1	2.0	0.8	0.6	5799.2	0.6	0.74	0.26	0.90
2	3.0	1.8	0.0	5799.2	0.6	0.00	0.00	0.00
3	4.0	2.8	0.0	5799.2	0.6	0.00	0.00	0.00
4	5.0	3.8	0.0	5799.2	0.6	0.00	0.00	0.00
5	6.0	4.8	0.0	5799.2	0.6	0.00	0.00	0.00
6	7.0	5.8	0.0	5799.2	0.6	0.00	0.00	0.00
7	8.0	6.8	12.7	5786.5	13.3	12.66	4.41	0.90
8	9.0	7.8	75.4	5711.1	88.7	75.15	26.17	0.90
9	10.0	8.8	75.7	5635.4	164.4	75.45	26.28	0.90
10	11.0	9.8	81.3	5554.1	245.7	81.03	28.22	0.90
11	12.0	10.8	90.4	5463.7	336.1	90.10	31.38	0.90
12	13.0	11.8	100.5	5363.2	436.6	100.17	34.89	0.90
13	14.0	12.8	110.5	5252.7	547.1	110.14	38.36	0.90
14	15.0	13.8	10.0	5242.7	557.1	9.97	3.47	0.90
15	16.1	14.9	25.1	5217.6	582.2	25.02	8.71	0.90
16	17.1	15.9	30.1	5187.5	612.3	30.00	10.45	0.90
17	18.1	16.9	32.5	5155.0	644.8	32.39	11.28	0.90
18	19.1	17.9	32.5	5122.5	677.3	32.39	11.28	0.90
19	20.1	18.9	40.2	5082.3	717.5	40.07	13.95	0.90
20	21.1	19.9	40.2	5042.1	757.7	40.07	13.95	0.90
21	22.1	20.9	50.2	4991.9	807.9	50.04	17.43	0.90
22	23.1	21.9	58.3	4933.6	866.2	58.11	20.24	0.90
23	24.1	22.9	60.3	4873.3	926.5	60.10	20.93	0.90
24	25.1	23.9	43.3	4830.0	969.8	43.16	15.03	0.90
25	26.1	24.9	15.0	4815.0	984.8	14.95	5.21	0.90
26	27.1	25.9	5.0	4810.0	989.8	4.98	1.74	0.90
27	28.1	26.9	10.1	4799.9	999.9	10.07	3.51	0.90
28	29.1	27.9	25.1	4774.8	1025.0	25.02	8.71	0.90
29	30.1	28.9	30.1	4744.7	1055.1	30.00	10.45	0.90
30	31.1	29.9	30.1	4714.6	1085.2	30.00	10.45	0.90
31	32.1	30.9	25.1	4689.5	1110.3	25.02	8.71	0.90
32	33.1	31.9	50.2	4639.3	1160.5	50.04	17.43	0.90
33	34.1	32.9	65.4	4573.9	1225.9	65.19	22.70	0.90
34	35.1	33.9	70.4	4503.5	1296.3	70.17	24.44	0.90
35	36.1	34.9	75.3	4428.2	1371.6	75.05	26.14	0.90
36	37.1	35.9	75.3	4352.9	1446.9	75.05	26.14	0.90
37	38.1	36.9	80.4	4272.5	1527.3	80.14	27.91	0.90
38	39.1	37.9	80.4	4192.1	1607.7	80.14	27.91	0.90
39	40.1	38.9	95.4	4096.7	1703.1	95.09	33.12	0.90
40	41.1	39.9	95.4	4001.3	1798.5	95.09	33.12	0.90

