DEVELOPMENT OF A DESIGN, INSTALLATION AND TESTING FEEDBACK MODEL FOR MICROPILES IN PROJECTS WITHOUT EXTENSIVE GEOTECHNICAL INFORMATION

Allan Herse B.Eng (Civil), MIEAust, CPEng, RPEQ

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PCA GROUND ENGINEERING


World Map
Hema maps
LEGEND
• Capital • City, Town
Traditional World Maps are drawn from the perspective of the first European explorers and cartographers – with the Northern Hemisphere at the top.
We think it's time to break with tradition and show the world from the perspective of all those people living in the Southern Hemisphere.
After all, there is no ancient geographical feature saying "This way up".
ANTARCTICA
SOUTHERN OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
SOUTH PACIFIC OCEAN
NORTH PACIFIC OCEAN
ARCTIC OCEAN
NORTH ATLANTIC OCEAN
AUSTRALIA
NEW ZEALAND
INDONESIA
PHILIPPINES
MALAYSIA
PAPUA NEW GUINEA
FIJI
TONGA
SAMOA
VANUATU
NAURU
KIRIBATI
SOLOMON ISLANDS
FED. STATES OF MICRONESIA
PALAU
MARSHALL ISLANDS
ARGENTINA
CHILE
BOLIVIA
BRAZIL
PERU
ECUADOR
COLOMBIA
VENEZUELA
PARAGUAY
URUGUAY
MEXICO
UNITED STATES OF AMERICA
CANADA
Alaska
Greenland
CHINA
MONGOLIA
RUSSIAN FEDERATION
KAZAKHSTAN
INDIA
PAKISTAN
AFGHANISTAN
IRAN
IRAQ
SAUDI ARABIA
YEMEN
OMAN
TURKEY
SYRIA
EGYPT
LIBYA
ALGERIA
SUDAN
CHAD
NIGERIA
NIGER
MALI
ETHIOPIA
KENYA
SOMALIA
TANZANIA
DEMOCRATIC REPUBLIC OF THE CONGO
ANGOLA
ZAMBIA
NAMIBIA
BOTSWANA
REPUBLIC OF SOUTH AFRICA
MADAGASCAR
MOZAMBIQUE
ZIMBABWE
UKRAINE
BELARUS
POLAND
GERMANY
FRANCE
SPAIN
PORTUGAL
ITALY
SWEDEN
NORWAY
FINLAND
ICELAND
UNITED KINGDOM
IRELAND
Abbreviations:
B.-HERZ. - BOSNIA AND HERZEGOVINA
KO. - KOSOVO
LIE. - LIECHTENSTEIN
LUX. - LUXEMBOURG
MAC. - MACEDONIA
MONT. - MONTENEGRO
RUS. FED. - RUSSIAN FEDERATION
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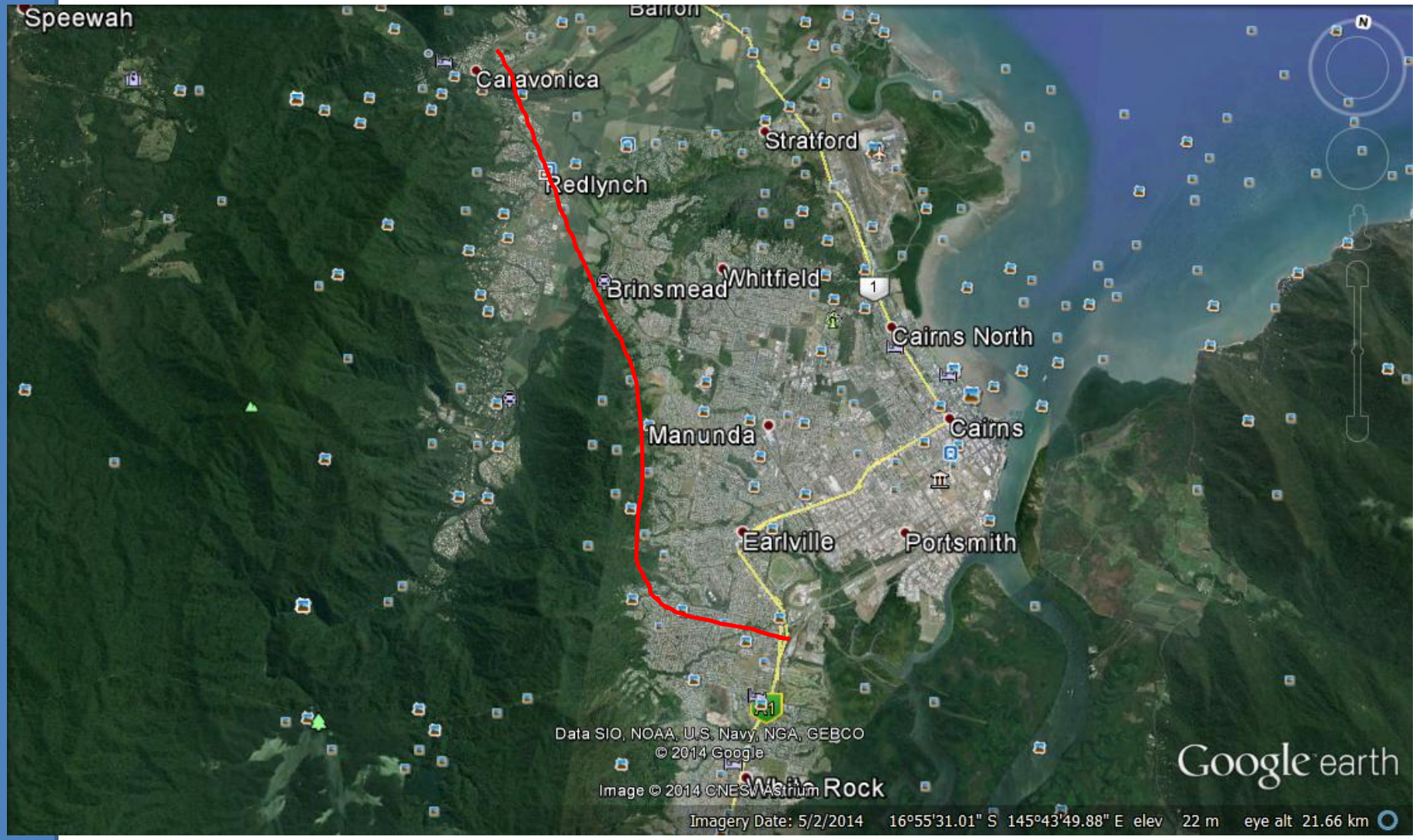
Speewah
Caravonica
Stratford
Redlynch
Brinsmead
Whitfield
Cairns North
Manunda
Cairns
Earlville
Portsmith
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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Image © 2014 CNES / Astrium
Google earth
Imagery Date: 5/2/2014 16°55'31.01" S 145°43'49.88" E elev 22 m eye alt 21.66 km

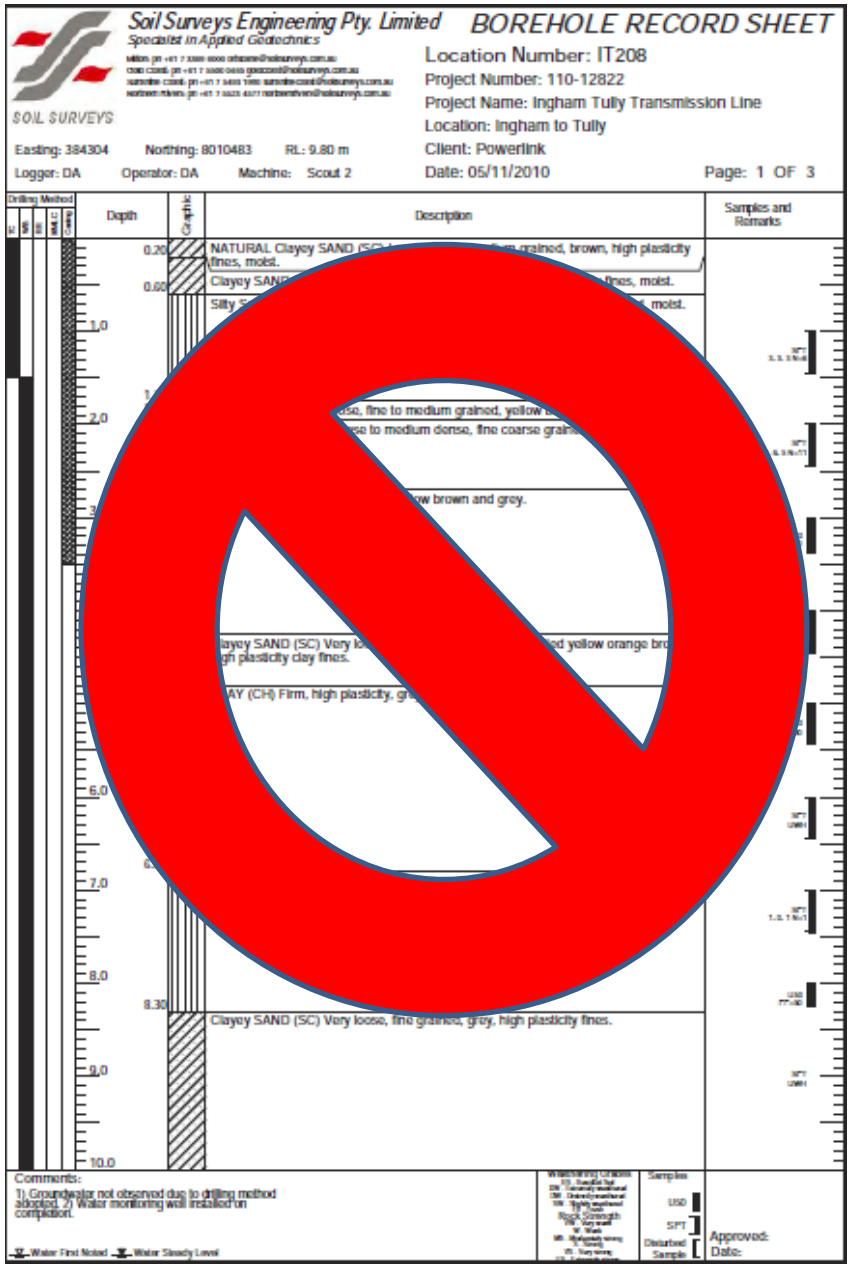
Foundations at the end of their design life

Challenging Locations

Needed to keep new foundations as small as possible to minimise visual impact and construction materials

Hollow bar micropile solution was proposed

No soils information….what to do?



