Review of the Approach for Estimation of Pullout Resistance of Soil Nails

GEO Report No. 264

W.M. Cheung & K.W. Shum

Geotechnical Engineering Office
Civil Engineering and Development Department
The Government of the Hong Kong
Special Administrative Region

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Preface

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Y.C. Chan
Head, Geotechnical Engineering Office
February 2012

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Foreword

This study forms a part of a series of soil nail studies. A review of local and international practice for the design of pullout resistance of soil nails has been carried out. As part of the study, about a thousand of field pullout test data collected from the LPM contracts have been analysed. The findings of the study set out the rationale behind the pullout resistance design guidelines given in Geoguide 7.

The study was carried out by Dr W.M. Cheung and Mr K.W. Shum of the Standards and Testing Division. Valuable assistance in collecting field pullout test data was provided by the Landslip Preventive Measures Division 2. Many other colleagues provided constructive comments on the formulation of the pullout resistance design guidelines. Their contributions are gratefully acknowledged.

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Abstract

Pullout resistance is one of the key parameters for the design of soil nails. At present, methods for estimating pullout resistance are not unified as reflected by the many approaches used in different technical standards and codes of practice. As part of a series of soil nail studies for the development of Geoguide 7, a review of the design methods and safety factors adopted by Hong Kong and overseas, including the US, Japan and some European countries (the UK, France, and Nordic countries), for estimation of pullout resistance of soil nails has been conducted. There are basically four design methods, namely empirical correlation, field pullout test method, undrained shear strength method and effective stress method. Each method has its own merits and limitations in accounting for the factors such as soil type, soil shear strength, surface roughness, grouting pressure and groundwater conditions. As most of these overseas countries adopt limit state design approach, it is not appropriate to make a direct comparison between the global safety factor of Hong Kong and the partial safety factors of these countries. Although some overseas countries adopt global safety factor approach, the values of these safety factors still cannot be compared directly with that in Hong Kong because different methods are adopted for the estimation of pullout resistance.

As part of the review, about one thousand of field pullout test data have also been collected from LPM sites for analysis. About 84% of the tests were conducted in weathered granite and volcanic rocks. The rest were conducted in other types of materials such as fill, colluvium and moderately decomposed rock. Most of the pullout tests were only tested to 90% of the yield strength of steel (T_p), where the ultimate pullout resistance (T_{ult}) was not reached. In general, the field test loads (T_p or T_{ult}) are several times higher than those estimated using the effective stress method.

In summary, each of the design methods has its merits and limitations. The field pullout test results indicate that the pullout resistance is generally higher than the theoretical value given by the effective stress method. This suggests that although the method has limitations, it gives a safe solution under the ground conditions and construction practice in Hong Kong.

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1 Introduction

Soil nailing is the most common slope stabilising method in Hong Kong. It offers an effective and robust reinforcing system for a variety of ground and groundwater conditions. The soil nailing technique improves the stability of slopes principally through the mobilisation of tension in the soil nails. The tensile forces in the soil nails reinforce the ground by directly supporting some of the applied shear loadings and by increasing the normal stresses in the soil on the potential failure surface, thereby allowing higher shearing resistance to be mobilised. The resistance against pullout failure of the soil nails is provided by the part of soil nails that is embedded into the ground behind the potential failure surface. Hence, pullout resistance is one of the key parameters for the design of soil nails.

In 2008, the Geotechnical Engineering Office (GEO) published a new guidance document on soil nailing, entitled Geoguide 7: Guide to Soil Nail Design and Construction (GEO, 2008). Modifications have been made to the previous pullout resistance design guidelines given in GEO Technical Guidance Note No. 23 Issue No. 1 (TGN23) (GEO, 2005). The changes were made based on the findings of a review of the approach for estimation of pullout resistance, which was part of a series of soil nail related studies initiated by GEO in developing Geoguide 7. In the review, the design methods and safety factors adopted in Hong Kong and overseas for estimation of pullout resistance of soil nails have been examined, and about a thousand of field pullout test data collected from the LPM contracts have been analysed. This report documents the findings of the review as well as the rationale behind the new pullout resistance design guidelines given in Geoguide 7.

2 Design Approaches of Pullout Resistance of Soil Nails

2.1 Design Approach in TGN 23

The design approach of pullout resistance of soil nails given in TGN23 basically followed that proposed by Watkins & Powell (1992). The effective stress method (see Section 2.2.2) was used to estimate the pullout resistance of the soil nails. A safety factor against pullout failure of 2.0 is applied to the estimated pullout resistance to obtain the allowable pullout resistance. Although not explicitly mentioned, the safety factor accounts for all uncertainties associated with the estimated pullout resistance. This includes the uncertainty on the surface area of grout sleeve, contact stress at the interface between grout and soil, grout surface roughness, change in bond resistance over time, etc.

2.2 Design Approaches in Overseas Countries

2.2.1 General

Soil nail design guidelines adopted overseas, including the US, the UK, France, Japan and Nordic countries (i.e., Norway, Sweden, Denmark, Finland and Iceland), have been reviewed. Different design methods and different safety factors are used in these countries to estimate the pullout resistance of soil nails.

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2.2.2 Design Methods

The pullout resistance of a soil nail is affected by many factors including soil type, soil shear strength, surface roughness, grouting pressure, groundwater condition, etc. According to literature (CIRIA, 2005; Clouterre, 1991; FHWA, 1998 & 2003; JHPC, 1998; NGS, 2005), there are four practical methods for estimation of pullout resistance of soil nails, namely empirical correlation, field pullout test method, undrained shear strength method and effective stress method.

Empirical correlations of the bond stress of soil nail in soil with various soil types and various construction methods have been developed overseas. This is one of the recommended methods in the US (correlated with soil type), Japan (correlated with SPT-N values) and France (correlated with limit pressure from pressuremeter tests) for design of soil nails. Typical values of soil-nail bond stress are also given in some overseas design guides (e.g., Clouterre, 1991; FHWA, 1998 & 2003; JHPC, 1998).

Field pullout test method requires the carrying out of site-specific pullout tests. Appropriate characteristic pullout resistance for design of soil nails can be determined from the measured values. This method is generally adopted in France and such provision is also given in other European countries and the US (BSI, 2002; FHWA, 2003).

The pullout resistance of soil nails in cohesive soils can be estimated based on the undrained soil shear strength and an adhesion factor, in a way similar to estimation of skin friction of pile foundation in clay.

The pullout resistance of soil nails in granular soils, and in cohesive soils under long-term conditions, can be calculated by considering the effective stress acting on the soil nail and the coefficient of interface friction. This method is generally adopted in the UK and Hong Kong.

2.2.3 Safety Factor against Pullout Failure

A summary of safety factor against pullout failure adopted in various design guides is given in Table 2.1. As the UK, France and Nordic countries adopt the limit state design approach, it is not appropriate to make a direct comparison between the global safety factor of Hong Kong and the partial safety factors of these countries. The global safety factors of Japan, US and Hong Kong also cannot be compared because different methods are adopted for the estimation of pullout resistance.

Table 2.1 Safety Factor against Pullout Failure Adopted in Different Soil Nail Design Guides

Design Guide	UK (HA 68/94)	UK (CIRIA C637)	Nordic Countries (NGS)	France (Clouterre)	US (FHWA)	Japan (JHPC)	HK (TGN23)
Safety Factor	1.0 (ϕ_{cv}') 1.5 (ϕ_{peak}')	1.5	1.5	1.4 (pullout test) 1.8 (chart)	2.0	2.0	2.0

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3 Field Pullout Test Data

For this study, field pullout test data have been collected from LPM contracts since 2004 up to 2006. Improved test set-up and procedures (GEO, 2004), which minimise friction loss along a test nail, better control the length of the grouted portion and increase the test load by using larger bar size, were adopted in these tests. A total of 913 test results were collected. About 84% of the tests were conducted in weathered granite and volcanic rocks. The rest were conducted in other types of materials including fill, colluvium and moderately decomposed rock.

Most of the pullout tests were only tested to 90% of the yield strength of steel (T_p) to avoid the risk of rupture of the steel reinforcement. The ultimate pullout resistance (T_{ult}) was not reached. Figure 3.1 shows the plot of the ratio of the field to the estimated pullout resistance using method recommended in TGN 23 (GEO, 2005) against the overburden pressure of those tests which reached the ultimate pullout resistance. Figure 3.2 presents the same plot with all the test data (i.e. those reaching either T_{ult} or T_p). The field pullout resistances are generally several times higher than those estimated using the effective stress method, and the safety margin (i.e. $T_{field}/T_{estimate}$) gradually decreases when overburden pressure increases. Some of the field pullout tests (26 nos.) were carried out under saturated condition, and the results do not show particularly low pullout resistance when compared with other pullout tests carried out under dry condition.

A summary of the field pullout test data is given in Appendix A.

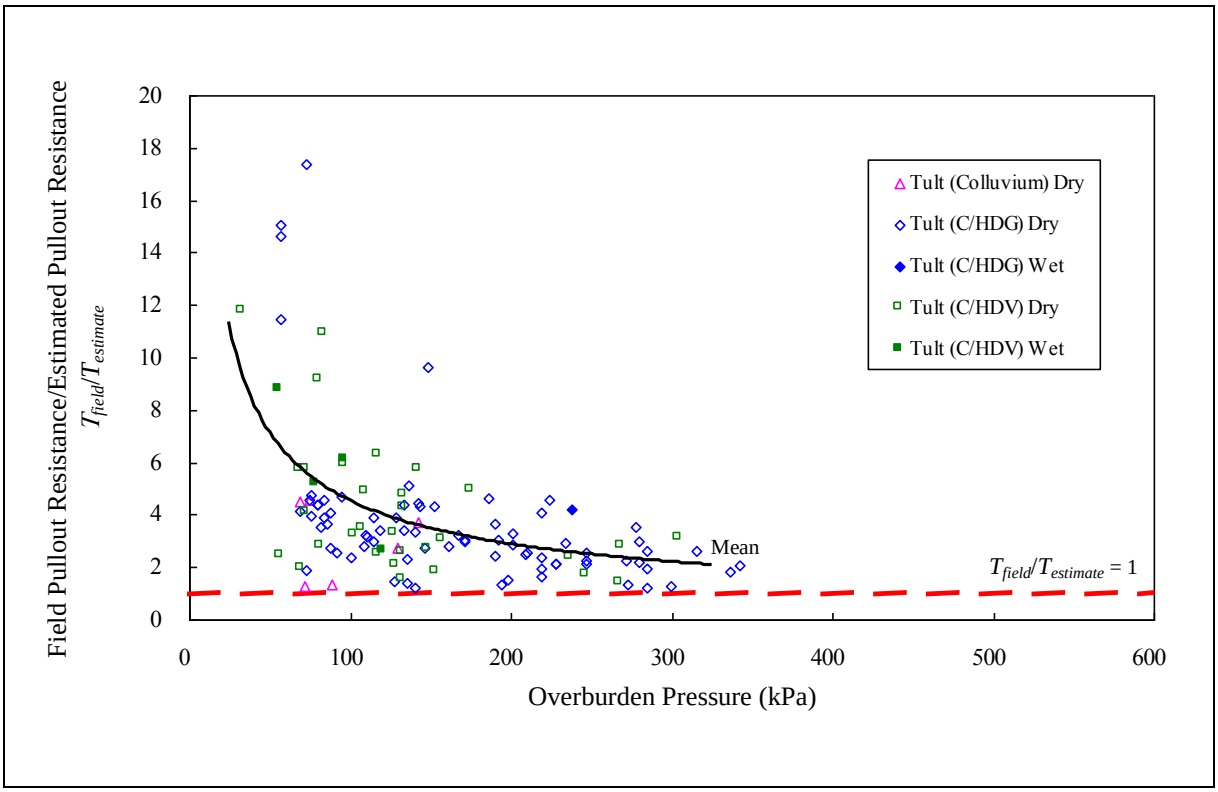

Figure 3.1 Plot of Field (T_{ult}) to Estimated Pullout Resistance against Overburden Pressure