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 5799.8; along Shaft 5179.8; at Toe 620.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
41	42.1	40.9	100.5	3900.8	1899.0	100.17	34.89	0.90
42	43.1	41.9	100.5	3800.3	1999.5	100.17	34.89	0.90
43	44.1	42.9	100.5	3699.8	2100.0	100.17	34.89	0.90
44	45.1	43.9	120.1	3579.7	2220.1	119.71	41.69	0.90
45	46.2	45.0	90.1	3489.6	2310.2	89.81	31.28	0.90
46	47.2	46.0	90.1	3399.5	2400.3	89.81	31.28	0.90
47	48.2	47.0	75.3	3324.2	2475.6	75.05	26.14	0.90
48	49.2	48.0	70.4	3253.8	2546.0	70.17	24.44	0.90
49	50.2	49.0	70.4	3183.4	2616.4	70.17	24.44	0.90
50	51.2	50.0	97.5	3085.9	2713.9	97.18	33.84	0.90
51	52.2	51.0	113.2	2972.7	2827.1	112.83	39.29	0.90
52	53.2	52.0	151.0	2821.7	2978.1	150.51	52.42	0.90
53	54.2	53.0	151.0	2670.7	3129.1	150.51	52.42	0.90
54	55.2	54.0	188.6	2482.1	3317.7	187.98	65.47	0.90
55	56.2	55.0	170.8	2311.3	3488.5	170.24	59.29	0.90
56	57.2	56.0	160.7	2150.6	3649.2	160.17	55.78	0.90
57	58.2	57.0	251.1	1899.5	3900.3	250.28	87.16	0.90
58	59.2	58.0	371.7	1527.8	4272.0	370.49	129.03	0.90
59	60.2	59.0	422.3	1105.5	4694.3	420.92	146.59	0.90
60	61.2	60.0	485.5	620.0	5179.8	483.91	168.53	0.90
Avg. Shaft			86.3			86.33	30.07	0.90
Toe			620.0				8743.84	0.50

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(mm)	3.0	3.0
Case Damping Factor		1.59	0.11
Damping Type		Viscous	Sm+Visc
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	15	
Soil Plug Weight	(kN)	18.033	2.500

CAPWAP match quality = 2.85 (Wave Up Match) ; RSA = 0
Observed: Final Set = 4.0 mm; Blow Count = 250 b/m
Computed: Final Set = 3.9 mm; Blow Count = 258 b/m
Transducer F3 (O073) CAL: 145.6; RF: 1.00; F4 (N679) CAL: 147.9; RF: 1.00
A1 (55452) CAL: 955; RF: 1.00; A2 (55450) CAL: 915; RF: 1.00

max. Top Comp. Stress = 212.4 MPa (T= 22.2 ms, max= 1.038 x Top)
max. Comp. Stress = 220.5 MPa (Z= 9.0 m, T= 23.7 ms)
max. Tens. Stress = -24.46 MPa (Z= 9.0 m, T= 44.3 ms)
max. Energy (EMX) = 180.9 kJ; max. Measured Top Displ. (DMX)= 18.7 mm

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages m	max. Force kN	min. Force kN	max. Comp. Stress MPa	max. Tens. Stress MPa	max. Trnsfd. Energy kJ	max. Veloc. m/s	max. Displ. mm
1	1.0	15057.3	-1148.1	212.4	-16.19	180.9	4.89	18.2
2	2.0	15039.2	-1209.9	212.1	-17.06	180.6	4.89	18.0
5	5.0	15102.2	-1531.7	213.0	-21.60	179.9	4.89	17.5
8	8.0	15500.1	-1719.0	218.6	-24.24	179.2	4.76	17.1
11	11.0	15272.6	-1544.2	215.4	-21.78	169.1	4.54	16.7
14	14.0	14266.7	-1130.6	201.2	-15.94	153.4	4.40	16.3
17	17.1	13708.0	-896.2	193.3	-12.64	145.0	4.31	15.8
20	20.1	13499.7	-883.6	190.4	-12.46	139.3	4.19	15.3
23	23.1	13231.9	-851.8	186.6	-12.01	132.0	4.08	14.8
26	26.1	12617.7	-805.8	177.9	-11.36	123.4	4.05	14.1
29	29.1	12648.8	-834.3	178.4	-11.77	120.9	3.99	13.5
32	32.1	12522.4	-973.4	176.6	-13.73	116.0	3.89	12.8
35	35.1	12309.3	-1099.2	173.6	-15.50	109.3	3.73	12.1
38	38.1	11869.2	-1160.0	167.4	-16.36	100.0	3.55	11.4
41	41.1	11402.3	-1176.6	160.8	-16.59	90.1	3.35	10.6
44	44.1	10805.2	-1133.2	152.4	-15.98	80.7	3.16	10.3
47	47.2	10084.6	-1075.5	142.2	-15.17	72.1	3.02	10.1
50	50.2	9710.5	-1021.7	136.9	-14.41	65.9	2.87	9.8
53	53.2	9447.7	-943.5	133.2	-13.31	58.9	2.65	9.4
56	56.2	8851.2	-764.0	124.8	-10.77	48.2	2.37	9.0
59	59.2	6615.6	-575.9	93.3	-8.12	35.9	2.87	8.7
61	61.2	2874.2	-282.9	40.5	-3.99	8.3	3.01	8.5
Absolute	9.0			220.5			(T =	23.7 ms)
	9.0				-24.46		(T =	44.3 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	15706	14293	12880	11467	10053	8640	7227	5814	4401	2988
RX	15706	14293	12880	11467	10053	8640	7227	5814	4401	2988
RU	16681	15365	14050	12734	11418	10102	8787	7471	6155	4840