- Live power lines made it difficult for geotechnical drilling beneath towers
- Access restrictions within residential areas
- Steep terrain
- Time
- Cost

Traditional design and installation sequence

Then we remembered what Nadir always says about having a customer with a need

Pile Length	Bar Yield Strength
9m	725kN

4	Titan 52/26	HC130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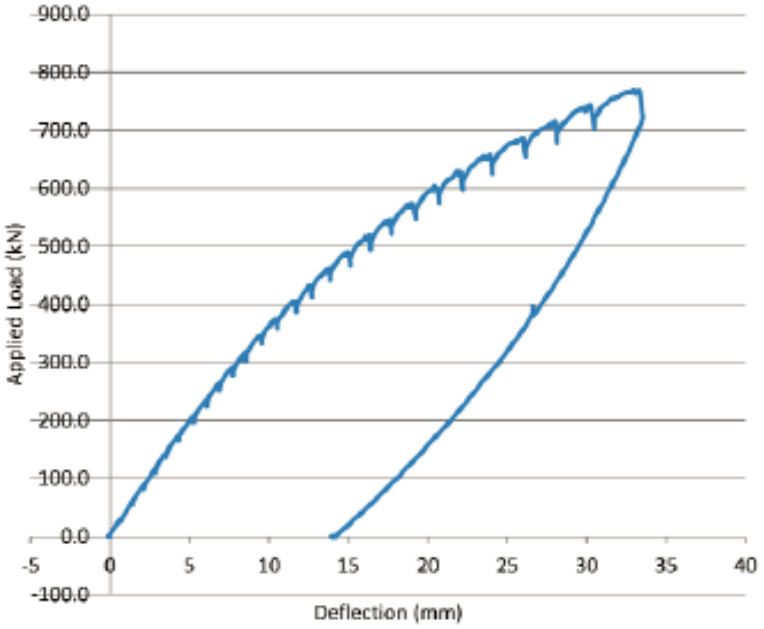
Site IT152 – What do we think?

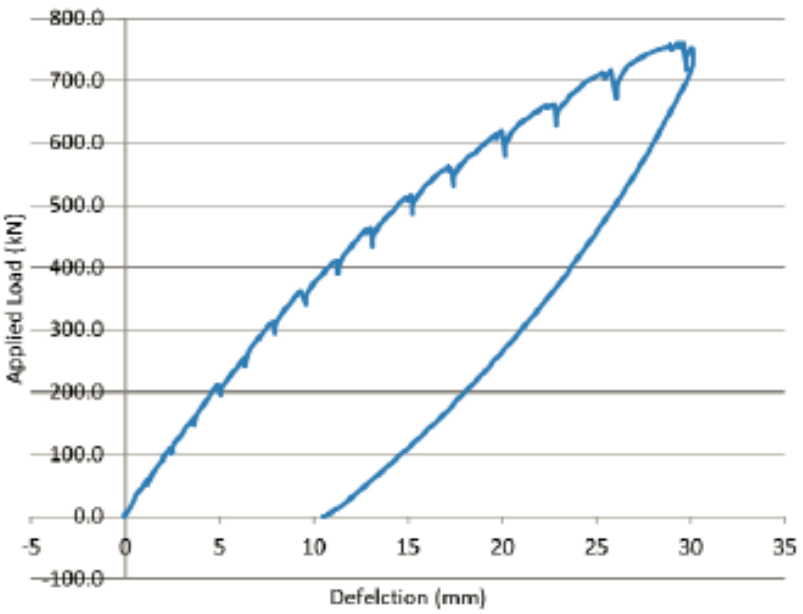
Layer Number	Soil Description	Layer position	SPT "n" value
1	Clayey Silt, Firm to Stiff	0-1.2m	N/A
2	Clayey Sand and Gravel, Medium Dense	1.2m-2.5m	13
3	Sand and Gravel, Loose	2.5m-4m	4
4	Silty Clay, Hard	4m-5.8m	40
5	Sandy Silty Clay, Hard	5.8m-7.2m	36
6	Sandy Silt, Stiff	7.2m-9.7m	10
7	Silty Sand, Loose	9.7m-11.8m	5 & 11
8	Sand, Medium Dense	To limit of tests	14 to 20

Design load estimate of the 9m pile was 250kN (56kips) if using AS2159 and values of skin friction based on Ischebeck data

