

## **2018 CGS-SOS Settlement Prediction Contest**

CGS-SOS is pleased to invite you to participate in the 2018 settlement prediction contest. All practitioners and students are encouraged to submit their predictions. This contest intends to provide an opportunity for geotechnical professionals to flex their brain muscles and showcase their expertise by estimating load-movement response (settlement) of a single close-ended steel pipe pile under static loading condition.

Please see below for the details of the problem and instructions for the submissions. All submissions will remain anonymous and only three top estimates will be announced and recognized at the 2018 CGS-SOS Christmas Dinner on December 10, 2018. The submission forms should be submitted via email by **5:00 p.m. on Friday, December 7, 2018**. The 2018 CGS-SOS Settlement Prediction Contest is sponsored by GHD.

### **1. Introduction**

Consideration was given to a deep foundation option comprised of a piled raft foundation to support a proposed development, as it was determined during the design that a shallow foundation option would experience settlements in excess of the serviceability limit states.

A static pile load test was completed on a close-ended 457 mm outside diameter (wall thickness 12.2 mm) steel pipe pile filled with concrete (Test Pile) at this site to assist with the design of the piled raft foundation. The static load test was completed in accordance with the procedure A (Quick Test) of the ASTM test method. The Test Pile was driven to a depth of 39.8 m below ground surface, as an end-bearing pile onto a till deposit at the site.

Prior to the static pile load test, Pile Dynamic Analyzer (PDA) testing was carried out on the Test Pile one day and seven days after the end of driving.

### **2. Test Pile Details and Available Subsurface Information**

Figure 1 shows the location of the Test Pile (designated as PT2-18) and boreholes drilled in the vicinity of the Test Pile. Before the static load test, the Test Pile was filled with concrete. The concrete inside the Test Pile was poured 6 days prior to the static load test with a compressive strength of 30.5 MPa.

The following items are provided:

1. Borehole Locations Plan;
2. Borehole Logs and CPT/SCPT logs; and,
3. PDA Test Results.

***The settlement of the Test Pile at 4,000 kN should be estimated.***



## 2018 Settlement Prediction Competition Submission Form

Name:

Date:

Organization (if applicable):

Contact Email:

Contact Phone Number:

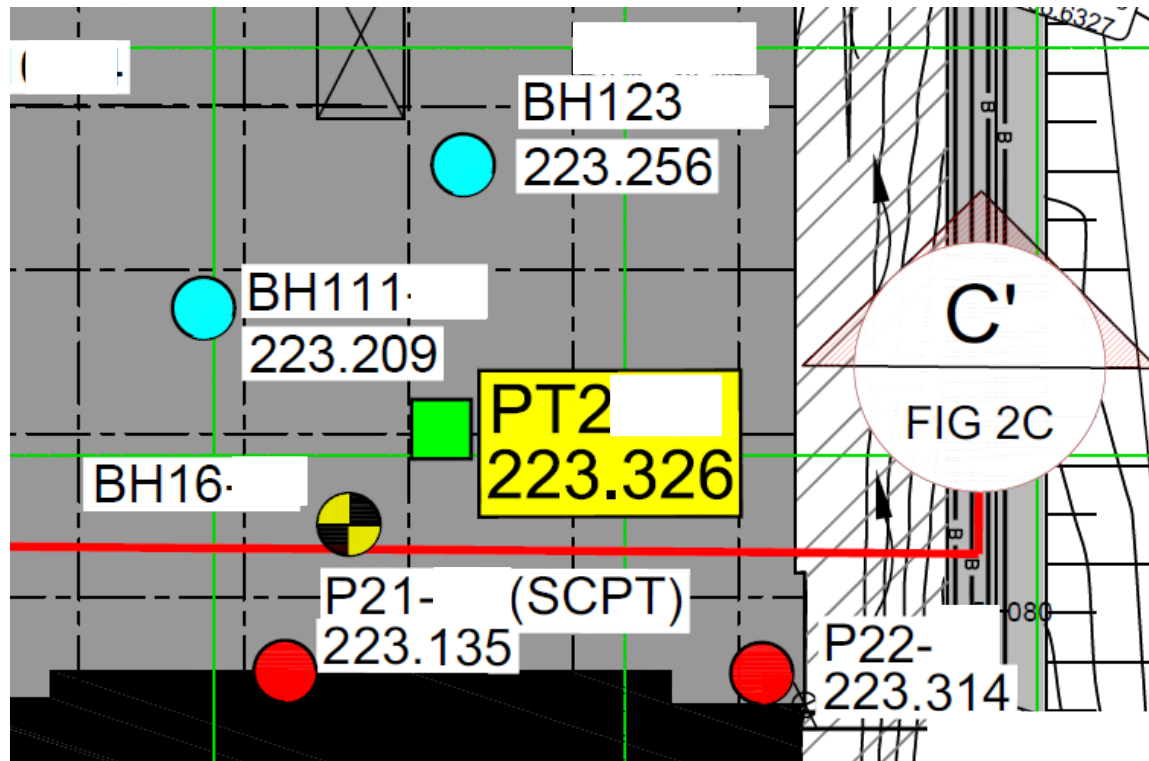
**The settlement of the Test Pile head at 4,000 kN is \_\_\_\_\_ mm.**

