International Society for Soil Mechanics and Geotechnical Engineering

Société Internationale de Mécanique des Sols et de la Géotechnique

Corporate Associates Presidential Group

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ARE WE OVERDESIGNING? – A SURVEY OF INTERNATIONAL PRACTICE

A joint initiative by: Corporate Associates Presidential Group (CAPG),
Young Members Presidential Group (YMPG,
Technical Committee TC205 (Safety and Serviceability), and
Technical Committee TC304 (Risk).

1. MOTIVATION

At the XVI Danube European Conference (Skopje Macedonia, June 2018), the question was raised "Are we overdesigning?". Although the question originated from the Asian Region, it is valid internationally where different countries and users of various testing techniques or design codes tend to follow local practice for geotechnical design.

This survey is intended to assess the consistency of calculation models and design methods for a variety of geotechnical structures and, where possible, to compare the results with full-scale tests and reliability analyses.

2. OUTLINE

The survey is based on two soil profiles, one in clay and the other in sand. Soil test results, typical of those one would find in a geotechnical investigation report, are provided for each soil profile. The soil properties for the clay and sand profiles are given in Annexes A and B respectively. Excel spreadsheets are also provided with numerical data.

Ten specimen problems have been proposed, namely concentrically and eccentrically loaded spread footings, axially and laterally loaded piles, slopes and retaining structures (see Annex C). The idea is to keep the problems easy to analyse and representative of every-day geotechnical structures.

Some problems require the prediction of performance of the geotechnical structure (prediction problems) while others call for the design of the structure as it would be constructed (design problems). The prediction problems are aimed assessing the selection of parameters and calculation models. The design problems are aimed at assessing the provisions made for safety and serviceability in geotechnical structures.

You do not need to analyse all ten problems, although it would be appreciated if you did. Please feel free to submit responses for only problems that are typical of the work you do on a day-to-day basis.

3. INSTRUCTIONS

1. Analyse as many or as few problems as you wish. Partial solutions will also be accepted.
2. Summarise the results on the reply sheets provided in Annex C.
3. Please use the analysis methods and design codes that would typically be applied in a design office in your country. This is not a competition to see who can get the "right" answer. It is an assessment of the results given by design methods in common use.
4. Please complete the "Details of Respondent" sheet and submit it with your reply sheets. Also fill in your country and occupation in the space provided on each reply sheet.
5. Submit the result as a scanned .pdf document to overdesign@issmge.org.
6. The closing date for submissions is Friday 2nd August 2019. Late submissions will be accepted but may not be included in the initial analysis of results for the Asian Regional Conference in October 2019.

4. PRESENTATION OF RESULTS

The initial results of the survey will be presented at the Asian Regional Conference in Taipei, October 2019. A detailed analysis of the results will be presented at the ISSMGE International Conference in Sydney 2021.

5. QUERIES

Queries regarding this survey may be addressed to overdesign@issmge.org. The data is what it is and no further data is available.

Thank you in advance for your participation. We look forward to receiving your responses.

Peter Day and Sukumar Pathmanandavel

ISSMGE CAPG

ANNEX A: CLAY PROFILE

A1 SOIL PROFILE

The clay profile is predominantly alluvial in origin and is overconsolidated.

The profile can be described as follows:

0 – 5.5m	Very stiff clay
5.5 – 6.5m	Medium dense sand parting (intermittent)
6.5 – 12.0m	Very stiff clay
12.0m +	Highly weathered shale.

The water table is at a depth of approximately 6m below ground level.

A2 SOIL PROPERTIES

The results of laboratory and field tests on the clay are summarised in Figures A1 and A2 respectively.

