Evaluation Report CCMC 13577-R

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Krinner Screw Foundations

1. Opinion

It is the opinion of the Canadian Construction Materials Centre (CCMC) that "Krinner Screw Foundations", when used as an auger-installed steel pile in a foundation system in accordance with the conditions and limitations stated in Section 3 of this Report, complies with the National Building Code 2010:

- Clause 1.2.1.1.(1)(b), Division A, as an alternative solution that achieves at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the following applicable acceptable solutions:
  - Clause 4.2.3.8.(1)(e) Steel Piles
  - Sentence 4.2.3.10.(1) Corrosion of Steel
  - Sentence 4.2.4.1.(1) Design Basis
  - Subclause 9.4.1.1.(1)(c)(i) General (structural requirements)

This opinion is based on CCMC's evaluation of the technical evidence in Section 4.1 provided by the Report Holder.

2. Description

The product is a steel screw pile prefabricated to support light structures. The steel is rolled into a conical shape with the seams welded and then the screw mechanism is welded over the conical body. The product is then galvanized for protection against corrosion.

Figure 1 shows a typical steel pile with helical screw.

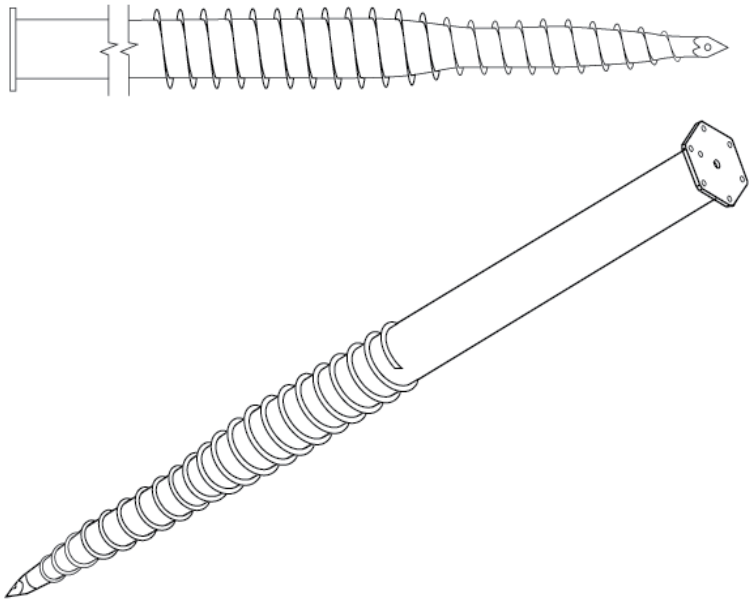

Figure 1. "Krinner Screw Foundations"

Table 1. Product specifications

Pile Code	Pile Type	Overall Length (m)	Outside Diameter (mm)	Wall Thickness (mm)	Area (mm^2)	Moment of Inertia (mm^4)	Section Modulus (mm^3)	Plastic Modulus (mm^2)
A	F140X2100	2.10	139.7	3.6	1,539.25	3,566,485.93	51,059.21	66,699.11
B	F76X1600	1.60	76.1	3.6	819.96	540,064.84	14,193.56	18,938.05
C	G76X2100	2.10	76.1	3.6	819.96	540,064.84	14,193.56	18,938.05
D	G76X1600	1.60	76.1	3.6	819.96	540,064.84	14,193.56	18,938.05
E	G66X650	0.65	60.1	2.0	365.05	154,217.12	5,132.02	6,753.89
F	E140X1600	1.60	139.7	3.6	1,539.25	3,566,485.93	51,059.21	66,699.11
G	M114X2100	2.10	114.3	3.6	1,251.99	1,919,836.76	33,592.94	44,131.72
H	M114X1600	1.60	114.3	3.6	1,251.99	1,919,836.76	33,592.94	44,131.72
J	M89X2100	2.10	88.9	3.6	964.72	878,986.79	19,774.73	26,209.48
K	M89X1600	1.60	88.9	3.6	964.72	878,896.79	19,774.73	26,209.48
L	M76X2100	2.10	76.1	3.6	819.96	540,064.84	14,193.56	18,938.05
M	M76X1600	1.60	76.1	2.6	600.36	405,918.04	10,668.02	14,051.71
N	M76X800	0.80	76.1	2.6	600.36	405,918.04	10,688.02	14,051.71

General notes to Table 1:

(1) Yield strength of steel, F_y = 248 MPa

(2) Modulus of Elasticity, E = 2.10E+05 N/mm^2

3. Conditions and Limitations

CCMC's compliance opinion in Section 1 is bound by the "Krinner Screw Foundations" being used in accordance with the conditions and limitations set out below.

- The product may be used as a foundation system to support various constructions, provided that it is installed according to the manufacturer's current instructions and within the scope of this Evaluation Report.
- When the product is installed as a deep helical foundation system in undisturbed soil, such as granular soil, silt, and some clay, there is a direct relationship between the applied torque and the allowable compressive and tensile loads. Tables 4.1.1 to 4.1.6 indicate the allowable compressive loads and uplift movement as a function of the applied torque.
- When the auger-installed steel pile is installed in disturbed or sensitive soil, such as uncontrolled fill and sensitive clays, the relationship between the applied torque and the allowable compressive loads and uplift movement is not as predictable as when the steel pile is installed in undisturbed soil. When it is installed in disturbed or sensitive soils the allowable compressive loads and uplift movement must be confirmed by on-site load tests. These load tests are also required if the allowable loads need to be greater than those stated in Tables 4.1.1 to 4.1.6. The tests must be conducted under the direct supervision of a professional geotechnical engineer skilled in such design and licensed to practice under the appropriate provincial or territorial legislation.
- In all cases, a registered professional structural engineer skilled in such design and licensed to practice under the appropriate provincial or territorial legislation must determine the number and spacing of the auger-installed steel piles required to carry the load.
- In all cases, the geotechnical engineer must provide a certificate attesting to the conformity of the installation and the allowable loads for the piles.
- The installation of the auger-installed steel pile must be carried out in accordance with the manufacturer's instructions. The anchors must be screwed into the ground using mechanized equipment. The anchor must be rotated into the ground with sufficient applied downward pressure (crowd) to advance the anchor one pitch distance per revolution. The anchor must be advanced until the applied torque value attains a specified value. Extensions are added to the central shaft as needed. The applied loads may be tensile (uplift), compressive (bearing), shear (lateral), or a combination thereof. Helical anchors can be installed quickly in a wide variety of soil formations using a variety of readily available equipment. They are ready for loading immediately after installation.
- When the product is installed in soil conditions that are corrosive to steel, adequate protection to the exposed steel must be provided.
- Installers of the "Krinner Screw Foundations" auger-installed steel piles must be certified, must use approved equipment and must follow the manufacturer's installation instructions and the conditions and limitations specified in this Report. Each installer must carry a certification card bearing their signature.
- Each "Krinner Screw Foundations" auger-installed steel pile must be identified with a label containing the following information:
    - manufacturer's identification; and
    - the phrase "CCMC 13193-R."

4. Technical Evidence

The Report Holder has submitted technical documentation for CCMC's evaluation. Testing was conducted at laboratories recognized by CCMC. The corresponding technical evidence for this product is summarized below.

4.1 Performance Requirements

"Krinner Screw Foundation" auger-installed steel piles were tested to ASTM D 1143/D 1143M-07e1, "Standard Test Methods for Deep Foundations Under Static Axial Compressive Load," Procedure A: Quick Test, ASTM D 3689-07, "Standard Test Methods for Deep Foundations Under Static Axial Tensile Load," Procedure A: Quick Test, and ASTM D 966-07, "Standard Test Method for Deep Foundations Under Lateral Loads," Procedure A: Standard Loading.

Testing was conducted on two different sites. The first site was a cohesive soil composed of fine-grained material including layers of silty clay overlying layers of clayey and sandy silts. The second site was composed mainly of granular material including sand and gravelly sand. A series of 18 tests were performed. The intent of the testing was to determine a correlation between the torque applied during installation and the allowable loads.

Table 4.1.1 Measurements at ultimate for tension tests in cohesive site

Pile Size	Pile Code, Gr (Dir)	Pile Penetration		Max Install Torque		Ultimate Load Test		Approximate Uplift Movement at Ultimate	
		(ft)	(m)	(ft-lbf)	(N-m)	(lbs)	(N)	(in)	(mm)
F140X2100	A (N)	6.47	1.973	N/A	N/A	14500	64499	0.35	8.9
	A (E)	6.14	1.871	1578	2140	8300	36920	0.43	10.9
	A (W)	6.10	1.859	1955	2650	16400	72951	0.50	12.7
F76X1600	B (N)	4.58	1.397	1608	2180	8500	37810	0.46	11.7
	B (E)	4.65	1.416	1328	1800	4450	19795	0.35	8.9
	B (W)	4.56	1.390	1475	2000	5800	25800	0.35	8.9
G76X2100	C (N)	6.12	1.865	2463	3340	16100	71616	0.51	13.0
	C (E)	6.04	1.840	2006	2720	14800	65834	0.36	9.1
	C (W)	6.20	1.890	2463	3340	17400	77399	0.49	12.4
G76X1600	D (N)	4.50	1.371	1232	1670	6200	27579	0.35	8.9
	D (E)	4.27	1.302	1696	2300	6200	27579	0.35	8.9
	D (W)	4.33	1.321	1556	2110	7200	32027	0.40	10.2
G66X650	E (N)	1.67	0.510	671	910	475	2113	0.28	7.1
	E (E)	1.67	0.510	730	990	600	2669	0.45	11.4
	E (W)	1.78	0.542	755	1023	590	2624	0.57	14.5
E140X1600	F (N)	4.73	1.441	2360	3200	11400	50710	0.72	18.3
	F (E)	4.62	1.410	2419	3280	11500	51155	0.48	12.2
	F (W)	4.58	1.397	1180	1600	13300	59161	0.65	16.5
M114X2100	G (N)	6.20	1.890	2316	3140	12400	55158	0.34	8.6
	G (E)	6.25	1.906	2611	3540	15600	69392	0.38	9.7
	G (W)	6.20	1.890	N/A	N/A	14500	64499	0.39	9.9
M114X1600	H (N)	4.65	1.416	2183	2960	9700	43148	0.45	11.4
	H (E)	4.67	1.422	2921	3960	10000	44482	0.36	9.1

Table 4.1.1 Measurements at ultimate for tension tests in cohesive site (cont.)

Pile Size	Pile Code, Gr (Dir)	Pile Penetration		Max Install Torque		Ultimate Load Test		Approximate Uplift Movement at Ultimate	
		(ft)	(m)	(ft-lbf)	(N-m)	(lbs)	(N)	(in)	(mm)
M89X2100	H (W)	4.62	1.410	2036	2760	8700	38700	0.40	10.2
	J (N)	6.24	1.903	2950	4000	23500	104533	0.52	13.2
	J (E)	5.93	1.808	3267	4430	22200	98751	0.28	7.1
	J (W)	6.10	1.859	2972	4030	20200	89854	0.41	10.4
M89X1600	K (N)	4.44	1.352	1800	2440	8400	37365	0.38	9.7
	K (E)	4.52	1.378	1438	1950	6800	30248	0.37	9.4
	K (W)	4.37	1.333	1416	1920	5200	23131	0.41	10.4
M76X2100	L (N)	6.18	1.884	1851	2510	15000	66723	0.34	8.6
	L (E)	6.33	1.929	N/A	N/A	18700	83182	0.33	8.4
	L (W)	6.14	1.871	1571	2130	14100	62720	0.31	7.9
M76X1600	M (N)	3.77	1.148	N/A	N/A	3450	15346	0.53	13.5
	M (E)	3.64	1.110	N/A	N/A	4800	21351	0.34	8.6
	M (W)	3.62	1.103	N/A	N/A	3750	16681	0.40	10.2
M76X800	N (N)	2.21	0.673	959	1300	1640	7295	0.51	13.0
	N (E)	2.10	0.641	1055	1430	1680	7473	0.50	12.7
	N (W)	2.02	0.616	1003	1360	1140	5071	0.40	10.2

Table 4.1.2 Measurements at ultimate for compression tests in cohesive site

Pile Size	Pile Code, Gr (Dir)	Pile Penetration		Max Install Torque		Ultimate Load Test		Approximate Vertical Movement at Ultimate	
		(ft)	(m)	(ft-lbf)	(N-m)	(lbs)	(N)	(in)	(mm)
F140X2100	A (N)	6.10	1.859	2382	3230	17750	78956	0.68	17.3
	A (E)	6.14	1.871	2545	3450	23000	102309	0.75	19.1
	A (W)	6.12	1.865	2906	3940	24450	108759	0.92	23.4
F76X1600	B (N)	4.69	1.429	1770	2400	15500	68947	0.56	14.2
	B (E)	4.79	1.460	1320	1790	9200	40924	0.52	13.2
	B (W)	4.58	1.397	1505	2040	11900	52934	0.48	12.2
G76X2100	C (N)	6.04	1.840	1888	2560	18600	82737	0.56	14.2
	C (E)	6.12	1.865	1770	2400	14500	64499	0.49	12.4
	C (W)	6.01	1.833	1925	2610	19400	86295	0.66	16.8
G76X1600	D (N)	4.46	1.359	1320	1790	7000	31138	0.50	12.7
	D (E)	4.56	1.390	1099	1490	5150	22908	0.71	18.0
	D (W)	4.31	1.314	1269	1720	10250	45594	0.50	12.7
G66X650	E (N)	1.53	0.466	730	990	660	2936	0.23	5.8
	E (E)	1.32	0.402	715	970	740	3292	0.47	11.9
	E (W)	1.67	0.510	730	990	890	3959	0.40	10.2
E140X1600	F (N)	4.54	1.384	2102	2850	22000	97861	1.03	26.2

Table 4.1.2 Measurements at ultimate for compression tests in cohesive site (cont.)

	F (E)	4.29	1.308	2168	2940	16700	74285	0.60	15.2
	F (W)	4.54	1.384	2065	2800	15600	69392	0.76	19.3
M114X2100	G (N)	6.70	2.043	N/A	N/A	19500	86740	0.46	11.7
	G (E)	6.37	1.941	2286	3100	17000	75620	0.50	12.7
	G (W)	6.35	1.935	3186	4320	31500	140119	0.39	9.9
M114X1600	H (N)	4.65	1.416	1549	2100	20600	91633	0.77	19.6
	H (E)	4.71	1.435	1896	2570	14000	62275	0.67	17.0
	H (W)	4.71	1.435	2028	2750	17000	75620	0.62	15.7
M89X2100	J (N)	6.24	1.903	2766	3750	31000	137895	0.56	14.2
	J (E)	6.24	1.903	2884	3910	27000	120102	0.52	13.2
	J (W)	6.10	1.859	2058	2790	19400	86295	0.44	11.2
M89X1600	K (N)	4.67	1.422	1235	1675	7700	34251	0.41	10.4
	K (E)	4.73	1.441	1438	1950	6400	28469	0.38	9.7
	K (W)	4.56	1.390	1165	1580	7900	35141	0.44	11.2
M76X2100[(1)]	L (N)	6.39	1.948	2626	3560	31500	140119	0.59	15.0
	L (E)	6.56	1.998	N/A	N/A	30000	133447	0.66	16.8
	L (W)	6.20	1.890	2191	2970	28600	127219	0.70	17.8
M76X1600	M (N)	3.81	1.160	N/A	N/A	8700	38700	0.66	16.8
	M (E)	3.89	1.186	N/A	N/A	5650	25132	0.53	13.5
	M (W)	3.89	1.186	N/A	N/A	7350	32694	0.38	9.7
M76X800	N (N)	2.21	0.673	959	1300	1950	8674	0.27	6.9
	N (E)	2.17	0.660	937	1270	2000	8896	0.18	4.6
	N (W)	2.27	0.692	981	1330	2125	9452	0.35	8.9

Note to Table 4.1.2:

(1) Table values for M76X2100 (L)-West Pile Ultimate Values are estimated only.

Table 4.1.3 Measurements at ultimate for lateral tests in cohesive site

Pile Size	Pile Code, Gr (Dir)	Pile Penetration		Max Install Torque		Ultimate Load Test		Approximate Lateral Movement at Load HT at Ultimate	
		(ft)	(m)	(ft-lbf)	(N-m)	(lbs)	(N)	(in)	(mm)
F140X2100	A (N)	6.31	1.922	3024	4100	5500	24465	1.08	27.4
	A (E)	6.22	1.897	3245	4400	5000	22241	1.08	27.4
	A (W)	6.12	1.865	3245	4400	5000	22241	1.48	37.6
F76X1600	B (N)	4.56	1.390	1342	1820	1950	8674	0.92	23.4
	B (E)	4.62	1.410	1475	2000	2175	9675	1.02	25.9
	B (W)	4.62	1.410	1364	1850	1950	8674	1.03	26.2
G76X2100	C (N)	6.16	1.878	2286	3100	1650	7340	0.86	21.8
	C (E)	5.99	1.827	3297	4470	1975	8785	0.98	24.9
	C (W)	6.16	1.878	N/A	N/A	2400	10676	1.16	29.5

Table 4.1.3 Measurements at ultimate for lateral tests in cohesive site (cont.)

G76X1600	D (N)	4.65	1.416	1232	1670	2175	9675	1.06	26.9
	D (E)	4.58	1.397	1298	1760	1975	8785	1.08	27.4
	D (W)	4.27	1.302	1276	1730	1825	8118	1.06	26.9
G66X650	E (N)	1.70	0.517	763	1035	410	1824	0.79	20.1
	E (E)	1.72	0.523	738	1000	475	2113	0.86	21.8
	E (W)	1.76	0.536	819	1110	300	1334	0.80	20.3
E140X1600	F (N)	4.65	1.416	1800	2440	2800	12455	1.17	29.7
	F (E)	4.75	1.448	1918	2600	3150	14012	1.00	25.4
	F (W)	4.42	1.346	1770	2400	2950	13122	1.15	29.2
M114X2100	G (N)	6.35	1.935	2913	3950	3775	16792	0.93	23.6
	G (E)	6.16	1.878	2139	2900	3925	17459	1.04	26.4
	G (W)	6.26	1.910	2913	3950	3925	17459	1.04	26.4
M114X1600	H (N)	4.44	1.352	1837	2490	2675	11899	0.88	22.4
	H (E)	4.60	1.403	1733	2350	2675	11899	0.88	22.4
	H (W)	4.85	1.479	N/A	N/A	3900	17348	0.98	24.9
M89X2100	J (N)	6.14	1.871	1645	2230	2300	10231	1.14	29.0
	J (E)	6.24	1.903	1394	1890	2300	10231	0.96	24.4
	J (W)	6.08	1.852	2058	2790	2100	9341	0.96	24.4
M89X1600	K (N)	4.65	1.416	2168	2940	2525	11232	1.06	26.9
	K (E)	4.83	1.473	1696	2300	2525	11232	0.99	25.1
	K (W)	4.65	1.416	1984	2690	2700	12010	0.99	25.1
M76X2100	L (N)	6.22	1.897	N/A	N/A	1175	5227	0.43	10.9
	L (E)	6.14	1.871	N/A	N/A	1550	6895	0.60	15.2
	L (W)	6.14	1.871	2508	3400	1075	4782	0.55	14.0
M76X1600	M (N)	3.62	1.103	N/A	N/A	1200	5338	0.65	16.5
	M (E)	3.68	1.122	N/A	N/A	1200	5338	0.65	16.5
	M (W)	3.72	1.135	N/A	N/A	1325	5894	0.59	15.0
M76X800	N (N)	2.25	0.686	981	1330	500	2224	0.33	8.4
	N (E)	2.12	0.648	981	1330	490	2180	0.38	9.7
	N (W)	2.12	0.648	959	1300	770	3425	0.53	13.5

Table 4.1.4 Measurements at ultimate for tension tests in cohesionless site

Pile Size	Pile Code, Gr (Dir)	Pile Penetration		Max Install Torque		Ultimate Load Test		Approximate Uplift Movement at Ultimate	
		(ft)	(m)	(ft-lbf)	(N-m)	(lbs)	(N)	(in)	(mm)
F140X2100	A (N)	6.22	1.897	4425	6000	13200	58717	0.36	9.1
	A (E)	6.31	1.922	4352	5900	13200	58717	0.36	9.1
	A (S)	6.35	1.935	3688	5000	13200	58717	0.36	9.1
F76X1600	B (N)	4.85	1.479	1106	1500	8400	37365	0.38	9.7
	B (E)	4.81	1.467	1475	2000	9300	41368	0.34	8.6

Table 4.1.4 Measurements at ultimate for tension tests in cohesionless site (cont.)

	B (S)	4.90	1.492	959	1300	8000	35586	0.26	6.6
G76X2100	C (N)	6.24	1.903	1623	2200	14800	65834	0.50	12.7
	C (E)	6.06	1.846	2213	3000	14800	65834	0.37	9.4
	C (S)	6.18	1.884	1918	2600	16000	71172	0.34	8.6
G76X1600	D (N)	4.60	1.403	1475	2000	7800	34696	0.32	8.1
	D (E)	4.71	1.435	1623	2200	9000	40034	0.36	9.1
	D (S)	4.67	1.422	1106	1500	7500	33362	0.40	10.2
G66X650	E (N)	1.82	0.555	N/A	N/A	470	2091	0.24	6.1
	E (E)	1.88	0.574	N/A	N/A	635	2825	0.12	3.0
	E (S)	1.88	0.574	N/A	N/A	615	2736	0.10	2.5
E140X1600	F (N)	4.69	1.429	2360	3200	9900	44037	0.29	7.2
	F (E)	4.65	1.416	2581	3500	9400	41813	0.29	7.2
	F (S)	4.60	1.403	2655	3600	9000	40034	0.26	6.6
M114X2100	G (N)	5.89	1.795	4425	6000	19000	84516	0.26	6.6
	G (E)	6.31	1.922	4425	6000	17750	78956	0.36	9.1
	G (S)	6.37	1.941	4425	6000	16750	74508	0.30	7.6
M114X1600	H (N)	4.87	1.486	1844	2500	7100	31582	0.32	8.1
	H (E)	4.90	1.492	1696	2300	7250	32250	0.25	6.4
	H (S)	4.83	1.473	1844	2500	7950	35363	0.34	8.6
M89X2100	J (N)	6.43	1.960	3540	4800	17500	77844	0.27	6.9
	J (E)	6.43	1.960	3319	4500	18000	80068	0.30	7.6
	J (S)	6.49	1.979	2655	3600	17000	75620	0.27	6.9
M89X1600	K (N)	4.83	1.473	2139	2900	9400	41813	0.27	6.7
	K (E)	4.75	1.448	3835	5200	13500	60051	0.28	7.1
	K (S)[(1)]	4.73	1.441	2803	3800	11000	48930	N/A	N/A
M76X2100	L (N)	6.43	1.960	2950	4000	18800	83627	0.37	9.4
	L (E)	6.47	1.973	2803	3800	13000	57827	0.28	7.0
	L (S)	6.39	1.948	2950	4000	15400	68503	0.30	7.6
M76X1600	M (N)	3.91	1.192	369	500	3400	15124	0.26	6.6
	M (E)	3.91	1.192	885	1200	6550	29136	0.20	5.1
	M (S)	3.93	1.198	738	1000	6300	28024	0.24	6.1
M76X800	N (N)	2.29	0.698	428	580	1800	8007	0.09	2.2
	N (E)	2.31	0.705	11	15	1700	7562	0.13	3.3
	N (S)	2.33	0.711	26	35	1530	6806	0.08	1.9

Note to Table 4.1.4:

(1) The ultimate load for K (S) is estimated.

Table 4.1.5 Measurements at ultimate for compression tests in cohesionless site

Pile Size	Pile Code, Gr (Dir)	Pile Penetration		Max Install Torque		Ultimate Load Test		Approximate Vertical Movement at Ultimate	
		(ft)	(m)	(ft-lbf)	(N-m)	(lbs)	(N)	(in)	(mm)
F140X2100	A (N)	5.99	1.827	N/A	N/A	43500	193498	-0.80	-20.3
	A (E)	6.06	1.846	4425	6000	38000	169032	-0.92	-23.4
	A (S)	5.87	1.789	4425	6000	54000	240204	-0.54	-13.7
F76X1600	B (N)	4.87	1.486	3467	4700	40000	177929	-0.80	-20.3
	B (E)	4.77	1.454	3282	4450	33500	149015	-0.72	-18.3
	B (S)	4.83	1.473	2618	3550	31500	140119	-0.76	-19.3
G76X2100	C (N)	6.20	1.890	2729	3700	39000	173481	-0.92	-23.4
	C (E)	6.12	1.865	1254	1700	28500	126774	-1.08	-27.4
	C (S)	6.22	1.897	2065	2800	32000	142343	-0.88	-22.4
G76X1600	D (N)	4.56	1.390	1033	1400	19000	84516	-1.10	-27.9
	D (E)	4.54	1.384	1475	2000	22000	97861	-0.90	-22.9
	D (S)	4.62	1.410	1549	2100	27100	120547	-1.00	-25.4
G66X650	E (N)	1.80	0.548	N/A	N/A	3000	13345	-0.92	-23.4
	E (E)	1.86	0.567	N/A	N/A	3600	16014	-0.96	-24.4
	E (S)	1.78	0.542	N/A	N/A	3000	13345	-0.92	-23.4
E140X1600	F (N)	4.69	1.429	3688	5000	37500	166808	-1.00	-25.4
	F (E)	4.65	1.416	3614	4900	32000	142343	-1.00	-25.4
	F (S)	4.69	1.429	3762	5100	36000	160136	-0.92	-23.4
M114X2100	G (N)	6.12	1.865	4425	6000	40750	181265	-0.84	-21.3
	G (E)	6.20	1.890	4425	6000	37500	166808	-0.76	-19.3
	G (S)	5.89	1.795	4425	6000	50000	222411	-0.76	-19.3
M114X1600	H (N)	4.65	1.416	2950	4000	32000	142343	-0.96	-24.4
	H (E)	4.71	1.435	3172	4300	38250	170144	-0.88	-22.4
	H (S)	4.65	1.416	3614	4900	30750	136783	-0.90	-22.9
M89X2100	J (N)	6.22	1.897	4425	6000	50000	222411	-0.52	-13.2
	J (E)	6.26	1.910	3467	4700	38000	169032	-0.84	-21.3
	J (S)	6.24	1.903	4278	5800	50500	224635	-0.88	-22.4
M89X1600	K (N)	4.79	1.460	2360	3200	22000	97861	-0.98	-24.9
	K (E)	4.83	1.473	2655	3600	20750	92301	-0.76	-19.3
	K (S)	4.73	1.441	2581	3500	27000	120102	-0.65	-16.5
M76X2100	L (N)	6.31	1.922	4057	5500	45500	202394	-0.96	-24.4
	L (E)	6.49	1.979	3835	5200	48000	213515	-0.68	-17.3
	L (S)	6.41	1.954	N/A	N/A	48000	213515	-0.74	-18.8
M76X1600	M (N)	3.77	1.148	1180	1600	23000	102309	-0.86	-21.8
	M (E)	3.91	1.192	627	850	18000	80068	-1.02	-25.9
	M (S)	3.70	1.129	516	700	18500	82292	-0.84	-21.3

Table 4.1.5 Measurements at ultimate for compression tests in cohesionless site (cont.)

M76X800	N (N)	2.35	0.717	48	65	10500	46706	-0.90	-22.9
	N (E)	2.35	0.717	30	40	8800	39144	-1.00	-25.4
	N (S)	2.33	0.711	74	100	9600	42703	-1.00	-25.4

Table 4.1.6 Measurements at ultimate for lateral tests in cohesionless site

Pile Size	Pile Code, Gr (Dir)	Pile Penetration		Max Install Torque		Ultimate Load Test		Approximate Lateral Movement at Load HT at Ultimate	
		(ft)	(m)	(ft-lbf)	(N-m)	(lbs)	(N)	(in)	(mm)
F140X2100	A (N)	6.01	1.833	4425	6000	6000	26689	1.06	26.9
	A (E)	5.87	1.789	4425	6000	5000	22241	1.08	27.3
	A (S)	5.54	1.687	4425	6000	5500	24465	1.04	26.4
F76X1600	B (N)	4.85	1.479	516	700	3300	14679	1.00	25.4
	B (E)	4.85	1.479	885	1200	3000	13345	1.15	29.2
	B (S)	4.92	1.498	885	1200	2950	13122	1.00	25.4
G76X2100	C (N)	6.24	1.903	1623	2200	2500	11121	1.00	25.4
	C (E)	6.26	1.910	2286	3100	2500	11121	1.02	25.9
	C (S)	6.29	1.916	1549	2100	2550	11343	1.14	28.8
G76X1600	D (N)	4.75	1.448	2213	3000	3000	13345	1.04	26.4
	D (E)	4.50	1.371	1549	2100	3300	14679	1.36	34.5
	D (S)	4.62	1.410	N/A	N/A	2725	12121	1.04	26.4
G66X650	E (N)	1.78	0.542	N/A	N/A	467	2077	1.28	32.5
	E (E)	1.86	0.567	N/A	N/A	483	2148	1.00	25.4
	E (S)	1.80	0.548	N/A	N/A	588	2616	1.06	26.9
E140X1600	F (N)	4.65	1.416	1991	2700	4050	18015	1.00	25.4
	F (E)	4.65	1.416	1991	2700	4375	19461	1.40	35.6
	F (S)	4.73	1.441	3098	4200	5350	23798	1.16	29.5
M114X2100	G (N)	6.39	1.948	4278	5800	5500	24465	1.04	26.4
	G (E)	6.43	1.960	4352	5900	6000	26689	1.04	26.4
	G (S)	6.33	1.929	4204	5700	5500	24465	1.04	26.4
M114X1600	H (N)	4.83	1.473	2434	3300	4750	21129	1.08	27.4
	H (E)	4.83	1.473	1733	2350	3900	17348	1.31	33.3
	H (S)	4.85	1.479	1549	2100	4350	19350	1.12	28.4
M89X2100	J (N)	6.47	1.973	3393	4600	4100	18238	1.20	30.5
	J (E)	6.45	1.967	3024	4100	3600	16014	1.20	30.5
	J (S)	6.49	1.979	N/A	N/A	4550	20239	1.32	33.5
M89X1600	K (N)	4.85	1.479	1770	2400	4000	17793	1.04	26.4
	K (E)	4.87	1.486	1328	1800	4000	17793	1.24	31.5
	K (S)	4.90	1.492	1180	1600	3175	14123	1.32	33.5
M76X2100	L (N)	6.49	1.979	N/A	N/A	3050	13567	1.28	32.5
	L (E)	6.49	1.979	N/A	N/A	2850	12677	1.20	30.5

Table 4.1.6 Measurements at ultimate for lateral tests in cohesionless site (cont.)

M76X1600	L (S)	6.49	1.979	N/A	N/A	3650	16236	1.00	25.4
	M (N)	3.81	1.160	516	700	2750	12233	1.10	27.9
	M (E)	3.87	1.179	701	950	3900	17348	1.00	25.4
	M (S)	3.87	1.179	590	800	3000	13345	1.10	27.9
M76X800	N (N)	2.40	0.730	23	31	1475	6561	1.00	25.4
	N (E)	2.33	0.711	91	124	1500	6672	0.92	23.4
	N (S)	2.35	0.717	137	186	1300	5783	1.08	27.4

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