Please submit your submission form electronically to [Ali.NasseriM@GHD.com](mailto:Ali.NasseriM@GHD.com) by **5:00 p.m. on Friday, December 7, 2018.**

1. How did you develop the soil parameters for your analysis/assessment?
  - a) SPT Boreholes only
  - b) SPT and CPT Boreholes
  - c) Back-calculation from PDA results
  - d) Other
  
2. What method did you use for your settlement prediction?
  - a) Application of the Elastic Theory (Poulos and Davis)
  - b) Semi-empirical Method (Vesic, 1977)
  - c) Closed-form solutions based on Analytical Methods
  - d) Load-Transfer (t-z curves) Method
  - e) Scientific Wild Guess Method
  - f) Other:

WEBSITE: [WWW.CGS-SOS.CA](http://WWW.CGS-SOS.CA)

LINKEDIN: [HTTPS://WWW.LINKEDIN.COM/COMPANY/CGS-SOS/](https://WWW.LINKEDIN.COM/COMPANY/CGS-SOS/)



Note:

- BH - Borehole
- PT - Test Pile
- P19 - Cone Penetration Test
- SCPT - Seismic Cone Penetration Test

## BOREHOLE LOCATION PLAN





**BOREHOLE No.:** BH16  
**ELEVATION:** 223.16 m

**BOREHOLE REPORT**

Page: 3 of 3

CLIENT: \_\_\_\_\_

PROJECT: \_\_\_\_\_

LOCATION: \_\_\_\_\_

DESCRIBED BY: \_\_\_\_\_

DATE (START): \_\_\_\_\_

**LEGEND**

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ▮ RC - ROCK CORE
- ▼ - WATER LEVEL

Depth	Elevation (m)		Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR	Shear test (Cu) Sensitivity (S)		△ Field	
	Feet	Metres									w <sub>p</sub>	w <sub>L</sub>	□ Lab	
		223.16		GROUND SURFACE			%			N	10 20 30 40 50 60 70 80 90			
75		23.0	▨	very stiff	☒	SS-29	100	23	4-4-5-6	9	● ○			
76														
77														
78														
79		24.0												
80			▨	SILTY CLAY TILL, some gravel, grey, very moist, very stiff	☒	SS-30	100	24	7-8-8-11	16	● ○			
81														
82		25.0												
83														
84		25.46 197.70												
85														
86		26.0					☒	SS-31	100	12	4-8-15-13	23	○ ●	
87														
88														
89		27.0					☒	SS-32	100	13	5-9-10-15	19	○ ●	
90			▨	hard	☒	SS-33	100	14	6-13-19-18	32	○ ●			
91														
92		28.0												
93														
94														
95		29.0					☒	SS-34	100	11	4-8-26-26	34	○ ●	
96														
97														
98		30.0												
99														
100														
101		31.0												
102		31.10 192.06												
103														
104														
105		32.0												
106														
107														
108		33.0												
109														
110														
111														

