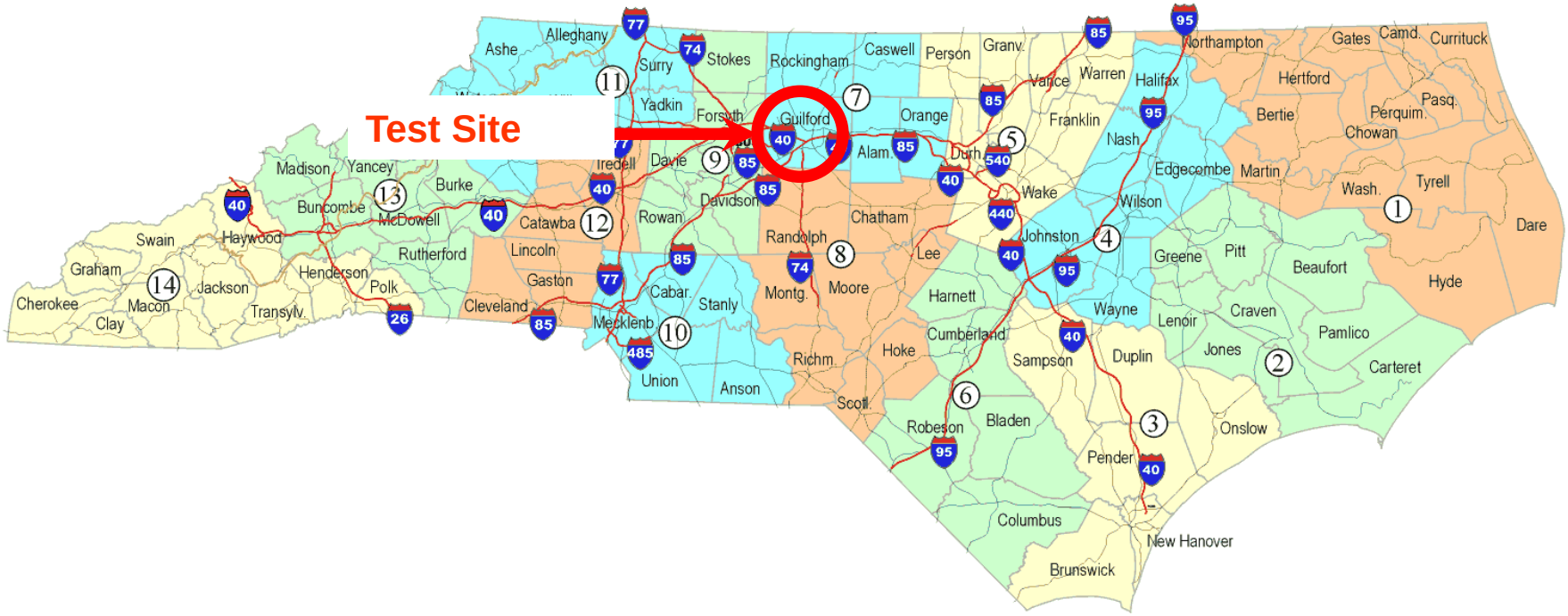
Instrumentation of Steel Sheet Pile Wall and Steep Cut Slopes in Piedmont Residual Soils for Research

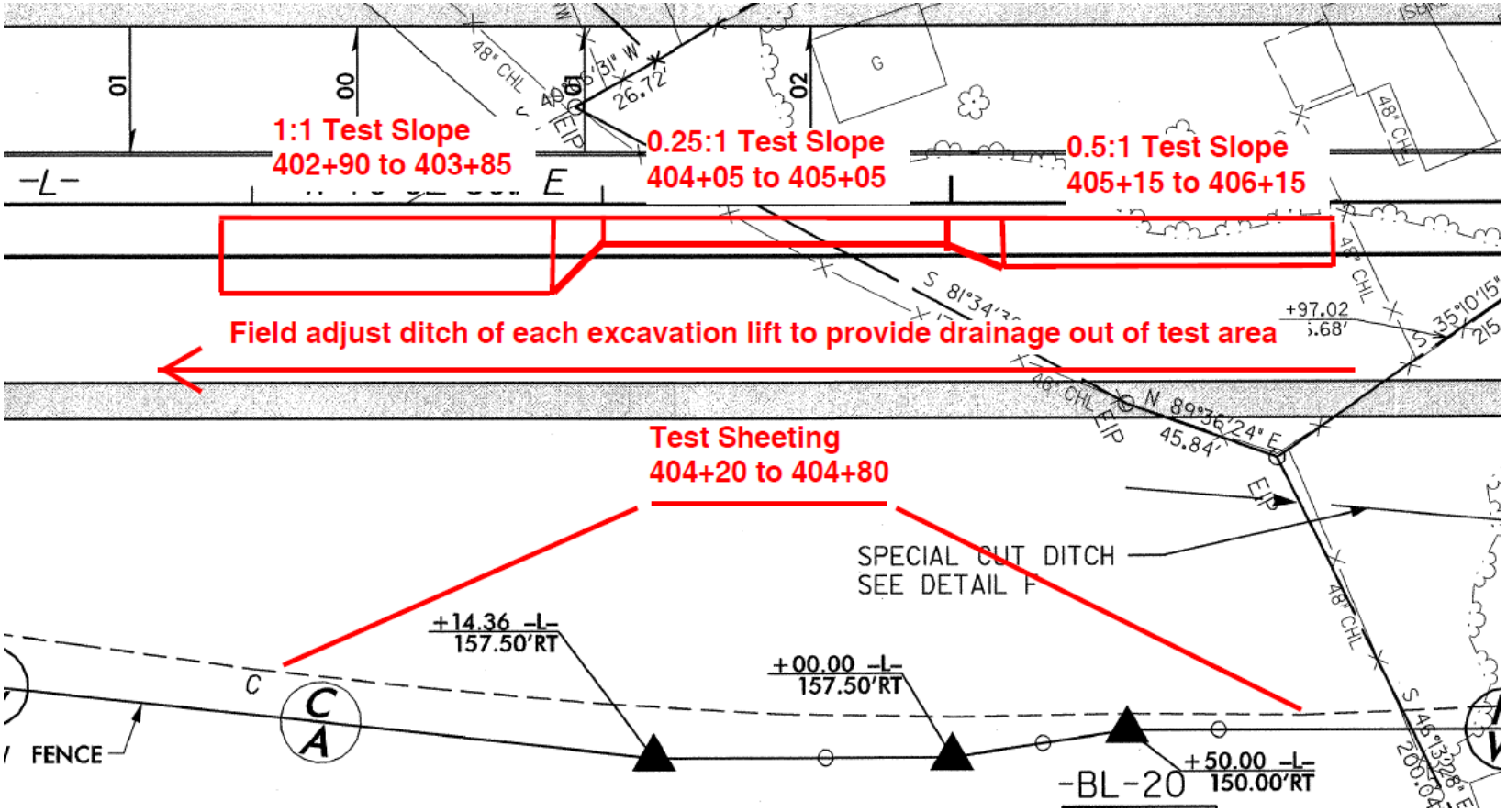
Michael Valiquette – ICE of Carolinas
Jungmok Lee – Subsurface Construction
Roy Borden – North Carolina State University
Mohammed Gabr – North Carolina State University

