

PRODUCT SELECTION GUIDE - HELICAL SCREW PILE FOUNDATIONS

1. Shaft

Helical foundation pile includes a lead and extension(s). The lead section is made of a central steel shaft with single or multiple helices. The extension can be plain or with single or multiple helices.

Round Cornered Square Shaft (RCS from 1.25" to 2.00"): Hot Rolled, Low Carbon, High Strength Alloy, solid steel bar conforming to ASTM A29 and ASTM A576 - Grade 1045, 10V45M, 1530M, or equal. Coupling shall be an integral part of the shaft, with an upset hot forged socket, except the 2" RCS. A cast steel coupler is used for the 2" extension.

Pipe Pile (2.875" OD to 8.625" OD): Structural steel pipe, welded or seamless as per ASTM A500 grade C or equal welded with "Strength Square" couplings. The coupling shall be made of cast steel with matching square shapes.

Coupling for 2" RCS and Pipe Piles: Cast steel as per ASTM A958 grade SC1045 or equal with minimum of 40 ksi yield and 80 ksi ultimate strength.

Table 12.1
MATERIAL SPECIFICATIONS

Shaft Size for Leads and Extensions	Designation	ASTM Specification or Equal	Minimum Yield Strength (ksi)
1.25" Square Shaft	D3	A576-Gr. 1045	60
1.50" Square Shaft	D6	A576-Gr. 10V45M	70
1.50" Square Shaft – High Strength	D7	A576-Gr. 1530M	90
1.75" Square Shaft	D10	A576-Gr. 1530M	90
2.00" Square Shaft	D15	A576-Gr. 1530M	90
2.875" O.D. (0.203" wall, Sch40 Pipe)	P28	A500-Gr. C	50
2.875" O.D. (0.276" wall, Sch80 Pipe)	P28H	A500-Gr. C	50
3.500" O.D. (0.216" wall, Sch40 Pipe)	P35	A500-Gr. C	50
3.500" O.D. (0.300" wall, Sch80 Pipe)	P35H	A500-Gr. C	50
4.500" O.D. (0.237" wall, Sch40 Pipe)	P45	A500-Gr. C	50
4.500" O.D. (0.337" wall, Sch80 Pipe)	P45H	A500-Gr. C	50
8.625" O.D. X 0.1875" wall	P8	A500-Gr. C	50

A. Torque vs. Ultimate Load Capacity

The required Rated Torsional Strength of the shaft will typically equal the pile's desired Geotechnical Ultimate Helix Bearing Capacity divided by the Torque Factor (K_t) of the shaft. i.e. $K_t \times \text{Torque (ft-lbs)} = \text{Ultimate Capacity (lbs)}$ The values of K_t shown in Table 12.2 are empirically based on experience and/or field-testing in various locations and soil types. In some cases K_t can vary. See Section 7 for a more detailed discussion of K_t .

Using Table 12.2, the shaft size or sizes with the required Rated Torsional Capacity can be selected. We recommend limiting the estimated required torque to a value somewhat less than the Rated Torsional Capacity. This will facilitate installation when unexpected hard layers are encountered.

SECTION 12

The values of K_t shown below are intended to assist the designer in selecting the proper shaft size for his particular application. Larger values of K_t can provide greater geotechnical pile capacities, but Design Loads should not induce: (1) stresses into the shaft which exceed one-half of the Yield Strength shown in Table 12.1 or (2) Helix loads exceeding the values shown in Table 12.3.