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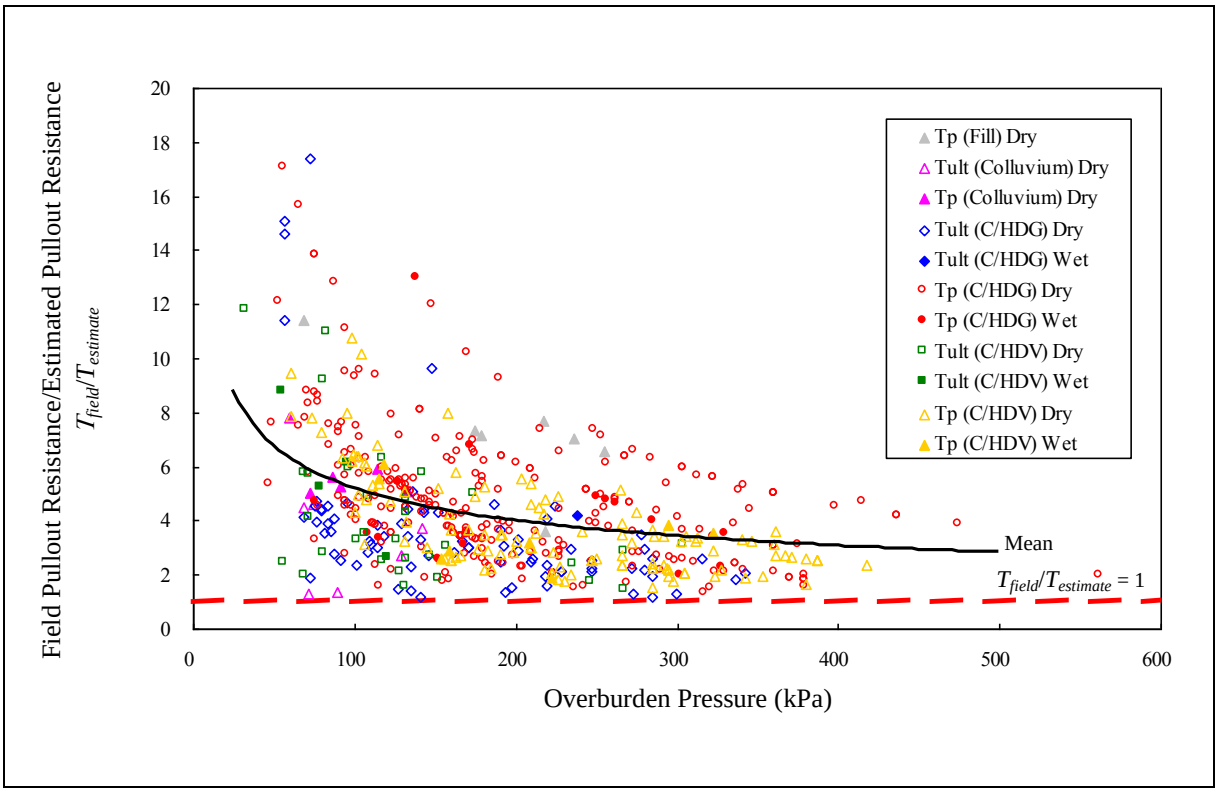

Figure 3.2 Plot of Field (T_p + T_{ult}) to Estimated Pullout Resistance against Overburden Pressure

4 Discussion

4.1 Design Method

As mentioned in Sections 2.1 and 2.2, there are four practical methods for the estimation of pullout resistance of soil nails. The merits and limitations of each method are summarised in Table 4.1.

Many overseas design guidelines recommend the use of empirical correlation. The overseas experience may not be applicable to Hong Kong because of difference in ground properties. To develop a correlation specific to a site in Hong Kong, sufficient good quality data have to be collected.

The effective stress method does not account for factors including soil arching, restrained soil dilatancy, soil suction, roughness of drillhole surface, over-break, etc. All these factors except soil arching tend to result in higher pullout resistance than the design value. Although the effective stress method has limitations, local designers are familiar with the method and it gives a safe solution for soil nail design in Hong Kong.

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Table 4.1 Merits and Limitations of the Methods for Estimation of Pullout Resistance of Soil Nails

Method	Merits	Limitations
Empirical correlation	Related to field performance data; can better account for influencing factors.	Need a large number of field data and take a long time to establish a reasonable correlation; a general correlation may not be applicable to all sites.
Field pullout test	Related to site-specific performance data.	Need to carry out a considerable number of field pullout tests during the design stage; not feasible for small-scale project; time consuming.
Undrained shear strength	Based on soil mechanics principles; easy to apply.	Generally not suitable for Hong Kong because clay slopes are not common; many factors that affect the pullout resistance are not accounted for in the theoretical equation.
Effective stress	Based on soil mechanics principles; easy to apply.	Many factors that affect the pullout resistance are not accounted for in the theoretical equation.

4.2 Safety Factor against Pullout Failure

Many factors that affect the pullout resistance of a soil nail are difficult to be quantified in a design. A statistical approach has been adopted to assess the probability of failure in pullout using the field pullout test data. The probabilities of failure in pullout with safety factor of 2.0 and 1.5 are estimated by comparing the field pullout resistance with the allowable pullout resistance, where allowable pullout resistance is equal to the estimated pullout resistance divided by the safety factor against pullout failure. Failure is defined as a case for which the field pullout resistance is less than the allowable pullout resistance. The frequency distribution and probability density function plots of $T_{field}/T_{allowable}$ for safety factors equal to 2.0 and 1.5 are given in Figures 4.1 and 4.2 respectively.

By fitting the field test results with log-normal model as in Figures 4.1 and 4.2, nearly all of the statistically-modelled field pullout resistance is larger than the allowable pullout resistance, with mean ratios (field vs allowable) of 7.6 and 5.7 if the factor of safety equals to 2.0 and 1.5 respectively.

4.3 Effect of Soil Arching

The process of drilling in soil nail construction introduces soil arching at the drillhole. The grouting process during construction and subsequent change to the soil condition surrounding a soil nail, e.g. wetting and drying, will reduce the amount of soil arching along time. The effect of soil arching reduces the radial stress acting on the soil nail. This will theoretically result in a pullout resistance lower than that estimated from the effective stress equation. In actual fact, field pullout test results show that the field pullout resistance is generally higher than the theoretical values given by the effective stress method. This reflects the limitation of the effective stress method which does not account for surface

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roughness, soil dilatancy, etc., as noted in Section 4.1 above.

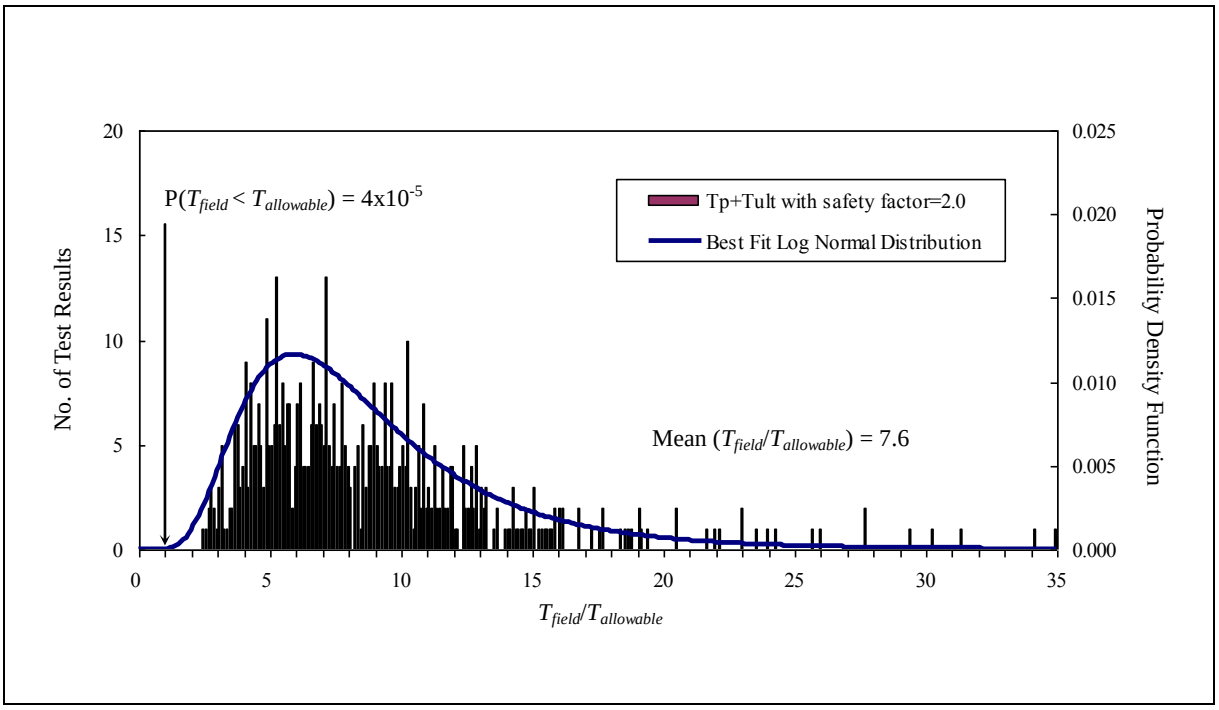

Figure 4.1 Plot of Frequency Distribution and Probability Density Function of Field to Allowable Pullout Resistance with Safety Factor against Pullout Failure = 2.0