April 11, 2017

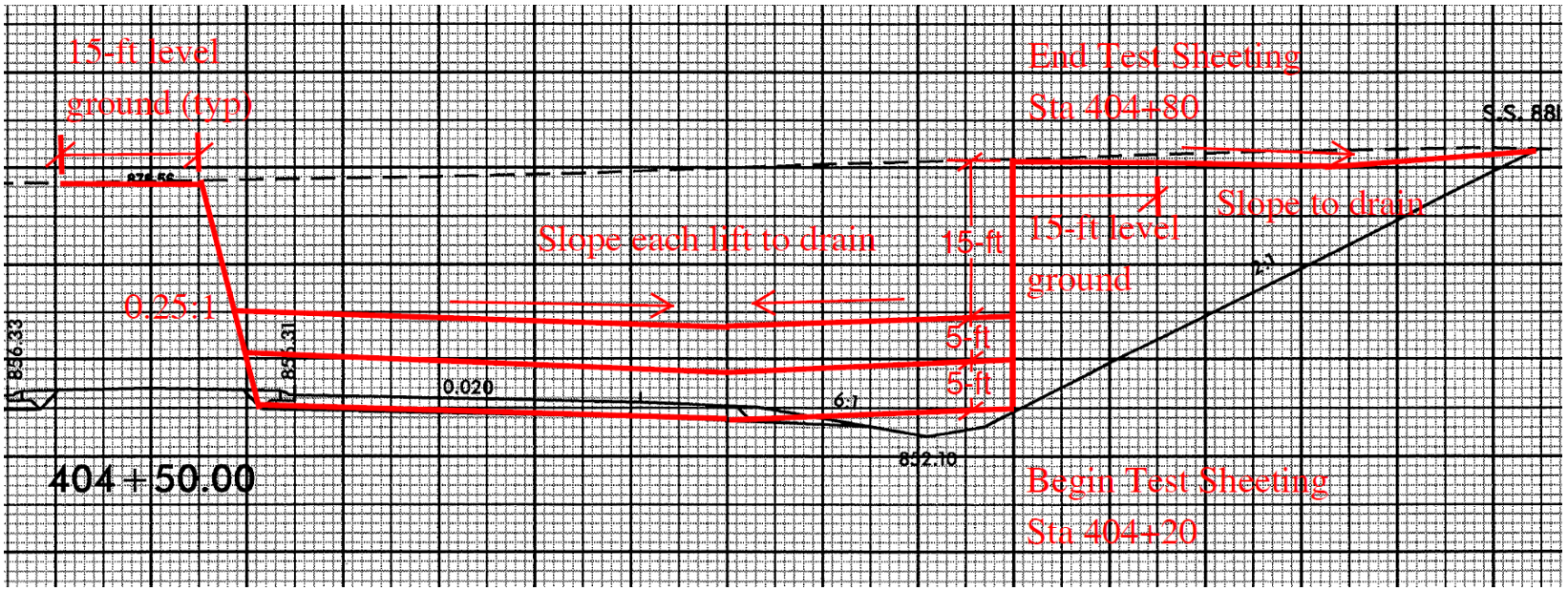
Location of Test Site



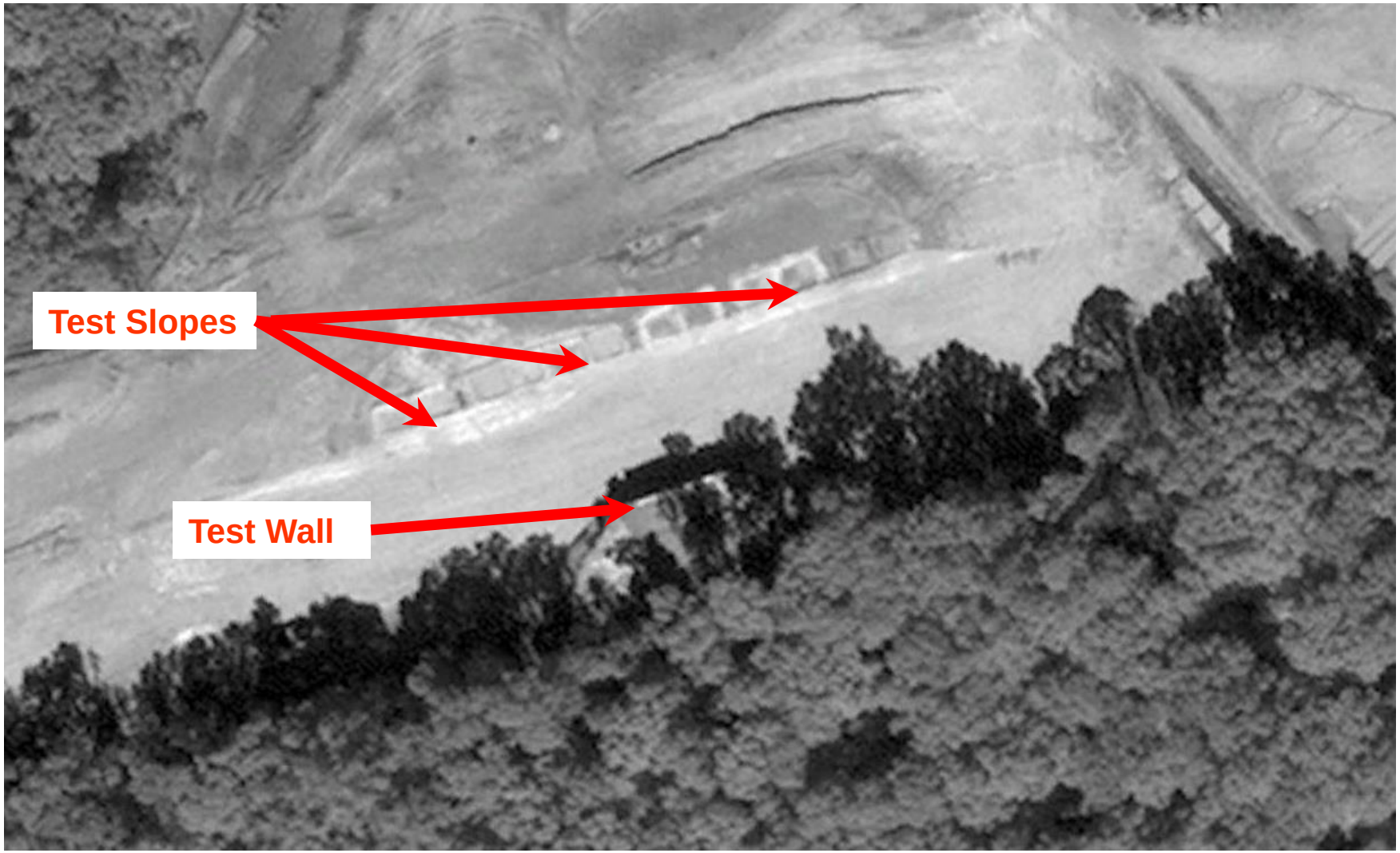
Test Site Plan View



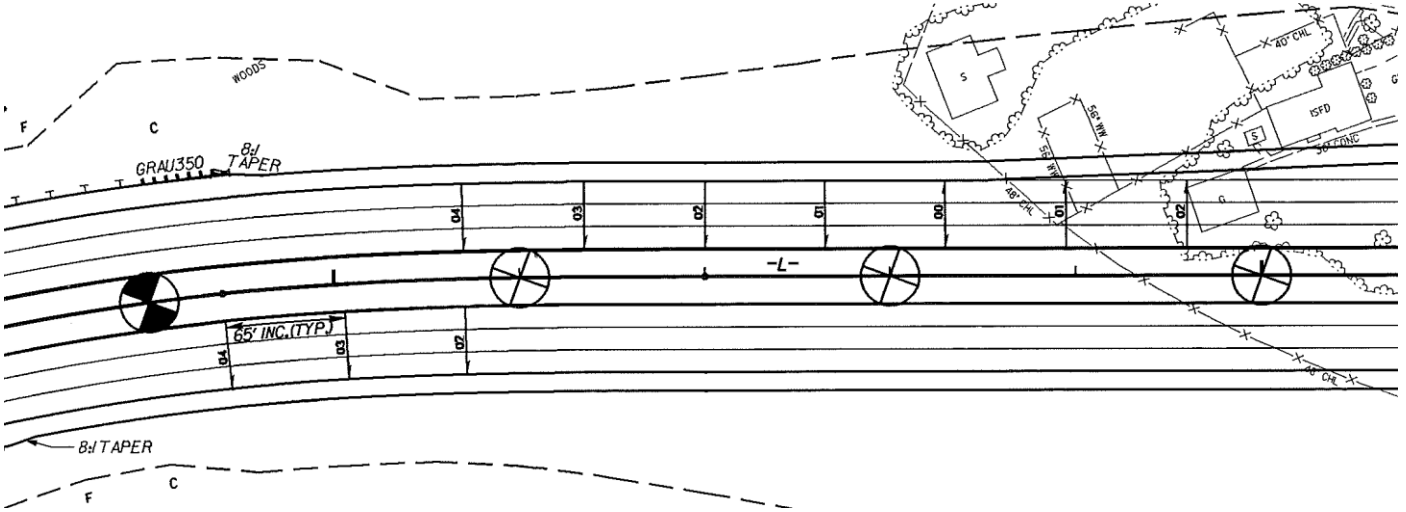
Test Site Cross-Section

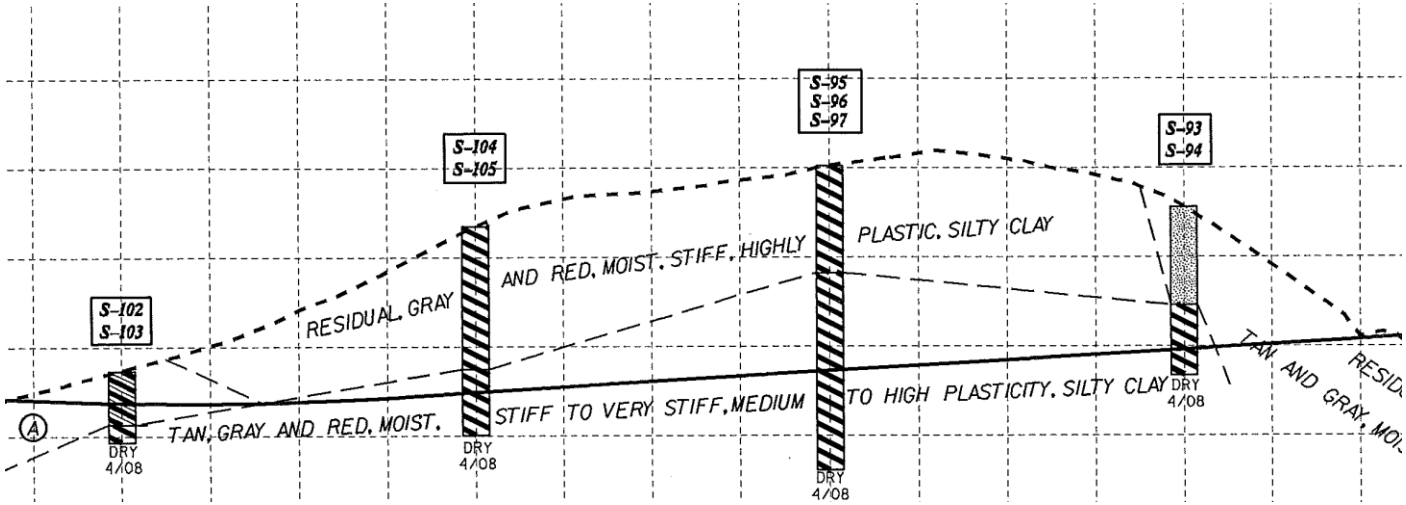


Test Site Overhead Photo



Subsurface Condtions





Additional Subsurface Investigation

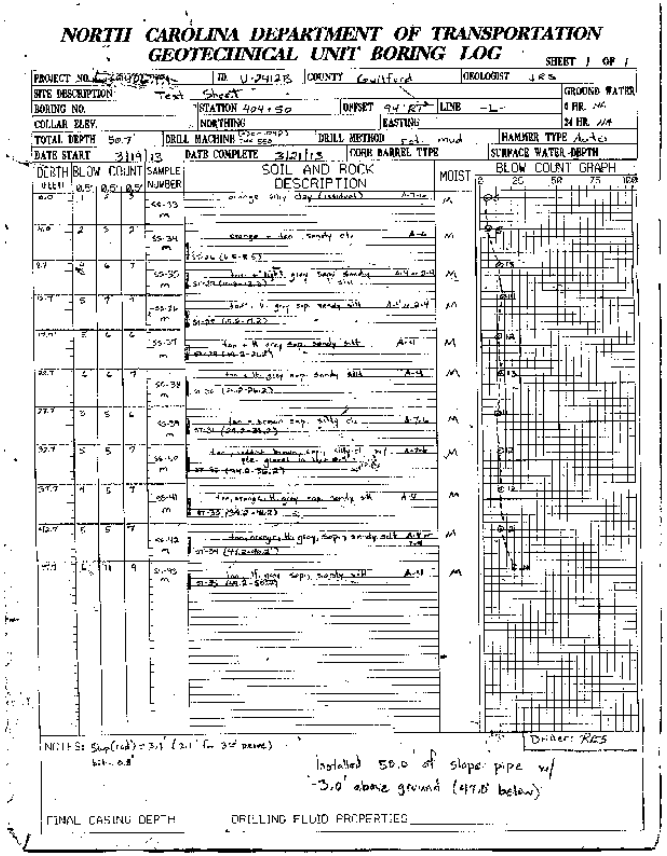
Additional Subsurface Investigations

Test Slope 1

Test Slope 2

CPT, DMT, SPT
Pressuremeter
Triaxial
Consolidation

Test Slope 3



NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL UNIT BORING LOG

SOIL AND ROCK DESCRIPTION

BLOW COUNT GRAPH

Installed 58.0' of slope pipe w/ -3.0' above ground (47.0' below)