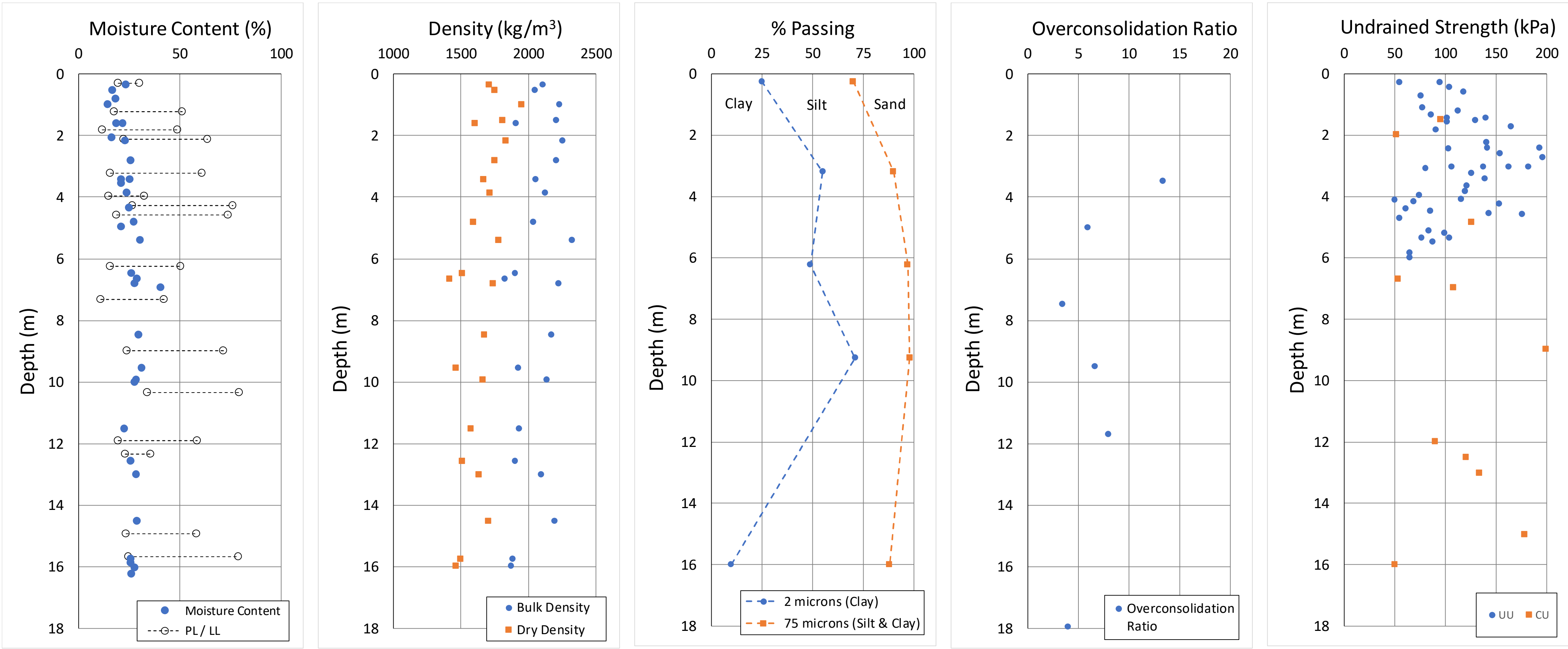


Figure A1: CLAY PROFILE - Summary of Laboratory Test Results

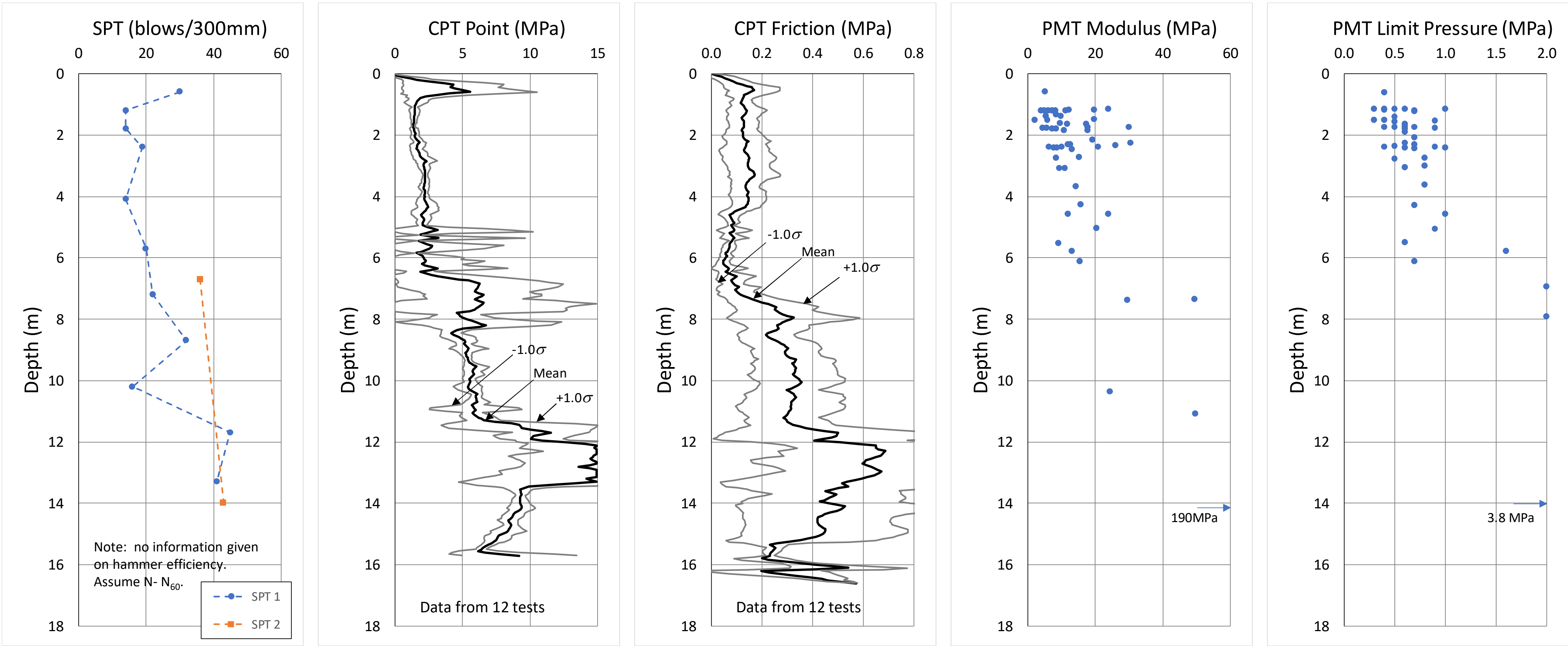


Figure A2: CLAY PROFILE - Summary of Field Test Results

ANNEX B: SAND PROFILE

B1 SOIL PROFILE

The sand profile is also primarily of alluvial origin.

The soil profile may be described as follows:

0 – 4.0m	Silty sand
4.0 – 8.0m	Clean sand
8.0 – 12.5m	Clayey sand
12.5m +	Highly weathered shale.

The water table is at a depth of about 5m below ground level.

B2 SOIL PROPERTIES

The results of field and laboratory tests are given in the following figures:

Figure B1: Grading analyses

Figure B2: SPT test results

Figure B3: Moisture content results

Figure B4: CPTu results

Figure B5: Pressuremeter test results

Figure B6: Dilatometer test results

Figure B7: Cross-hole seismic results

Sieve Grading Analysis

Seive Size (mm)	% Passing by weight 0.1m	1.6m	2.5m	3.7m	4.8m	8.9m
9.5				100	100	
2	100	100	100	91	96	100
1.18	99			89	94	
0.85				88	93	
0.425	95	99	99	70	86	99
0.25	78		72			
0.18		61		26	13	92
0.125	27		7			
0.075	8	16	2	22	6	35

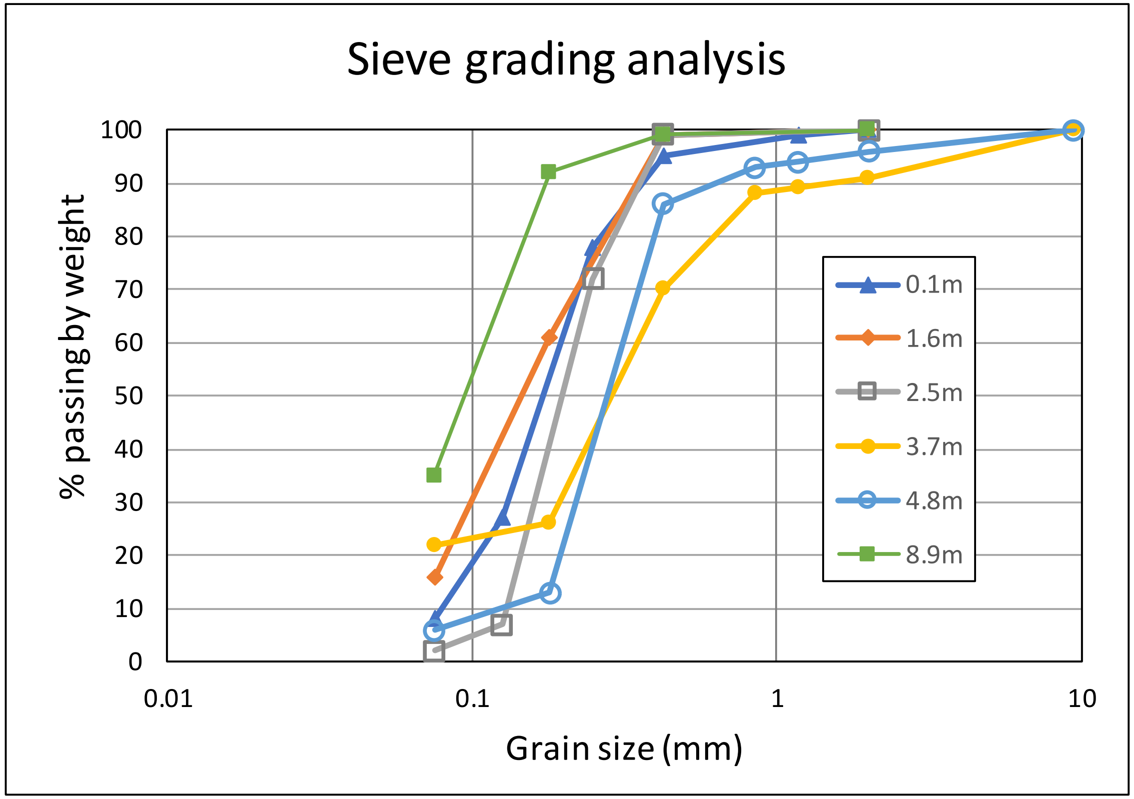


Figure B1: SAND PROFILE – Summary of Grading Analysis

Depth (m)	SPT1	SPT2	SPT3	SPT4	SPT5	SPT6
			blows / 300mm			
0.23	11	12	13	11	12	13
0.98	23	23	18	13	15	19
1.60	30	18	25	18	20	18
2.20	21	18	17	17	19	13
2.80	23	16	18	16	16	14
3.75	28	19	19	15	16	26
4.95		17	26	14	27	23
5.85	34	21	22	17	18	20
7.40	17	14	19	16	16	28
8.90	13	21	10	20	25	8
10.45	54	63	44	60	64	49
11.95	76	40	99	70	38	51
13.50	40	39	46	53	36	53
15.00	53	57	36	60	49	54

NB: Average SPT system efficiency 53% (46% - 60%).