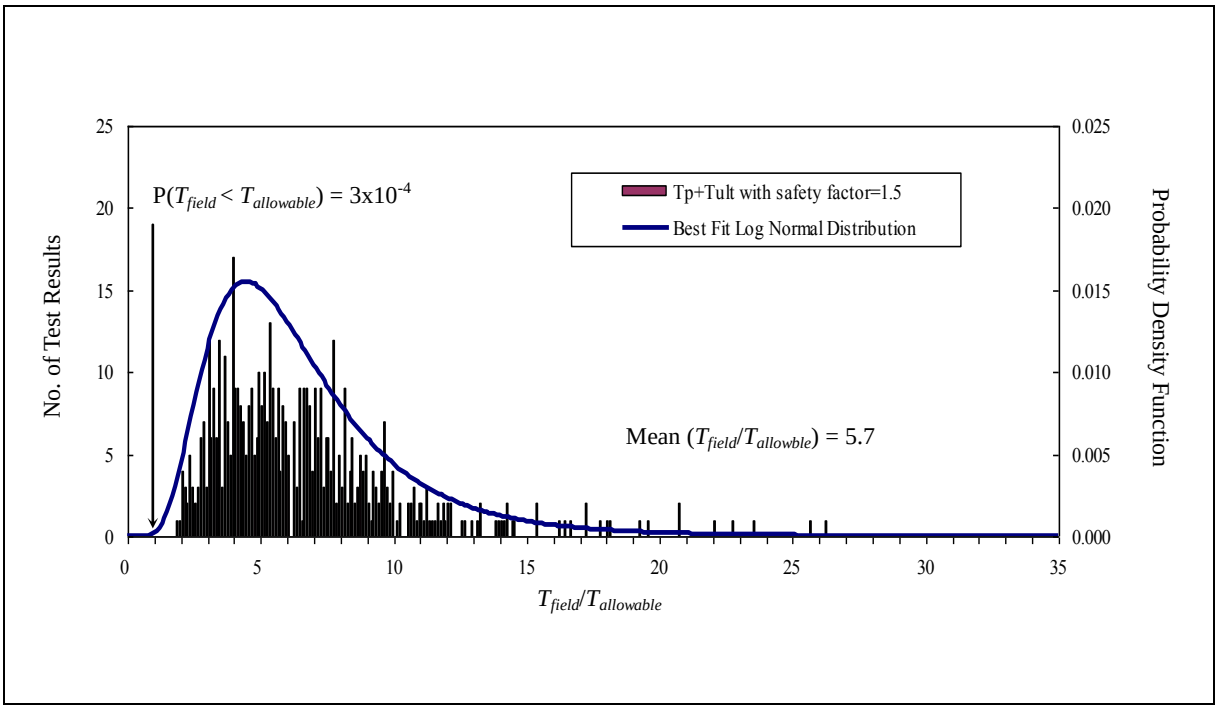

Figure 4.2 Plot of Frequency Distribution and Probability Density Function of Field to Allowable Pullout Resistance with Safety Factor against Pullout Failure = 1.5

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5 Conclusions

A review of the approaches to the estimation of pullout resistance of soil nails in Hong Kong and overseas has been conducted. As part of the study, about a thousand of field pullout test data collected from the LPM contracts has been analysed. The field pullout resistance is generally higher than the theoretical values given by the effective stress method. This shows that although the method has limitations, it gives a safe solution under the ground conditions and construction practice in Hong Kong. This report documents the findings of the review and the analysis. These form the rationale behind the pullout resistance design guidelines given in Geoguide 7.

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Appendix A

Summary of Field Pullout Test Data

Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 1 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7SE-A/C342	TN1	4	25	150	20	3.0	47.5	CDG	Dry	8	32	203
14NE-B/C175	P2	4	20	100	20	2.0	50.0	CDG	Dry	5	35	130
11NE-B/C439	TN11	8	25	100	15	2.0	53.4	CDG	Dry	3	35	203
6NE-D/C1	C	5	40	150	20	2.0	57.0	CDG	Dry	6	36	520
10SE-B/C6	TN2	5	25	150	20	2.0	59.6	Colluvium	Dry	3	33	203
11SW-D/CR250	TN2	4	25	100	20	2.0	60.7	C/HDV	Dry	5	37	203
7SE-D/C77&97	P3	5	25	120	20	2.0	60.8	C/HDV	Dry	5	37	203
11NW-D/C90	PT14	6	32	100	20	2.0	66.5	CDG	Dry	2	37	333
7SW-C/C293	TN4	8	25	120	15	2.0	66.5	CDG	Dry	3	38	203
6NE-D/FR81	P1	6	25	100	10	2.0	68.4	Fill	Dry	0	33	203
14NW-D/C21	B	4	25	100	20	2.0	70.0	CDG	Dry	7	38	203
6SW-A/C670	TN02	6	25	100	30	2.0	71.6	CDG	Dry	5	35	203
9SW-D/C208	P3	8	20	150	20	2.0	72.0	Colluvium	Dry	2	29	130
7SW-C/C524	TN1	6	25	150	22	2.0	72.4	CDG	Dry	4	36	203
11NW-A/C245	TN1	6	32	150	20	2.0	72.9	CDG	Dry	5	39	333
13NE-A/C83	TN03	8	25	100	15	2.0	73.1	CDV	Dry	5	38	203
11NW-A/C588	TN1	5	25	100	20	4.0	76.0	C/HDG	Dry	9	40	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 2 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NW-D/C90	PT4	11	32	100	20	2.0	76.0	CDG	Dry	2	37	333
11NW-D/C90	PT17	6	32	100	20	2.0	76.0	CDG	Dry	2	37	333
11NE-A/C455	2TN10	5	25	100	15	2.0	76.0	CDG	Dry	2	36	203
11SW-D/C1132	TN3	7	25	150	50	2.0	76.7	CDG	Wet	8	38	203
11NW-A/C181	TN1	4	25	100	15	2.0	77.9	CDG	Dry	4	35	203
11NE-B/C439	TN14	6	25	100	15	2.0	77.9	CDG	Dry	3	35	203
13NE-A/C83	TN02	8	25	100	15	2.0	79.5	CDV	Dry	5	38	203
7SE-C/CR183	TN1	5	25	100	20	2.0	85.5	CDG	Dry	5	35	203
6SW-A/C302	TN01	8	25	100	25	2.0	85.6	CDG	Dry	2	40	203
10SE-B/C6	TN1	7	25	150	20	2.0	85.8	Colluvium	Dry	3	33	203
11SE-C/CR29	TN4	5	40	150	10	2.0	88.0	CDG	Dry	1	37	520
7SW-D/F442	TN2	6	25	150	20	2.0	91.2	CDG	Dry	2	36	203
10SE-B/C6	TN3	7	25	150	20	2.0	91.2	Colluvium	Dry	3	33	203
11NW-A/C181	TN2	6	25	100	15	2.0	91.2	CDG	Dry	4	35	203
11NE-B/C439	TN13	6	25	100	15	2.0	91.2	CDG	Dry	3	35	203
7SE-A/C314	TN7	6	25	100	15	2.0	91.2	C/HDG	Dry	9	38	203
13NE-A/C83	TN04	8	25	100	15	2.0	92.3	CDV	Dry	5	38	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 3 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NW-A/C181	TN6	9	25	100	15	2.0	93.1	CDG	Dry	1	35	203
9SW-C/C21	P3	7	32	150	20	2.0	95.0	CDV	Dry	5	33	333
7SW-D/F440	TN1	7	25	150	10	2.0	95.0	CDG	Dry	2	36	203
6NE-D/C1	B	5	40	150	20	2.0	95.0	CDG	Dry	6	36	520
14NW-A/C70	P5	5	25	150	20	2.0	95.0	CDG	Dry	4	35	203
7SE-A/C300	TN1	6	25	150	15	3.0	95.0	CDG	Dry	6	38	203
7SW-C/C524	TN7	8	25	150	15	2.0	95.0	CDG	Dry	4	36	203
7SW-D/C922	TN4	7	32	120	15	2.0	95.0	CDG	Dry	3	36	335
11NE-A/C455	2TN4	6	25	100	15	2.0	95.0	CDG	Dry	10	38	203
6SW-D/C553	TN01	8	25	100	15	2.0	95.0	CDG	Dry	3	38	203
3SW-D/C29	B	6	40	150	20	2.0	97.9	CDV	Dry	6	36	520
11SW-D/CR250	TN1	9	25	100	20	2.0	98.2	C/HDV	Dry	5	37	203
6SW-A/C670	TN01	6	25	100	30	2.0	98.8	CDG	Dry	5	35	203
7SE-A/CR312	TN2	6	25	100	20	3.0	98.8	CDG	Dry	3	38	203
7SW-D/F440	TN3	8	25	150	10	2.0	98.8	CDG	Dry	2	36	203
13NE-A/C48	TN01	7	25	100	15	2.0	99.0	CDG	Dry	5	38	203
11SW-D/FR126	TN3	6	32	150	24	2.0	99.4	C/HDV	Dry	7	37	333