FINAL CASING DEPTH

DRILLING FLUID PROPERTIES

Additional Subsurface Investigations

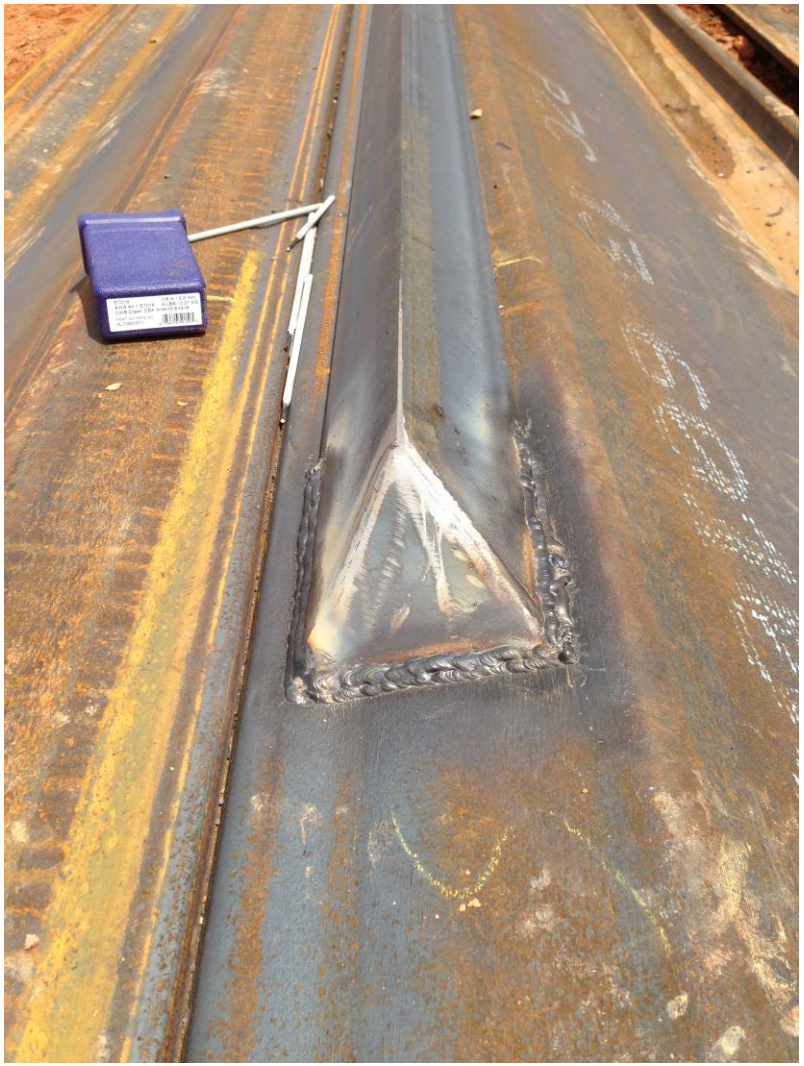
Soil Suction Measurements

Sheet Piling, PZC-13

Strain Gauge Installation

Strain Gauge Installation

Strain Gauge Cover Angles



Strain Gauge Cover Angles

Sheet Pile Vibratory Refusal, Advanced to tip with Diesel Hammer

Push in Pressure Cells

Push in Pressure Cells

In situ Instrumentation

In situ Instrumentation

In situ Instrumentation, Moisture Sensor

In situ Instrumentation, Suction Sensors

In situ Instrumentation, Suction Sensors

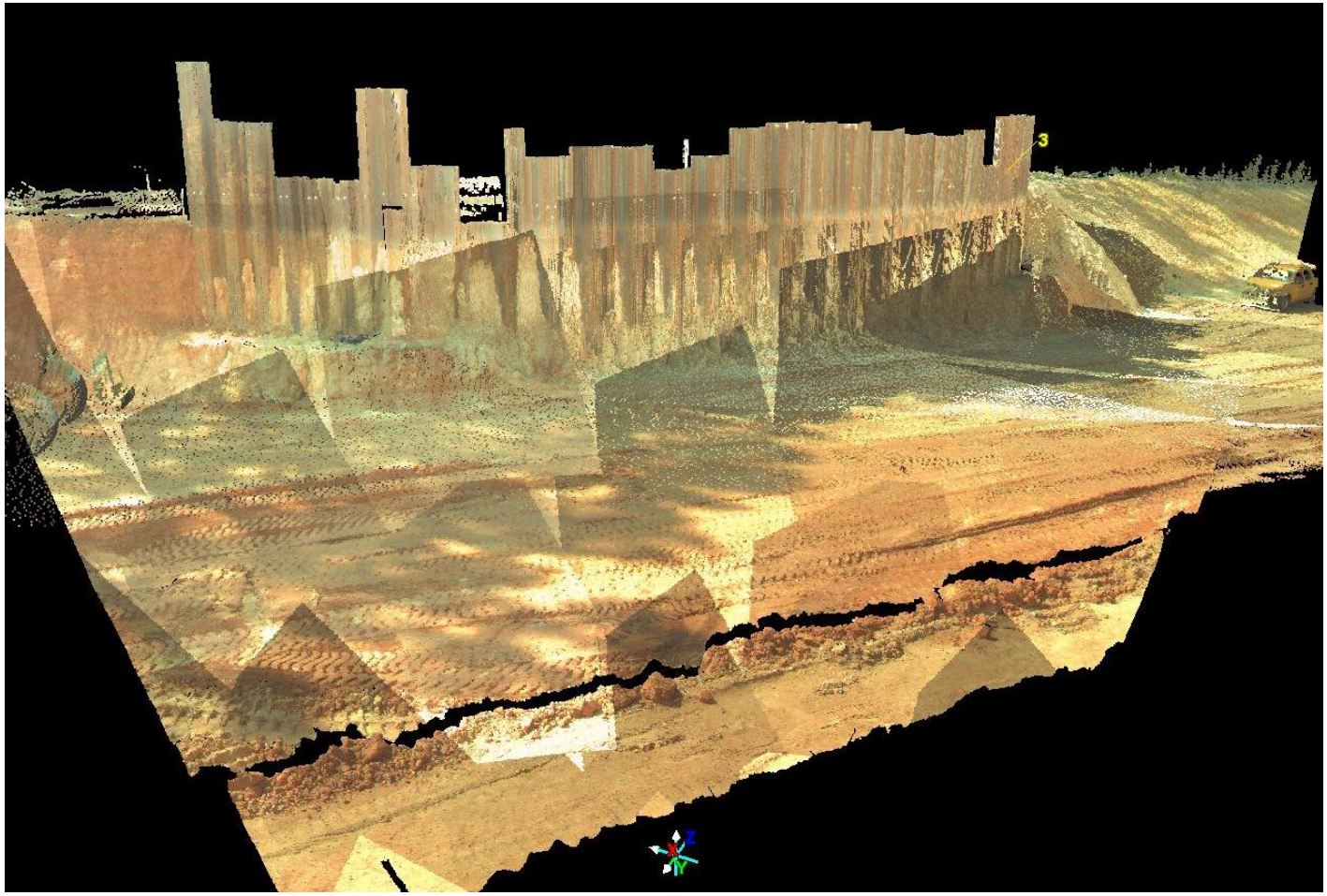
In situ Instrumentation, Suction Sensors

Initial Excavation Stage

Initial Excavation Stage

LiDAR Scanning

LiDAR Scanning



Infiltration Ponds

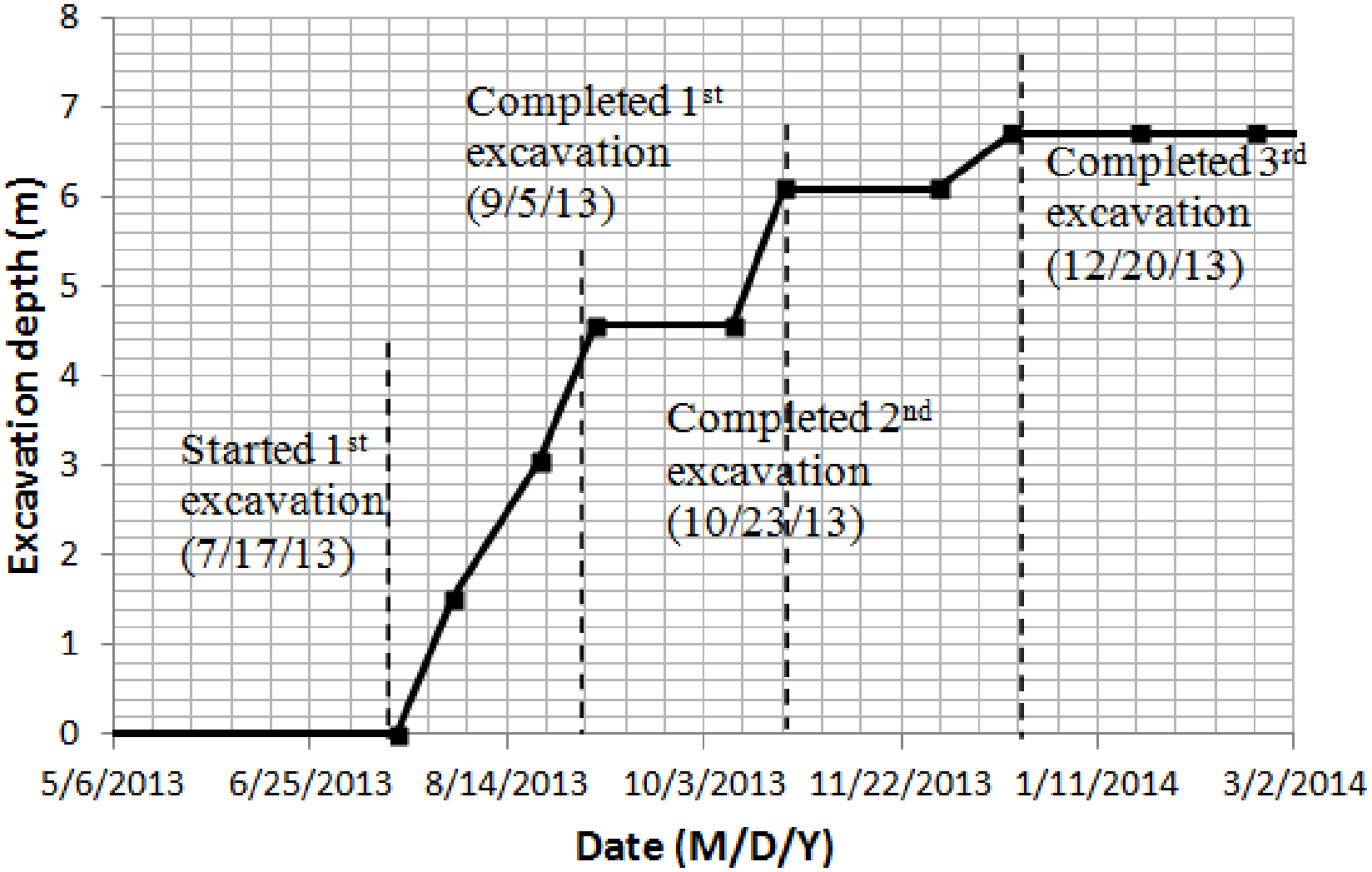
Full Height Excavation

Full Height Excavation

Full Height Excavation

Picture of field site after 6.7 m excavation

Excavation depths over time



Classification of test site soils

	Soil 1	Soil 2
Gs	2.75	2.74
LL	35	58
PI	7	21
% of fine content	58	88
AASHTO	A-4	A-7-5
USCS	ML	MH

By Wang (2014)