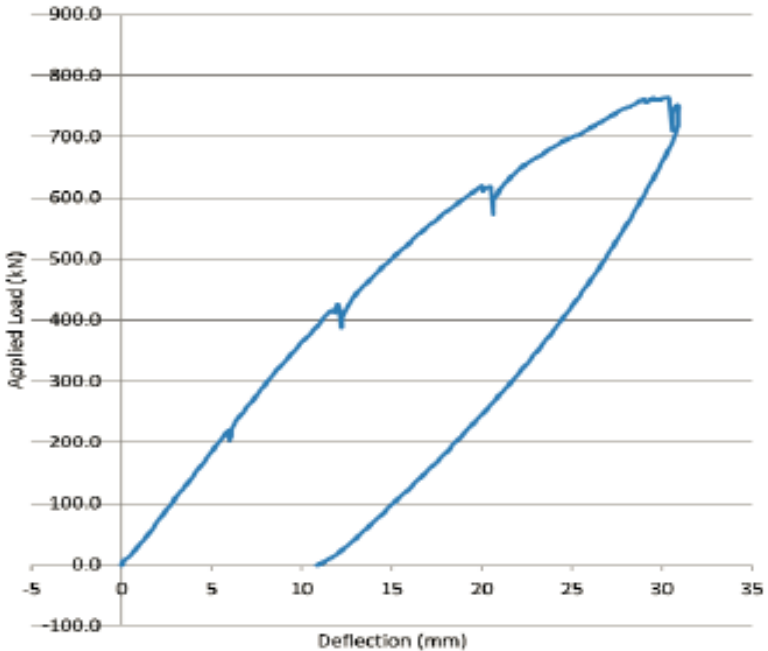
IT152 TP1 9m



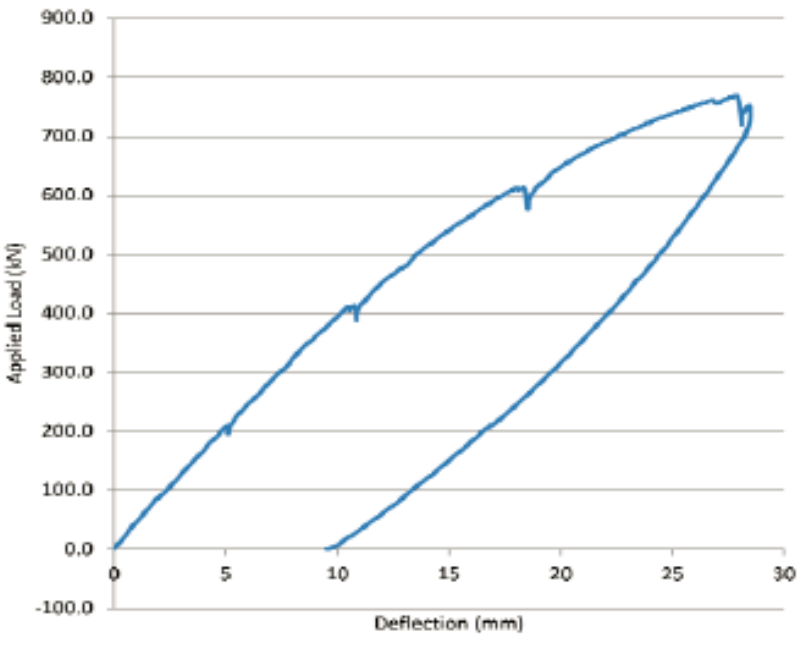
IT152 TP2 12m



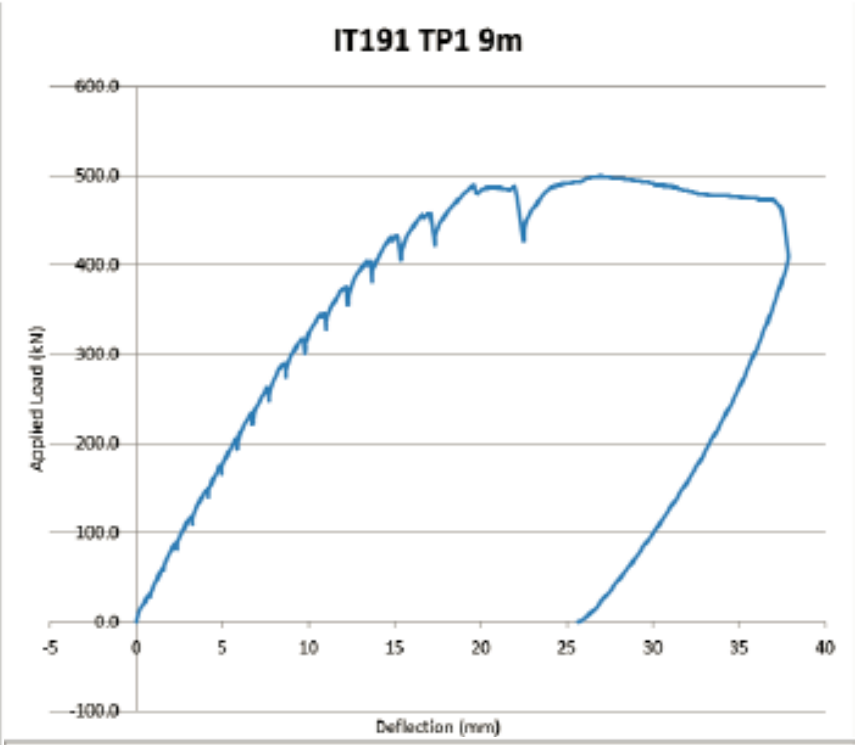
IT152 TP3 15m



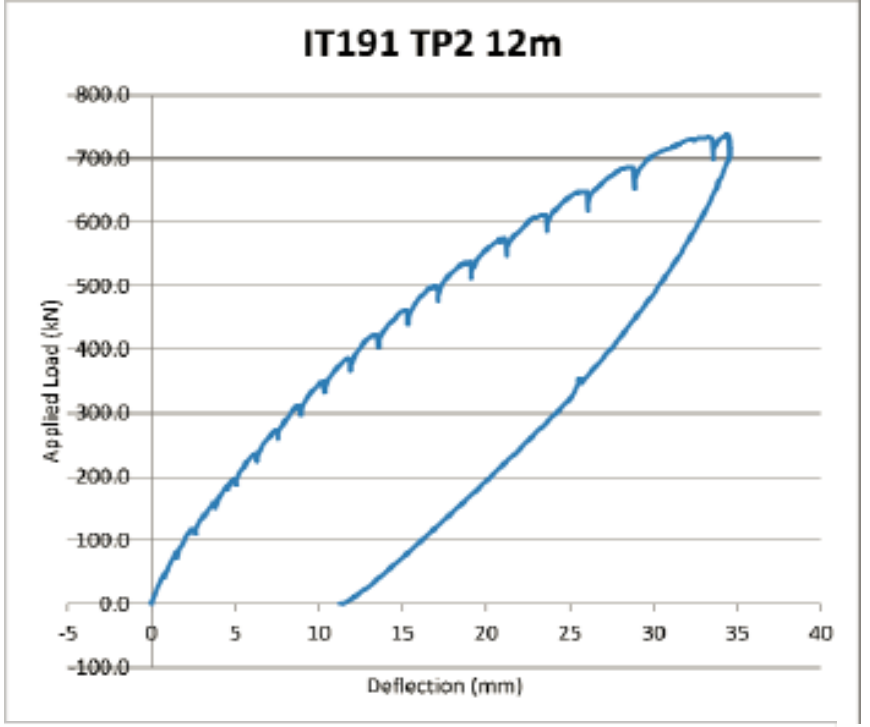
IT152 TP4 18m



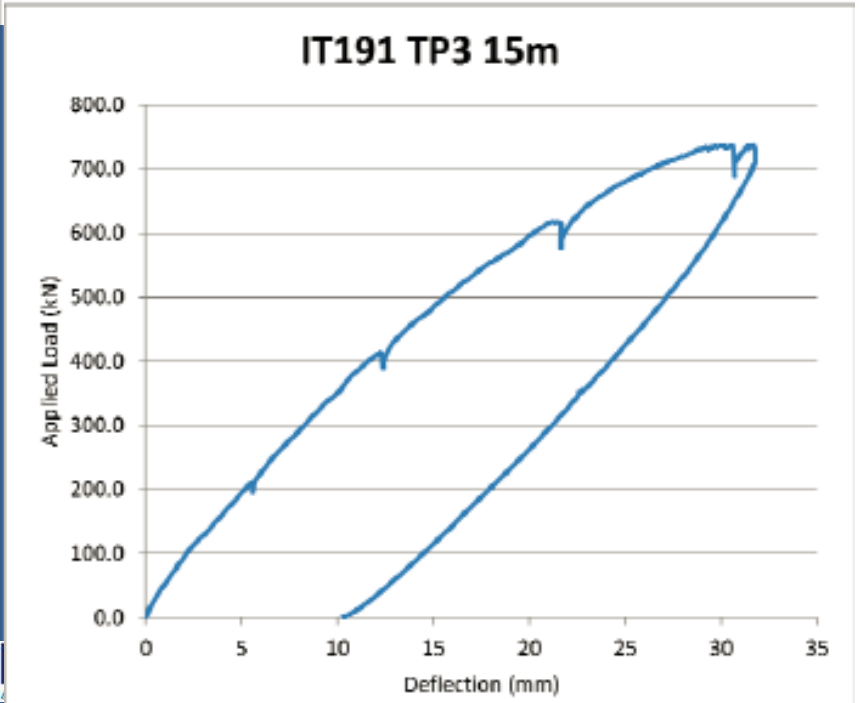
IT191 TP1 9m



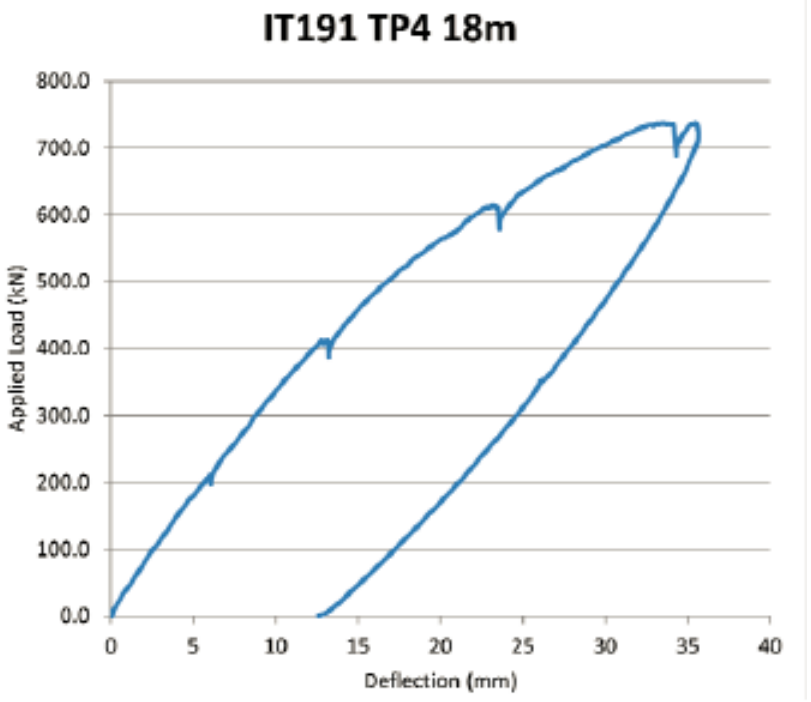
IT191 TP2 12m

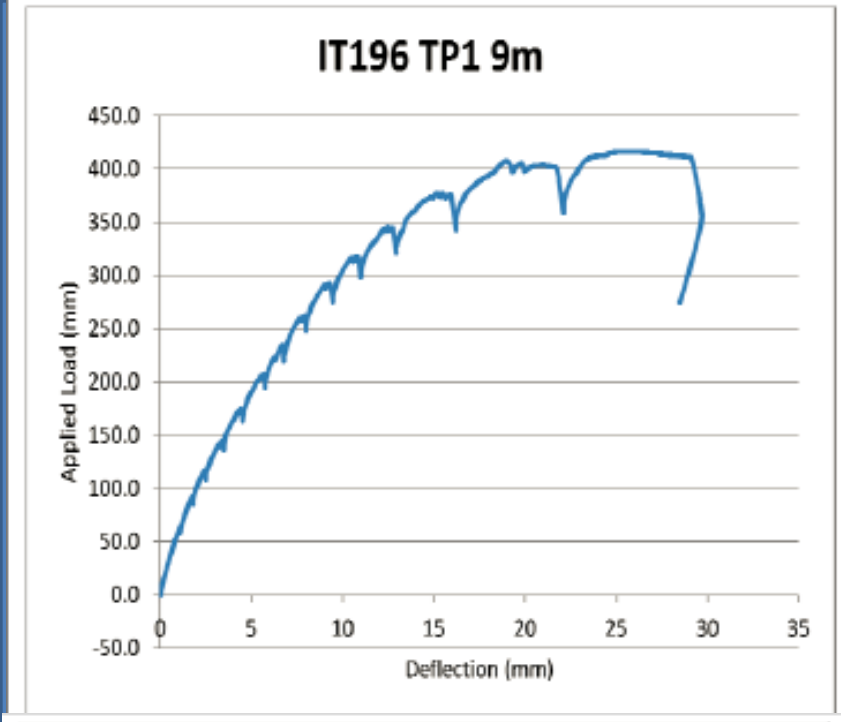


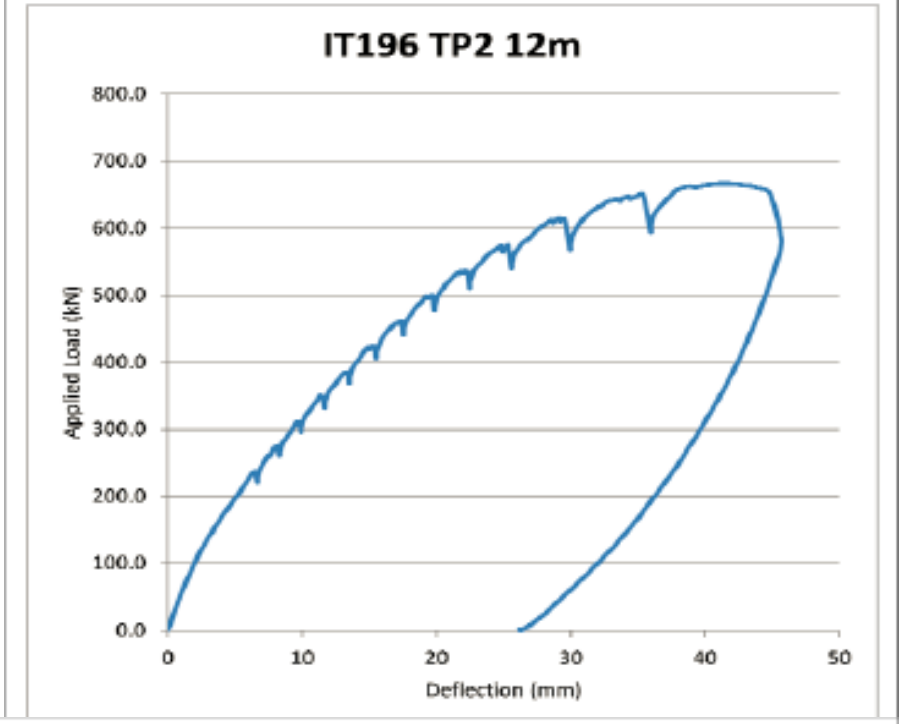
IT191 TP3 15m

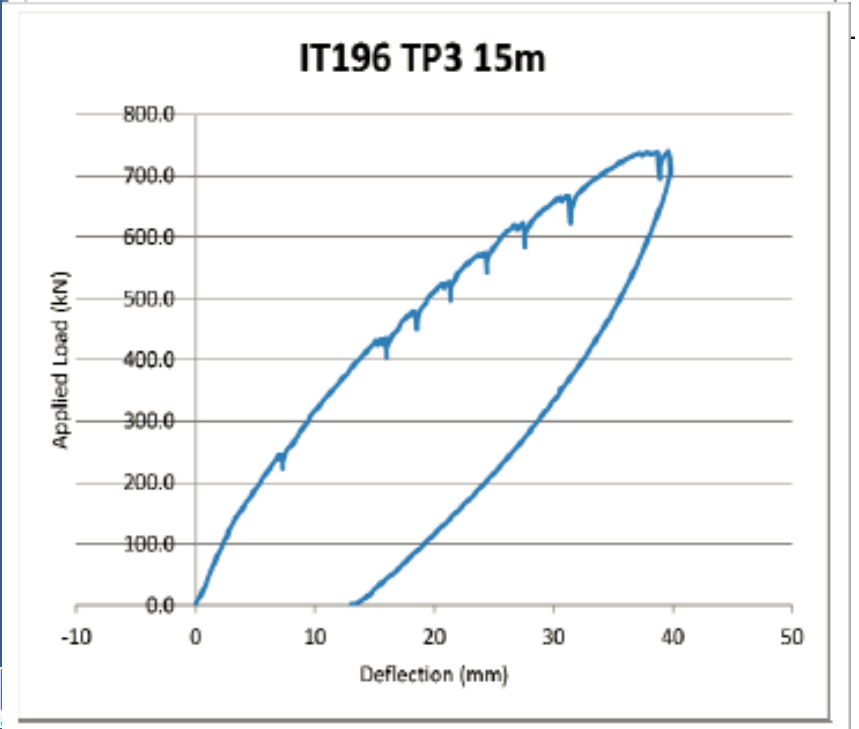


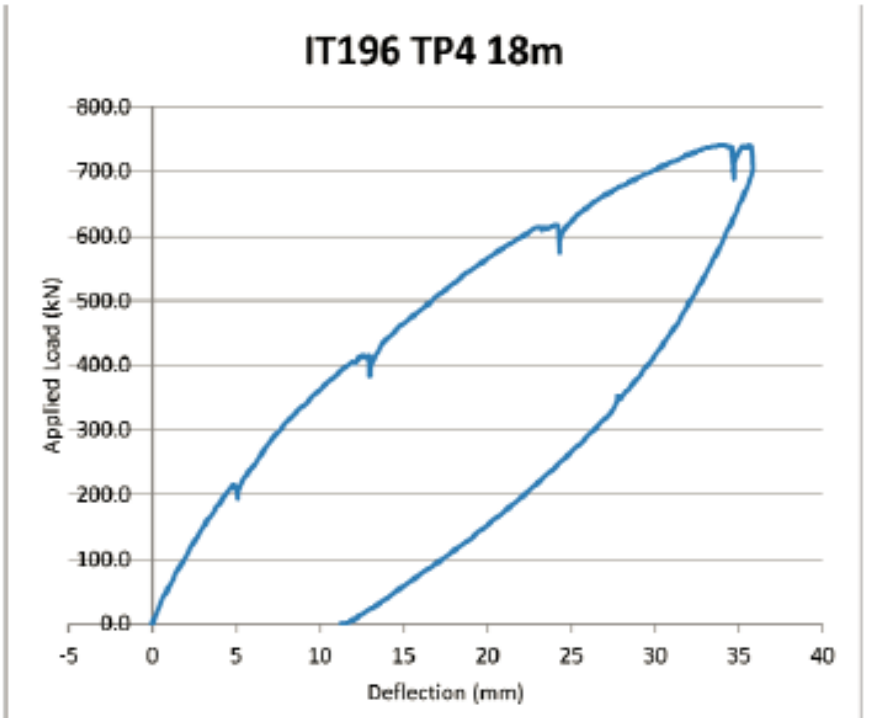
IT191 TP4 18m

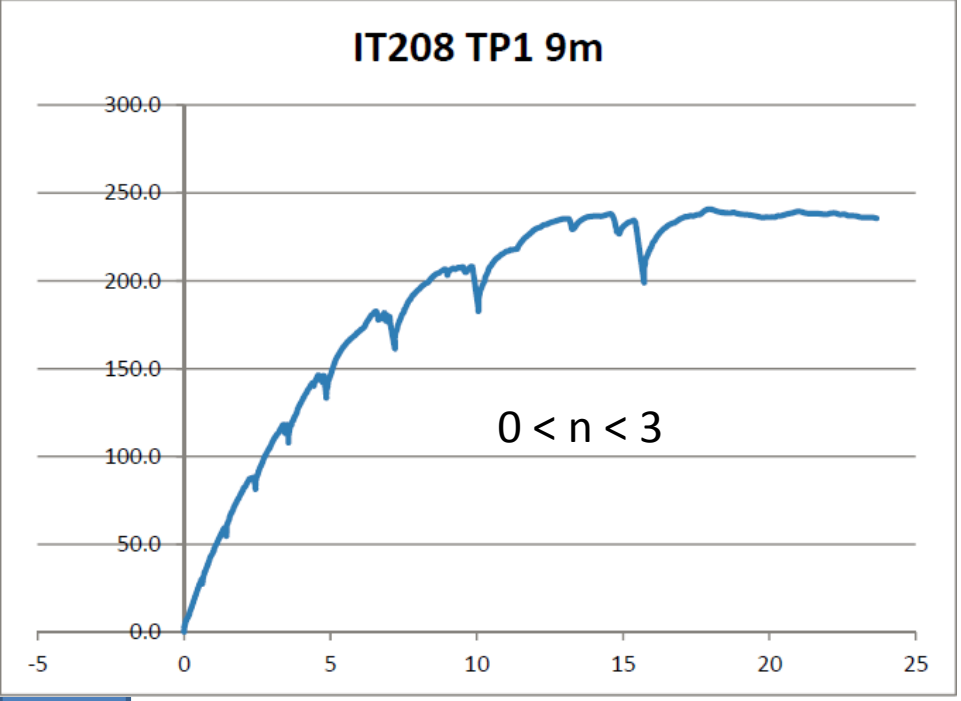