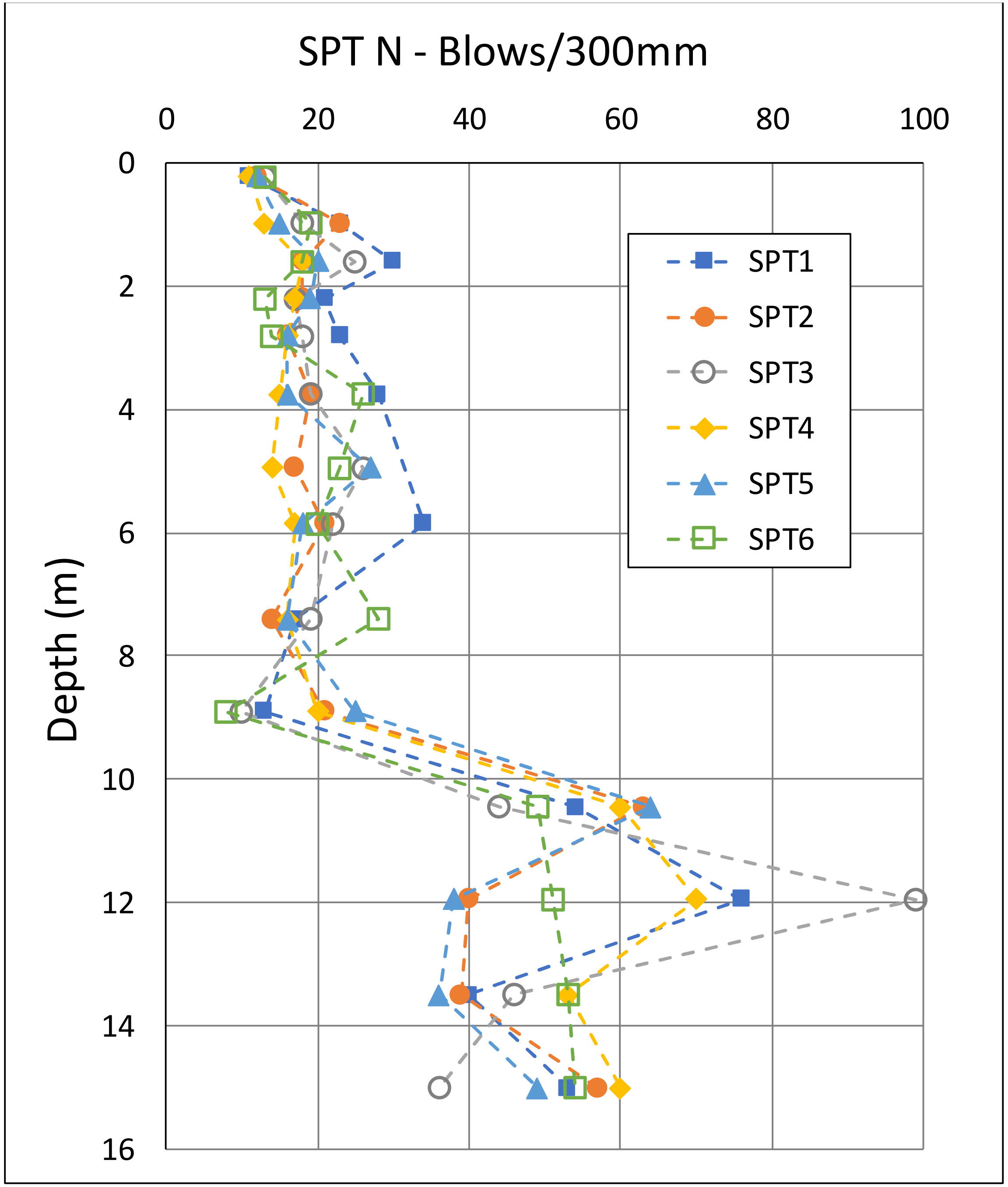


Figure B2: SAND PROFILE - Summary of SPT results

Depth (m)	SPT2	SPT3	SPT4	SPT5	SPT6
	Moisture Content (%)				
0.23	14.3	11.9	16.8	14.4	15.9
0.98	13.0	12.1	11.6	13.0	12.4
1.60	17.2	15.5	11.8	14.0	11.1
2.20	19.2	18.3	14.1	20.5	20.5
2.80	21.8	21.5	19.0	17.6	18.9
3.75	16.3	21.1	20.9	16.6	18.3
4.95	16.6	19.2	20.7	16.6	18.7
5.85	27.7	25.4	25.0	19.4	12.2
7.40	29.2	29.3	33.5	29.7	31.2
8.90	27.4	23.0	20.9	29.6	29.0
10.45	27.0	30.9	32.6	26.7	28.6
11.95	27.5	34.0	36.7	29.3	29.0
13.50	27.2	21.9	28.5	32.1	30.7
15.00	22.1	25.8	21.7	25.1	23.4