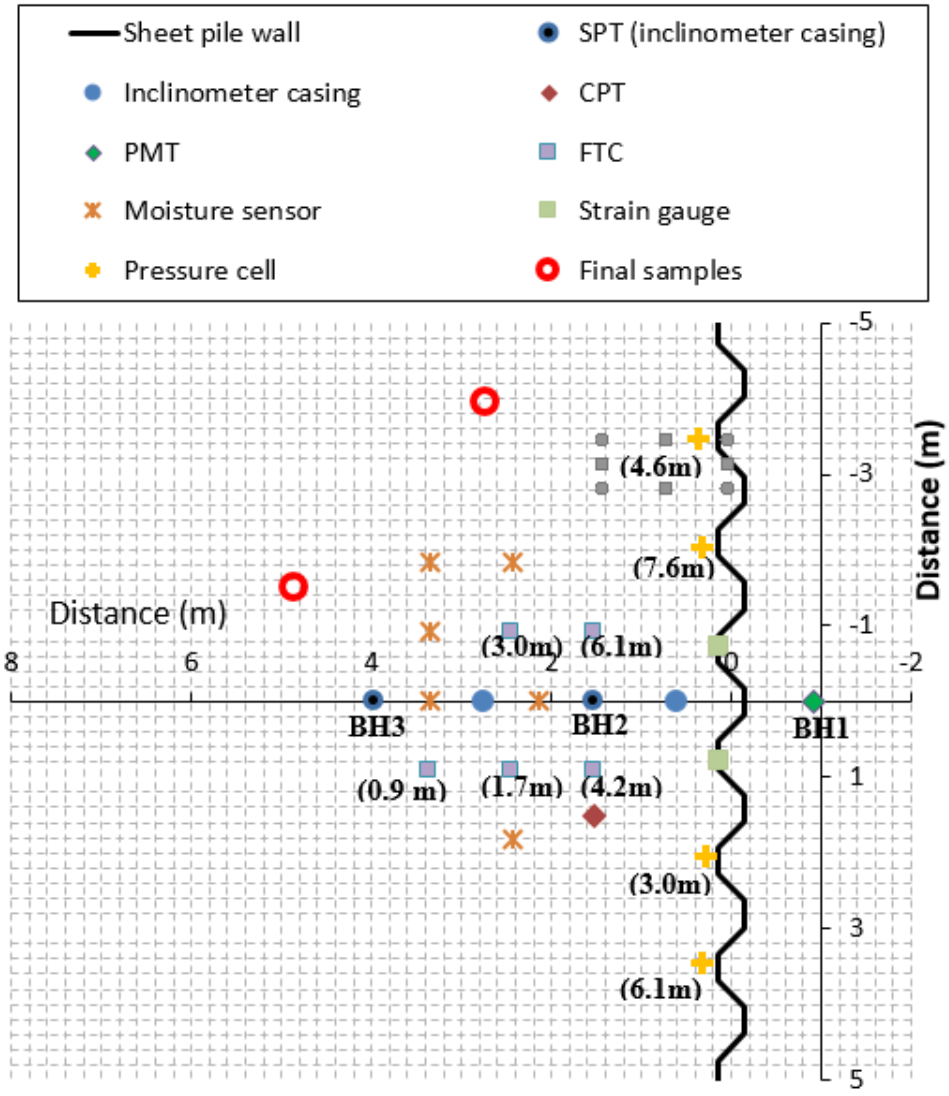
Effective strength parameter (By Tang, 2014)

- A-7-5 soil : ϕ'= 27° and c'=10 kPa
- A-4 soil : ϕ'= 30° without effective cohesion

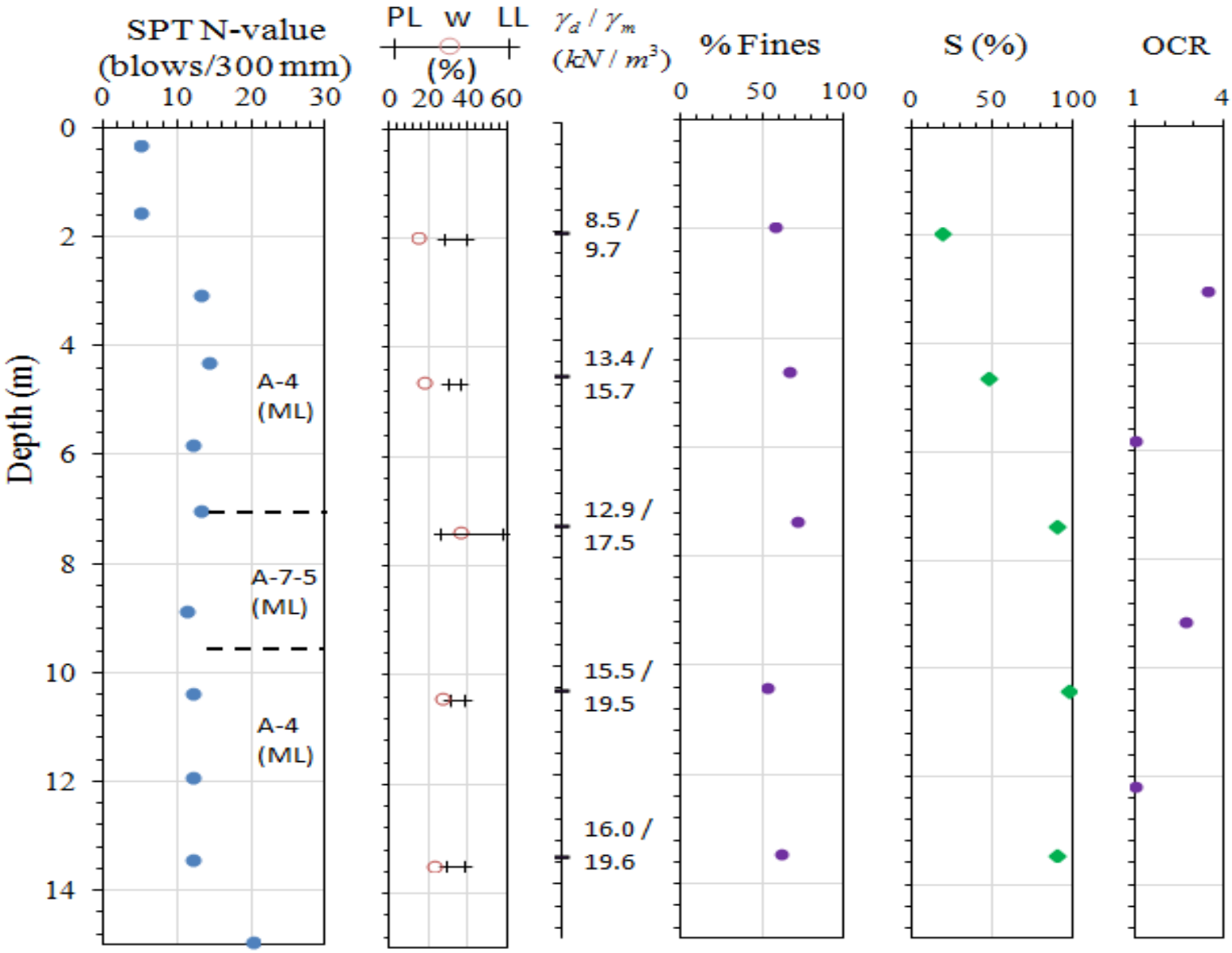
Saturated permeability (Ks)

- A-7-5 soil : 3.15 x 10^-5 cm/s
- A-4 soil : 5.9 x 10^-5 cm/s

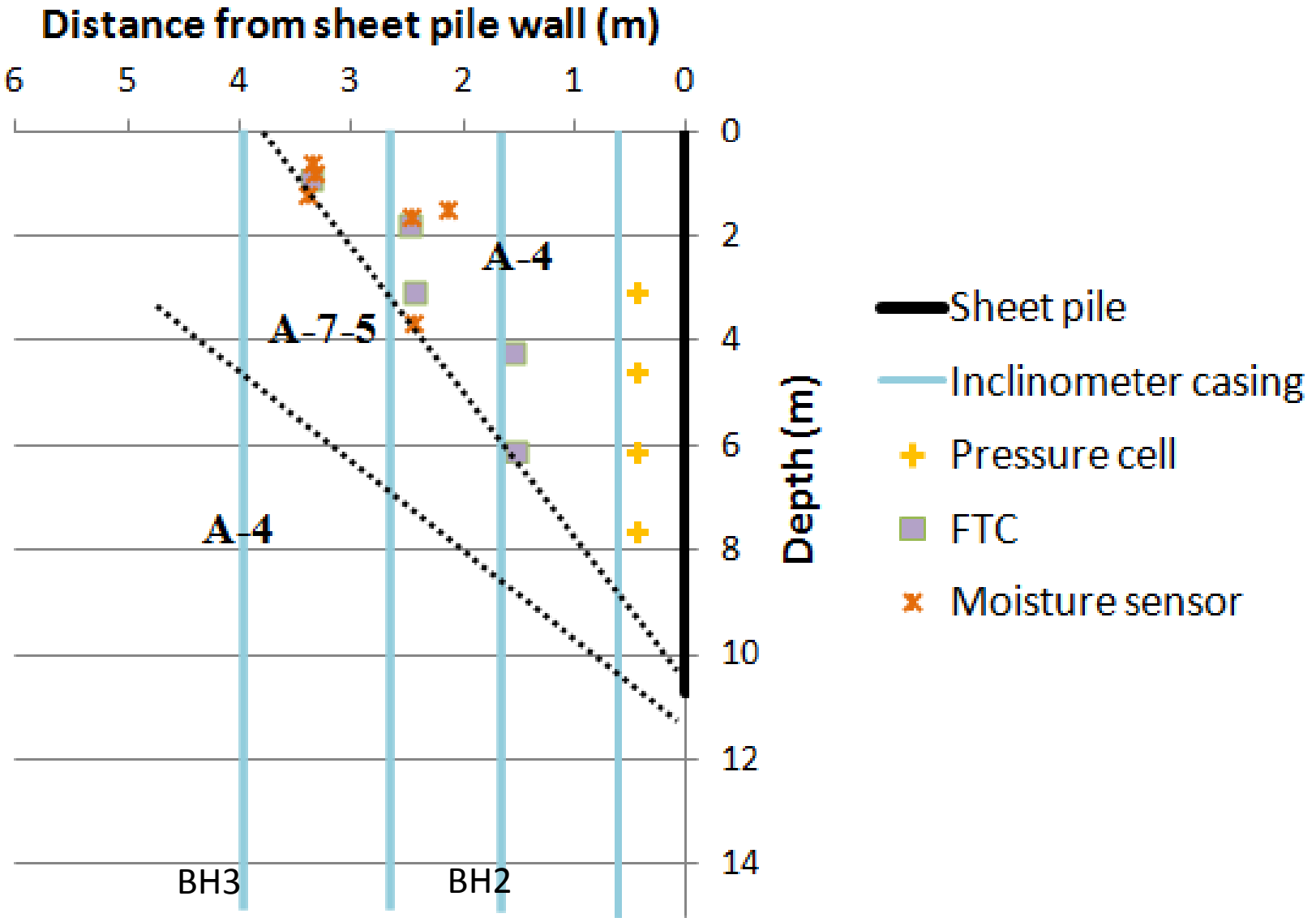
Location of instruments at sheet pile wall area