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 4 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7NW-D/C173	A	8	25	150	20	2.0	100.0	CDV	Dry	5	35	203
11SW-D/FR126	TN4	8	32	150	23	2.0	100.7	C/HDV	Dry	7	37	333
11NW-A/C245	TN2	8	32	100	30	2.0	101.2	CDG	Dry	5	39	333
10NE-B/C249	PT12	7	25	100	20	2.0	102.6	CDV	Dry	5	35	203
7SE-A/CR312	TN1	5	25	100	20	3.0	102.6	CDG	Dry	3	38	203
6SW-C/C625	TN2	7	32	150	20	2.0	102.6	CDG	Dry	5	33	333
7SW-D/F440	TN2	6	25	150	10	2.0	102.6	CDG	Dry	2	36	203
7SE-D/C77&97	P2	8	25	120	20	2.0	102.6	C/HDV	Dry	5	37	203
6SW-A/C118	TN02	10	25	100	15	2.0	104.5	CDG	Dry	5	38	203
6SW-A/C115	TN02	16	32	150	15	2.0	104.5	CDG	Dry	3	39	333
11NW-D/CR46	TN 1	12	40	150	10	2.0	104.5	C/HDG	Dry	5	38	520
7SW-D/F441	TN2	8	32	150	10	2.0	104.5	CDG	Dry	2	36	335
3SW-D/C29	A	8	40	150	20	2.0	104.5	CDV	Dry	6	36	520
11NE-D/C20	P6	6	25	120	15	2.0	104.5	C/HDG	Dry	5	38	205
13NE-B/C129	P1	8	20	150	20	2.0	106.0	CDV	Dry	2	32	130
10NE-B/C249	PT11	7	25	100	20	2.0	106.4	CDV	Dry	5	35	203
11SW-A/C108	TN1	9	25	120	15	2.0	107.0	CDV	Dry	3	38	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 5 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11SW-D/FR126	TN5	6	32	150	20	2.0	107.4	C/HDV	Dry	7	37	333
11NE-B/C439	TN3	8	25	100	15	2.0	108.5	CDG	Dry	3	35	203
11SW-D/C1132	TN1	9	25	150	50	2.0	108.8	CDG	Wet	8	38	203
7SE-C/CR388	TN1	8	25	100	15	2.0	110.2	CDG	Dry	7	35	203
11NE-B/CR270	P1	7	25	120	15	2.0	110.4	C/HDG	Dry	6	36	203
13NE-A/C83	TN01	8	25	100	15	2.0	111.5	CDV	Dry	5	38	203
7SW-C/C524	TN3	8	25	150	22	2.0	112.5	CDG	Dry	4	36	203
7SW-C/C524	TN4	8	25	150	22	2.0	112.5	CDG	Dry	4	36	203
7SW-C/C524	TN2	9	25	150	22	2.0	113.0	CDG	Dry	4	36	203
11NW-A/CR296	TN1	7	25	100	20	4.0	114.0	C/HDG	Dry	9	40	203
9SW-C/C21	P2	10	32	150	20	2.0	114.0	CDV	Dry	5	33	333
11NW-D/C90	PT18	7	32	100	20	2.0	114.0	CDG	Dry	2	37	333
7SW-C/C524	TN5	8	25	150	15	2.0	114.0	CDG	Dry	4	36	203
7SW-C/C524	TN6	8	25	150	15	2.0	114.0	CDG	Dry	4	36	203
11NE-A/C455	1TN10	10	25	100	15	2.0	114.0	Colluvium	Dry	2	36	203
11NE-A/C455	2TN2	6	25	100	15	2.0	114.0	CDG	Dry	10	38	203
3NE-D/C74	P1	8	25	100	15	2.0	114.8	CDV	Wet	7	35	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 6 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11SW-D/CR250	TN3	10	25	100	20	2.0	115.0	C/HDV	Dry	5	37	203
11SW-D/C1132	TN2	9	25	150	50	2.0	115.6	CDG	Wet	8	38	203
6SW-C/C167	TN3	8	32	150	15	3.0	115.9	CDG	Dry	3	38	130
7SE-C/CR388	TN2	7	25	100	15	2.0	117.8	CDG	Dry	7	35	203
7SW-D/C922	TN1	7	25	120	15	3.0	117.8	CDG	Dry	3	36	203
11NE-B/CR270	P2	7	25	120	15	2.0	117.8	C/HDG	Dry	6	36	203
11NE-B/C87	TN8	8	25	100	15	2.0	118.0	CDG	Dry	2	35	203
12NW-C/R4	P3	8	32	150	20	2.0	118.5	C/HDV	Wet	5	35	333
7SW-D/F440	TN5	10	25	150	10	2.0	119.7	CDG	Dry	2	36	203
9SW-D/C170	TN02	6	25	100	15	2.0	121.6	CDV	Dry	3	40	203
11NE-B/C87	TN9	8	25	100	15	2.0	121.8	CDG	Dry	2	35	203
10NE-B/C6	TN3	9	25	100	15	2.0	123.3	CDG	Dry	5	35	203
10NE-B/CR253	PT17	13	32	150	20	3.0	123.5	CDG	Dry	5	32	333
7SE-A/C301	TN1	6	25	150	15	3.0	123.5	CDG	Dry	6	38	203
7SE-C/C41	TN9	5	32	100	15	2.0	123.5	CDG	Dry	6	38	333
11NE-A/C455	2TN6	7	25	100	15	2.0	123.5	CDG	Dry	2	36	203
6SW-C/CR508	TN02	8	25	100	20	2.0	123.5	CDG	Dry	4	37	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 7 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NW-B/C634	P1	5	25	150	15	2.0	124.5	CDG	Dry	6	35	203
11NW-B/C634	P2	5	25	150	15	2.0	124.5	CDG	Dry	6	35	203
7SW-D/F441	TN1	8	32	150	10	2.0	127.3	CDG	Dry	2	36	335
11NE-B/C439	TN9	8	25	100	15	2.0	127.5	CDG	Wet	3	35	203
11NE-B/C439	TN6	8	25	100	15	2.0	127.5	CDG	Dry	3	35	203
11NE-B/C435	TN9	10	25	100	10	2.0	129.2	CDG	Dry	2	35	203
7SW-D/C922	TN2	8	32	120	15	2.0	129.2	CDG	Dry	3	36	335
11NW-A/C181	TN4	9	25	100	15	2.0	129.6	CDG	Dry	4	35	203
11SW-D/FR1	TN7	14	32	150	25	2.0	130.5	CDG	Dry	0	39	333
3NE-A/C144	P1	9	25	100	10	2.0	131.3	CDV	Dry	5	35	203
3SW-C/C241	P2	9	25	150	10	2.0	131.3	CDV	Dry	5	36	203
7SE-D/C77&97	P1	8	25	120	20	2.0	131.8	C/HDV	Dry	5	37	203
6SW-A/C302	TN02	8	25	100	25	2.0	132.7	CDG	Dry	2	40	203
7SW-C/CR316	PT3	8	25	100	25	2.0	133.0	CDG	Dry	2	35	203
6SW-A/C14	TN03	9	25	100	20	2.0	133.0	CDG	Dry	2	40	203
6SW-A/C14	TN04	9	25	100	20	2.0	133.0	CDG	Dry	2	40	203
11NE-A/C455	2TN17	10	25	100	15	2.0	133.0	CDG	Dry	2	36	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 8 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
6SW-C/C7	P1	8	25	100	15	2.0	133.0	CDG	Dry	5	32	200
6SW-C/C7	P3	8	25	100	15	2.3	133.0	CDG	Dry	5	32	200
11NE-A/C455	1TN13	10	25	100	15	2.0	133.0	CDG	Dry	2	36	203
11NE-A/C455	1TN16	10	25	100	15	2.0	133.0	Colluvium	Dry	2	36	203
11NE-A/C455	2TN8	10	25	100	15	2.0	133.0	CDG	Dry	2	36	203
7SW-C/C293	TN1	10	25	120	15	2.0	135.0	CDG	Dry	3	38	203
11SW-D/FR1	TN4	16	32	150	25	2.0	135.7	CDG	Dry	0	39	333
11SW-D/FR1	TN5	16	32	150	25	2.0	135.7	CDG	Dry	0	39	333
7NW-B/CR615	TN1	10	32	150	15	2.0	137.4	CDG	Dry	5	34	333
11NE-B/C87	TN5	8	40	100	15	2.0	138.9	CDG	Wet	2	35	520
11NW-A/C152	TN3	7	25	100	15	2.0	139.7	CDG	Dry	5	35	203
6SW-C/C88	TN1	9	32	100	15	2.0	141.6	CDG	Dry	3	35	333
6SW-C/C88	TN2	9	32	100	15	2.0	141.6	CDG	Dry	3	35	333
7SE-C/C177	TN1	8	25	150	20	2.0	142.5	CDG	Dry	7	36	203
10NE-B/C6	TN1	9	25	100	15	2.0	142.5	C/HDG	Dry	5	35	203
6SW-A/C118	TN01	10	25	100	15	2.0	142.5	CDG	Dry	5	38	203
7SE-A/C301	TN2	6	25	150	15	3.0	144.4	CDG	Dry	6	38	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 9 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
6NE-D/C53	P3	9	25	100	15	3.0	144.9	C/HDV	Dry	5	36	203
11SW-D/FR1	TN6	16	32	150	25	2.0	144.9	CDG	Dry	0	39	333
11NW-A/C181	TN8	9	25	100	15	2.0	148.2	CDG	Dry	4	35	203
7SW-D/F444	TN1	9	32	150	20	2.0	148.2	CDG	Dry	2	36	335
6SW-C/C7	P4	8	25	100	15	2.2	148.2	CDG	Dry	5	32	200
11NE-B/C439	TN5	10	40	100	15	2.0	148.8	CDG	Dry	3	35	520
9SW-C/C21	P1	8	32	150	20	2.0	152.0	CDV	Dry	5	33	333
11NE-A/C455	2TN16	10	25	100	15	2.0	152.0	CDG	Dry	2	36	203
7SW-D/F444	TN3	9	32	150	20	2.0	152.0	CDG	Dry	2	36	335
6SE-C/C293	P1	8	32	100	15	2.0	152.0	CDG	Dry	5	36	330
11SW-D/C1132	TN5	13	25	150	53	2.0	152.4	CDG	Wet	8	38	203
11NW-B/C658	P1	7	25	150	20	2.0	153.9	CDG	Wet	10	38	203
13NE-B/CR127	P5	14	25	150	20	2.0	154.0	CDV	Wet	7	38	203
7SE-A/C300	TN2	6	25	150	15	3.0	155.8	CDG	Dry	6	38	203
13NW-B/C135	P3	12	25	150	5	2.0	155.8	C/HDV	Dry	5	38	203
6SW-A/C115	TN04	16	32	150	15	2.0	156.4	CDG	DRY	3	39	333
6SW-A/C115	TN05	16	32	150	15	2.0	156.4	CDG	DRY	3	39	333

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 10 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7SE-C/C533	TN2	10	25	100	20	4.0	157.7	CDG	Dry	5	37	203
2SE-D/C348	TN1	10.1	40	150	20	2.0	157.7	CDV	Dry	4	33	520
9SW-D/C208	P4	11	25	150	20	2.0	158.3	CDV	Wet	3	35	203
7SW-D/C74	TN5	7	32	100	20	2.0	158.4	CDG	Dry	6	38	335
6SW-A/C12	TN04	14	25	100	20	2.0	158.7	CDG	Dry	2	40	203
11SW-D/FR126	TN1	9	32	150	24	2.0	158.7	C/HDV	Dry	7	37	333
7SW-D/C922	TN3	9	25	120	15	4.0	159.6	CDG	Dry	3	36	203
9SW-D/C170	TN01	7	25	100	15	2.0	159.6	CDV	Dry	3	40	203
13NW-B/C135	1	11	25	150	20	2.0	160.0	C/HDV	Dry	5	38	203
13NW-B/C135	3	12	25	150	5	2.0	160.0	C/HDV	Dry	5	38	203
14NW-D/C21	A	6	25	100	30	2.0	160.0	CDG	Dry	7	38	203
6SW-A/C14	TN05	9	25	100	20	2.0	161.5	CDG	Dry	2	40	203
11NE-A/C455	2TN3	9	25	100	15	2.0	161.5	CDG	Dry	2	36	203
7SW-D/CR842	TN2	9	32	100	20	2.0	162.0	CDG	Dry	6	38	335
11SW-B/CR17	TN1	8	32	150	20	2.0	162.3	CDG	Dry	7	34	333
6SW-A/C115	TN03	16	32	150	15	2.0	162.5	CDG	Dry	3	39	333
11SW-A/C107	TN14	8	40	150	15	2.0	162.8	CDV	Dry	8	40	520

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 11 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
6NE-D/C53	P1	15	25	100	15	3.0	162.9	C/HDV	Dry	5	36	203
11SE-C/C863	TN6	8	25	100	15	2.0	162.9	CDG	Dry	5	40	203
11SE-C/C863	TN10	8	25	100	15	2.0	162.9	CDG	Dry	5	40	203
11SW-D/FR1	TN1	19	40	150	25	2.0	164.6	CDG	Dry	0	39	520
3NE-C/C77	P1	9	25	150	10	2.0	166.1	CDV	Dry	5	35	203
10NE-B/C87	TN4	12	25	120	15	2.0	166.9	CDG	Dry	5	35	203
10NE-B/C87	TN5	12	25	120	15	2.0	166.9	CDG	Dry	5	35	203
10NE-B/C77	PT6	21	40	150	15	2.0	167.0	CDG	Dry	8	33.5	520
10NE-B/C87	TN7	12	25	120	15	2.0	167.0	CDG	Dry	5	35	203
11NE-B/C435	TN8	10	25	100	10	2.0	167.2	CDG	Dry	2	35	203
10NE-B/C87	TN1	13	25	120	15	2.0	167.3	CDG	Dry	5	35	203
10NE-B/C87	TN2	13	25	120	15	2.0	167.3	CDG	Dry	5	35	203
10NE-B/C87	TN3	13	25	120	15	2.0	167.3	CDG	Dry	5	35	203
11NE-A/C455	1TN8	12	25	100	15	2.0	168.5	CDG	Wet	15	40	203
14NW-A/C70	P4	9	25	150	20	2.0	170.0	CDG	Dry	4	35	203
6SW-A/C115	TN01	12	25	100	15	2.0	170.8	CDG	Dry	3	39	203
7SE-A/C314	TN5	8	25	100	15	2.0	171.0	C/HDG	Dry	9	38	203

Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 12 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NW-B/FR38	PT9	16	40	100	30	2.0	171.0	CDG	Dry	5	35	520
7SW-D/F444	TN2	9	32	150	20	2.0	171.0	CDG	Dry	2	36	335
6SE-C/C254	P1	9	25	100	15	2.0	171.0	CDG	Dry	6	38	200
11SW-A/CR8	TN22	12	25	100	15	2.0	171.0	CDV	Dry	3	38	203
6SW-D/C54	TN01	10	25	100	15	2.0	171.0	CDG	Dry	3	38	203
11NE-B/C87	TN4	9	32	100	15	2.0	172.3	CDG	Wet	2	35	333
7SE-B/R81&82	TN2	10	32	100	20	2.0	174.8	CDG	Dry	3	35	335
11NE-A/C455	1TN12	10	25	100	15	2.0	174.8	CDG	Dry	10	38	203
13NE-B/C129	P5	12	32	150	20	2.0	175.0	CDV	Dry	2	32	333
7SW-C/C116	P11A	15	32	100	15	2.0	175.0	CDG	Dry	6	32	330
6NE-D/FR80	P1	18	32	100	39	2.0	175.0	Fill	Dry	0	33	333
11NE-A/C153	P12	10	25	150	20	2.0	175.2	CDG	Dry	5	35	203
11SE-C/CR29	TN3	9	40	150	10	2.0	175.9	CDG	Dry	1	37	520
7SW-D/C74	TN2	9	32	100	20	2.0	176.4	CDG	Dry	6	38	335
11SE-C/C863	TN5	8	25	100	25	2.0	176.7	CDG	Dry	5	40	203
11SW-A/C108	TN3	12	25	120	15	2.0	176.7	CDV	Dry	3	38	203
11SE-C/C863	TN3	8	25	100	25	2.0	176.7	CDG	Dry	5	40	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 13 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7SW-D/C74	TN6	7	32	100	20	2.0	178.6	CDG	Dry	10	39	335
6NE-D/FR80	P4	18	32	100	39	2.0	179.0	Fill	Dry	0	33	333
13NW-B/C319	B	11	25	150	20	2.0	180.0	C/HDV	Dry	10	38	203
7SE-C/CR388	TN3	6	25	100	40	2.0	180.5	CDG	Dry	7	35	203
7SW-D/F440	TN4	15	32	150	10	2.0	180.5	CDG	Dry	10	40	333
6SW-A/C14	TN01	9	25	100	20	2.0	180.5	CDG	Dry	2	40	203
7SE-A/C314	TN3	15	32	100	15	2.0	180.5	C/HDG	Dry	9	38	333
11SW-A/C107	TN13	8	40	150	15	2.0	180.5	CDV	Dry	8	40	520
11SW-A/CR8	TN31	18	25	100	15	2.0	180.5	CDV	Dry	3	38	203
11NW-D/CR46	TN 6	15	40	150	10	2.1	180.5	C/HDG	Dry	5	38	520
11NE-A/C455	2TN1	9	25	100	15	2.0	180.5	CDG	Dry	15	40	203
11NE-A/C153	P14	11	25	150	20	2.0	180.9	CDG	Dry	5	35	203
11NE-B/C254	PT21	15	40	150	15	2.0	181.3	CDG	Dry	6	36	520
7SE-C/C177	TN2	8	25	150	20	2.0	182.4	CDG	Dry	7	36	203
11SW-A/C108	TN4	10	25	120	15	2.0	182.4	CDV	Dry	3	38	203
11NW-A/C181	TN3	9	25	100	15	2.0	183.6	CDG	Dry	4	35	203
11SW-D/FR1	TN8	14	25	150	25	2.0	184.5	CDG	Dry	0	39	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 14 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
6NE-D/C53	P2	12	25	100	15	3.2	185.0	C/HDV	Dry	5	36	203
10NE-B/C251	PT9	14	25	100	15	4.0	186.2	CDG	Dry	5	33	203
6SW-A/C14	TN02	9	25	100	20	2.0	186.2	CDG	Dry	2	40	203
14NW-A/C70	P3	9	25	150	20	2.0	190.0	CDG	Dry	4	35	203
11NE-A/C455	1TN15	10	25	100	15	2.0	190.0	CDG	Dry	2	36	203
11SW-A/C108	TN2	13	25	120	15	2.0	190.0	CDV	Dry	3	38	203
11NW-D/CR46	TN 4	12	40	150	10	2.2	190.0	C/HDG	Dry	5	38	520
11NW-B/FR38	PT10	16	40	100	30	2.0	190.0	CDG	Dry	5	35	520
7SE-A/CR148	TN1	11	32	150	20	2.0	190.0	CDV	Dry	7	38	335
7SW-D/F441	TN3	12	32	150	10	2.0	190.0	CDG	Dry	2	36	335
3NE-D/C74	P2	9	25	100	15	2.0	191.3	CDV	Dry	7	35	203
7SW-C/C116	P2	15	32	100	15	2.0	192.5	CDG	Dry	6	32	330
7SW-C/C116	P10	15	32	100	15	2.0	192.5	CDG	Dry	6	32	330
14NW-A/C70	P1	10	25	150	20	2.0	193.8	CDG	Dry	4	35	203
7SW-D/F441	TN4	12	32	150	10	2.0	193.8	CDG	Dry	2	36	335
11NW-A/CR296	TN2	10	32	100	20	3.0	197.6	CDG	Dry	5	37	333
11NE-C/CR207	P8	13	32	150	15	2.0	197.6	CDG	Dry	3	35	330

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 15 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11SW-A/CR8	TN18	15	25	100	15	2.0	198.0	C/HDV	Dry	9	40	203
11NE-A/C455	1TN5	12	25	100	15	2.0	199.5	CDG	Dry	15	40	203
13NW-B/C319	A	10	32	150	20	2.0	200.0	C/HDV	Dry	10	38	333
7SW-C/C116	P17	12	32	100	15	2.0	201.3	CDG	Dry	6	32	330
7NW-A/CR237	P1a	18	32	100	15	2.0	202.9	CDV	Dry	5	35	333
11NE-A/C153	P13	12	25	150	20	2.0	203.9	CDG	Dry	5	35	203
10NE-B/C251	PT8	14	25	100	15	4.0	205.2	CDG	Dry	5	33	203
14NW-A/C70	P2	10	25	150	20	2.0	205.2	CDG	Dry	4	35	203
13NE-B/CR127	P2	14	32	150	20	2.0	207.9	CDV	Wet	7	38	333
11SW-A/CR8	TN4	12	25	100	15	2.0	209.0	CDV	Dry	3	38	203
11SW-A/CR8	TN17	12	25	100	15	2.0	209.0	CDV	Dry	3	38	203
11SW-A/CR8	TN5	12	25	100	15	2.0	209.0	CDV	Dry	3	38	203
11SW-A/C107	TN12	10	40	150	15	2.0	209.4	CDV	Dry	8	40	520
7NW-A/CR237	P4a	18	32	100	15	2.0	209.7	CDV	Dry	5	35	333
11SW-D/CR1169	PT1	13	32	150	15	2.0	210.0	CDG	Dry	6	42	331
7SW-C/C116	P7	15	32	100	15	2.0	210.0	CDG	Dry	6	32	330
7SW-C/C116	P8	15	32	100	15	2.0	210.0	CDG	Dry	6	32	330

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 16 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11SW-D/C639	TN2	10	32	150	15	2.0	212.5	CDV	Dry	5	35	333
7SW-D/F441	TN5	15	40	150	10	2.0	212.8	CDG	Dry	2	36	520
11NE-C/CR207	P6	13	32	150	15	2.0	212.8	CDG	Dry	3	35	330
11SW-A/C107	TN9	14	40	150	15	2.0	214.7	CDV	Dry	8	40	520
11NW-B/C228	TN 1	12	40	100	15	2.0	216.0	CDG	Dry	5	38	520
11SW-A/CR8	TN15	15	32	100	15	2.0	217.0	C/HDV	Dry	9	40	333
6NE-D/FR80	P7	18	40	120	39	2.0	217.0	Fill	Dry	0	33	520
6NE-D/FR80	P2	20	25	100	39	2.0	218.0	Fill	Dry	0	33	203
7SE-A/CR148	TN2	11	40	150	20	2.0	218.5	CDV	Dry	7	38	520
11NE-A/C455	2TN11	10	25	100	15	2.0	218.5	CDG	Dry	2	36	203
6SW-A/C12	TN03	14	25	100	20	2.0	219.8	CDG	Dry	2	40	203
13NW-B/C135	P2	12	25	150	5	2.0	221.9	C/HDV	Wet	5	38	203
3NE-C/C223	P1	9	25	150	20	2.0	222.3	CDV	Dry	5	35	203
3NE-C/C223	P2	9	25	150	20	2.0	222.3	CDV	Dry	5	35	203
11SW-A/CR8	TN12	12	25	100	15	2.0	222.8	CDV	Dry	3	38	203
11NW-D/C295	P1	8	25	150	20	2.0	224.0	CDG	Dry	5	36	203
11NW-D/C295	P2	8	25	150	20	2.0	224.0	CDG	Dry	5	36	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 17 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
13NW-B/C319	G	14	40	150	20	2.0	226.0	CDV	Dry	8	36	520
11SW-D/CR495	PN2	10	25	100	10	3.4	226.2	CDV	Dry	5	34	203
11SW-A/C108	TN11	13	25	120	15	2.0	227.4	CDV	Dry	3	38	203
7SW-C/CR316	PT4	13	25	100	25	2.0	228.0	C/HDG	Dry	5	37	203
6SW-A/C12	TN05	14	25	100	20	2.0	228.0	CDG	Dry	2	40	203
7SW-D/CR842	TN1	9	40	100	20	2.0	228.0	CDG	Dry	10	39	520
11NW-A/CR201	TN4	18	40	150	15	2.2	228.0	CDG	Dry	5	37	520
7SE-A/C157	TN20	12	32	150	15	2.0	228.0	C/HDG	Dry	6	36	333
6SW-D/C553	TN03	15	25	100	15	2.0	228.0	CDG	Dry	3	38	203
13NW-B/C135	2	12	25	150	5	2.0	230.0	C/HDV	Dry	5	38	203
7SW-C/C293	TN3	16	32	150	15	2.0	231.2	CDG	Dry	3	38	333
11NE-B/C380	P1	13	25	150	15	2.0	233.7	CDV	Dry	5	34	200
6NE-D/FR80	P6	20	40	120	39	2.0	236.0	Fill	Dry	0	33	520
7SW-C/CR316	PT6	14	25	100	25	4.0	237.5	CDG	Dry	2	35	203
13NE-B/C129	P3	13	32	150	20	2.0	241.0	CDV	Dry	2	32	333
10NE-B/C251	PT5	17	25	100	15	4.0	243.2	CDG	Dry	5	33	203
7SW-C/C115	P1	16	32	100	15	2.0	245.0	CDG	Dry	6	32	330