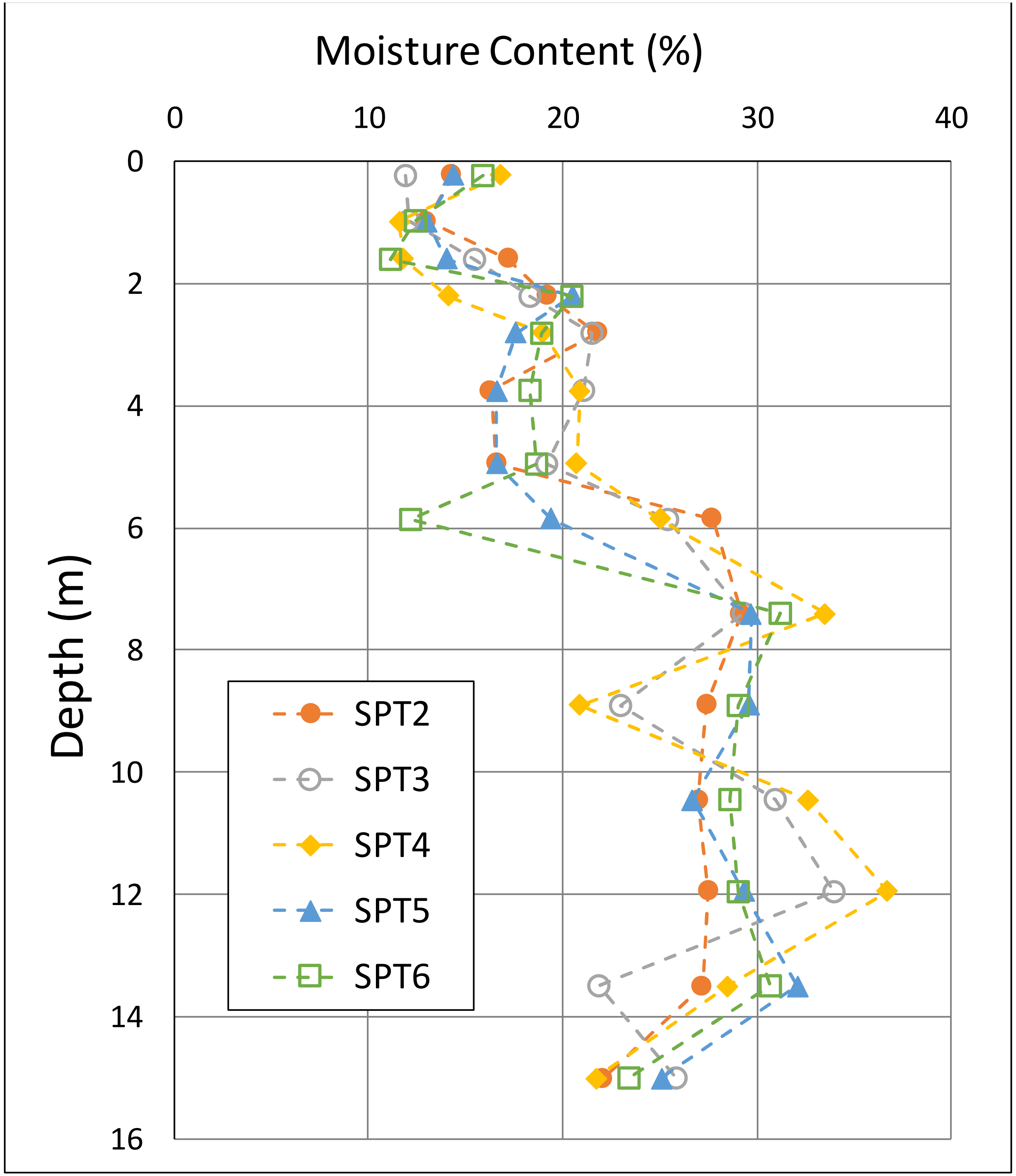


Figure B3: SAND PROFILE - Summary of Moisture Content results

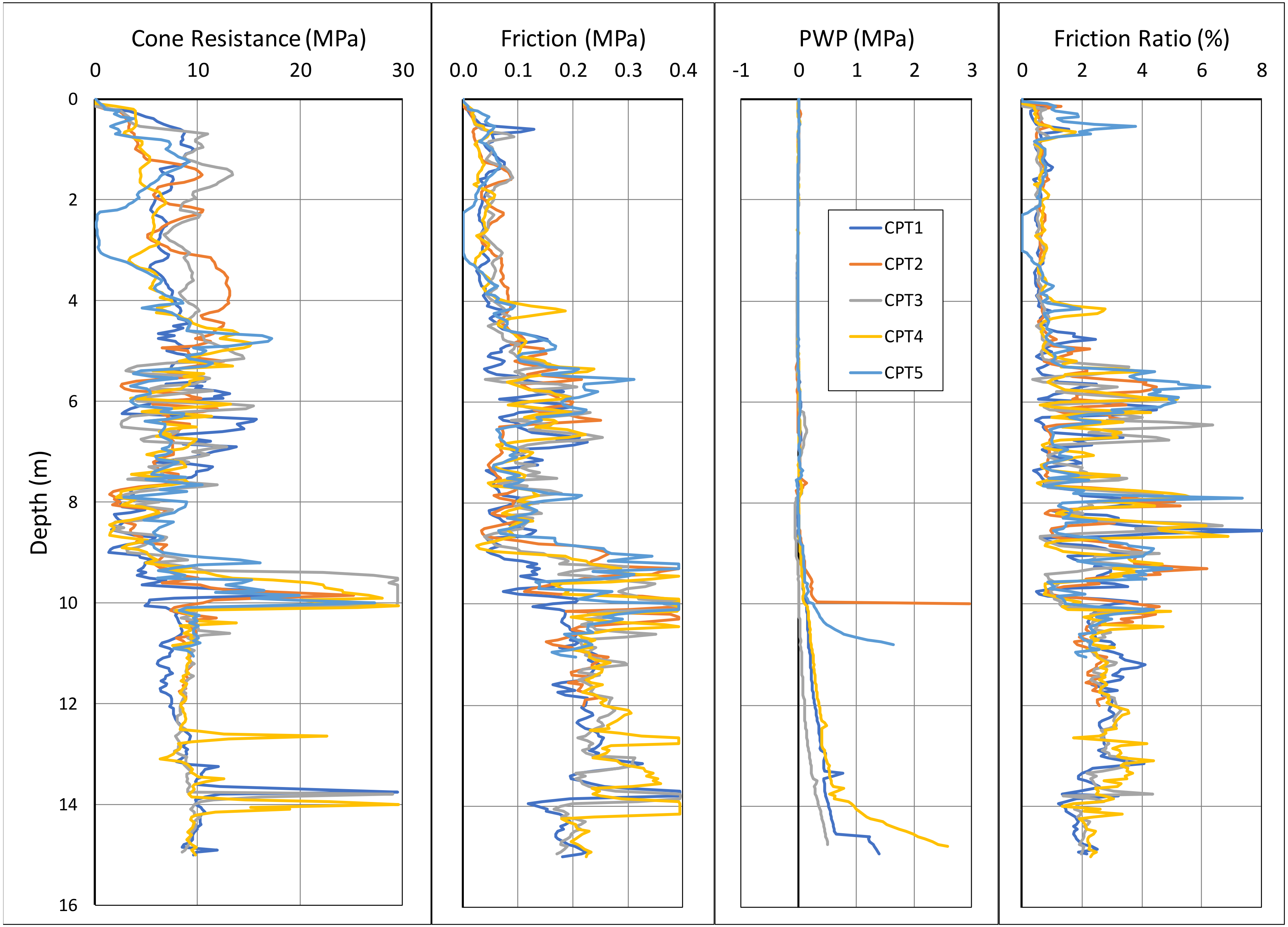


Figure B4: SAND PROFILE - Summary of CPTu results

MENARD PRESUREMETER TESTS

	Depth (m)	Init Mod (MPa)	Reload Mod (MPa)	Limit Press (MPa)
PMT 1	0.5	6.42	21.90	0.40
	1.2	6.27	24.34	0.46
	2.1	7.44	33.90	0.80
	3.3	7.75	51.43	0.74
	5.1	12.60	78.11	1.10
	7.5	4.62	61.10	0.90
	10.8	173.88	369.55	4.20
PMT 2	0.5	7.62	34.34	0.58
	1.2	10.56	47.89	0.90
	2.1	8.08	57.78	0.84
	3.3	9.49	55.51	0.92
	5.1	13.37	84.97	1.25
	7.5	6.39	41.97	1.00
	10.8	132.93	253.73	4.40
PMT 3	1.4	8.56	87.76	0.78
	2.1	9.66	59.29	0.80
	3.0	8.13	52.08	0.80
PMT 4	1.4	14.87	29.57	0.85
	2.1	12.37	25.45	0.90
	3.0	9.86	23.09	0.72