RAU = 1027 (kN); RA2 = 3493 (kN)

Current CAPWAP Ru = 5800 (kN); Corresponding J(RP)= 0.70; J(RX) = 0.70

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
m/s	ms	kN	kN	kN	mm	mm	mm	kJ	kN	kN/mm
4.94	21.98	14499	15339	15339	18.7	4.0	4.0	181.5	15975	207

PILE PROFILE AND PILE MODEL

Depth	Area	E-Modulus	Spec. Weight	Perim.
m	cm^2	MPa	kN/m^3	m
0.0	709.1	217222.3	77.287	2.87
61.2	709.1	217222.3	77.287	2.87

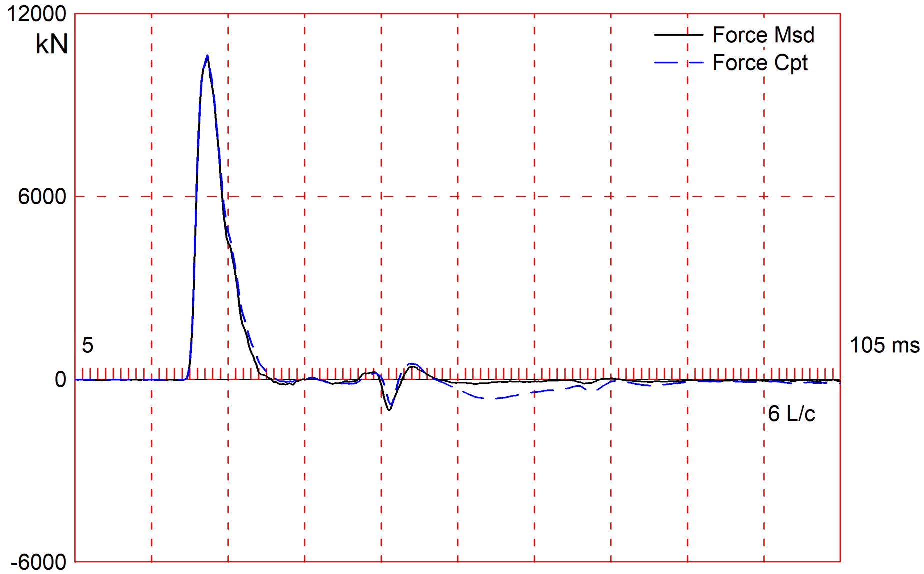
Toe Area 709.1 cm^2

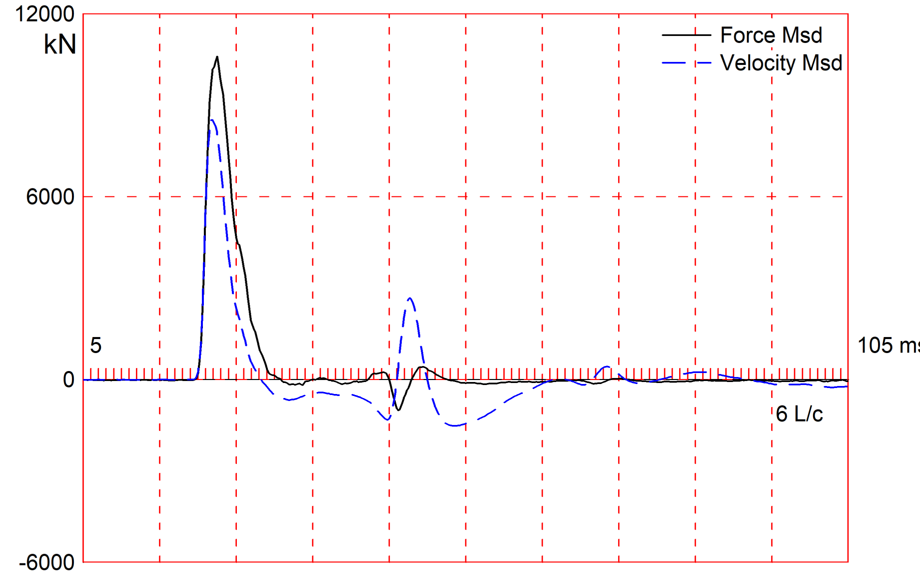
Segmnt Number	Dist. B.G.	Impedance	Imped. Change	Tension Slack	Tension Eff.	Compression Slack	Compression Eff.	Perim.	Wave Speed	Soil Plug