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 18 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7SW-C/C116	P4	15	32	100	15	2.0	245.0	CDG	Dry	6	32	330
7SW-C/C116	P5	15	32	100	15	2.0	245.0	CDG	Dry	6	32	330
11SW-A/CR8	TN30	18	25	100	15	2.0	247.0	CDV	Dry	3	38	203
11NW-D/CR46	TN 11	12	40	150	40	2.2	247.0	CDG	Dry	5	38	520
11SW-A/CR8	TN20	15	25	100	15	2.0	247.0	CDV	Dry	3	38	203
11SW-A/CR8	TN11	15	25	100	15	2.0	247.0	CDV	Dry	3	38	203
6SW-A/C12	TN01	14	25	100	20	2.0	248.0	CDG	Dry	2	40	203
11NE-B/C87	TN6	13	40	100	15	2.0	249.0	CDG	Dry	2	35	520
13NW-B/C319	N	14	32	150	20	2.0	250.0	C/HDV	Dry	10	38	333
11NW-D/CR46	TN 8	12	40	150	10	2.0	250.8	C/HDG	Dry	5	38	520
7SW-D/C74	TN1	9	32	100	20	2.0	250.8	CDG	Dry	10	39	335
11NE-B/C435	TN1	15	40	150	15	2.0	251.2	CDG	Wet	2	35	520
7SW-C/C115	P2	16	32	100	15	2.0	253.8	CDG	Dry	6	32	330
11NE-B/C439	TN8	14	40	100	15	2.0	253.9	CDG	Dry	3	35	520
6NE-D/FR80	P3	20	40	120	39	2.0	255.0	Fill	Dry	0	33	520
11NE-B/C254	PT7	20	40	150	15	2.0	255.7	CDG	Dry	6	36	520
11NE-B/C87	TN2	15	40	100	15	2.0	256.5	C/HDG	Dry	8	38	520

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 19 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NE-B/C435	TN2	15	40	150	15	2.0	256.9	CDG	Wet	2	35	520
7SW-D/C74	TN4	9	32	100	20	2.0	258.4	CDG	Dry	10	39	335
7SW-C/C115	P5	18	32	100	15	2.0	262.5	CDG	Dry	6	32	333
7SW-C/C115	P10	18	32	100	15	2.0	262.5	CDG	Dry	6	32	330
11NE-B/C435	TN3	15	40	150	15	2.0	262.6	CDG	Wet	2	35	520
13NE-B/C129	P2	15	40	150	20	2.0	264.8	CDV	Dry	2	32	520
11SW-A/CR8	TN7	15	32	100	15	2.0	265.4	C/HDV	Dry	9	40	333
13NW-B/C319	K	11	32	150	20	2.0	266.0	CDV	Dry	8	36	333
11SW-A/CR8	TN8	15	25	100	15	2.0	266.0	CDV	Dry	3	38	203
11SW-A/CR8	TN3	15	32	100	15	2.0	266.0	CDV	Dry	3	38	333
11SW-A/CR8	TN13	15	25	100	15	2.0	266.0	CDV	Dry	3	38	203
11NE-B/C254	PT4	20	40	100	15	2.0	268.7	CDG	Dry	6	36	520
11NE-B/C254	PT1	16	40	100	15	2.0	269.0	CDG	Dry	6	36	520
11NW-A/C419	P4	10	25	150	10	2.0	270.2	CDG	Dry	5	36	203
7SW-C/C115	P6	18	32	100	15	2.0	271.3	CDG	Dry	6	32	330
7SW-C/C115	P7	18	32	100	15	2.0	271.3	CDG	Dry	6	32	330
3SW-C/C774	P7	9	32	150	20	2.0	271.9	CDV	Dry	3	32	333

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 20 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7NE-C/FR24	P3	27	40	100	38	2.0	273.6	CDG	Dry	8	34	520
7SW-D/F440	TN6	15	32	150	10	2.0	273.6	CDG	Dry	10	40	333
7SW-D/C74	TN3	9	32	100	20	2.0	273.6	CDG	Dry	10	39	335
11NE-C/CR207	P2	18	32	150	15	2.0	273.6	CDG	Dry	3	35	330
11SW-D/FR522	TN1	12	40	150	30	2.0	274.9	CDV	Dry	5	35	520
11NE-C/CR207	P4	18	32	150	15	2.0	277.4	CDG	Dry	3	35	330
11SW-A/CR8	TN1	18	32	100	15	2.0	284.4	CDV	Dry	3	38	333
13NW-B/C319	H	12	25	150	20	2.0	285.0	CDV	Dry	8	36	203
11SW-A/C108	TN8	16	32	150	15	2.0	285.0	CDV	Dry	3	38	333
11SW-A/CR8	TN6	15	25	100	15	2.0	285.0	CDV	Dry	3	38	203
11SW-A/CR8	TN26	18	25	100	15	2.0	285.0	CDV	Dry	3	38	203
11NW-B/FR37	PT15	14	40	100	41	2.0	285.0	CDG	Dry	5	35	520
11SW-A/C107	TN10	14	40	150	15	2.0	285.4	CDV	Dry	8	40	520
11SE-C/CR29	TN2	14	40	150	10	2.0	286.0	CDG	Wet	1	37	520
7SW-C/C115	P3A	18	32	100	15	2.0	288.8	CDG	Dry	6	32	330
11NE-C/CR207	P3	18	32	150	15	2.0	288.8	CDG	Dry	3	35	330
7SW-D/F440	TN7	15	32	150	10	2.0	290.7	CDG	Dry	10	40	333

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 21 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
12SW-A/C124	P4	20	32	100	15	2.0	291.6	C/HDV	Dry	9	38	333
11SW-A/C108	TN5	20	32	150	15	2.0	291.8	CDV	Dry	3	38	333
13NW-B/C319	I	12	32	150	20	2.0	294.0	C/HDV	Dry	10	38	333
11SW-A/CR8	TN16	18	25	100	15	2.0	294.2	C/HDV	Dry	9	40	203
11SW-A/CR8	TN28	18	25	100	15	2.0	294.5	CDV	Dry	3	38	203
11SW-A/CR8	TN25	18	25	100	15	2.0	294.5	CDV	Dry	3	38	203
12SW-A/C129	P11	16	32	100	15	2.0	294.6	C/HDV	Dry	5	35	330
11NE-B/C87	TN1	15	40	100	15	2.0	294.9	C/HDG	Dry	8	38	520
11NE-C/CR207	P1	18	32	150	15	2.0	296.4	CDG	Dry	3	35	330
13NE-B/C129	P2	10	25	150	20	2.0	298.0	CDV	Dry	2	32	203
11NW-A/C419	P2	12	32	150	10	2.0	299.8	CDG	Dry	5	36	333
10NE-B/C255	PT1	25	40	150	15	2.0	301.0	CDG	Dry	8	33.5	520
6SW-A/C12	TN02	14	25	100	20	2.0	302.1	CDG	Wet	2	40	203
11SW-A/C107	TN11	14	40	150	15	2.0	302.5	CDV	Dry	8	40	520
11NW-D/C89	PT2	12	32	100	20	2.0	304.0	CDG	Dry	2	37	333
11SW-A/CR8	TN29	18	25	100	15	2.0	304.0	CDV	Dry	3	38	203
11NW-B/FR38	PT11	19	40	100	30	2.0	304.0	CDG	Dry	5	35	520

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 22 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NE-C/CR207	P5	18	32	150	15	2.0	304.0	CDG	Dry	3	35	330
11SW-A/CR8	TN23	18	25	100	15	2.0	304.0	CDV	Dry	3	38	203
11NW-B/FR37	PT16	14	40	100	41	2.0	304.0	CDG	Dry	5	35	520
13NW-B/C319	J	12	40	150	20	2.0	305.0	C/HDV	DRY	10	38	520
12SW-A/C124	P3	20	32	100	15	2.0	311.4	C/HDV	Dry	9	38	333
7SW-D/C167	TN2	16	32	150	20	2.0	311.6	CDG	Dry	2	36	335
11SW-A/CR8	TN2	18	32	100	15	2.0	312.6	CDV	Dry	3	38	333
11NE-A/C454	TN13	21	40	100	15	2.0	313.5	CDG	Dry	2	36	520
11NE-B/C254	PT5	20	40	150	15	2.0	315.2	CDG	Dry	6	36	520
11NW-A/CR472	P1	8	25	150	10	2.0	317.3	CDG	Dry	5	38	203
11NW-B/CR245	P1	10	25	150	10	2.0	321.3	CDG	Dry	4	35	203
12SW-A/C129	P10	16	32	100	15	2.0	322.2	C/HDV	Dry	5	35	330
11SW-A/CR8	TN9	15	32	100	15	2.0	322.4	C/HDV	Dry	9	40	333
11NW-D/C89	PT4	13	32	100	20	2.0	323.0	CDG	Dry	2	37	333
11NW-B/FR37	PT5	18	40	100	41	2.0	323.0	CDG	Dry	5	35	520
11NW-B/FR37	PT6	18	40	100	41	2.0	323.0	CDG	Dry	5	35	520
11SW-A/CR8	TN27	20	25	100	15	2.0	323.0	CDV	Dry	3	38	203

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 23 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NW-B/C658	P2	13	32	150	20	2.0	324.5	CDG	Dry	10	38	333
13NW-B/C319	E	16	32	150	20	2.0	327.0	CDV	Dry	8	36	333
7SE-A/C157	TN18	20.5	32	150	15	2.0	328.2	C/HDG	Wet	6	36	333
11SE-C/CR29	TN1	16	40	150	10	2.0	330.0	CDG	Wet	1	37	520
11NW-A/CR472	P2	12	32	150	10	2.0	330.2	CDG	Dry	5	38	333
10NE-B/C263	PT4	23	40	150	20	2.0	336.0	CDG	Dry	5	33	520
11SE-C/C863	TN1	14	32	100	30	2.0	337.4	CDG	Dry	10	45	333
11SE-C/C863	TN2	14	32	100	30	2.0	337.4	CDG	Dry	10	45	333
11NE-B/C254	PT2	20	40	100	15	2.0	339.3	CDG	Dry	6	36	520
13NW-B/C319	C	16	40	150	20	2.0	340.0	CDV	Dry	8	36	520
11NW-B/FR38	PT12	21	40	100	30	2.0	342.0	CDG	Dry	5	35	520
7SE-A/C157	TN9	20	32	150	15	2.0	342.0	CDG	Dry	6	36	333
11SW-A/CR8	TN24	20	25	100	15	2.0	342.0	CDV	Dry	3	38	203
13NW-B/C319	D	17	40	150	20	2.0	346.0	CDV	Dry	8	36	520
11NW-B/C167	TN 1	10	40	100	15	2.1	346.0	CDG	Dry	8	38	520
11SW-A/C108	TN7	20	32	150	15	2.0	352.8	CDV	Dry	3	38	333
13NW-B/C319	M1	11	40	150	20	2.0	360.0	CDV	Dry	8	36	520