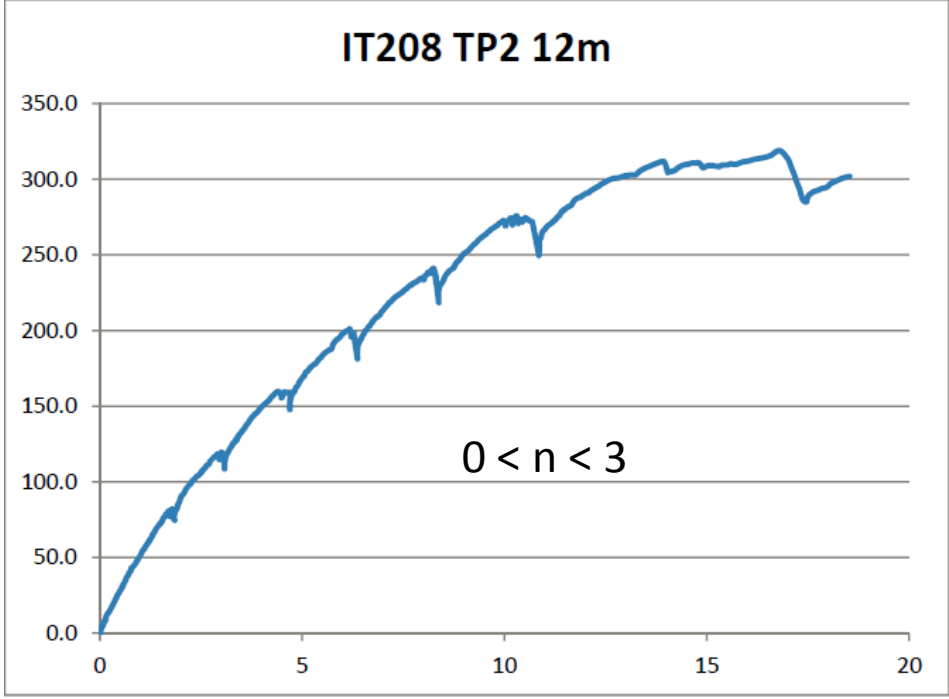

IT196 TP1 9m
Applied Load (mm)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
0
5
10
15
20
25
30
35
Deflection (mm)

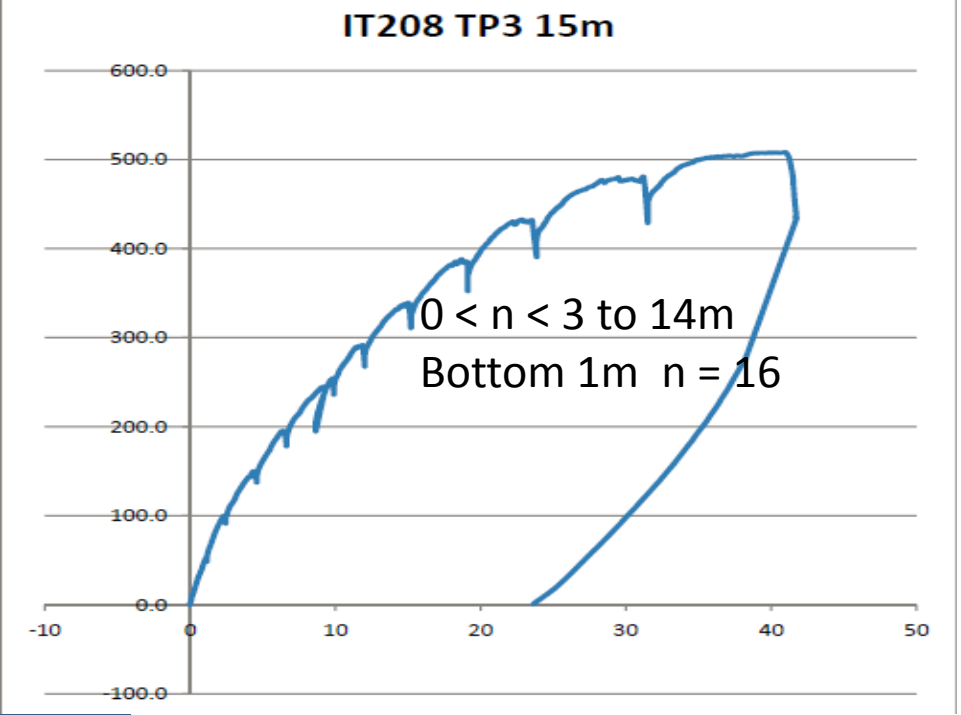

IT196 TP2 12m
Applied Load (kN)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
10
20
30
40
50
Deflection (mm)

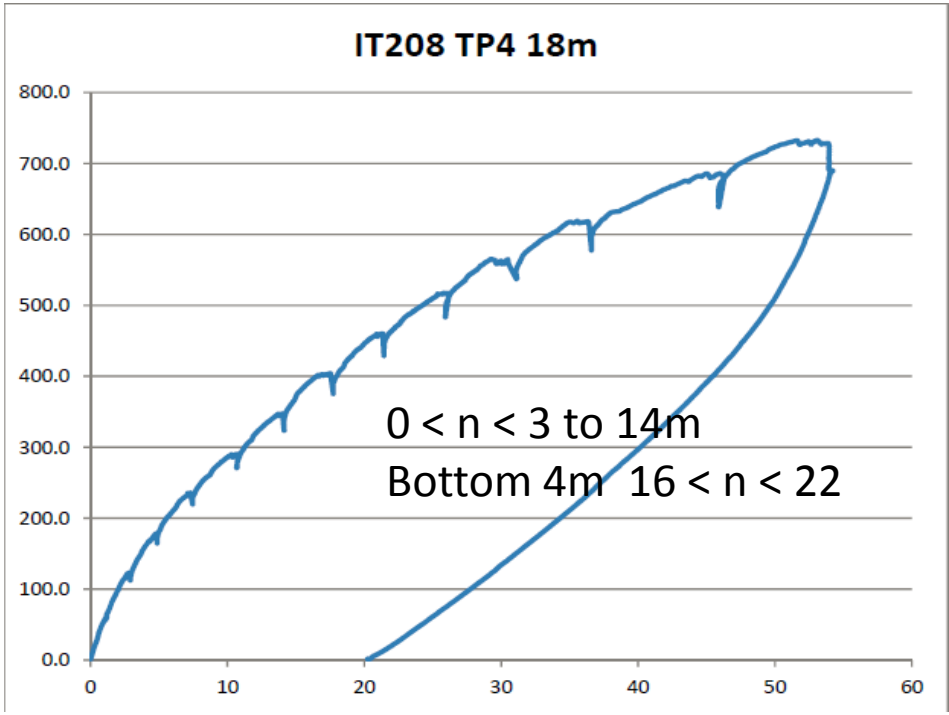

IT196 TP3 15m
Applied Load (kN)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-10
0
10
20
30
40
50
Deflection (mm)


IT196 TP4 18m
Applied Load (kN)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-5
0
5
10
15
20
25
30
35
40
Deflection (mm)


IT208 TP1 9m
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-5
0
5
10
15
20
25
0 < n < 3


IT208 TP2 12m
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
5
10
15
20
0 < n < 3


IT208 TP3 15m
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-100.0
-10
0
10
20
30
40
50
0 < n < 3 to 14m
Bottom 1m n = 16


IT208 TP4 18m
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
10
20
30
40
50
60
0 < n < 3 to 14m
Bottom 4m 16 < n < 22

ULTIMATE SKIN FRICTION

The ultimate geotechnical capacity of the soils can be determined from the following formula;