Table 12.2
RATED MAXIMUM DESIGN LOADS (ALLOWABLE LOADS) – BASED ON
INSTALLATION TORQUE *

Shaft Size	Designation	K_t	Rated Torsional Capacity (ft-lbs)	Ultimate Capacity		Maximum Design Load	
				Tension (lbs)	Compression (lbs)	Tension (lbs)	Compression (lbs)
1.25" Square Shaft	D3	10	3,400	34,000	34,000	17,000	17,000
1.50" Square Shaft	D6	10	5,500	60,000	55,000	30,000	27,500
1.50" Square Shaft (high str.)	D7	10	7,000	70,000	70,000	35,000	35,000
1.75" Square Shaft	D10	10	10,000	100,000	100,000	50,000	50,000
2.00" Square Shaft	D15	10	15,000	150,000	150,000	75,000	75,000
2.875" O.D. (0.203" wall)	P28	8	7,500	80,000	60,000	40,000	30,000
2.875" O.D. (0.276" wall)	P28H	8	9,000	100,000	72,000	50,000	36,000
3.500" O.D. (0.216" wall)	P35	7	11,400	100,000	80,000	50,000	40,000
3.500" O.D. (0.300" wall)	P35H	7	15,000	140,000	105,000	70,000	52,500
4.500" O.D. (0.237" wall)	P45	6	20,000	140,000	120,000	70,000	60,000
4.500" O.D. (0.337" wall)	P45H	6	26,000	200,000	156,000	100,000	78,000
8.625" O.D. X 0.1875" wall	P8	4.5	44,500	240,000	200,000	120,000	100,000**

- * Maximum Design Loads (Allowable Loads) are based on a Factor of Safety of 2 (See Section 5). Column buckling considerations are not addressed (See Section 9).
- * Loads are axial.
- * Ultimate tension is based on mechanical strength of pipe and coupling.
- * Ultimate Compression Capacity (lbs) = ultimate helix/soil bearing capacity (lbs) = $K_t \times$ Torque (ft-lbs), (See Sec.13).
- * Rated maximum design loads assume that the torsional capacity of the pile has been achieved.
- * If the soil's bearing capacity beneath the helices is greater than that above the helices, the geotechnical compression capacity of the pile will be greater, but design loads should not induce: (1) stresses into the shaft which exceed one-half of the Yield Strength shown in Table 12.1 or (2) Helix loads exceeding the values shown in Table 12.3.
- ** Depending on pile depth and type of soil, skin friction (after soil remolds around the pipe) will increase the total capacity of the P45 and P8 Pipe Piles.
- ** A concrete or grout filled P8 Pipe Pile may significantly increase its capacity. P8 Pipe Piles have been successfully load tested to 180,000 lbs. Unless otherwise noted, the P8 Pipe Pile should be filled with suitably reinforced concrete or grout of sufficient strength after installation.

B. Square Shaft or Round Pipe Shaft?

Square shafts are more efficient than round pipe. When installed to the same torque, the capacity of a square shaft anchor will be greater than that of a round shaft anchor. (This is discussed in Section 13.) In addition, because of the small cross sectional area, square shafts can penetrate into denser soils (higher Standard Penetration Test "N" values) than round pipe sections. This is especially true in dense sands and gravel.

Square shafts are generally the best choice for new and existing construction unless:

1. Significant lateral (shear) loads are expected. (i.e. bending stresses which exceed the shaft's allowable yield stress or lateral loads, which exceed the pile/soil capacity.) See Section 10.

2. Large compressive loads, coupled with soft soils of very low confining strengths (with SPT blow counts less than 5) are expected (i.e. column buckling considerations). See Section 9.

As a general rule, buckling should not occur when the soil along the total length of the pile has an SPT blow count of 5 or greater. This assumes axial loading, with no shear or bending moment acting at the top of the pile.

When very weak soils are encountered (i.e. SPT blow counts of less than 5), hand calculations using the Davisson (1963) method or computer programs such as LPILE can be applied to perform buckling analysis. The Davisson (1963) method is discussed in detail in Section 9.

C. Pipe piles with Square coupling – 2.875” OD to 8.625” OD pipes

MacLean-Dixie “Strength Squared” couplings (patent pending) allow for the full torsional capacity of the pile to be transferred through the coupling to its adjacent member while maintaining full axial and torsional capacity during and after installation. This design eliminates the problems caused by elongated holes and deformation of the bolts, which often occurs with other types of couplings.

The MacLean-Dixie square male coupling also accommodates RCS helical leads. This combination of pipe with a RCS helical lead allows for a more efficient penetration into hard soils such as dense sand and gravel. The upper pipe section provides for an increase in buckling strength of the pile.