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 24 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
2SE-D/C348	TN3	19.9	40	150	20	2.0	361.0	CDV	Dry	4	33	520
11NW-D/C89	PT1	12	32	100	20	2.0	361.0	CDG	Dry	2	37	333
11NW-D/C90	PT1	12	32	100	20	2.0	361.0	CDG	Dry	2	37	333
11NW-D/C90	PT5	11	32	100	20	2.0	361.0	CDG	Dry	2	37	333
11SW-A/C107	TN6	21	40	150	15	2.0	361.0	CDV	Dry	8	40	520
11NW-B/FR37	PT7	20	40	100	41	2.0	361.0	CDG	Dry	5	35	520
11NW-B/FR37	PT8	20	40	100	41	2.0	361.0	CDG	Dry	5	35	520
11NW-B/FR37	PT9	20	40	100	41	2.0	361.0	CDG	Dry	5	35	520
7SE-A/C157	TN10	20	32	150	15	2.0	361.0	CDG	Dry	6	36	333
11SW-A/C107	TN1	15	40	150	15	2.0	366.7	CDV	Dry	8	40	520
11SW-A/C107	TN8	19	40	150	15	2.0	370.5	CDV	Dry	8	40	520
7SE-A/C157	TN11	20	32	150	15	2.0	370.5	CDG	Dry	9	38	333
7SE-A/C157	TN13	20	32	150	15	2.0	370.5	CDG	Dry	9	38	333
7NE-C/FR24	P10	20	40	100	37	2.0	375.9	CDG	Dry	8	34	330
11SW-A/C107	TN5	21	40	150	15	2.0	380.0	CDV	Dry	8	40	520
7SE-A/C157	TN12	20	32	150	15	2.0	380.0	CDG	Dry	9	38	333
7SE-A/C157	TN14	20	32	150	15	2.0	380.0	CDG	Dry	9	38	333

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Table A1 - Pullout Test Data for Test Soil Nails Reaching T_p (Sheet 25 of 25)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_p (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7SE-A/C157	TN15	20	32	150	15	2.0	380.0	C/HDG	Dry	9	38	333
7SE-A/C157	TN17	20	32	150	15	2.0	380.0	C/HDG	Dry	10	42	333
7SE-A/C157	TN19	20	32	150	15	2.0	380.0	C/HDG	Dry	6	36	333
11SW-A/CR8	TN21	20	25	100	15	2.0	380.0	CDV	Dry	3	38	203
11SW-A/C107	TN2	17	40	150	15	2.0	386.7	CDV	Dry	8	40	520
11SW-A/C107	TN3	18	40	150	15	2.0	386.7	CDV	Dry	8	40	520
11SW-A/C107	TN4	19	40	150	15	2.0	386.7	CDV	Dry	8	40	520
11NW-B/FR37	PT13	20	40	100	41	2.0	399.0	CDG	Dry	5	35	520
11NE-B/C262	PT13	24	40	100	20	2.0	415.2	CDG	Dry	5	33	520
11SW-A/C107	TN7	19	40	150	15	2.0	418.0	CDV	Dry	8	40	520
11NW-B/FR37	PT11	23	40	100	41	2.0	437.0	CDG	Dry	5	35	520
11NW-B/FR37	PT14	23	40	100	41	2.0	437.0	CDG	Dry	5	35	520
11NW-B/FR37	PT12	23	40	100	41	2.0	475.0	CDG	Dry	5	35	520
11NW-B/C169	P9	22	40	150	15	2.0	562.6	CDG	Dry	5	38	520

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Table A2 - Pullout Test Data for Test Soil Nails Reaching T_{ult} (Sheet 1 of 7)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_{ult} (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11SW-D/C547	TN3	2.3	40	150	10	2.0	33.1	CDV	Dry	7	35	241
12NW-C/R4	P1	8	32	150	20	2.0	55.5	CDV	Wet	5	35	246
6NE-D/C1	TN1	6	40	150	20	2.0	57.0	CDG	Dry	6	36	447
6NE-D/C1	TN2	6	40	150	20	2.0	57.0	CDG	Dry	6	36	349
6NE-D/C1	TN3	6	40	150	20	2.0	57.0	CDG	Dry	6	36	460
11NE-B/C553	TN1	4	32	120	20	2.0	57.0	CDV	Dry	8	38	66
10SE-B/C6	TN4	7	25	150	20	2.0	68.4	Colluvium	Dry	3	33	133
11NE-B/C439	TN15	6	25	100	15	2.0	68.4	CDG	Dry	3	35	87
11SW-A/C331	TN1	5	32	150	20	2.0	69.0	CDV	Dry	6	35	199
3SE-C/C145	B	6	40	150	20	2.0	69.4	CDV	Dry	5	33	62
11NW-A/C118	TN4	6	25	120	15	2.0	71.2	Colluvium	Dry	4	34	34
8SW-C/CR46	P2	6	25	100	15	2.0	72.2	CDV	Dry	3	34	87
11NE-B/C752	P1	6	25	120	15	2.0	72.2	CDG	Dry	5	35	54
11NW-B/C739	TN 1	12	40	100	15	2.1	72.2	CDG	Dry	5	35	427
7NW-D/C90	C	9	40	100	20	2.0	72.2	CDV	Dry	5	33	125
11NW-A/C241	TN1	6	32	150	15	2.0	74.8	Colluvium	Dry	3	36	163
14NE-B/C175	P1	6	20	100	40	2.0	75.0	CDG	Dry	5	35	110

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Table A2 - Pullout Test Data for Test Soil Nails Reaching T_{ult} (Sheet 2 of 7)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_{ult} (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
7SW-C/CR316	PT1	9	25	100	25	2.5	76.0	CDG	Dry	2	35	134
7NW-B/C554	A	7	40	150	20	2.0	76.0	CDG	Dry	4	34	136
12NW-C/R4	P2	7	32	150	20	2.0	79.0	CDV	Wet	5	35	197
7NW-B/C149	A	6	40	150	20	2.0	79.8	CDG	Dry	4	33	154
11NE-B/C435	TN11	6	25	100	10	2.0	79.8	CDG	Dry	2	35	104
11NE-B/C477	P1	6	32	120	15	2.0	81.0	CDV	Dry	5	33	265
7SE-A/CR148	TN1	7	25	150	20	3.0	81.7	CDV	Dry	7	38	188
11NE-B/C752	P3	8	25	120	15	2.0	81.7	CDG	Dry	5	35	111
7NW-A/C86	A	6	40	150	20	2.0	83.6	CDV	Dry	5	35	435
11NE-D/C20	P3	6	25	100	15	2.0	83.6	CDG	Dry	5	38	114
11NE-B/C87	TN10	8	25	100	15	2.0	83.8	CDG	Dry	2	35	113
7SW-C/CR316	PT5	7	25	100	25	2.5	85.5	CDG	Dry	2	35	115
11NE-B/C435	TN10	6	25	100	10	2.0	87.4	CDG	Dry	2	35	105
7SW-C/C115	N1	6	40	100	15	2.3	87.5	CDG	Dry	6	32	80
7NW-A/C203	C	7	40	150	20	2.0	89.0	Colluvium	Dry	4	34	53
11NW-A/C181	TN7	8	25	105	15	2.0	91.2	CDG	Dry	1	35	70
6SW-C/C625	TN1	6	32	150	20	2.0	95.0	CDG	Dry	5	33	195

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Table A2 - Pullout Test Data for Test Soil Nails Reaching T_{ult} (Sheet 3 of 7)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_{ult} (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NE-B/C824	P5	7	25	100	15	2.0	96.3	CDV	Wet	5	32	166
8SW-C/CR46	P1	6	25	100	15	2.0	96.9	CDV	Dry	3	34	165
7NW-B/C554	B	7	40	150	20	2.0	100.7	CDG	Dry	4	34	106
7NW-A/CR236	B	5	40	150	20	2.0	102.6	CDV	Dry	5	33	145
11NW-B/CR245	P3	8	25	150	10	2.0	108.1	CDG	Dry	4	35	139
7NW-A/CR236	A	9	40	150	20	2.0	109.1	CDV	Dry	5	33	230
7NW-A/C130	B	7	40	150	20	2.0	109.3	CDG	Dry	4	33	150
11NE-B/C439	TN12	6	25	100	15	2.0	110.2	CDG	Dry	3	35	103
11NW-D/C90	PT10	11	32	100	20	2.0	114.0	CDG	Dry	2	37	138
7SW-B/C10	PT1	6	25	100	20	2.0	114.0	CDG	Dry	9	38	93
3SE-C/CR89	A1	8	25	150	20	2.0	117.6	CDV	Dry	5	32	122
11NE-B/C553	TN2	6	32	120	20	2.0	117.8	CDV	Dry	8	38	315
11NW-B/CR245	P4	8	25	150	10	2.0	118.2	CDG	Dry	4	35	184
13NE-B/CR127	P7	10	25	150	20	2.0	120.9	CDV	Wet	7	38	166
7NW-A/C130	A1	8	40	150	20	2.0	127.3	CDG	Dry	4	33	79
3SE-C/C145	A1	10	40	150	20	2.0	127.3	CDV	Dry	5	33	178
3SE-C/C90	A1	7	25	150	20	2.0	128.8	CDV	Dry	5	32	109

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Table A2 - Pullout Test Data for Test Soil Nails Reaching T_{ult} (Sheet 4 of 7)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_{ult} (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11SW-B/CR17	TN2	12	32	150	20	2.0	128.8	CDG	Dry	7	34	229
7NW-A/C203	B	7	40	150	20	2.0	129.0	Colluvium	Dry	4	34	154
7NW-D/C90	P1	9	40	100	20	2.0	132.0	CDV	Dry	5	33	58
11SW-A/C331	TN3	6	32	150	20	2.0	132.7	CDV	Dry	6	35	158
11NE-A/C454	TN14	9	25	100	25	2.0	133.0	CDG	Dry	2	36	137
7NW-D/C90	B	10	40	100	20	2.0	133.0	CDV	Dry	5	33	180
6SW-C/C7	P2	8	25	100	15	1.9	133.0	CDG	Dry	5	32	155
11NE-B/C477	P2	8	32	120	15	2.0	133.2	CDV	Dry	5	33	193
7SW-D/R15	TN2	9	25	120	45	2.0	134.9	CDG	Dry	5	31	98
14NW-D/C246	P2	11	25	150	20	2.0	135.0	CDG	Dry	3	35	83
11NW-B/C167	TN 3	10	40	100	15	2.1	136.0	CDG	Dry	8	38	255
11NE-B/C752	P2	8	25	120	15	2.0	140.6	CDG	Dry	5	35	61
11SW-D/FR1	TN3	16	32	150	25	2.0	140.6	CDG	Dry	0	39	228
7NW-A/C203	D	7	40	150	20	2.0	142.0	Colluvium	Dry	4	34	227
7NW-A/C86	B	8	40	150	20	2.0	142.5	CDV	Dry	5	35	372
7SE-B/R81&R82	TN1	9	32	100	20	2.0	142.5	CDG	Dry	3	35	185
11NW-A/C237	TN1	12	32	150	15	2.0	142.8	CDG	Dry	3	39	313