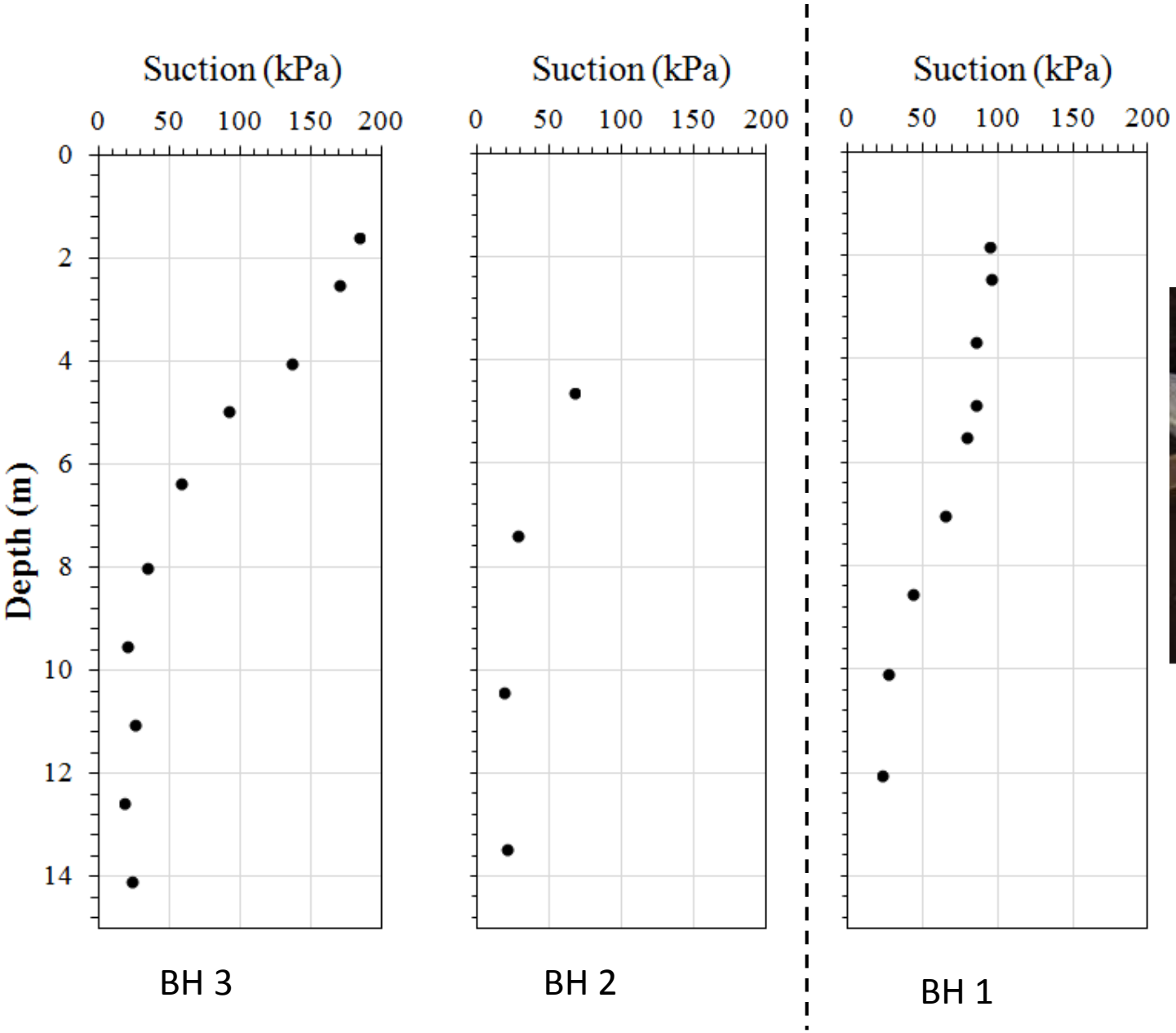
Soil characteristic profiles (BH 2)



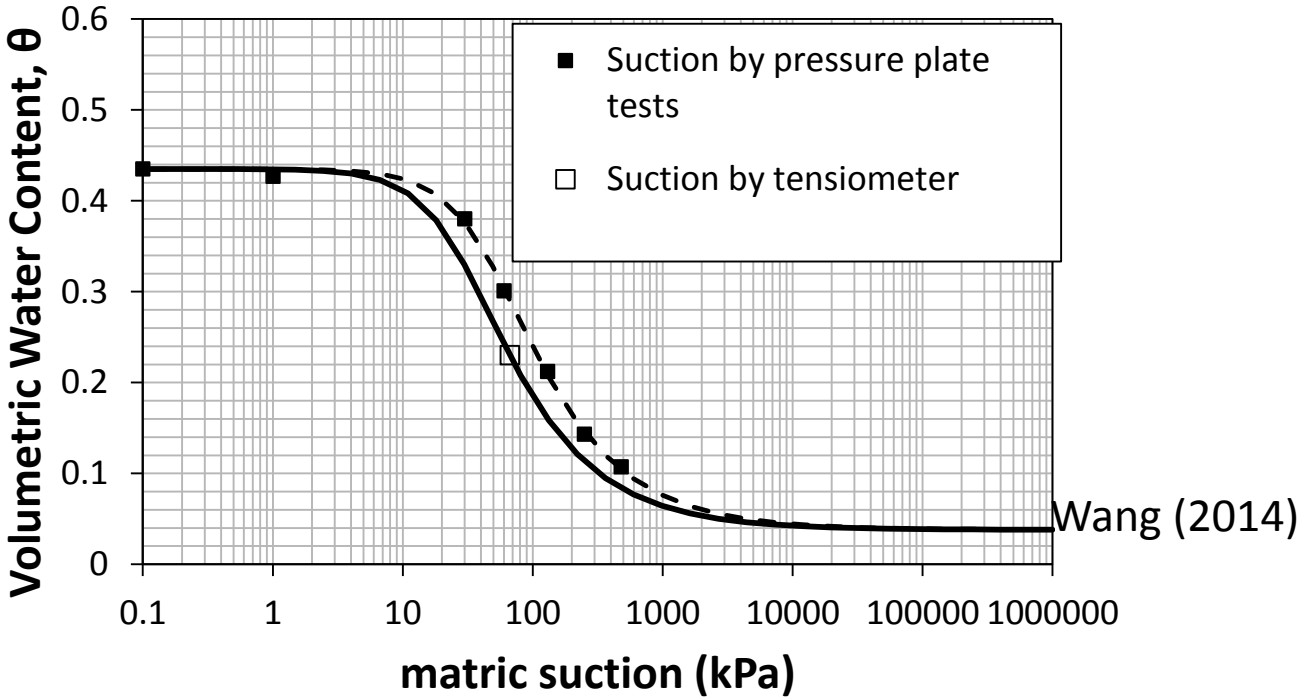
Cross-section of test site



Initial suction profiles

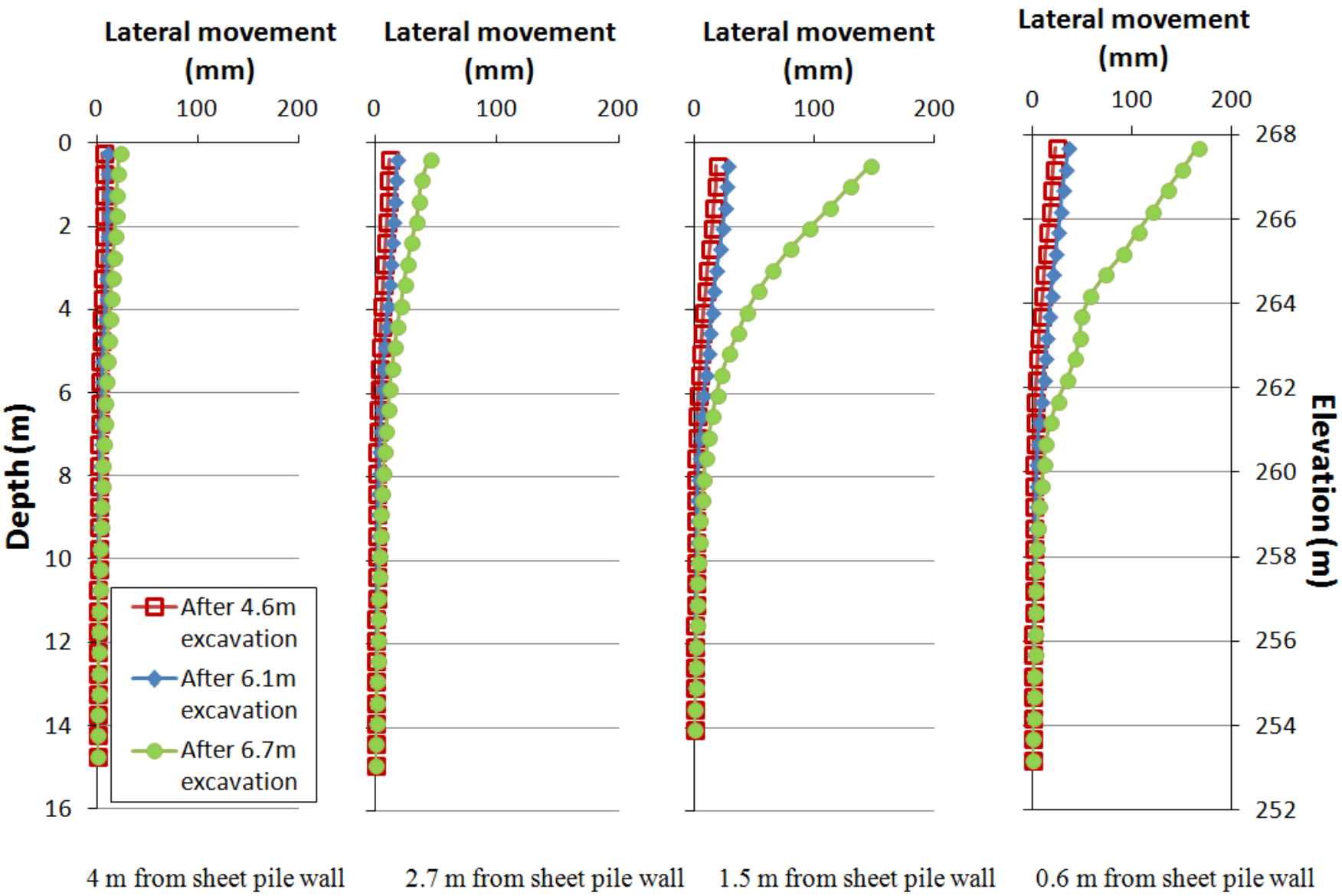


Field SWCC for sheet pile wall area



Sample Location	Depth (m)	Soil type	θ_s	θ_r	a (1/kPa)	n	m
BH2	4.5	A-4	0.435	0.038	0.034	1.771	0.435
	10.4	A-4	0.509	0.038	0.050	1.589	0.371
	13.5	A-4	0.490	0.038	0.065	1.511	0.338
BH3	1.6	A-7-5	0.533	0.17	0.078	1.328	0.247
	13.5	A-4	0.456	0.038	0.057	1.678	0.404