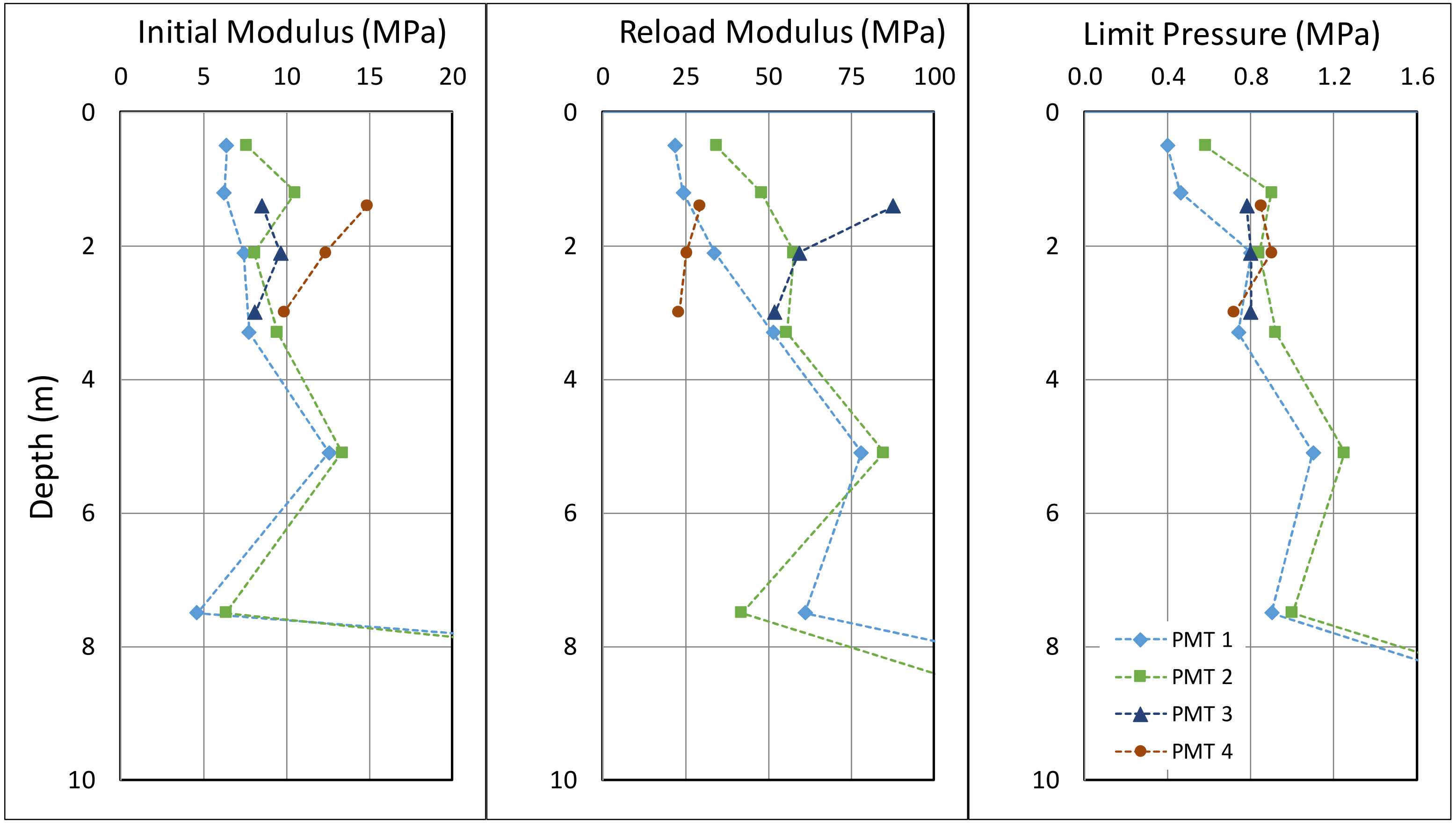


Figure B5: SAND PROFILE - Summary of Pressuremeter results

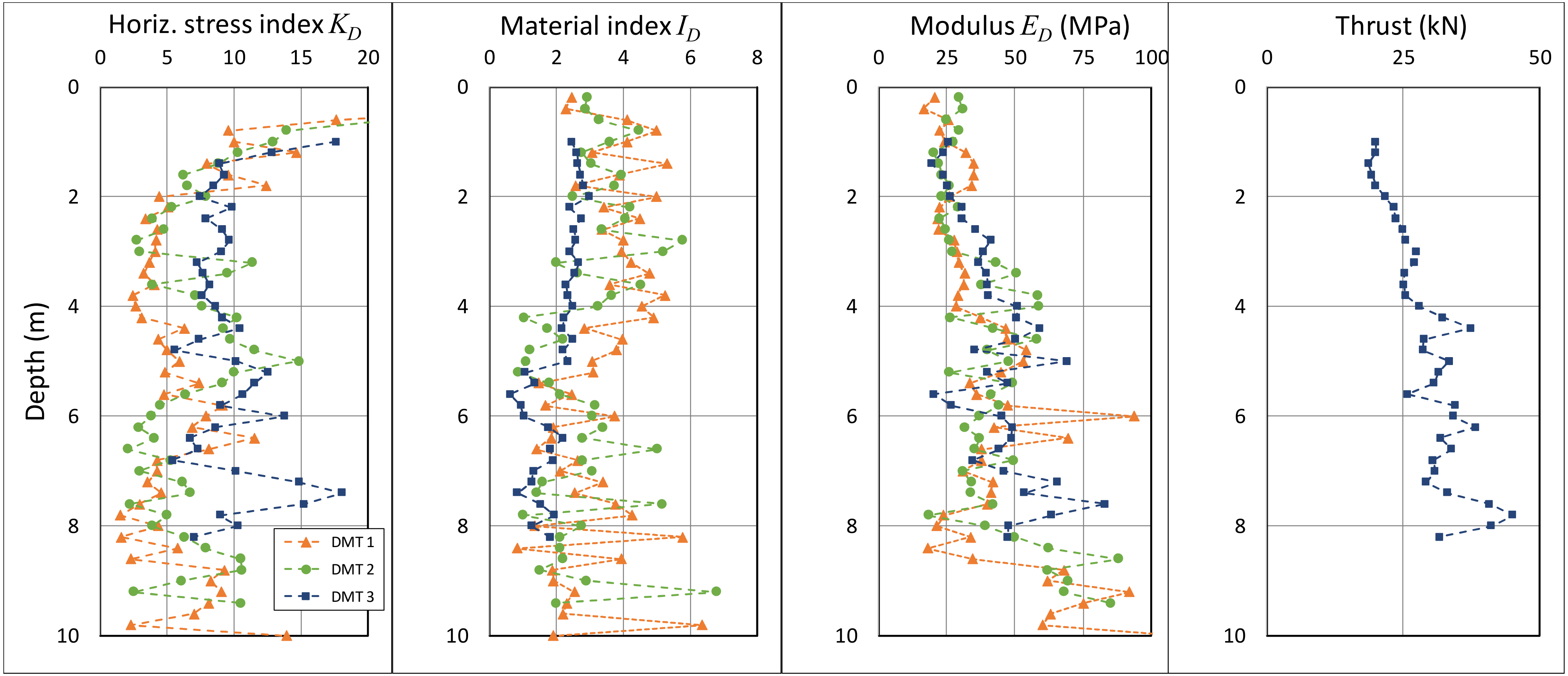
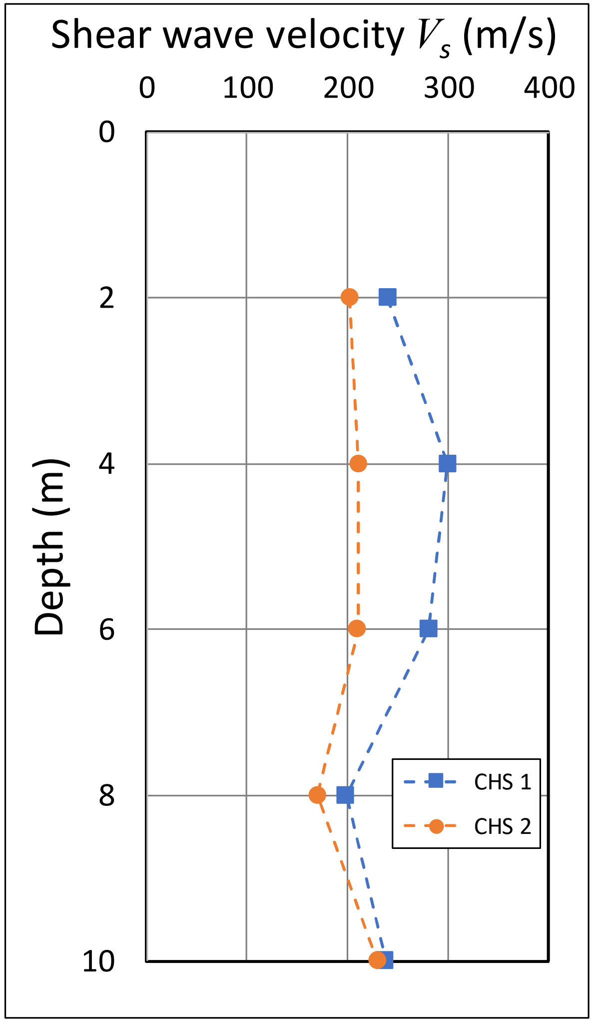


Figure B6: SAND PROFILE - Summary of Dilatometer results

	Depth (m)	V_s (m/s)	G_0 (MPa)
CHS 1	2	240	104
	4	300	162
	6	281	142
	8	199	71
	10	238	102

	Depth (m)	V_s (m/s)	G_0 (MPa)
CHS 2	2	202	73
	4	211	80
	6	210	79
	8	170	52
	10	230	95



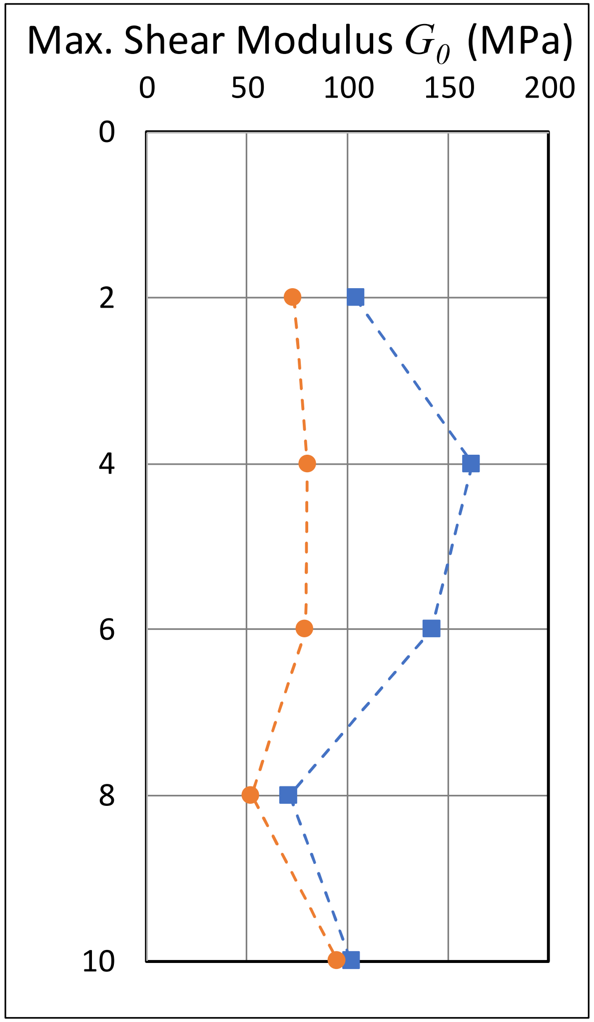


Figure B7: SAND PROFILE – Summary of Cross-hole Seismic test results

ANNEX C: SPECIMEN PROBLEMS

Problem CLAY 1 – Vertically loaded spread footing	(Prediction)
Problem CLAY 2 – Axially loaded pile	(Prediction)
Problem CLAY 3 – Laterally loaded pile	(Prediction)
Problem CLAY 4 – Slope design	(Design)
Problem SAND 1 – Vertically loaded spread footing	(Prediction)
Problem SAND 2 – Axially loaded pile	(Prediction)
Problem SAND 3 – Design of spread footing with horizontal load	(Design)
Problem SAND 4 – Slope design	(Design)
Problem SAND 5 – Embedded retaining wall	(Design)
Problem SAND 6 – Temporary soil nailed wall	(Design)

DETAILS OF RESPONDENT – Reply sheet

Name (optional) ………………………………………………………

Email (optional) ………………………………………………………

Occupation □ Student □ Academic □ Design consultant □ Contractor

□ Other (please specify) ………………………....

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

Country ………………………………………………………

Design methods used in your country

□ WLD: Working load design with global factor of safety

□ LRFD: Load and resistance factor design (e.g. AASHTO codes)

□ PF LSD: Partial factor limit states design (e.g. Eurocodes)

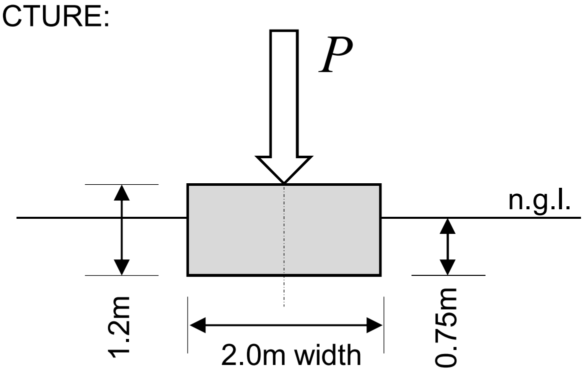
□ Other (please specify:

Geotechnical design codes used in your country:
(please specify standard number and year, e.g. EN1997-1:2004)

Your favourite geotechnical engineering textbooks (3 max.):

Problem CLAY 1 – Vertically loaded spread footing

STRUCTURE:



- 2.0m wide concrete strip footing founded on clay at 0.75m below ground level
- Concentric line load P excludes weight of footing

PROBLEM:

This problem requires the prediction of the performance of the footing.