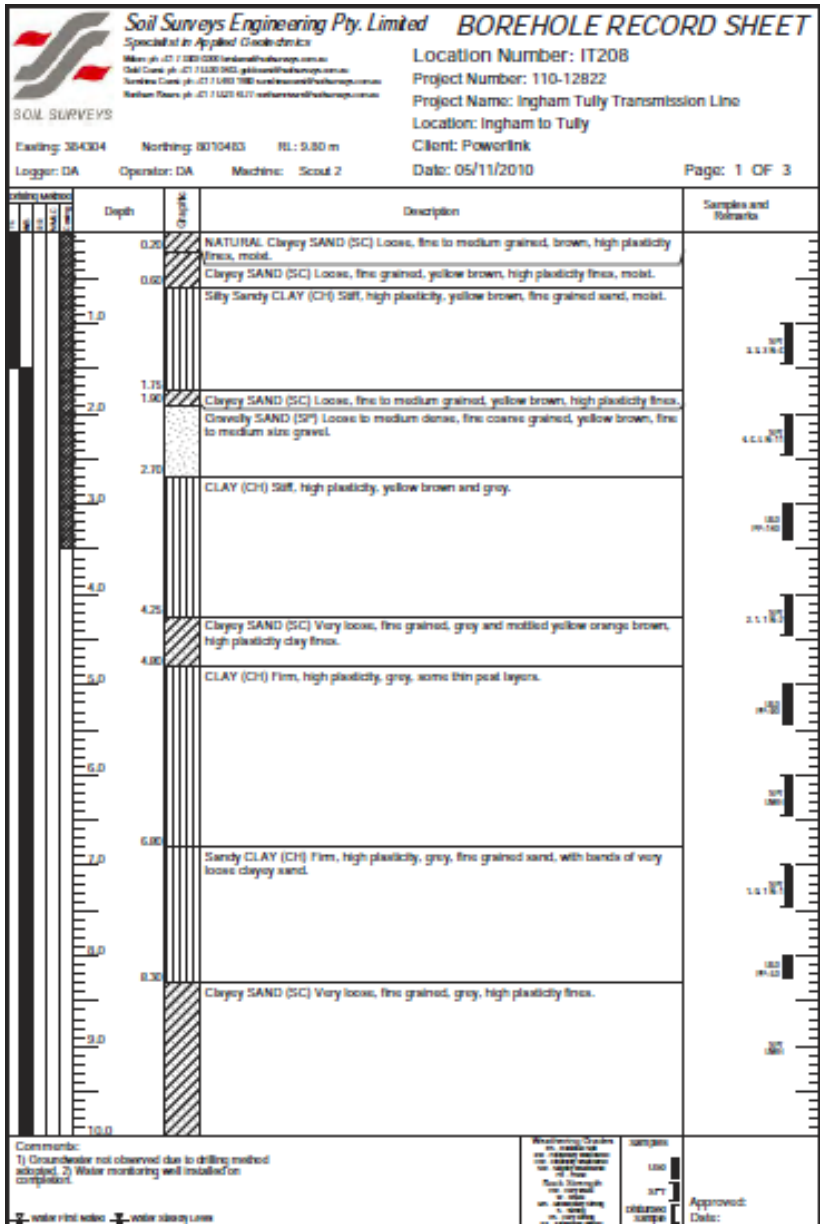
$$q_{usk} = \frac{R_{us}}{L\pi D}$$

Where:

R_{us} = Ultimate Structural Capacity of the pile
L = Pile Length
π = Pi
D = Diameter of the pile in contact with the soil
q_{usk} = Ultimate Skin Friction (kPa)

Pile	Ultimate Skin Friction			
Length	IT152	IT191	IT196	IT208
m	kPa	kPa	kPa	kPa
9	112	89	56	40
12		99	78	41
15			77	50
18				54
	Coloured cell indicates piles tested to steel yield			
	and provide approximate UGC			

Comparison with soils information


Soil Surveys Engineering Pty. Limited
Specialist in Applied Geotechnics
SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: IT208
Project Number: 110-12822
Project Name: Ingham Tully Transmission Line
Location: Ingham to Tully
Client: Powerlink
Date: 05/11/2010

Easting: 364304 Northing: 8010483 RL: 9.80 m
Logger: DA Operator: DA Machine: Scout 2
Page: 1 OF 3

Depth	Description	Samples and Remarks
0.20	NATURAL Clayey SAND (SC) Loose, fine to medium grained, brown, high plasticity fines, moist.	
0.60	Clayey SAND (SC) Loose, fine grained, yellow brown, high plasticity fines, moist.	
1.75	Silty Sandy CLAY (CH) Stiff, high plasticity, yellow brown, fine grained sand, moist.	
1.90	Clayey SAND (SC) Loose, fine to medium grained, yellow brown, high plasticity fines.	
2.70	Gravelly SAND (SP) Loose to medium dense, fine coarse grained, yellow brown, fine to medium size gravel.	
4.25	CLAY (CH) Stiff, high plasticity, yellow brown and grey.	
4.80	Clayey SAND (SC) Very loose, fine grained, grey and mottled yellow orange brown, high plasticity clay fines.	
6.80	CLAY (CH) Firm, high plasticity, grey, some thin peat layers.	
8.30	Sandy CLAY (CH) Firm, high plasticity, grey, fine grained sand, with bands of very loose clayey sand.	
	Clayey SAND (SC) Very loose, fine grained, grey, high plasticity fines.	

Comments:
1) Groundwater not observed due to drilling method adopted. 2) Water monitoring well installed on completion.

Approved:
Date:

Site IT208

Layer Number	Soil Description	Layer position
1	Clayey Sand, Loose	0-0.6m
2	Silty Sandy Clay	0.6m-1.75m
3	Clayey Sand, Loose	1.75m-1.9m
4	Gravelly Sand, Loose to Medium Dense	1.9m-2.7m
5	Clay, Stiff	2.7m-4.25m
6	Clayey Sand, Very Loose	4.25m-4.8m
7	Clay, Firm	4.8m-6.8m
8	Sandy Clay, Firm	6.8m-8.3m
9	Clayey Sand, Very Loose	8.3m-13.7m
10	Sandy Clay, Very Stiff	13.7m-13.9m
11	Clayey Sand, Medium Dense	13.9m-15.9m
12	Sand, Medium Dense	15.9m-17 m
13	Gravelly Sand, Medium Dense	17m-19.8m
14	Sandy Clay, Hard	19.8m-20.2m
15	Sand, Medium Dense	20.2m-20.5m

Pile Length	Ultimate Skin Friction			
	IT152	IT191	IT196	IT208
m	kPa	kPa	kPa	kPa
9	112	89	56	40
12		99	78	41
15			77	50
18				54

Coloured cell indicates piles tested to steel yield and provide approximate UGC

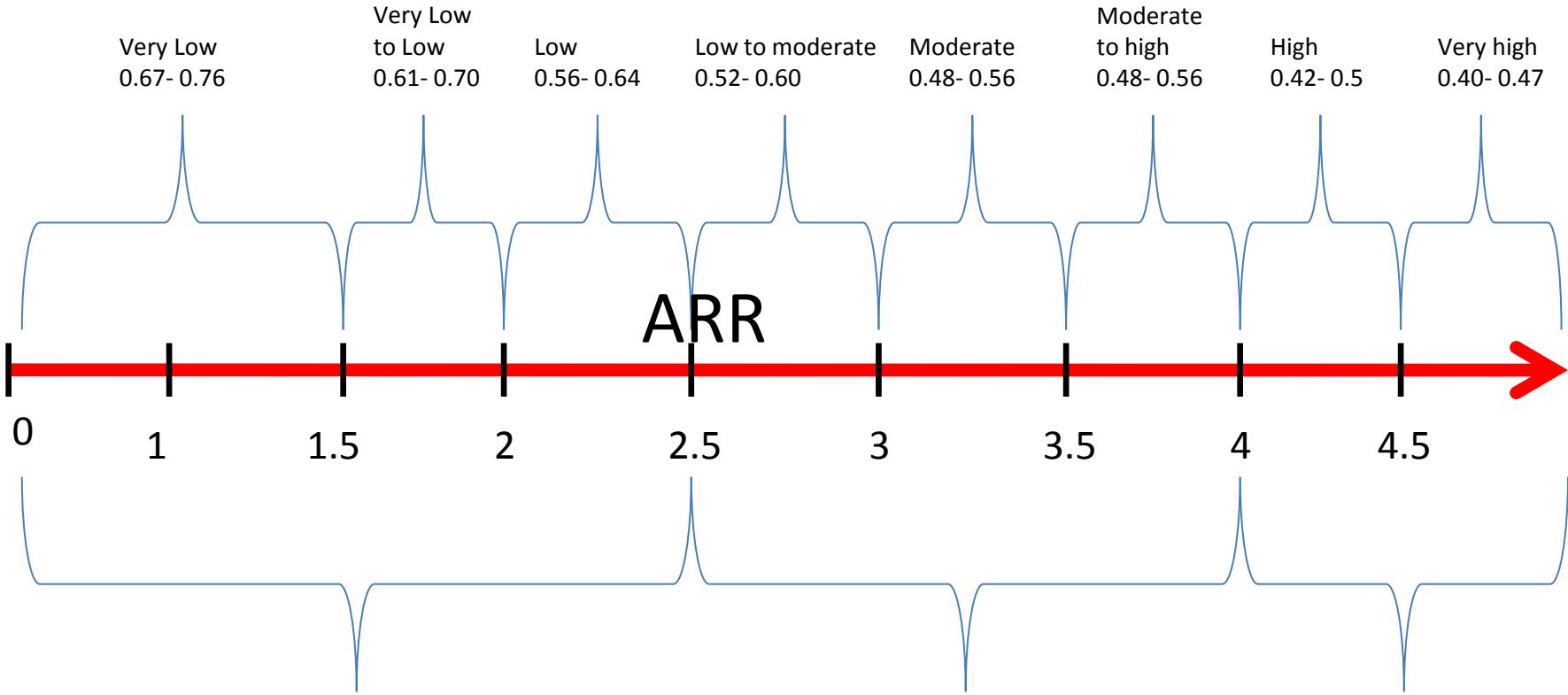
Analysis was also done on:

1. Rate of advance for each lin.m of pile installed
2. Degree of use for the top hammer of the drill per lin.m

From this information, we developed an approximation for capacity per lin.m related to the observed drilling conditions.

1. Rotary only no top hammer = W kN/lin.m
2. Top hammer < 2min/m = X kN/lin.m
3. Top hammer between 2 & 5min/lin.m = Y kN/lin.m
4. Top hammer greater than 5min/lin.m = Z kN/lin.m

This value was factored down by a geotechnical reduction factor (ϕ_g) from Australian Standard AS2159-2009.

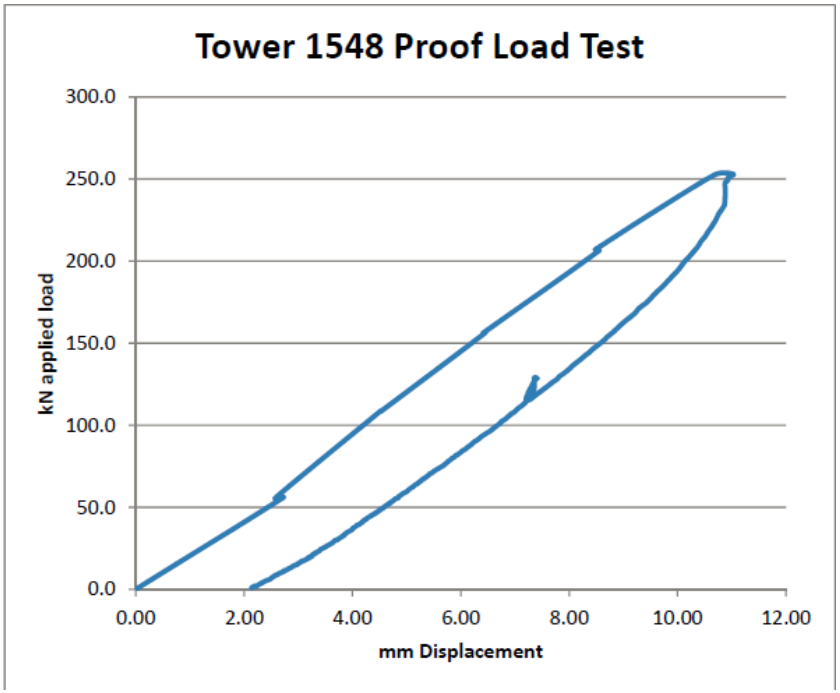


Mandatory load testing **and** good to excellent geotechnical investigation

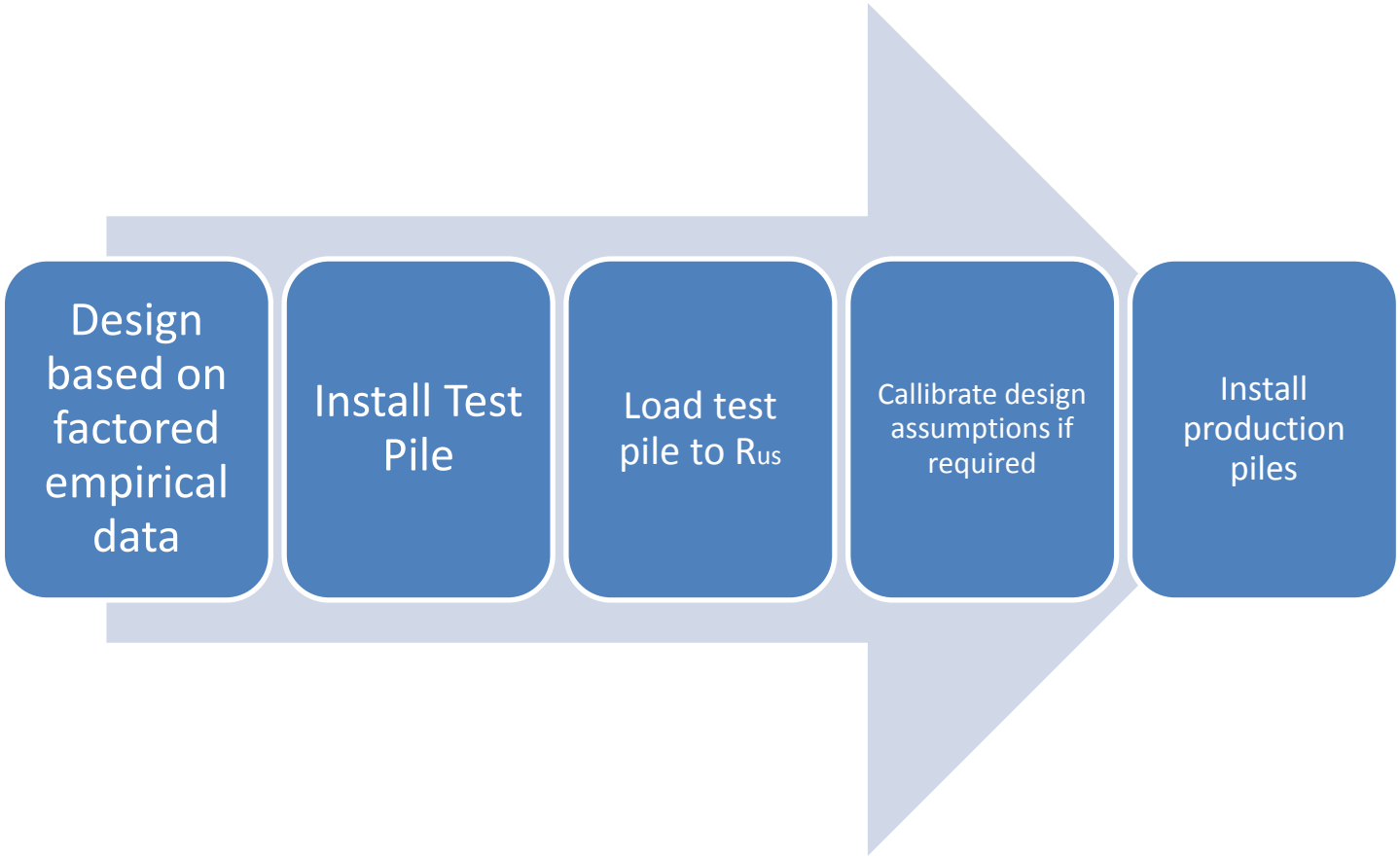
Good to excellent geotechnical work **or** a load testing program

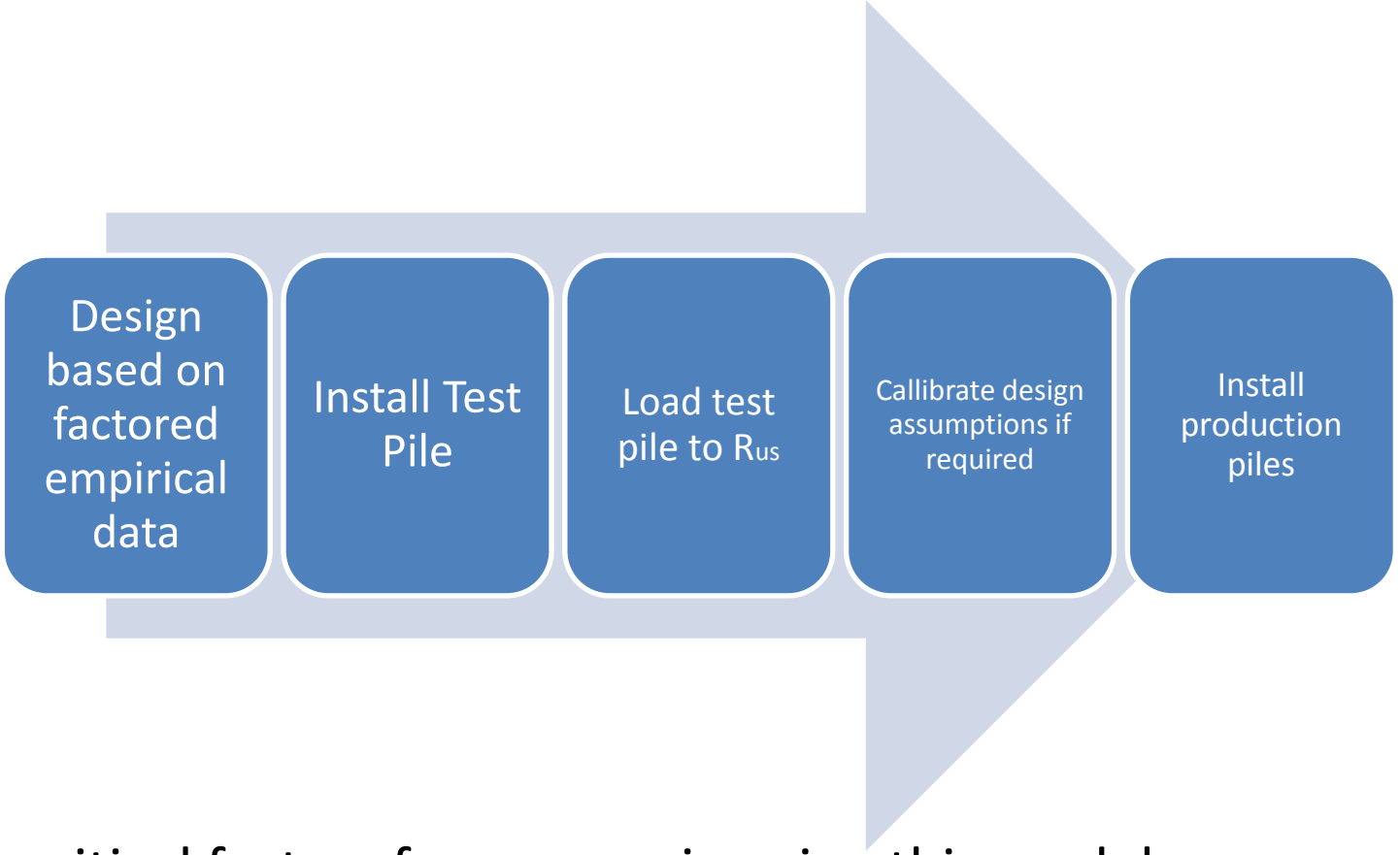
No load testing required and very little geotechnical work completed

Verification testing was carried out on each site



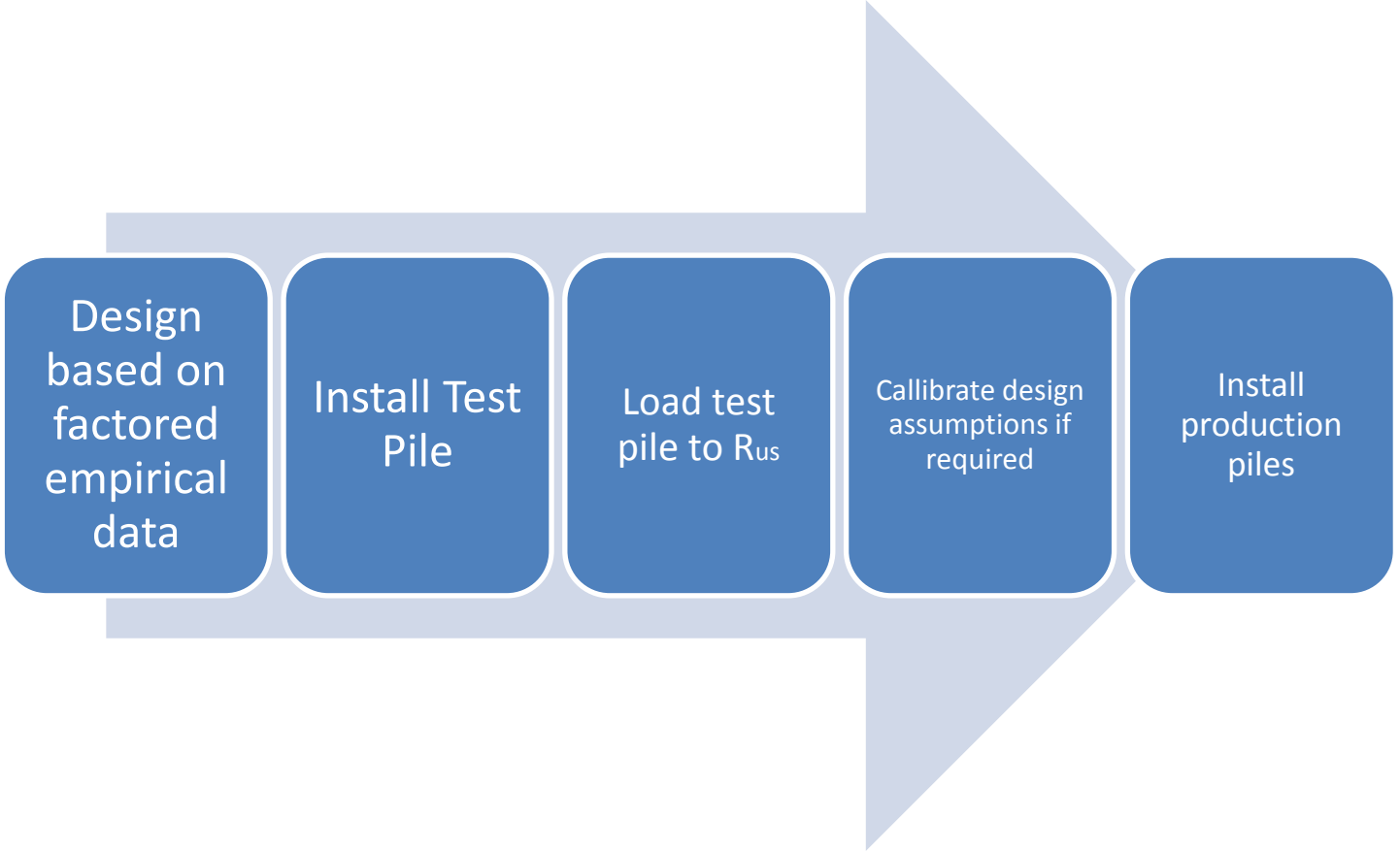
Design, installation and testing feedback model was created for production pile installation





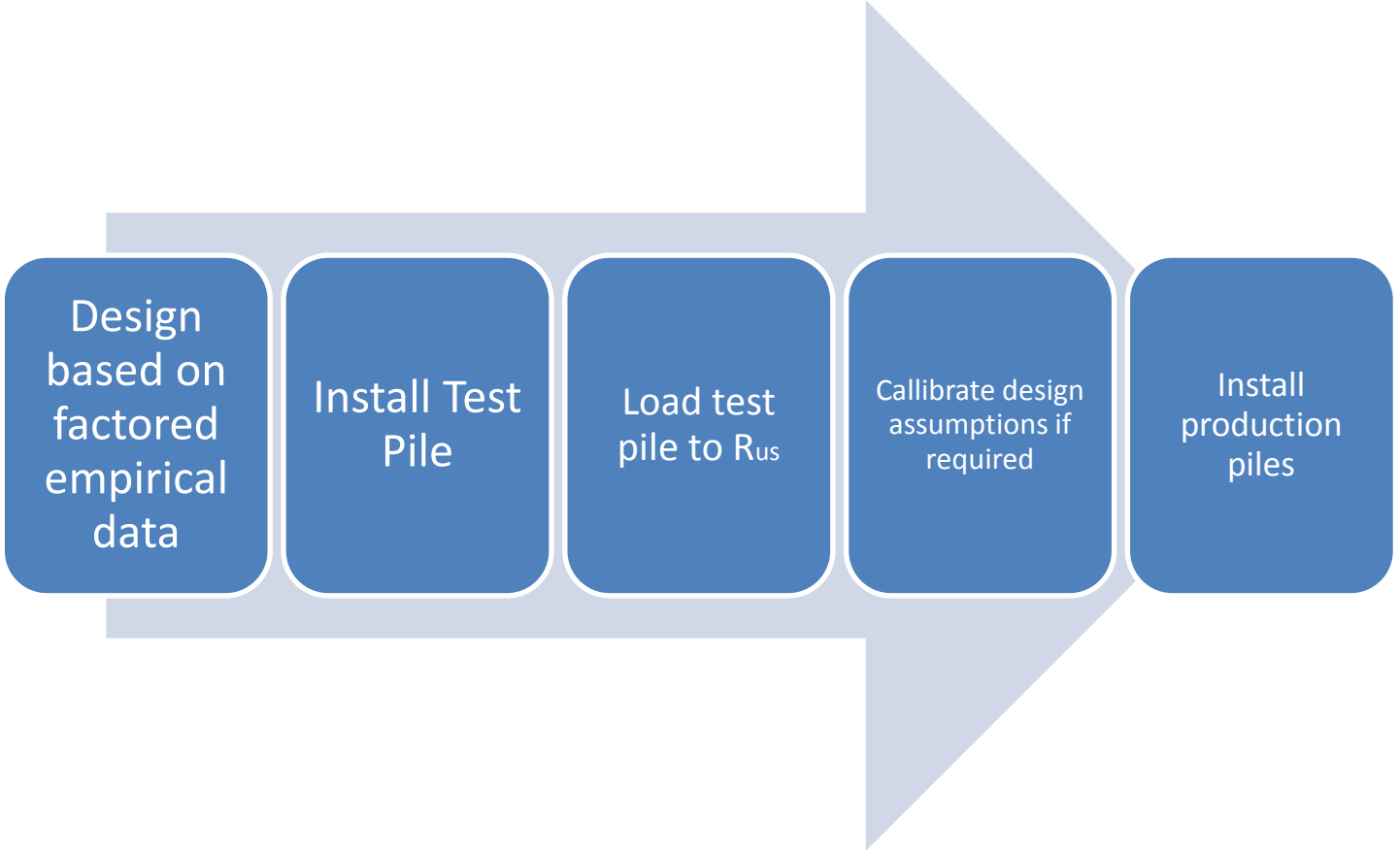
Some critical factors for success in using this model;

1. Design values need to be calibrated to the drill rig
2. Driller needs to have a clear set of instructions to understand the design intent. More than ever, they are in control of the end result
3. Supervision needs to be at a high level.
4. Client needs to understand the cost is not known until piles are installed



Main advantages

1. Enables projects to be undertaken where it may be impossible or cost prohibitive to obtain good geotechnical data
2. Speeds up delivery of a project by not having to wait for geotechnical data
3. The cost of the sacrificial test pile is equivalent to the cost of good geotechnical information but produces an arguably more reliable result



Main disadvantages

1. Difficult for owner to know the cost of a project and develop a reliable budget. They need to be committed to the project
2. Requires highly skilled crews and supervision
3. Can limit the number of bidders on a project due to the need to calibrate the design values against the drilling equipment

Thank you