D. Mechanical Properties

Design Loads (i.e. axial, shear and bending moments) transferred to the shaft (via the structure or the pile interface connection) shall not result in stresses or loads that exceed the properties shown in tables 12.1 through 12.4.

2. Helix

Helix Material: High Strength, Low Carbon Alloy Steel plate conforming to ASTM A1018 grade 55 with 55 ksi minimum yield strength. Helices are formed using matching dies to assure a true consistent helical shape and a uniform pitch. Thicknesses range from 3/8” for standard helices to 1/2” for high strength helices.

Helical foundation piles usually include one to six helices. In the case of multi-helical lead sections, the smaller diameter helix always enters the ground first – followed by larger or equal diameter helix or helices. The difference between diameters of adjacent helices should not exceed 2” except the P8. The P8 should not exceed 4” in diameter for the adjacent helices. The distance between any two helices should be at least three times the diameter of the lower helix.

Loads are transferred from the structure to the shaft. The shaft transfers its load to the helices, which in turn transfers their load to the soil. Section 8 discusses the Terzaghi General Bearing Equation, which can be applied through an iterative process to determine the required helix configuration. Data from geotechnical reports and soil boring logs are generally required when using this method. If geotechnical information is unavailable, assumptions will have to be made or an anchor test should be conducted. Also, see Section 7 for an alternate method of estimating soil properties.

The Ultimate Geotechnical Capacity of the pile will be the sum of the individual helix capacities as determined from the Terzaghi General Bearing Equation method (Section 8) or from other methods such as that discussed in Section 7.

The resulting load on any individual helix shall not exceed the values shown in Table 12.3.

The number of helices for clay (cohesive) soils should be limited to 4 or 5. The number of helices for granular or sandy soils (cohesionless) should be limited to 6. If more helices are used than recommended above, load testing is advisable.

3. Structure / Pile Interface Connection

The ultimate capacity of the structure/pile interface connection (or bracket) shall be at least two times the maximum Design Load.

Design Loads (i.e. axial, shear and bending moments) transferred to the shaft (via the structure or the pile interface connection) shall not induce: (1) stresses into the shaft which exceed one-half of the Yield Strength shown in Table 12.1 or (2) Helix loads exceeding the values shown in Table 12.3.

4. Center-to-Center Spacing Between Helical Screw Pile Foundations

The recommended spacing between adjacent helix of Helical Screw Pile Foundations is five times the diameter of the largest helix. The minimum spacing is three times the diameter of the largest helix, but this usually requires additional attention by the construction crew to assure that the helical lead sections do not drift towards each other during installation. Since spacing requirements apply only to the helices, a slight batter during the installation of the helical screw piles can provide a convenient method of maintaining the minimum spacing.

Table 12.3
HELICES

MECHANICAL RATED CAPACITIES - ALLOWABLE LOADS (DESIGN LOADS)

Mechanical rated capacities & units	1.25" Round Corner Square Shaft D3	1.50" Round Corner Square Shaft D6	1.50" Round Corner Square Shaft D7	1.75" Round Corner Square Shaft D10	2.00" Round Corner Square Shaft D15	2.875" O.D. Pipe Shaft		3.50" O.D. Pipe Shaft		4.50" O.D. Pipe Shaft		8.625" O.D. Pipe Shaft
						0.203" wall P28	0.276" wall P28H	0.216" wall P35	0.300" Wall P35H	0.237" wall P45	0.337" wall P45H	0.1875" Wall P8
Helix grade; ksi	55	55	55	55	55	55	55	55	55	55	55	55
3/8" ultimate Capacity; kips	22	30	30	40	NA	40	40	50	50	NA	NA	80
1/2" ultimate Capacity; kips	NA	50	50	60	60	NA	NA	60	60	70	70	100
Allowable												
3/8" allowable Capacity; kips	11	15	15	20	NA	20	20	25	25	NA	NA	40
1/2" allowable Capacity; kips	NA	25	25	30	30	NA	NA	30	30	35	35	50

Notes:

1. Ultimate Helix Capacities and Allowable Helix Loads are based on a 12" diameter helix, except for P8 Pipe Pile. For other helix sizes, see the Material and Quality Specifications section in the MacLean Engineering Manual.
2. All loads are axial.