1. Predict the applied load that will cause bearing capacity failure of the footing, P_{ult} (kN/m).
2. Predict the applied load P_{25mm} (kN/m) that will cause the footing to settle by 25mm in the long term.
3. Predict the expected performance of the footing based on the test results, not a conservative assessment as may be used in design calculations.

Problem CLAY 1 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………

Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

PREDICTION:

P_{ult} = __________ kN/m P_{25mm} = ___________ kN/m

DETAILS OF ANALYSIS:

Method of bearing capacity analysis: ………………………………………………………

Type of analysis: □ Total stress (undrained) □ Effective stress (drained) □ Both

Method of settlement analysis: ………………………………………………………

Codes or Standards used (if any): ………………………………………………………

Parameter values (if appropriate):

c_u Undrained shear strength ………kPa

c' Drained cohesion ………kPa

ϕ' Drained friction angle ………deg

E' Drained elastic modulus ………MPa

Other parameters / empirical factors used: (please specify)

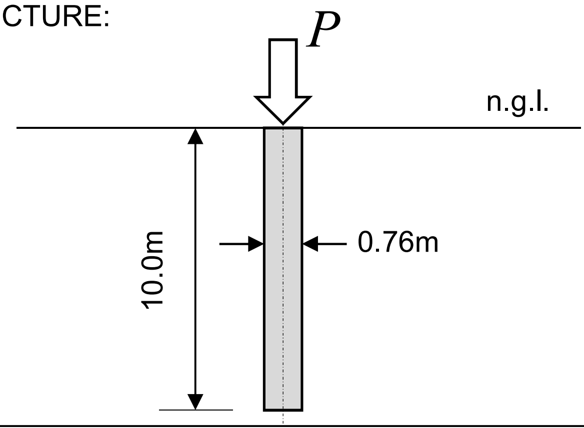
If you used a Skempton-type analysis, what value of N_c was used? ……………

References used:

Any comments:

Problem CLAY 2 – Axially loaded pile

STRUCTURE:



- 0.76m diameter, bored, cast in situ pile in clay
- Depth 10.0m below natural ground level.

PROBLEM:

This problem requires the prediction of the performance of the pile.

1. Predict the ultimate load capacity of the pile P_{ult}.
2. If the method used separates shaft and base resistance, state $P_{ult\ (shaft)}$ and $P_{ult\ (base)}$.
3. Predict the load-settlement curve to failure.
4. Predict the expected performance of the pile based on the test results, not a conservative assessment as may be used in design calculations.

Problem CLAY 2 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………..

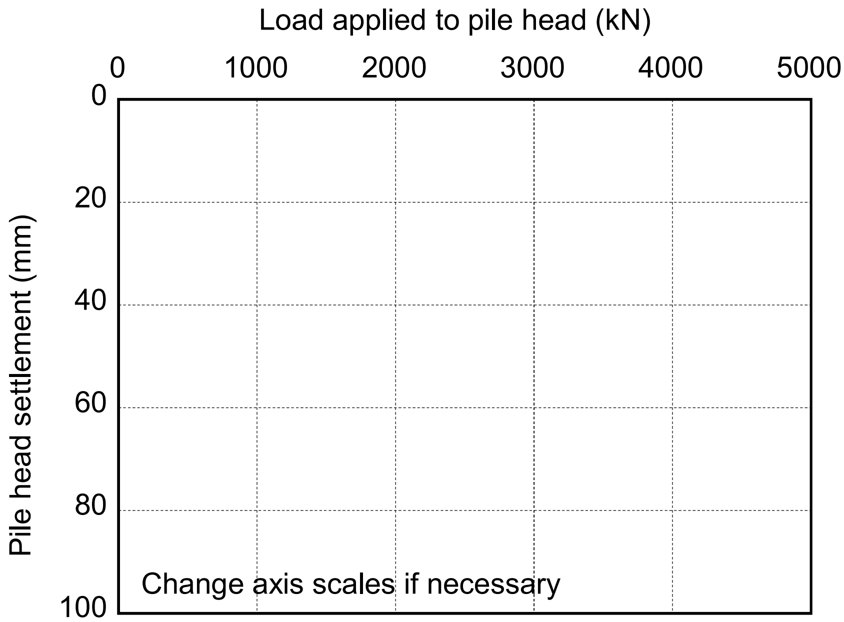
Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

PREDICTION:

P_{ult} = __________ kN

$P_{ult\ (shaft)}$ = ________kN $P_{ult\ (base)}$ = ________kN



Load (kN)	Settlement (mm)

DETAILS OF ANALYSIS:

Analysis based on: □ Empirical correlations with test results e.g. SPT, CPT, etc.

(specify tests …………………………………………………………..)

□ Soil strength and deformation parameters

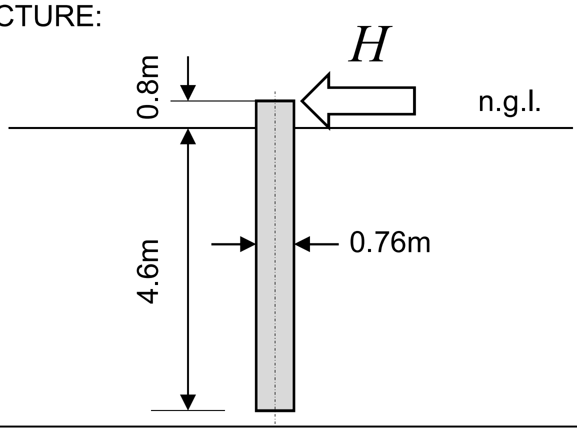
(specify parameters ……….……………………………………………)

References used:

Any comments:

Problem CLAY 3 – Laterally loaded pile

STRUCTURE:



- 0.76m diameter, bored, cast in situ pile in clay
- Founding depth 4.6m below natural ground level
- Load applied at 0.8m above ground level
- Pile reinforcement sufficient to prevent bending or shear failure of pile shaft.

PROBLEM:

This problem requires the prediction of the performance of the pile.

1. Predict the ultimate load capacity of the pile H_{ult}.
2. Predict the long term load-deflection curve to failure.
3. Predict the expected performance of the pile based on the test results, not a conservative assessment as may be used in design calculations.

Problem CLAY 3 – Reply sheet

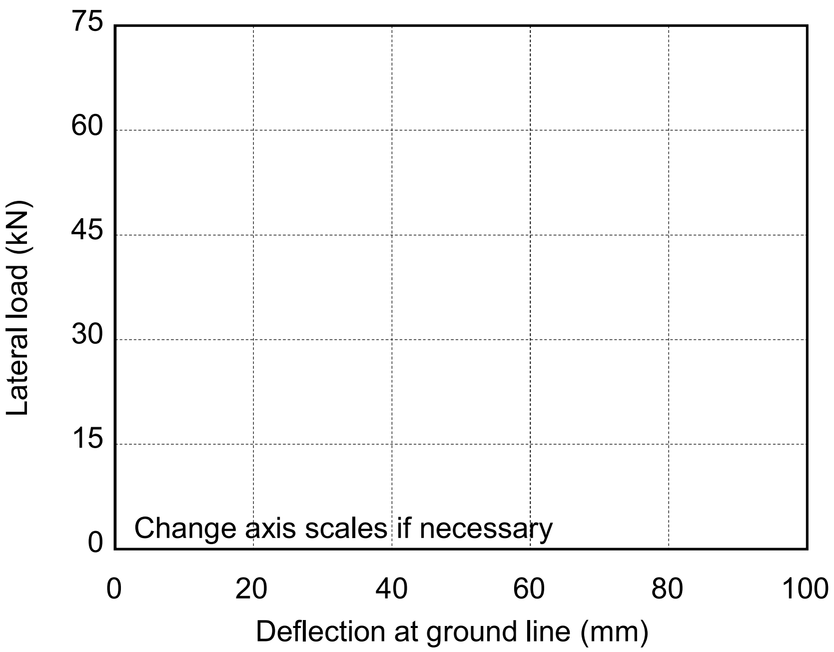
RESPONDENT PROFILE:

Country ……………………………………..