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Table A2 - Pullout Test Data for Test Soil Nails Reaching T_{ult} (Sheet 5 of 7)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_{ult} (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11SE-C/C571	TN1	7	32	150	20	2.0	146.1	CDG	Dry	3	37	187
3SE-C/CR137	B	8	40	150	20	2.0	148.2	CDV	Dry	5	32	160
11NW-B/C739	TN 2	12	40	100	15	2.1	148.2	CDG	Dry	5	35	451
11NW-D/C90	PT15	9	32	100	20	2.0	152.0	CDG	Dry	2	37	204
11SW-A/C331	TN2	9	32	150	20	2.0	153.2	CDV	Dry	6	35	128
14NW-D/C246	P1	9	25	150	20	2.0	155.0	CDG	Dry	3	35	61
3SE-C/CR137	A	12	40	150	20	2.0	157.7	CDV	Dry	5	32	193
6SE-C/C254	P3	9	25	100	15	2.0	161.5	CDG	Dry	6	38	153
10NE-B/C87	TN6	12	25	120	15	2.0	167.0	CDG	Dry	5	35	194
11NW-D/C90	PT13	9	32	100	20	2.0	171.0	CDG	Dry	2	37	160
6SE-C/C254	P2	9	25	100	15	2.0	171.0	CDG	Dry	6	38	171
2SE-D/C348	D	8	40	150	20	2.0	174.8	CDV	Dry	4	34	370
11NW-B/C167	TN 2	12	40	100	15	2.1	186.0	CDG	Dry	8	38	306
11NW-D/C89	PT7	13	32	100	20	2.0	190.0	CDG	Dry	2	37	144
11NW-D/C90	PT16	10	32	100	20	2.0	190.0	CDG	Dry	2	37	215
7SW-C/C115	P11	18	32	100	15	2.0	192.5	CDG	Dry	6	32	159
7NW-A/C5	PT3	8	25	114	20	2.0	193.8	CDG	Dry	2	39	100

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Table A2 - Pullout Test Data for Test Soil Nails Reaching T_{ult} (Sheet 6 of 7)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_{ult} (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NE-C/CR207	P7	13	32	150	15	2.0	197.6	CDG	Dry	3	35	130
7SW-C/C116	P11	15	32	100	15	2.0	201.3	CDG	Dry	6	32	156
7SW-C/C116	P16	12	32	100	15	2.0	201.3	CDG	Dry	6	32	179
11NW-D/C90	PT11	11	32	100	20	2.0	209.0	CDG	Dry	2	37	160
7SW-C/C116	P9	15	32	100	15	2.0	210.0	CDG	Dry	6	32	145
11NW-D/C90	PT12	10	32	100	20	2.0	218.5	CDG	Dry	2	37	133
7SW-C/C115	N2	15	40	100	15	2.1	218.8	CDG	Dry	6	32	100
7SW-C/C116	P3	15	32	100	15	2.0	218.8	CDG	Dry	6	32	240
7SW-C/C116	P18	12	32	100	15	2.0	218.8	CDG	Dry	6	32	140
11NW-B/C739	TN 3	12	40	100	15	2.1	224.2	CDG	Dry	5	35	317
11NW-D/C89	PT6	13	32	100	20	2.0	228.0	CDG	Dry	2	37	149
11NW-D/C90	PT9	11	32	100	20	2.0	228.0	CDG	Dry	2	37	149
11NW-B/C167	TN 5	12	40	100	15	2.1	234.0	CDG	Dry	8	38	241
3SE-C/CR9	A	12	32	150	20	2.0	236.4	CDV	Dry	5	32	224
11NE-B/C439	TN10	14	40	100	15	2.0	237.8	CDG	Wet	3	35	287
2SE-D/C348	TN2	14.7	40	150	20	2.0	247.0	CDV	Dry	4	33	172
11NW-D/C89	PT5	13	32	100	20	2.0	247.0	CDG	Dry	2	37	193

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Table A2 - Pullout Test Data for Test Soil Nails Reaching T_{ult} (Sheet 7 of 7)

Feature No.	Pullout Test Nail No.	Pullout Test Nail Information						Geological Information				T_{ult} (kN)
		Bar Length (m)	Bar Diameter (mm)	Hole Diameter (mm)	Bar Inclination (deg)	Test Bond Length (m)	Overburden Pressure on Bond Section (kPa)	Soil Type at Bond Section	GW Condition	c' (kPa)	ϕ' (deg)	
11NW-D/C90	PT6	11	32	100	20	2.0	247.0	CDG	Dry	2	37	160
11NW-D/C90	PT7	11	32	100	20	2.0	247.0	CDG	Dry	2	37	171
2SW-D/C41	A	12	32	150	20	2.0	267.9	CDV	Dry	5	35	166
12SW-A/C124	P5	20	32	100	15	2.0	268.2	CDV	Dry	6	36	230
7SW-C/C115	P9	18	32	100	15	2.0	271.3	CDG	Dry	6	32	160
11NE-B/C254	PT19	20	40	150	15	2.0	277.8	CDG	Dry	6	36	446
7SW-C/C115	P4	18	32	100	15	2.0	280.0	CDG	Dry	6	32	162
7SW-C/C115	P8	18	32	100	15	2.0	280.0	CDG	Dry	6	32	220
11NW-D/C90	PT2	12	32	100	20	2.0	285.0	CDG	Dry	2	37	226
11NW-D/C90	PT3	11	32	100	20	2.0	285.0	CDG	Dry	2	37	171
11NW-D/C90	PT8	11	32	100	20	2.0	285.0	CDG	Dry	2	37	105
11NE-B/C254	PT24	20	40	150	15	2.0	299.4	CDG	Dry	6	36	175
2SE-D/C348	C	15	40	150	20	2.0	304.0	CDV	Dry	4	34	392
7SW-C/C115	N3	20	40	100	15	2.2	315.0	CDG	Dry	6	32	235
11NW-B/C167	TN 4	12	40	100	15	2.1	336.0	CDG	Dry	8	38	213
11NW-B/CR245	P2	10	25	150	10	2.0	338.4	CDG	Dry	4	35	133
11NW-D/C89	PT3	12	32	100	20	2.0	342.0	CDG	Dry	2	37	215

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土力工程處刊物及訂購資料

A selected list of major GEO publications is given in the next page. An up-to-date full list of GEO publications can be found at the CEDD Website http://www.cedd.gov.hk on the Internet under "Publications". Abstracts for the documents can also be found at the same website. Technical Guidance Notes are published on the CEDD Website from time to time to provide updates to GEO publications prior to their next revision.

部份土力工程處的主要刊物目錄刊載於下頁。而詳盡及最新的土力工程處刊物目錄，則登載於土木工程拓展署的互聯網網頁 http://www.cedd.gov.hk 的"刊物"版面之內。刊物的摘要及更新刊物內容的工程技術指引，亦可在這個網址找到。

Copies of GEO publications (except geological maps and other publications which are free of charge) can be purchased either by:

Writing to
Publications Sales Section,
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Garden Road, Central, Hong Kong.
Fax: (852) 2598 7482

or
- Calling the Publications Sales Section of Information Services Department (ISD) at (852) 2537 1910
- Visiting the online Government Bookstore at http:// www.bookstore.gov.hk
- Downloading the order form from the ISD website at http://www.isd.gov.hk and submitting the order online or by fax to (852) 2523 7195
- Placing order with ISD by e-mail at puborder@isd.gov.hk

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香港中環花園道
美利大廈4樓402室
政府新聞處
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傳真: (852) 2598 7482

或
- 致電政府新聞處刊物銷售小組訂購 (電話：(852) 2537 1910)
- 進入網上「政府書店」選購，網址為 http://www.bookstore.gov.hk
- 透過政府新聞處的網站 (http://www.isd.gov.hk) 於網上遞交訂購表格，或將表格傳真至刊物銷售小組 (傳真：(852) 2523 7195)
- 以電郵方式訂購 (電郵地址：puborder@isd.gov.hk)

1:100 000, 1:20 000 and 1:5 000 geological maps can be purchased from:

Map Publications Centre/HK,
Survey & Mapping Office, Lands Department,
23th Floor, North Point Government Offices,
333 Java Road, North Point, Hong Kong.
Tel: (852) 2231 3187
Fax: (852) 2116 0774

讀者可於下列地點購買1:100 000、1:20 000及1:5 000地質圖：

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北角政府合署23樓
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電話: (852) 2231 3187
傳真: (852) 2116 0774

Requests for copies of Geological Survey Sheet Reports and other publications which are free of charge should be directed to:

For Geological Survey Sheet Reports which are free of charge:
Chief Geotechnical Engineer/Planning,
(Attn: Hong Kong Geological Survey Section)
Geotechnical Engineering Office,
Civil Engineering and Development Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon, Hong Kong.
Tel: (852) 2762 5380
Fax: (852) 2714 0247
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Geotechnical Engineering Office,
Civil Engineering and Development Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon, Hong Kong.
Tel: (852) 2762 5346
Fax: (852) 2714 0275
E-mail: thomashui @cedd.gov.hk

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免費地質調查報告:
香港九龍何文田公主道101號
土木工程拓展署大樓
土木工程拓展署
土力工程處
規劃部總土力工程師
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電話: (852) 2762 5380
傳真: (852) 2714 0247
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電話: (852) 2762 5346
傳真: (852) 2714 0275
電子郵件: thomashui@cedd.gov.hk

MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS
土力工程處之主要刊物

GEOTECHNICAL MANUALS

Geotechnical Manual for Slopes, 2nd Edition (1984), 302 p. (English Version), (Reprinted, 2011).

斜坡岩土工程手冊(1998)，308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

GEOGUIDES

Geoguide 1	Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2007).
Geoguide 2	Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).
Geoguide 3	Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).
Geoguide 4	Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).
Geoguide 5	Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).
岩土指南第五冊	斜坡維修指南，第三版(2003)，120頁(中文版)。
Geoguide 6	Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.
Geoguide 7	Guide to Soil Nail Design and Construction (2008), 97 p.

GEOSPECS

Geospec 1	Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).
Geospec 3	Model Specification for Soil Testing (2001), 340 p.

GEO PUBLICATIONS

GCO Publication No. 1/90	Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
GEO Publication No. 1/93	Review of Granular and Geotextile Filters (1993), 141 p.
GEO Publication No. 1/2006	Foundation Design and Construction (2006), 376 p.
GEO Publication No. 1/2007	Engineering Geological Practice in Hong Kong (2007), 278 p.
GEO Publication No. 1/2009	Prescriptive Measures for Man-Made Slopes and Retaining Walls (2009), 76 p.
GEO Publication No. 1/2011	Technical Guidelines on Landscape Treatment for Slopes (2011), 217 p.

GEOLOGICAL PUBLICATIONS

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

TECHNICAL GUIDANCE NOTES

TGN 1	Technical Guidance Documents