**END OF BOREHOLE:**

NOTE :  
 End of Borehole at 31.1 m bgs  
 Groundwater level measured at 4.29 m bgs upon completion  
 Borehole backfilled and sealed to the top with cement grout  
 bgs denotes 'below ground surface'  
 NP denotes 'Non-Plastic'  
 LL denotes Liquid Limit  
 PL denotes Plastic Limit

**BOREHOLE No.:** BH111

**ELEVATION:** 223.21 m

**BOREHOLE REPORT**

Page: 1 of 4

CLIENT: \_\_\_\_\_





PROJECT: \_\_\_\_\_




LOCATION: \_\_\_\_\_

DESCRIBED BY: \_\_\_\_\_ CHECKED BY: \_\_\_\_\_

DATE (START): 2 DATE (FINISH): \_\_\_\_\_

**LEGEND**

-  SS - SPLIT SPOON
-  ST - SHELBY TUBE
-  RC - ROCK CORE
-  - WATER LEVEL

Depth	Elevation (m)		Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR	Shear test (Cu) Sensitivity (S)										Field	
	Feet	Metres									Atterberg limits (%)											Lab
GROUND SURFACE												N										
		223.21					%					10	20	30	40	50	60	70	80	90		
1	0.05	223.16		TOPSOIL : 50 mm		SS-1	87	19	2-3-6-9	9	●	○									m	
2	0.55	222.66		FILL : SILT, oxidized seams, brown, moist, loose																		
3	1.0			NATIVE : SILT, trace clay, oxidized seams, grey, moist to very moist, loose																		
4																						
5																						
6	2.0					SS-2	50	21	3-4-3-7	7	●	○										
7																						
8																						
9																						
10	3.0			trace sand, grey, compact																		
11						SS-3	75	18	5-6-7-7	13	●	○										
12																						
13	4.0																					
14																						
15																						
16	5.0					SS-4		14	6-11-12-9	23	○	●										
17																						
18																						
19																						
20	6.0			Gravel 0%, Sand 8%, Silt 82%, Clay 10%; NP		SS-5	61	21	4-7-6	11	●	○										
21																						
22																						
23	7.0			SHELBY TUBE at 6.86 m bgs		ST-5	100	20		--												
24																						
25																						
26	8.0					SS-6	75	20	6-6-8-10	14	●	○										
27																						
28																						
29																						
30	9.0																					
31						SS-7	75	24	4-8-9-13	17	●	○										
32																						
33	10.0																					
34																						
35																						
36	11.0					SS-8	87	19	7-9-13-15	22	●											
37																						
38																						
39	12.0																					