SECTION 12

Table 12.4
PROPERTIES OF SHAFTS AND COUPLINGS

Shafts	1.25" Round Corner Square Shaft D3	1.50" Round Corner Square Shaft D6	1.50" Round Corner Square Shaft D7	1.75" Round Corner Square Shaft D10	2.00" Round Corner Square Shaft D15	2.875" O.D. Pipe Shaft		3.50" O.D. Pipe Shaft		4.50" O.D. Pipe Shaft		8.625" O.D. Pipe Shaft
						0.203" wall P28	0.276" wall P28H	0.216" wall P35	0.300" Wall P35H	0.237" wall P45	0.337" wall P45H	0.1875" Wall P8
Yield Str., ksi	60	70	90	90	90	50	50	50	50	50	50	50
Section area, in ²	1.510	2.190	2.190	3.010	3.940	1.704	2.253	2.228	3.016	3.174	4.407	4.970
Perimeter, in	4.571	5.571	5.571	6.571	7.571	9.032	9.032	10.996	10.996	14.137	14.137	27.096
Moment of inertia, in ⁴ I _{xx} =I _{yy} =I _{xy}	0.194	0.396	0.396	0.746	1.260	1.530	1.924	3.017	3.894	7.233	9.611	44.250
Section mod. S _{xx} =S _{yy} ; in ³	0.310	0.528	0.528	0.853	1.260	1.064	1.339	1.724	2.225	3.214	4.271	10.261
Section mod., - S _{xy} ; in ³	0.240	0.414	0.414	0.657	0.980	1.064	1.339	1.724	2.225	3.214	4.271	10.261
Coupling												
AS Forged	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Cast steel SC 1045; ksi	NA	NA	NA	NA	40/80	40/80	40/80	40/80	40/80	40/80	40/80	40/80
Bolt(s) Dia.* ASTMA325	5/8	3/4	3/4	7/8	NA	3/4	3/4	7/8	7/8	7/8	NA	NA
Bolt(s) Dia.* SAE J429	NA	NA	NA	NA	1 1/8	NA	NA	NA	NA	NA	1 1/8	3/4
Bolt qty. (ea)	1	1	1	1	1	2	2	2	2	2	2	4
Transition												
Pipe to RCS**	NA	NA	NA	NA	NA	1 1/2	1 1/2	1 3/4	1 3/4	2	2	1 3/4, 2

* Bolt diameter in inches.

** Use same coupling bolt shown for RCS

Table 12.5
HELIX NET BEARING AREAS *

Nominal diameter (in)	units	1.25" Round Corner Square Shaft D3	1.50" Round Corner Square Shaft D6	1.50" Round Corner Square Shaft D7	1.75" Round Corner Square Shaft D10	2.00" Round Corner Square Shaft D15	2.875" O.D. Pipe Shaft		3.50" O.D. Pipe Shaft		4.50" O.D. Pipe Shaft		8.625" O.D. Pipe Shaft
							0.203" wall P28	0.276" wall P28H	0.216" wall P35	0.300" wall P35H	0.237" wall P45	0.337" wall P45H	0.1875" Wall P8
6	ft ²	.166	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	ft ²	.313	.308	.308	.303	.296	0.300	0.300	0.278	0.278	0.236	0.236	NA
10	ft ²	.505	.501	.501	.495	.489	0.494	0.494	0.473	0.473	0.430	0.430	NA
12	ft ²	.729	.724	.724	.719	.712	0.732	0.732	0.711	0.711	0.668	0.668	NA
14	ft ²	1.007	1.002	1.002	.996	.990	1.014	1.014	0.993	0.993	0.950	0.950	0.659
16	ft ²	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.984
20	ft ²	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.766
24	ft ²	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.719

* Shaft areas have been deducted