	m	kN/m/s	%	mm		mm		m	m/s	kN
1	1.0	2933.8	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.000
2	2.0	2933.8	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.300
61	61.2	2933.8	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.301

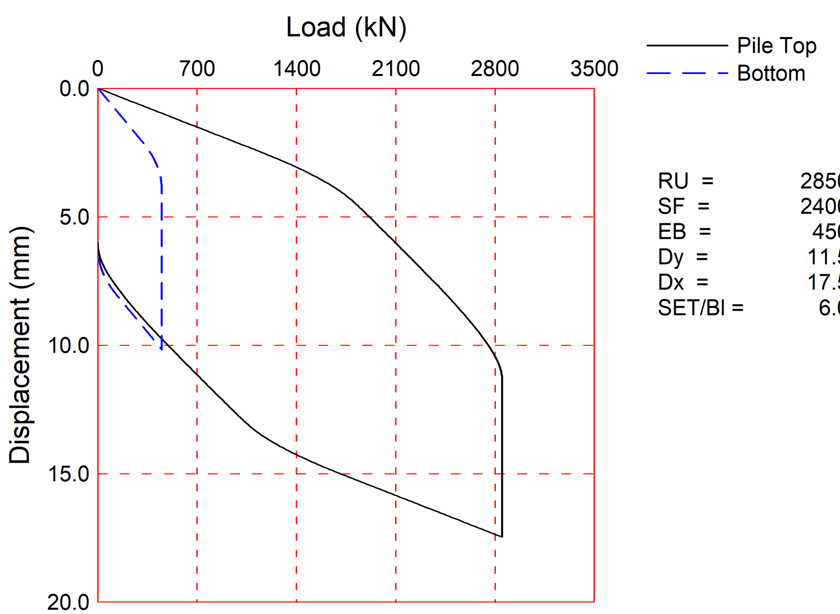
Wave Speed: Pile Top 5250.0, Elastic 5250.0, Overall 5250.0 m/s
Pile Damping 1.00 %, Time Incr 0.191 ms, 2L/c 23.3 ms
Total volume: 4.340 m^3; Volume ratio considering added impedance: 1.000

Livingstone Rd UP; Pile: Test Pile _6; eoid 2; Blow: 7 (Test: 07-Jun-2021 13:25:)
BC Ministry of Transportation (BC MOTI)

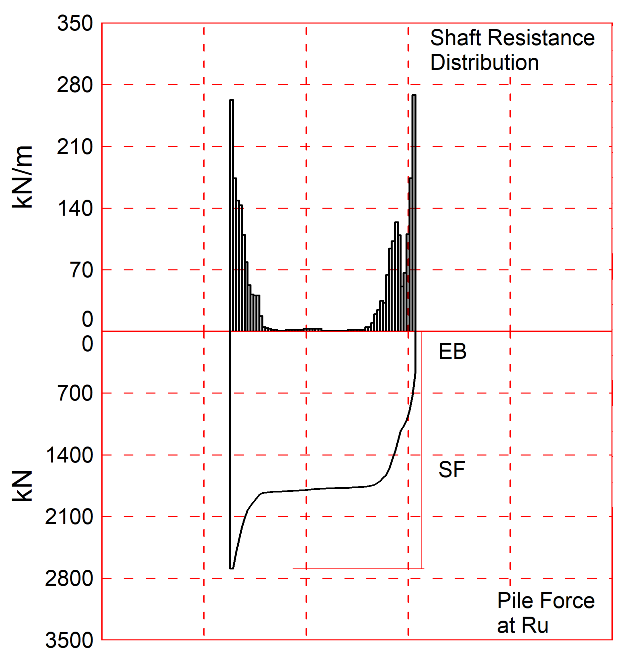
07-Jun-2021
CAPWAP(R) 2014-3







RU =	2850 kN
SF =	2400 kN
EB =	450 kN
Dy =	11.5 mm
Dx =	17.5 mm
SET/Bl =	6.0 mm



Length b. Sensors	63.6 m
Embedment	63.2 m
Top Area	709.1 cm^2
End Bearing Area	709.1 cm^2
Top Perimeter	2.87 m
Top E-Modulus	217222 MPa
Top Spec. Weight	77.3 kN/m^3
Top Wave Spd.	5250 m/s
Overall W.S.	5250 m/s
Match Quality	3.22
Top Compr. Stress	153.3 MPa
Max Compr. Stress	153.3 MPa
Max Tension Stress	-31.59 MPa
Avg. Shaft Quake	3.2 mm
Toe Quake	3.0 mm
Avg. Shaft Smith Dpg.	1.25 s/m
Toe Smith Damping	0.50 s/m

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal "match quality" (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 2849.9; along Shaft 2399.9; at Toe 450.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa
				2849.9			
1	1.0	0.6	160.2	2689.7	160.2	262.83	91.53
2	2.0	1.6	175.8	2513.9	336.0	174.14	60.65
3	3.0	2.6	149.9	2364.0	485.9	148.49	51.71
4	4.0	3.6	144.8	2219.2	630.7	143.43	49.95
5	5.0	4.6	110.7	2108.5	741.4	109.66	38.19
6	6.1	5.7	79.7	2028.8	821.1	78.95	27.49
7	7.1	6.7	53.1	1975.7	874.2	52.60	18.32
8	8.1	7.7	42.5	1933.2	916.7	42.10	14.66
9	9.1	8.7	41.3	1891.9	958.0	40.91	14.25
10	10.1	9.7	41.3	1850.6	999.3	40.91	14.25
11	11.1	10.7	17.6	1833.0	1016.9	17.43	6.07
12	12.1	11.7	5.2	1827.8	1022.1	5.15	1.79
13	13.1	12.7	4.1	1823.7	1026.2	4.06	1.41
14	14.1	13.7	3.1	1820.6	1029.3	3.07	1.07
15	15.1	14.7	2.1	1818.5	1031.4	2.08	0.72
16	16.2	15.8	2.1	1816.4	1033.5	2.08	0.72
17	17.2	16.8	1.0	1815.4	1034.5	0.99	0.34
18	18.2	17.8	1.0	1814.4	1035.5	0.99	0.34
19	19.2	18.8	1.0	1813.4	1036.5	0.99	0.34
20	20.2	19.8	2.1	1811.3	1038.6	2.08	0.72
21	21.2	20.8	2.1	1809.2	1040.7	2.08	0.72
22	22.2	21.8	2.1	1807.1	1042.8	2.08	0.72
23	23.2	22.8	2.1	1805.0	1044.9	2.08	0.72
24	24.2	23.8	2.1	1802.9	1047.0	2.08	0.72
25	25.2	24.8	2.1	1800.8	1049.1	2.08	0.72
26	26.2	25.8	3.1	1797.7	1052.2	3.07	1.07
27	27.3	26.9	3.1	1794.6	1055.3	3.07	1.07
28	28.3	27.9	3.1	1791.5	1058.4	3.07	1.07
29	29.3	28.9	3.1	1788.4	1061.5	3.07	1.07
30	30.3	29.9	3.1	1785.3	1064.6	3.07	1.07
31	31.3	30.9	3.1	1782.2	1067.7	3.07	1.07
32	32.3	31.9	1.0	1781.2	1068.7	0.99	0.34
33	33.3	32.9	1.0	1780.2	1069.7	0.99	0.34
34	34.3	33.9	1.0	1779.2	1070.7	0.99	0.34
35	35.3	34.9	1.0	1778.2	1071.7	0.99	0.34
36	36.3	35.9	1.0	1777.2	1072.7	0.99	0.34
37	37.4	37.0	1.0	1776.2	1073.7	0.99	0.34
38	38.4	38.0	1.0	1775.2	1074.7	0.99	0.34
39	39.4	39.0	1.0	1774.2	1075.7	0.99	0.34
40	40.4	40.0	1.0	1773.2	1076.7	0.99	0.34

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 2849.9; along Shaft 2399.9; at Toe 450.0 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa
41	41.4	41.0	2.1	1771.1	1078.8	2.08	0.72
42	42.4	42.0	2.1	1769.0	1080.9	2.08	0.72
43	43.4	43.0	2.1	1766.9	1083.0	2.08	0.72
44	44.4	44.0	2.1	1764.8	1085.1	2.08	0.72
45	45.4	45.0	2.1	1762.7	1087.2	2.08	0.72
46	46.4	46.0	2.1	1760.6	1089.3	2.08	0.72
47	47.4	47.0	5.2	1755.4	1094.5	5.15	1.79
48	48.5	48.1	5.2	1750.2	1099.7	5.15	1.79
49	49.5	49.1	10.0	1740.2	1109.7	9.91	3.45
50	50.5	50.1	20.1	1720.1	1129.8	19.91	6.93
51	51.5	51.1	25.1	1695.0	1154.9	24.86	8.66
52	52.5	52.1	35.1	1659.9	1190.0	34.77	12.11
53	53.5	53.1	33.1	1626.8	1223.1	32.79	11.42
54	54.5	54.1	65.2	1561.6	1288.3	64.58	22.49
55	55.5	55.1	95.3	1466.3	1383.6	94.40	32.88
56	56.5	56.1	103.4	1362.9	1487.0	102.42	35.67
57	57.5	57.1	125.4	1237.5	1612.4	124.22	43.26
58	58.6	58.2	110.4	1127.1	1722.8	109.36	38.09
59	59.6	59.2	51.7	1075.4	1774.5	51.21	17.84
60	60.6	60.2	67.2	1008.2	1841.7	66.57	23.18
61	61.6	61.2	111.7	896.5	1953.4	110.65	38.53
62	62.6	62.2	175.6	720.9	2129.0	173.94	60.58
63	63.6	63.2	270.9	450.0	2399.9	268.34	93.45
Avg. Shaft			38.1			37.97	13.22
Toe			450.0				6346.33

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		1.25	0.50
Quake	(mm)	3.2	3.0
Case Damping Factor		1.02	0.08
Damping Type		Viscous	Sm+Visc
Reloading Level	(% of Ru)	100	100
Soil Plug Weight	(kN)	15.500	2.000

CAPWAP match quality = 3.22 (Wave Up Match) ; RSA = 0
Observed: Final Set = 6.0 mm; Blow Count = 167 b/m
Computed: Final Set = 6.2 mm; Blow Count = 160 b/m
Transducer F3 (O073) CAL: 145.6; RF: 1.00; F4 (N679) CAL: 147.9; RF: 1.00
A1 (55452) CAL: 955; RF: 1.00; A2 (55450) CAL: 915; RF: 1.00

max. Top Comp. Stress = 153.3 MPa (T= 22.7 ms, max= 1.000 x Top)
max. Comp. Stress = 153.3 MPa (Z= 1.0 m, T= 22.7 ms)
max. Tens. Stress = -31.59 MPa (Z= 38.4 m, T= 39.4 ms)
max. Energy (EMX) = 80.0 kJ; max. Measured Top Displ. (DMX)= 10.2 mm

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages m	max. Force kN	min. Force kN	max. Comp. Stress MPa	max. Tens. Stress MPa	max. Trnsfd. Energy kJ	max. Veloc. m/s	max. Displ. mm
1	1.0	10871.1	-1340.9	153.3	-18.91	80.0	2.80	9.5
2	2.0	10364.4	-1718.2	146.2	-24.23	74.6	2.71	9.4
6	6.1	8416.7	-2052.8	118.7	-28.95	57.9	2.51	9.3
10	10.1	7698.3	-1755.4	108.6	-24.76	52.0	2.44	9.2
14	14.1	7455.2	-1804.0	105.1	-25.44	50.1	2.42	9.2
18	18.2	7439.6	-1881.6	104.9	-26.54	49.8	2.42	9.1
22	22.2	7432.6	-1948.5	104.8	-27.48	49.5	2.42	9.1
26	26.2	7422.3	-1921.2	104.7	-27.10	49.1	2.41	9.1
30	30.3	7387.7	-1984.5	104.2	-27.99	48.5	2.40	9.1
34	34.3	7362.5	-2148.8	103.8	-30.30	48.1	2.40	9.0
38	38.4	7370.6	-2239.7	103.9	-31.59	48.0	2.40	8.9
42	42.4	7372.5	-2154.2	104.0	-30.38	47.6	2.40	8.7
46	46.4	7385.2	-1945.4	104.2	-27.44	47.0	2.39	9.0
50	50.5	7491.9	-1391.5	105.7	-19.62	46.0	2.32	9.3
54	54.5	7662.8	-916.1	108.1	-12.92	42.5	2.15	9.5
58	58.6	6770.2	-647.1	95.5	-9.13	32.1	2.32	9.5
59	59.6	6309.4	-572.4	89.0	-8.07	28.9	2.55	9.5
60	60.6	5816.8	-527.0	82.0	-7.43	27.4	2.73	9.5
61	61.6	4881.8	-463.1	68.8	-6.53	25.3	2.87	9.5
62	62.6	3413.6	-357.5	48.1	-5.04	21.7	2.92	9.4
63	63.6	2252.3	-214.0	31.8	-3.02	7.2	2.91	9.4
Absolute	1.0			153.3			(T =	22.7 ms)
	38.4				-31.59		(T =	39.4 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	8595	7612	6630	5648	4665	3683	2701	1718	736	0
RX	8666	7650	6634	5648	4665	3683	2701	1718	1433	1418
RU	8154	7128	6102	5075	4049	3023	1996	970	0	0

RAU = 1334 (kN); RA2 = 2858 (kN)

Current CAPWAP Ru = 2850 (kN); Corresponding J(RP)= 0.58; J(RX) = 0.58

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
m/s	ms	kN	kN	kN	mm	mm	mm	kJ	kN	kN/mm
2.92	21.92	8580	9838	10679	10.2	6.0	6.0	81.4	10083	150

PILE PROFILE AND PILE MODEL

Depth	Area	E-Modulus	Spec. Weight	Perim.
m	cm^2	MPa	kN/m^3	m
0.0	709.1	217222.3	77.287	2.87
63.6	709.1	217222.3	77.287	2.87

Toe Area 709.1 cm^2

Segmnt Number	Dist. B.G.	Impedance	Imped. Change	Tension Slack	Tension Eff.	Compression Slack	Compression Eff.	Perim.	Wave Speed	Soil Plug
	m	kN/m/s	%	mm		mm		m	m/s	kN
1	1.0	2933.8	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.000
2	2.0	2933.8	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.250
63	63.6	2933.8	0.0	0.00	0.000	-0.00	0.000	2.87	5250.0	0.250

Wave Speed: Pile Top 5250.0, Elastic 5250.0, Overall 5250.0 m/s
Pile Damping 1.00 %, Time Incr 0.192 ms, 2L/c 24.2 ms
Total volume: 4.510 m^3; Volume ratio considering added impedance: 1.000