Occupation ☐ Student ☐ Academic ☐ Design consultant ☐ Contractor ☐ Other

Experience ☐ 0 – 10 years ☐ 10 – 20 years ☐ 20 – 30 years ☐ 30+ years

PREDICTION: H_{ult} = __________ kN



Load (kN)	Deflection (mm)

DETAILS OF ANALYSIS:

Analysis based on:

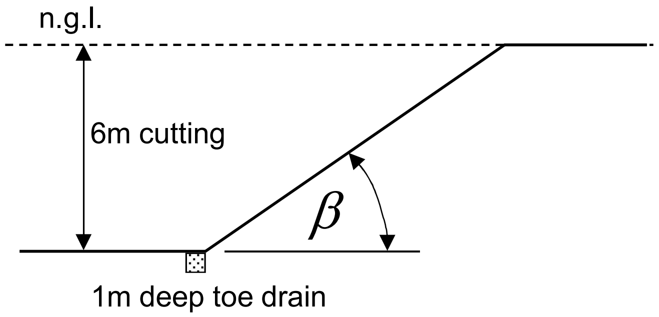
☐ Empirical correlations with test results e.g. SPT, CPT, etc.
(specify tests ……………………………………………………….)

☐ Soil strength and deformation parameters
(specify parameters ……..……………………………………….)

References used:

Problem CLAY 4 – Slope design

STRUCTURE:



- Permanent cutting for a public road.
- No surcharges.

PROBLEM:

This is a design problem requiring the specification of the slope angle for construction.

1. Specify the angle β at which the slope is to be cut.

Problem CLAY 4 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………

Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

DESIGN:

β = _________ degrees

DETAILS OF ANALYSIS:

Design Code used (if any): ………………………………………………………….

Method of slope stability analysis: ………………………………………………………….

Type of analysis: □ Total stress (undrained) □ Effective stress (drained) □ Both

Parameter values:	z<6m	z>6m	(* delete as required)
c_u Undrained shear strength	………	………kPa	(average* / characteristic*)
c' Drained cohesion	……….	………kPa	(average* / characteristic*)
ϕ' Drained friction angle	……….	………deg	(average* / characteristic*)

Other parameters / empirical factors used: (please specify)

Did your analysis include a tension crack? □ Yes □ No

If so, to what depth? …………… m

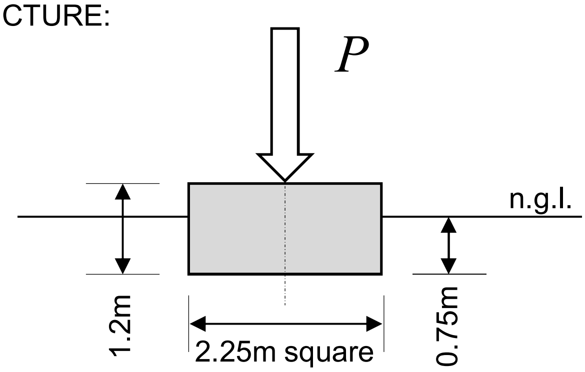
Did you assume this crack could fill with water? □ Yes □ No

References used:

Any comments:

Problem SAND 1 – Vertically loaded spread footing

STRUCTURE:



- 2.25m square concrete footing founded on sand at 0.75m below ground level
- Concentric applied load P excludes weight of footing

PROBLEM:

This problem requires the prediction of the performance of the footing.

1. Predict the ultimate load capacity of the footing P_{ult}.
2. Predict the load P_{25mm} that will cause the footing to settle by 25mm in the long term.
3. Predict the expected performance of the footing based on the test results, not a conservative assessment as may be used in design calculations.

Problem SAND 1 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………..

Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

PREDICTION:

P_{ult} = __________ kN P_{25mm} = ___________ kN

DETAILS OF ANALYSIS:

Method of bearing capacity analysis: ……………………………………………………………

Method of settlement analysis: ……………………………………………………………

Codes or Standards used (if any): ……………………………………………………………

Parameter values (if appropriate):

c' Drained cohesion ………kPa

ϕ' Drained friction angle ………deg

E' Drained elastic modulus ………MPa

Other parameters used: (please supply)

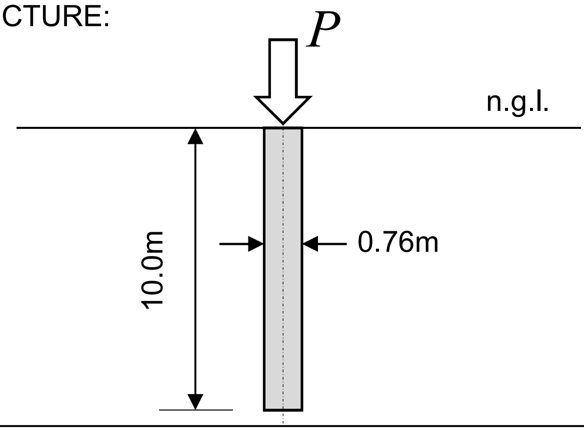
Did your method of bearing capacity analysis include depth correction factors? □ Yes □ No

References used:

Any comments:

Problem SAND 2 – Axially loaded pile

STRUCTURE:



- 0.76m diameter, bored, cast in situ pile in sand. Installed under slurry.
- Depth 10.0m below natural ground level.

PROBLEM:

This problem requires the prediction of the performance of the pile.

1. Predict the ultimate load capacity of the pile P_{ult}.
2. If the method used separates shaft and base resistance, state $P_{ult\ (shaft)}$ and $P_{ult\ (base)}$.
3. Predict the load-settlement curve to failure.
4. Predict the expected performance of the pile based on the test results, not a conservative assessment as may be used in design calculations.

Problem SAND 2 – Axially loaded pile

RESPONDENT PROFILE:

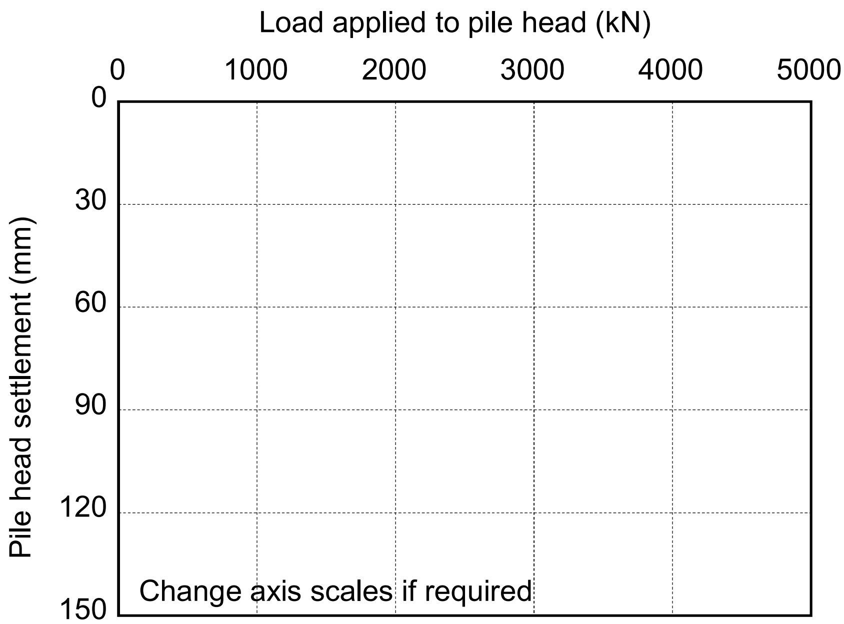
Country ……………………………………

Occupation ◻ Student ◻ Academic ◻ Design consultant ◻ Contractor ◻ Other

Experience ◻ 0 – 10 years ◻ 10 – 20 years ◻ 20 – 30 years ◻ 30+ years

Prediction: P_{ult} = __________ kN

$P_{ult\ (shaft)}$ = ________kN $P_{ult\ (base)}$ = ________kN



Load (kN)	Settlement (mm)

DETAILS OF ANALYSIS:

Analysis based on:

◻ Empirical correlations with test results e.g. SPT, CPT, etc.
(specify tests ……………………………………………………….)