Bentonite Grout

WL 2.03 m  
25/05/2016

2.59 m  
Bentonite Seal

3.05 m  
Sand

Screen

5.03 m

**BOREHOLE No.:** BH111

**ELEVATION:** 223.21 m

**BOREHOLE REPORT**

Page: 2 of 4

CLIENT: \_\_\_\_\_

PROJECT: \_\_\_\_\_

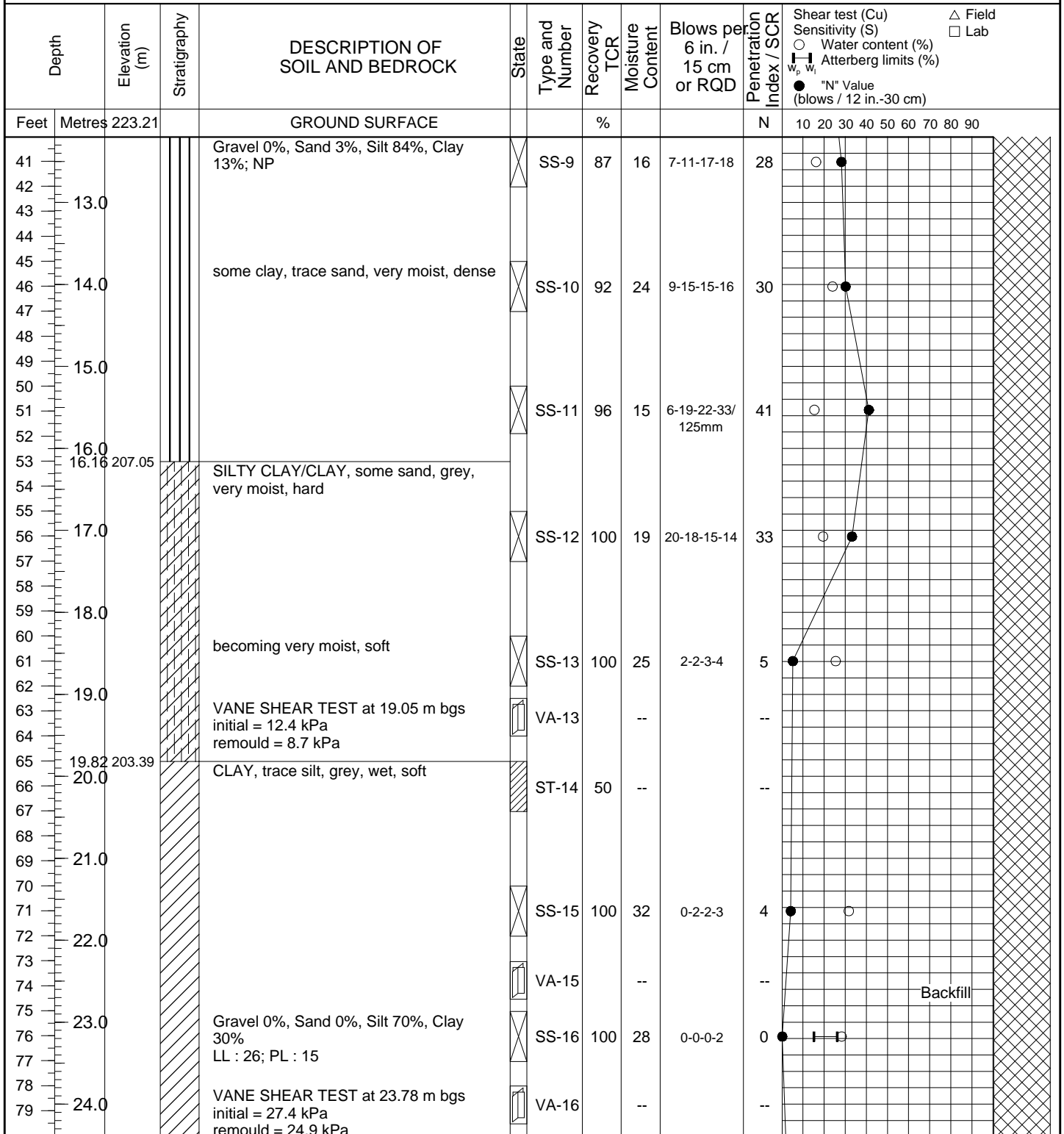
LOCATION: \_\_\_\_\_

DESCRIBED BY: \_\_\_\_\_

DATE (START): \_\_\_\_\_

**LEGEND**

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ▮ RC - ROCK CORE
- ▼ - WATER LEVEL



Backfill





**BOREHOLE No.:** BH111

**ELEVATION:** 223.21 m

**BOREHOLE REPORT**

Page: 4 of 4

CLIENT: \_\_\_\_\_

PROJECT: \_\_\_\_\_

LOCATION: \_\_\_\_\_

DESCRIBED BY: \_\_\_\_\_

DATE (START): \_\_\_\_\_

**LEGEND**

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ▮ RC - ROCK CORE
- ▼ - WATER LEVEL

Depth	Elevation (m)		Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR	Shear test (Cu) Sensitivity (S)		△ Field
	Feet	Metres									w <sub>p</sub>	w <sub>L</sub>	□ Lab
		223.21		GROUND SURFACE			%			N	10 20 30 40 50 60 70 80 90		
121	36.59	186.62	[Hatched Box]	SILTY SAND with GRAVEL, grey, moist, dense	☒	SS-25	42	9	18-16-19-19	35	○	●	
122	37.0												
123													
124													
125	38.0			very dense	☒	SS-26	42	12	18-37-36-24	73	▮	●	
126				Gravel 13%, Sand 55%, Silt 22%, Clay 10%									
127				LL : 14%, PL : 9%									
128	39.0												
129													
130	39.64	183.57		becoming compact	☒	SS-27	100	15	4-4-9-24	13	●		
131	40.0												
132													
133				<b>END OF BOREHOLE:</b>									
134				NOTE :									
135	41.0			End of Borehole at 40.25 m bgs									
136				Borehole remained dry upon completion									
137				Groundwater level at 2.03 m bgs depth on May 25, 2016									
138	42.0			50 mm diameter monitoring well installed at 5.03 m bgs									
139				bgs denotes 'below ground surface'									
140				NP denotes 'Non-Plastic'									
141	43.0			LL denotes 'Liquid Limit'									
142				PL denotes 'Plastic Limit'									
143													
144	44.0												
145													
146													
147	45.0												
148													
149													
150	46.0												
151													
152	47.0												
153													
154	48.0												
155													
156													
157													
158													
159													

40.25 m

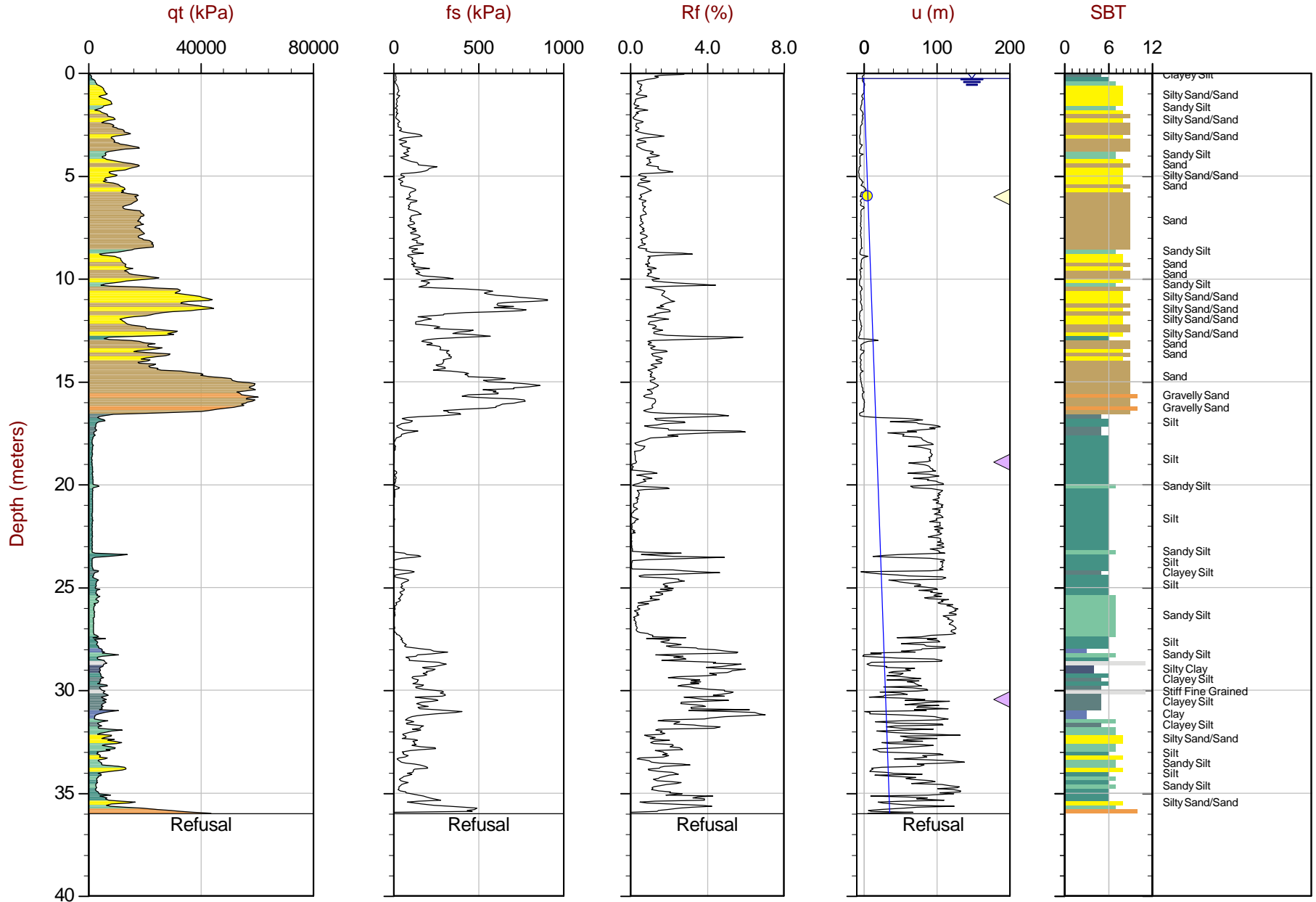








Sounding: SCPT P21  
Cone: 452:T1500F15U500

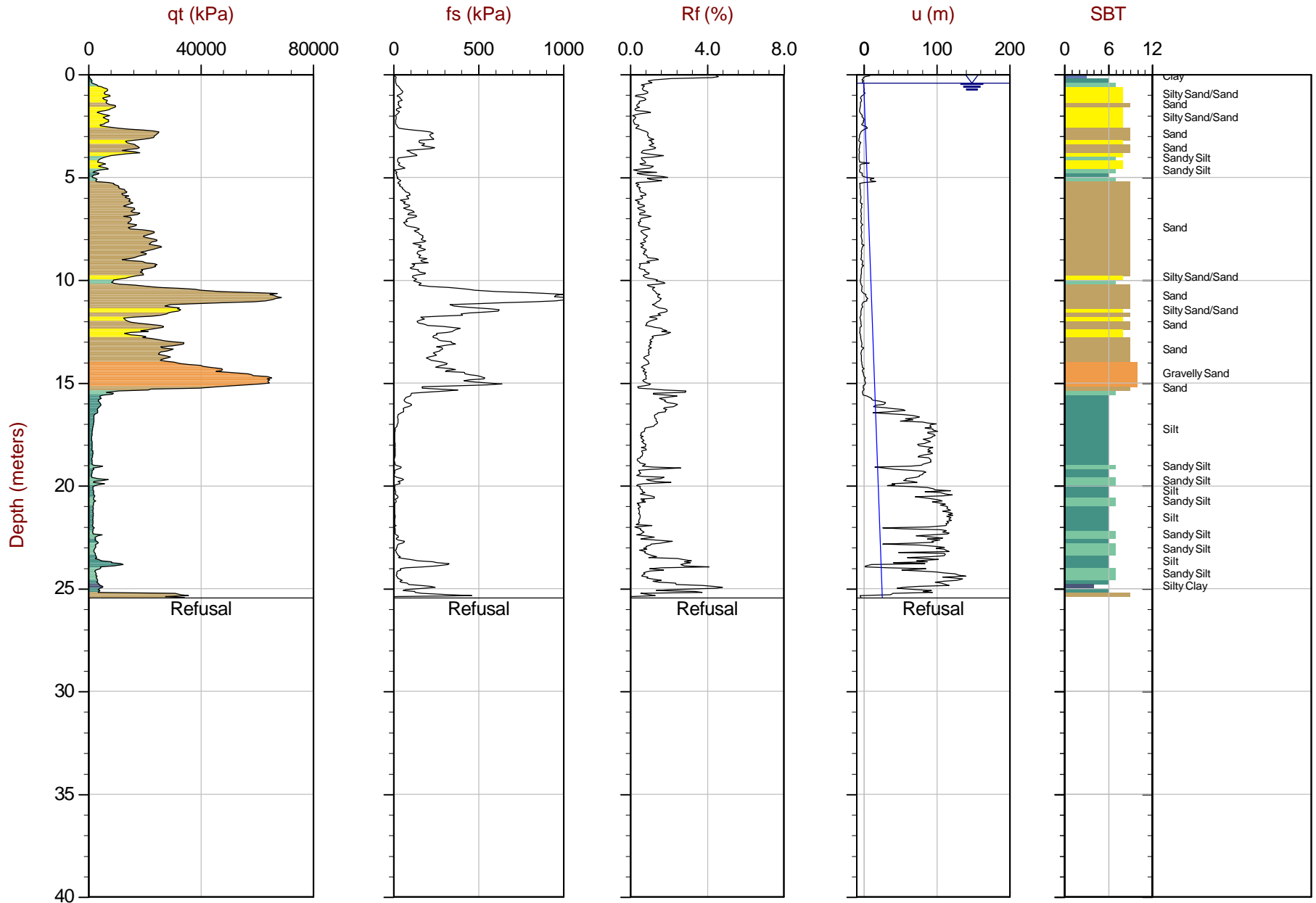


Max Depth: 36.000 m / 118.11 ft  
Depth Inc: 0.050 m / 0.164 ft  
Avg Int: 0.200 m

File: UnitWt: SBTZones

● Equilibrium Pore Pressure (Ueq)    ● Assumed Ueq    ◀ Dissipation, Ueq achieved    ◀ Dissipation, Ueq not achieved    — Hydrostatic Line

Sounding: CPT P22-  
Cone: 452:T1500F15U500



Max Depth: 25.450 m / 83.50 ft  
Depth Inc: 0.050 m / 0.164 ft  
Avg Int: 0.200 m

File: UnitWt: SBTZones

● Equilibrium Pore Pressure (Ueq)

● Assumed Ueq

◀ Dissipation, Ueq achieved

◀ Dissipation, Ueq not achieved

— Hydrostatic Line



## DYNAMIC TESTING OF PILES

**Client :**  
**Project :**

**File no :**  
**Date :**  
**Page :**

PILE CHARACTERISTICS AND PILE DRIVING ANALYZER RESULTS		
Pile No.		PT 2
Pile type et dimensions		Closed ended Steel pipe pile 457 x 12.2 mm
Inclination		Vertical
Initial Driving or Restrike		Beginning of restrike
Date of test		One - day after End of driving
Embedded pile length (m)		39.80
Cross section (mm <sup>2</sup> )		17 062
Type and ram weight (kN)		Diesel hammer (D46-32) 45.1 kN
Hammer blow rate (BPM)		38
Stroke (m)		2.86
Potential energy (kJ)		129.0
Maximum energy transferred to pile (kJ)		82.8
Energy ratio transferred (%)		64
Maximum measured compression force (kN)		4053
Maximum compression stress (MPa)		238
Final displacement (mm)		0.1
Mobilized static bearing capacity (Case Method) (kN)		3494.2 <sup>(1)</sup>
Target load (kN)		5300
Estimated shaft resistance (kN)		507.0
Estimated percentage of shaft resistance (%)		14.5
Estimated unit shaft resistance (kPa)		8.87
Estimated end bearing capacity (kN)		2987.2
Percentage of end bearing capacity (%)		85.5
<b>Notes :</b>		
<p><i>T The pile driving analyses of the test piles were carried out in accordance with ASTM D 4945-17.</i></p> <p>(1) CAPWAP analysis.</p>		
<b>Comments :</b>		

## DYNAMIC TESTING OF PILES

**Client :**  
**Project :**

**File no :**  
**Date :**  
**Page :**

PILE CHARACTERISTICS AND PILE DRIVING ANALYZER RESULTS		
Pile No.	PT 2	
Pile type et dimensions	Closed ended Steel pipe pile 457 x 12.2 mm	
Inclination	Vertical	
Initial Driving or Restrike	Beginning of restrike	
Date of test	7 - days after end of driving	
Embedded pile length (m)	39.80	
Cross section (mm <sup>2</sup> )	17 062	
Type and ram weight (kN)	Diesel hammer (D46-32) 45.1 kN	
Hammer blow rate (BPM)	39.3	
Stroke (m)	2.77	
Potential energy (kJ)	124.9	
Maximum energy transferred to pile (kJ)	79.0	
Energy ratio transferred (%)	63	
Maximum measured compression force (kN)	4445	
Maximum compression stress (MPa)	269	
Final displacement (mm)	0.4	
Mobilized static bearing capacity (Case Method) (kN)	3914.6 <sup>(1)</sup>	
Target load (kN)	5300	
Estimated shaft resistance (kN)	1104.3	-
Estimated percentage of shaft resistance (%)	28.2	-
Estimated unit shaft resistance (kPa)	19.33	-
Estimated end bearing capacity (kN)	2810.3	-
Percentage of end bearing capacity (%)	71.8	-
<b>Notes :</b>		
The pile driving analyses of the test piles were carried out in accordance with <b>ASTM D 4945-17</b> .		
<sup>(1)</sup> CAPWAP analysis.		
<b>Comments :</b>		