Measured displacement of soil

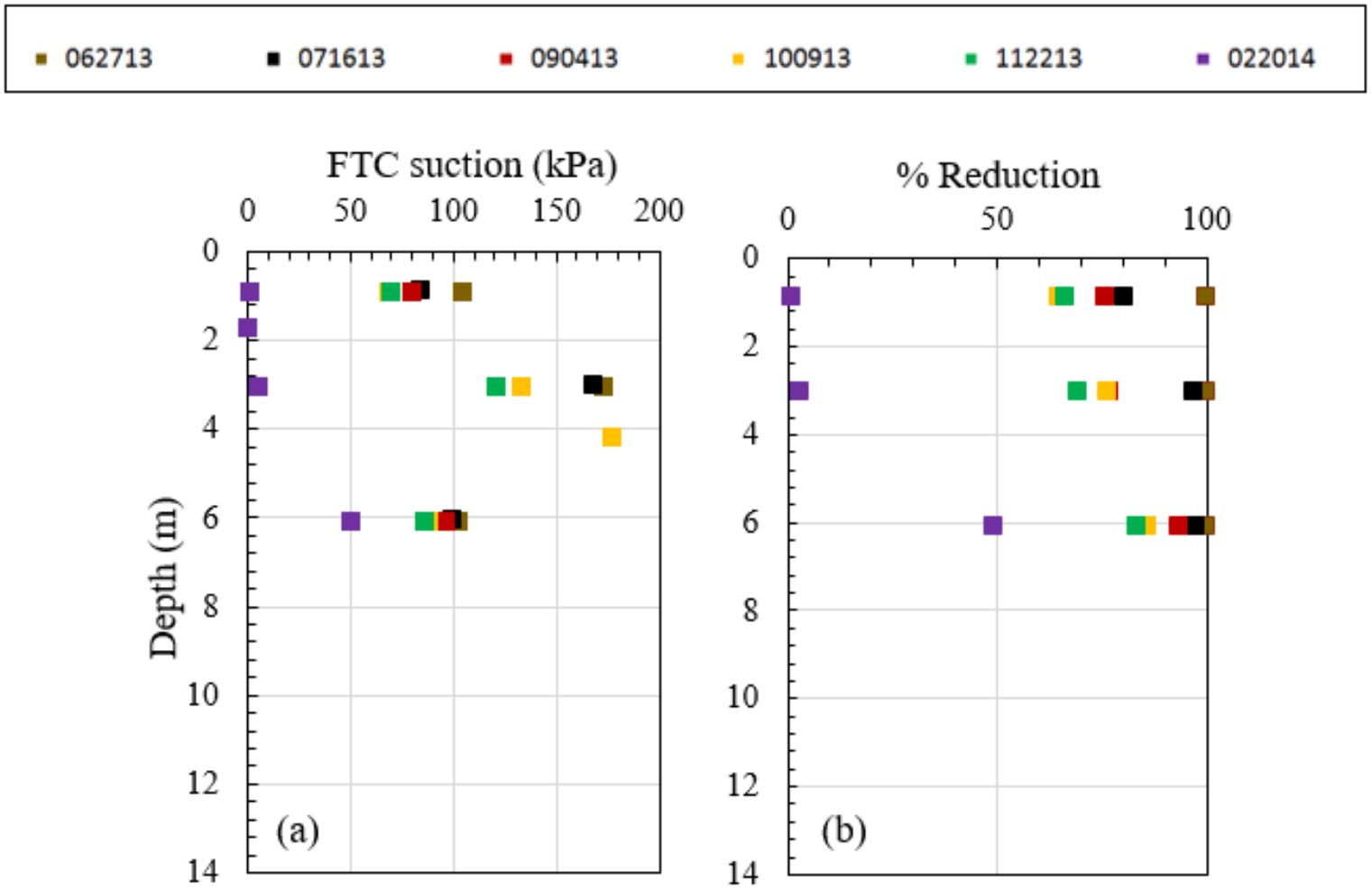


Observed gap and cracks

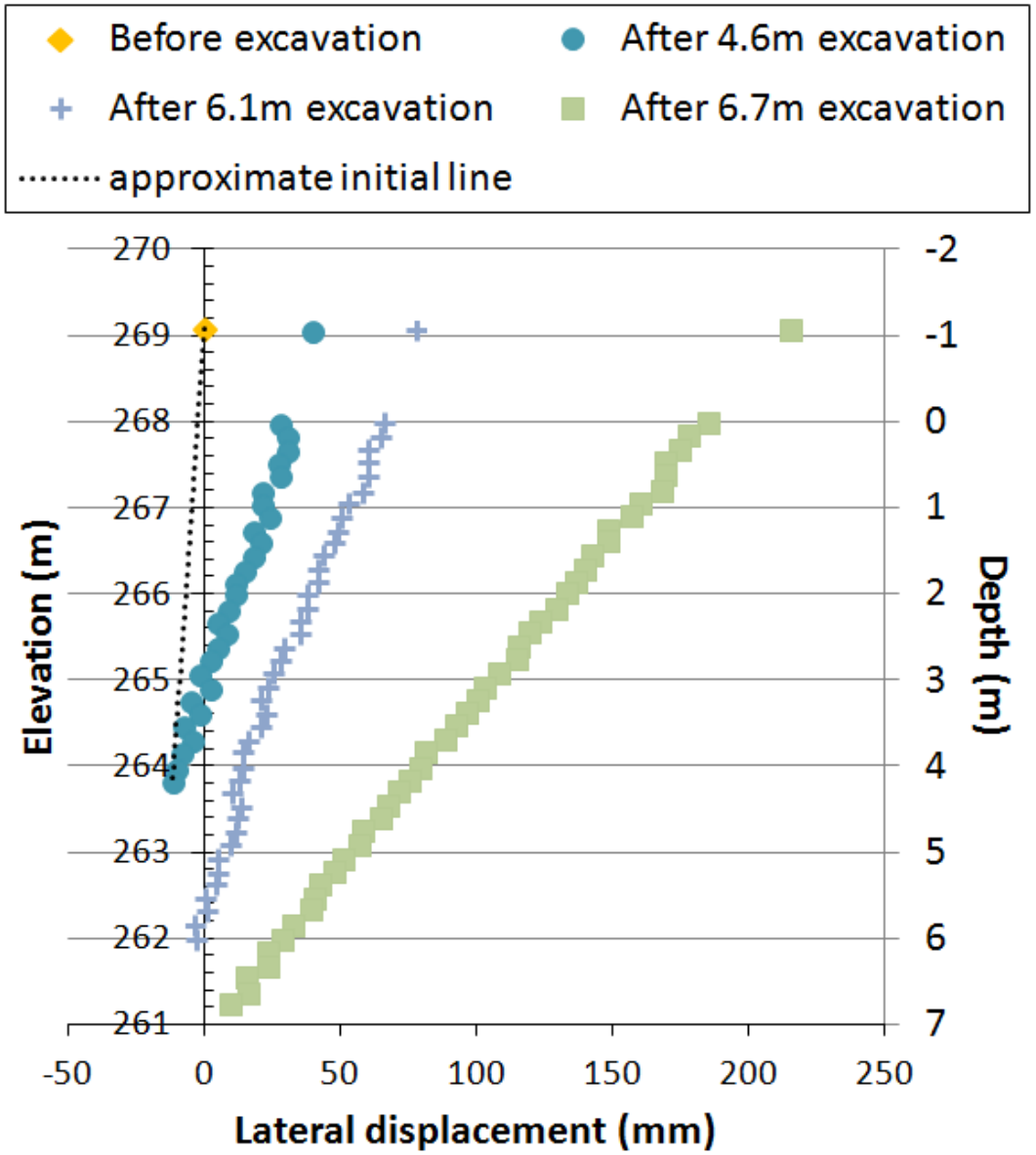
after 6.1 m excavation

after 6.7 m excavation

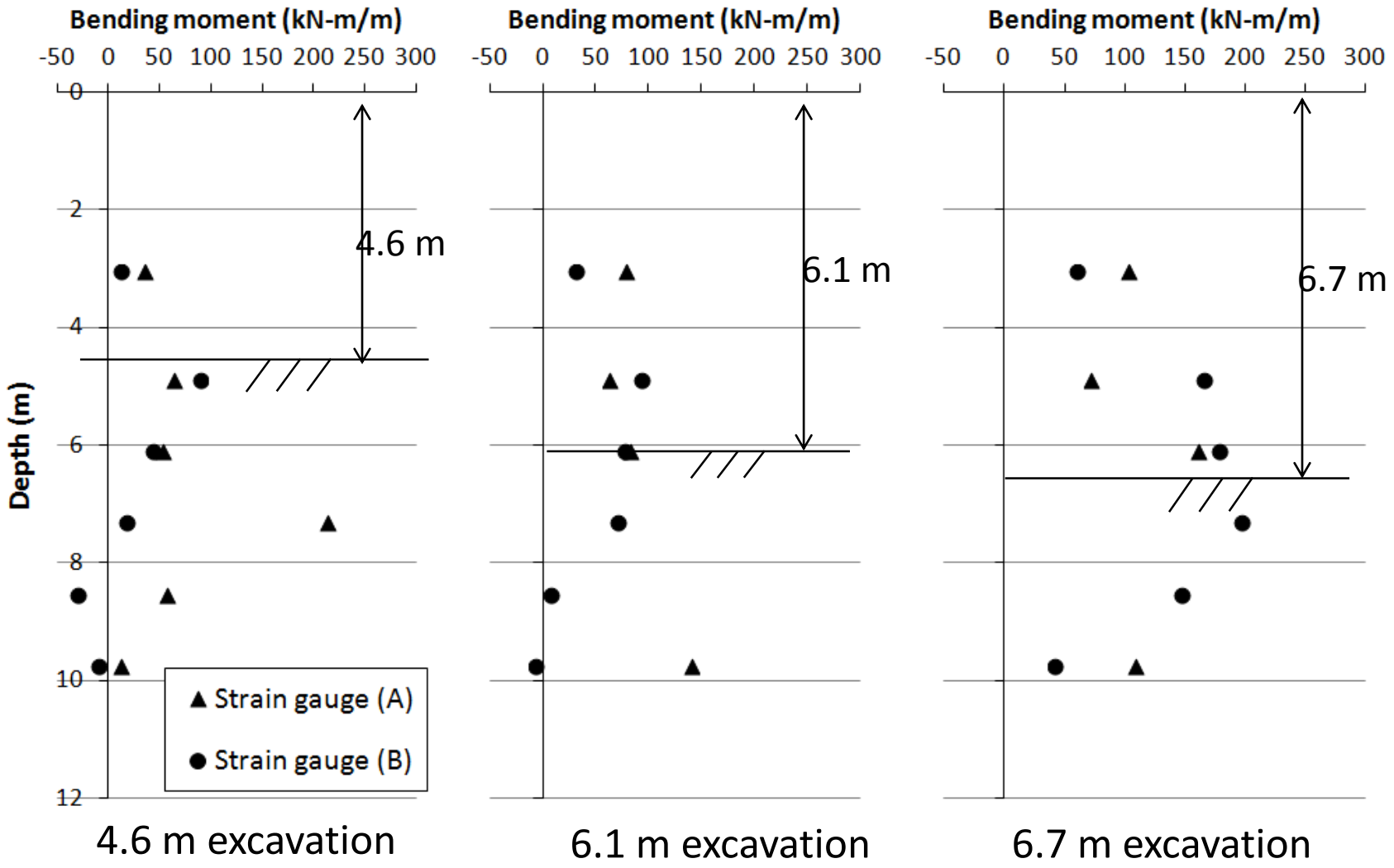
Suction profile (BH 2) from FTC



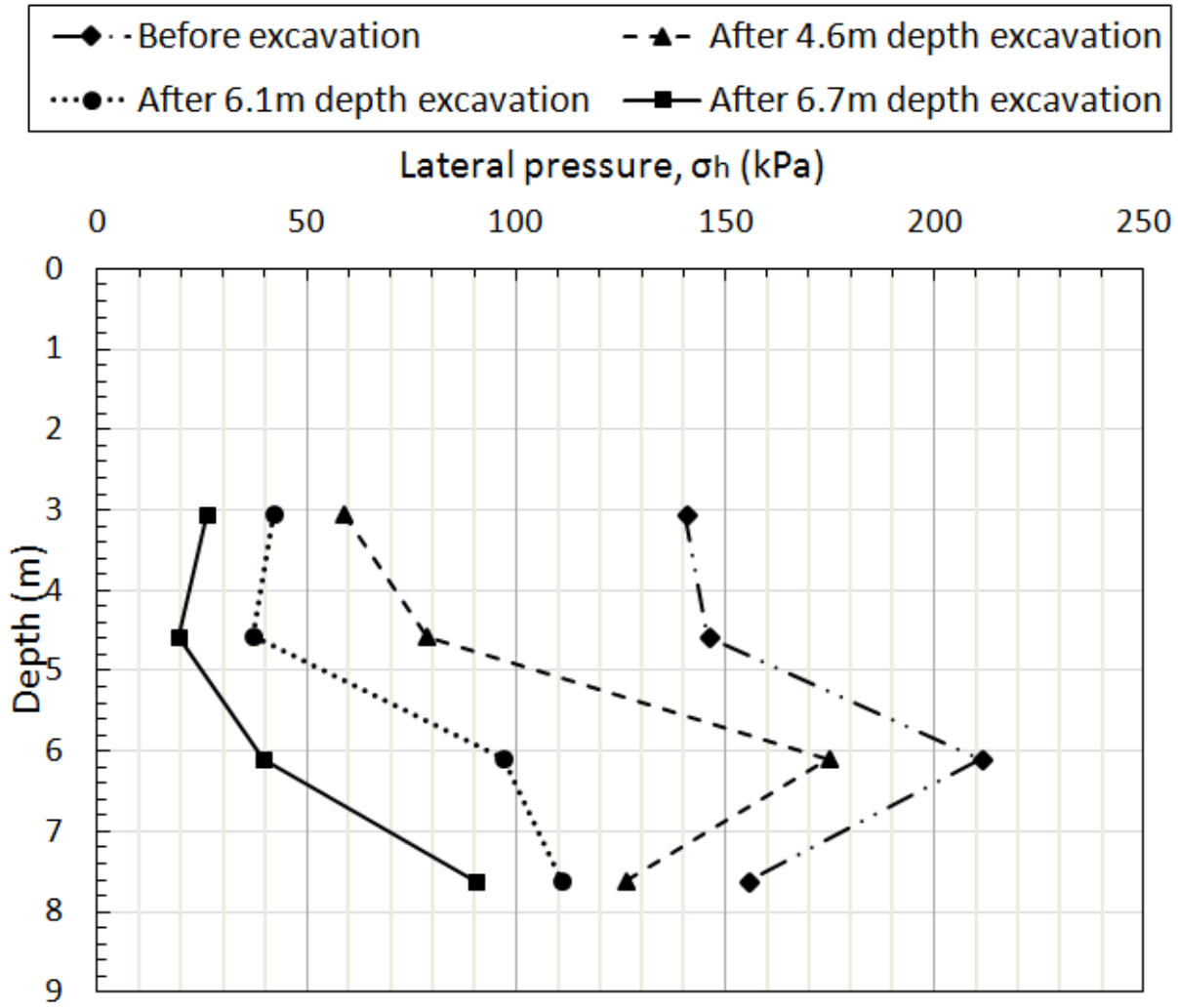
Movement of sheet pile wall



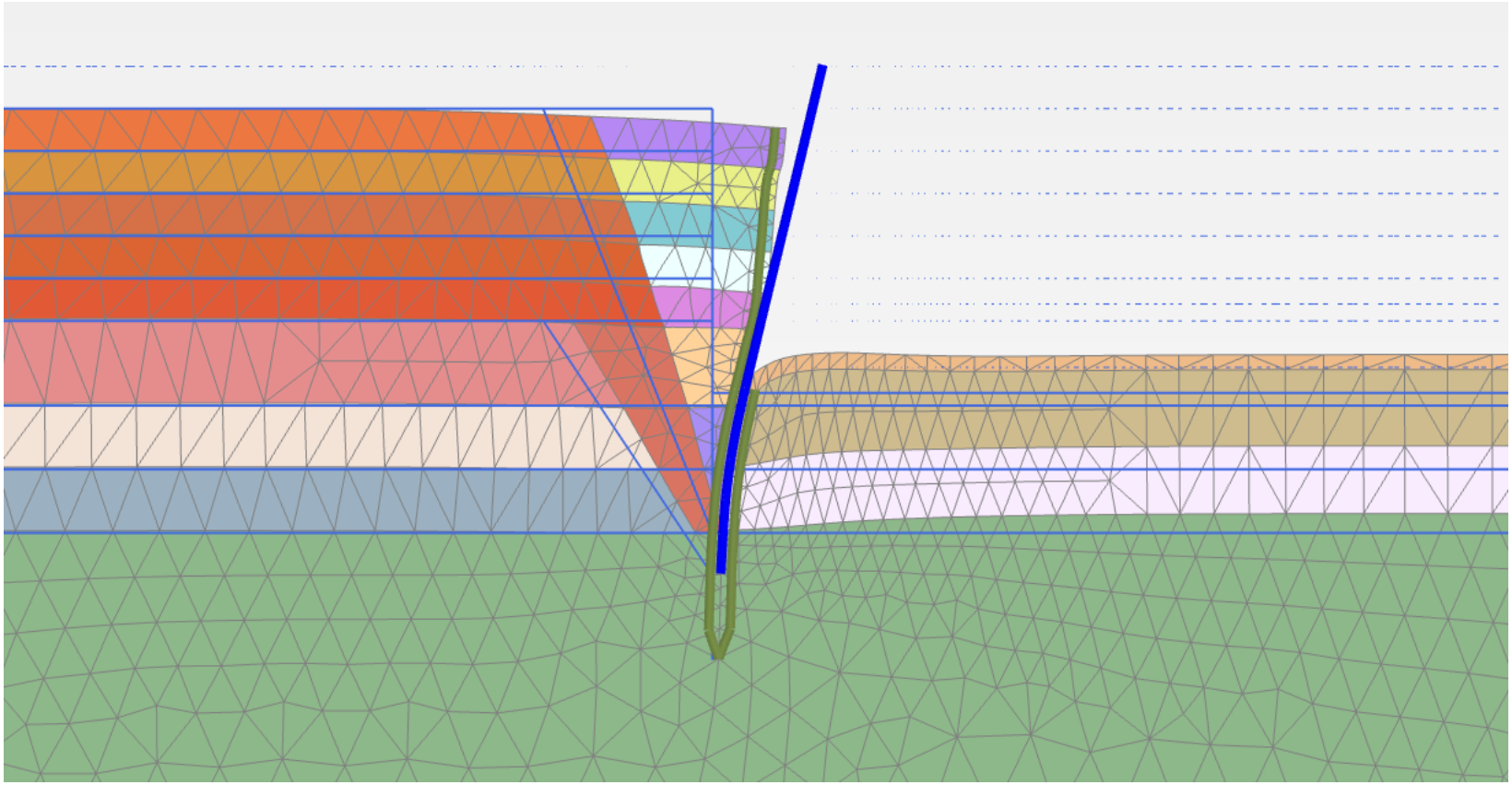
Bending moments obtained from measured strain gauge



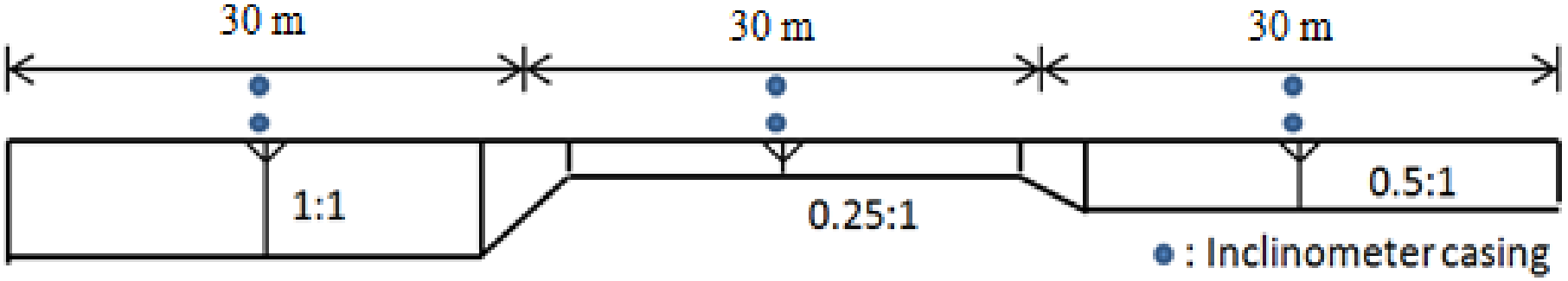
Measured lateral stress change using pressure cell



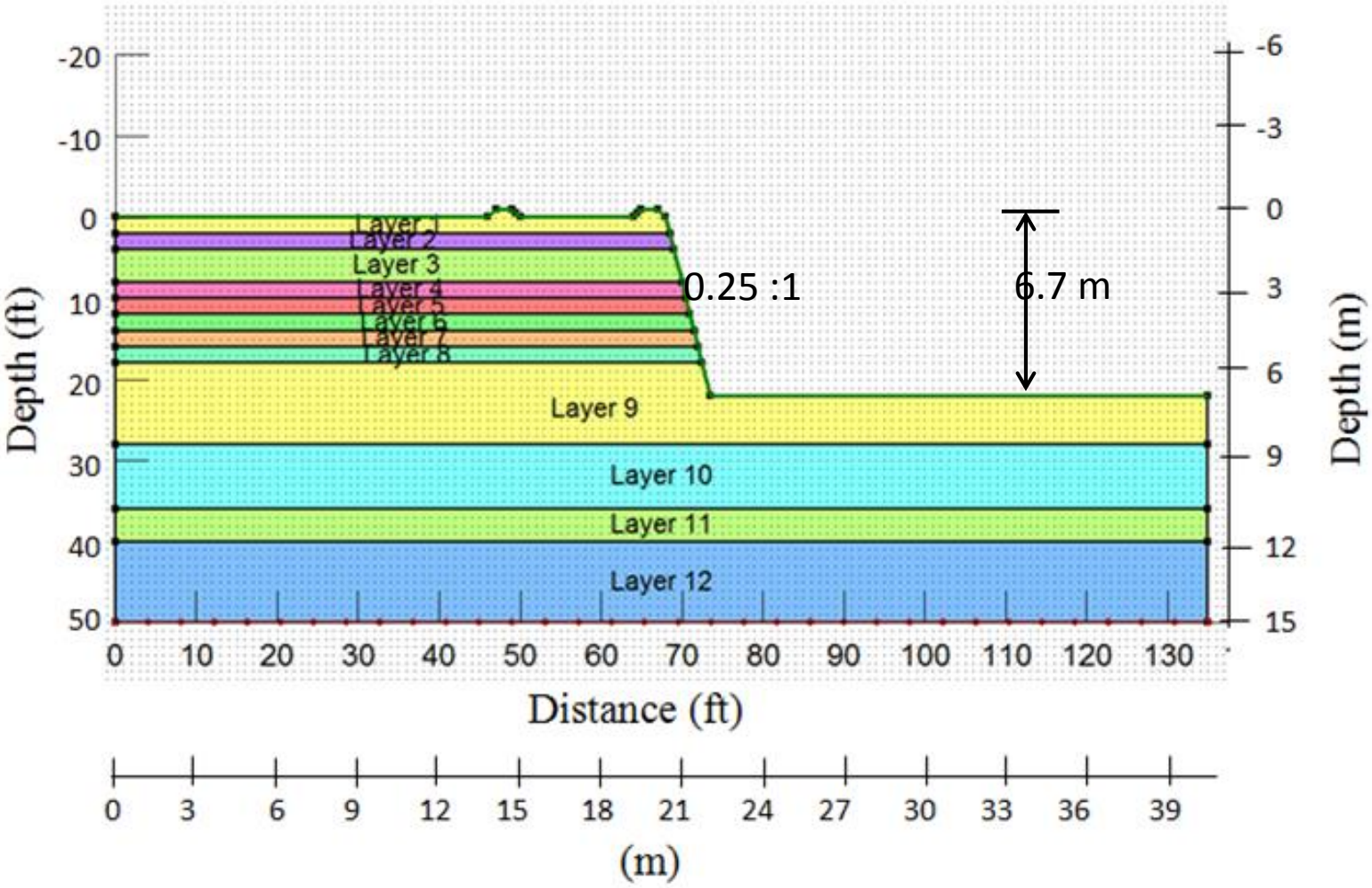
FEM Modeling of Wall



Field tests for the slopes



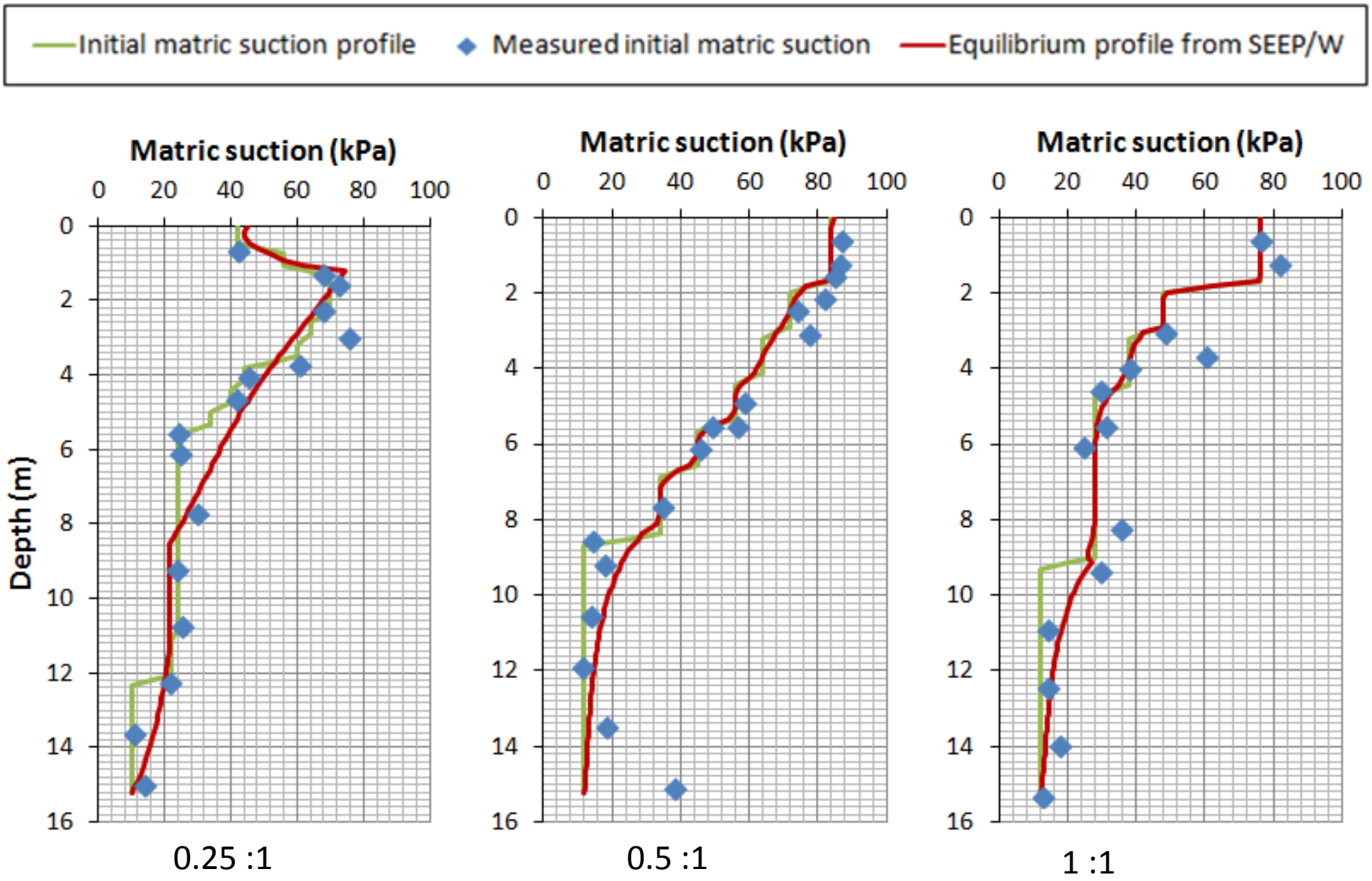
Geometry of model for 0.25:1 slope



Material properties for 0.25:1 slope

Layer	Soil type	Layer thickness	γ_{sat}	γ_{dry}	Fines	PI	$(u_a - u_w)$	c'	φ'
		(m)	(kN/m^3)	(kN/m^3)	%		(kPa)	(kPa)	(deg.)
1	A-7-5 (1)	0.6	17.5	11.9	86	22	42	10	27
2	A-7-5 (1)	0.6	17.5	11.9	86	22	56	10	27
3	A-7-5 (2)	1.2	17.1	11.3	86	22	70	10	27
4	A-7-5 (2)	0.6	17.1	11.3	86	22	64	10	27
5	A-7-5 (2)	0.6	17.1	11.3	86	22	60	10	27
6	A-7-5 (2)	0.6	15.8	9.9	84	23	44	10	27
7	A-7-5 (2)	0.6	15.8	9.9	84	23	40	10	27
8	A-7-5(2)	0.6	17.6	11	84	17	34	10	27
9	A-7-5(2)	3	17.6	11	84	17	24	10	27
10	A-4 (1)	2.4	20.3	15.7	59	11	24	0	30
11	A-4 (1)	1.2	20.3	15.7	59	11	22	0	30
12	A-4 (1)	3	21.1	17.1	42	5	10	0	30

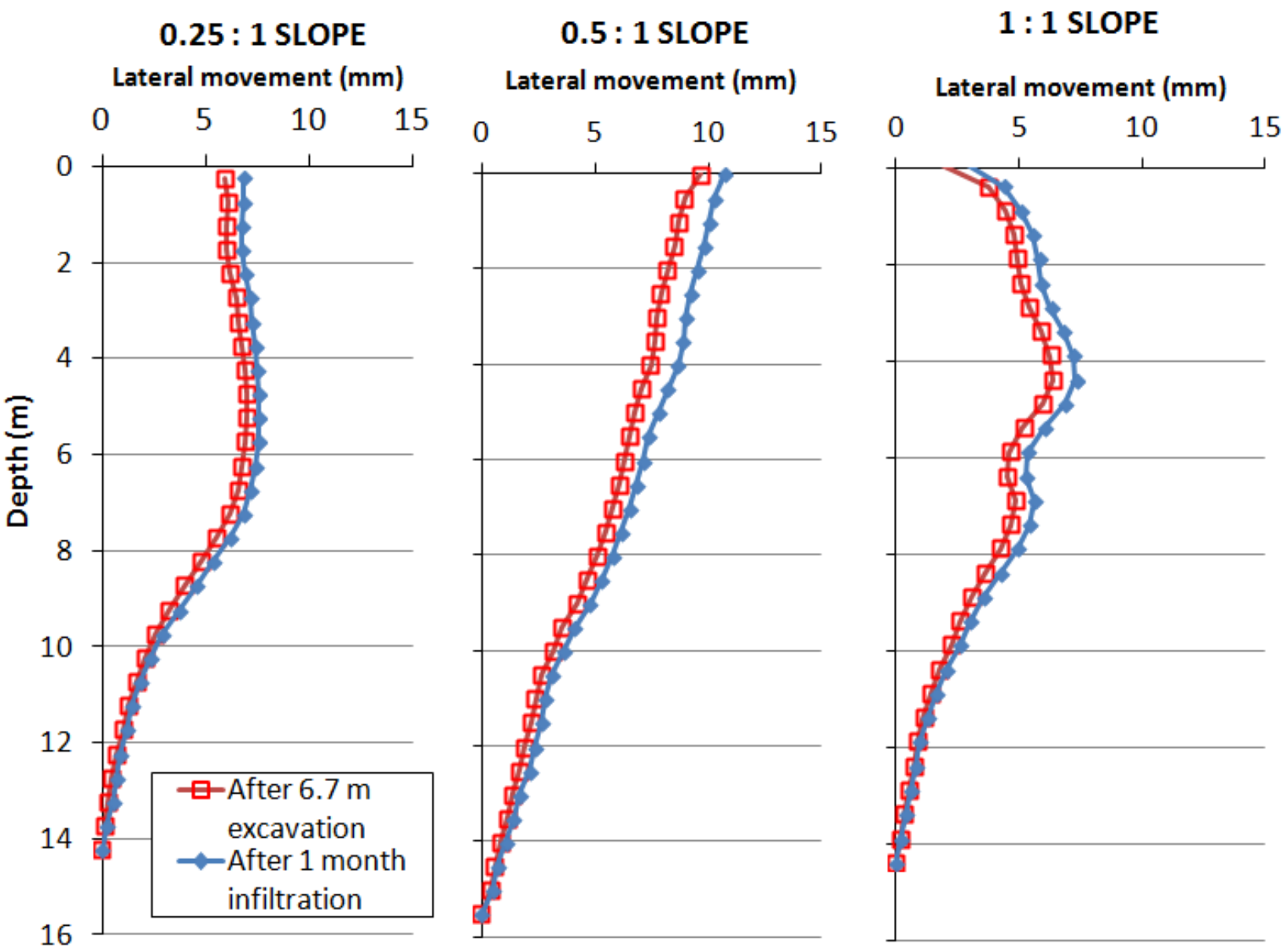
Initial suction profile



FS for different initial matric suction profile

Initial matric suction profile	FS		
	0.25:1 slope	0.5:1 slope	1:1 slope
Measured	1.55	1.75	1.91
No matric suction	0.80	1.02	0.86

Lateral displacement from inclinometer



Conclusion

- Measurement of Instrumentations help us understand the behavior of unsaturated Piedmont Residual soils
- NCDOT determining how to incorporate research results into construction practices

REFERENCE

- Wang, Cheng. (2014). Soil Suction Characterization and New Model for Predicting Suction in Residual Soil. North Carolina State University, Raleigh, NC
- Tang, Chien-ting. (2016). Predication of Shear Strength as a Function of Matric Suction for North Carolina Residual Soils. North Carolina State University , Raleigh, NC
- Lee, Jungmok. (2016). Analysis and Design of Temporary Slopes and Excavation Support Systems in Unsaturated Piedmont Residual Soils. North Carolina State University , Raleigh, NC

Questions ?