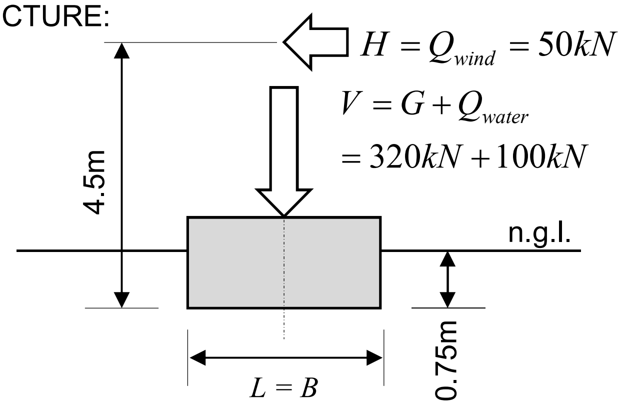
◻ Soil strength and deformation parameters
(specify parameters ………..…………………………………….)

Did you include end bearing of bored pile below water table?: ◻ Yes ◻ No

References used:

Problem SAND 3 – Design of spread footing with horizontal load

STRUCTURE:



- Foundation is for a water tank stand
- Vertical load V includes dead load G excluding weight of footing) and weight of water in tank Q_{water}.
- Horizontal load H is due to wind only Q_{wind}. Can act in any horizontal direction.
- Loads are given as characteristic values.

PROBLEM:

This is a design problem requiring the specification of the footing size for construction.

1. Determine the size of footing required ($L = B$).

Problem SAND 3 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………..

Occupation ◻ Student ◻ Academic ◻ Design consultant ◻ Contractor ◻ Other

Experience ◻ 0 – 10 years ◻ 10 – 20 years ◻ 20 – 30 years ◻ 30+ years

DESIGN:

$L=B$ = ________ m

DETAILS OF ANALYSIS:

Design method (Limit states, working load, etc.): ………………………………………...

Code or standard used: …………………………………………………………

Method of bearing capacity calculation: …………………………………………………………

Parameter values (if appropriate): (* delete as required)

c' Drained cohesion*	………kPa	(average* / characteristic*)
ϕ' Drained friction angle*	………deg	(average* / characteristic*)
γ Bulk density of sand*	………kN/m^3	(average* / characteristic*)

Other parameters used: (please supply)

Design situation: ◻ Tank empty ◻ Tank full

Factors applied (load factors, combination factors, material factors, resistance factors, FoS, etc.)

……………………………………………………………………………………………………

……………………………………………………………………………………………………

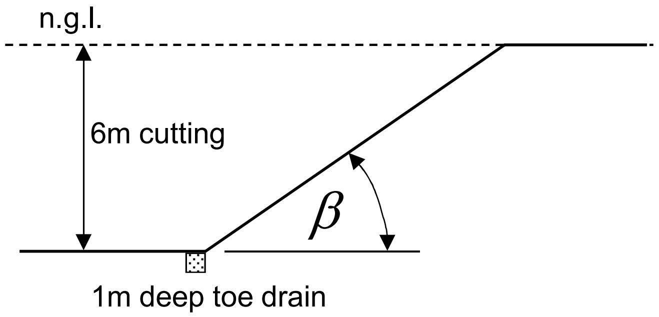
Allowance for large eccentricity (if any): …………………………………………………………

For EN1997-1 users:
Design approach used: ◻ DA1 ◻ DA2 ◻ DA2* ◻ DA3
Critical ultimate limit state: ◻ GEO ◻ STR ◻ EQU

Any comments:

Problem SAND 4 – Slope design

STRUCTURE:



- Permanent cutting for a public road.
- No surcharges.

PROBLEM:

This is a design problem requiring the specification of the slope angle for construction.

1. Specify the angle β at which the slope is to be cut.

Problem SAND 4 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………..

Occupation ☐ Student ☐ Academic ☐ Design consultant ☐ Contractor ☐ Other

Experience ☐ 0 – 10 years ☐ 10 – 20 years ☐ 20 – 30 years ☐ 30+ years

DESIGN:

β = _________ degrees

DETAILS OF ANALYSIS:

Design Code used: ……………………………………………………………

Method of slope stability analysis: ……………………………………………………………

Type of analysis: ☐ Total stress (undrained) ☐ Effective stress (drained) ☐ Both

Parameter values:	z<4m	4m - 8m	z>8m		(* delete as required)
c' Drained cohesion	……….	……….	………	kPa	(average* / characteristic*)
ϕ' Drained friction angle	……….	……….	………	deg	(average* / characteristic*)

For WLD, specify Factor of Safety used: ……………….

Other parameters / empirical factors used: (please specify):

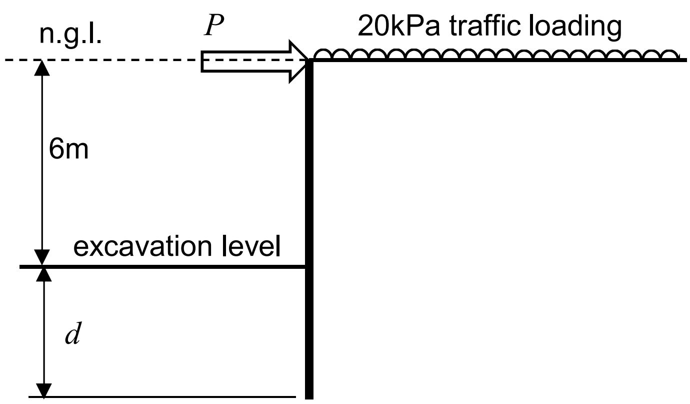
For EN1997-1 users:
Design approach used: ☐ DA1 ☐ DA2 ☐ DA3

References used:

Any comments:

Problem SAND 5 – Propped embedded retaining wall design

STRUCTURE:



- Permanent retaining wall propped at top.
- 6.0m deep excavation.
- 20kPa variable loading (surcharge) due to traffic.

PROBLEM:

This is a design problem requiring the specification of the geometry of the wall, the propping force and the strength of the wall in bending.

1. Specify the required depth of embedment d (m).
2. Specify the propping force P (kN/m).
3. Specify the minimum yield moment of wall element M_{yield} (kNm/m).

Design to be based on the stability of the wall without considering serviceability requirements.

Problem SAND 5 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………

Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

DESIGN:

d =	________	metres	
P =	________	kN/m	(working load* / LSD design value*)
M_{yield} =	________	kNm/m	(minimum yield moment)
			(* delete as required)

DETAILS OF ANALYSIS:

Design Code used: ………………………………………………………………………

Method of analysis: ………………………………………………………………………

Parameter values:	z<4m	4m - 8m	z>8m	(* delete as required)
c' Drained cohesion	……….	……….	……… kPa	(average* / characteristic*)
ϕ' Drained friction angle	……….	……….	……… deg	(average* / characteristic*)

Other parameters / empirical factors used: (please specify)

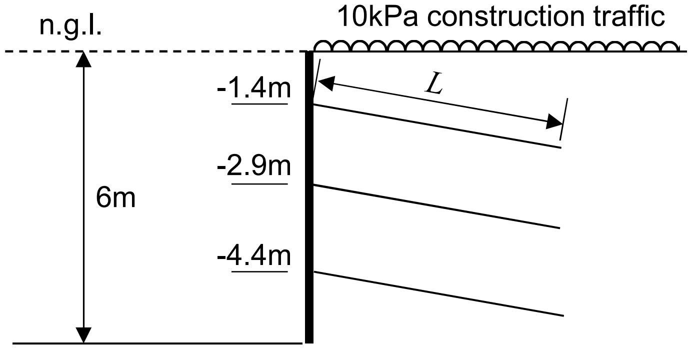
For EN1997-1 users:
Design approach used: □ DA1 □ DA2 □ DA3

References used:

Any comments:

Problem SAND 6 – Soil nailed retaining wall design

STRUCTURE:



- Temporary soil nailed wall.
- 10kPa variable loading (construction traffic).
- 10^o nail inclination.
- 20mm nails: F_y = 140kN.
- All nails L m long.

PROBLEM:

This is a design problem requiring the specification of the length of the soil nails and their horizontal spacing.

1. Specify the required length of the soil nails (L).
2. Specify horizontal spacing (S_H).

Design to be based on the stability of the wall without considering serviceability requirements.

Problem SAND 6 – Reply sheet

RESPONDENT PROFILE:

Country ……………………………………

Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

DESIGN:

L = __________ m

S_H = __________ m

DETAILS OF ANALYSIS:

Design Code used: …………………………………………………………………………

Method of analysis: …………………………………………………………………………

Parameter values:	z<4m	4m - 8m	z>8m	(* delete as required)
c' Drained cohesion	……….	……….	……… kPa	(average* / characteristic*)
ϕ' Drained friction angle	……….	……….	……… deg	(average* / characteristic*)

Other parameters / empirical factors used: (please specify)

For EN1997-1 users:
Design approach used: □ DA1 □ DA2 □ DA3

References used:

Any comments: