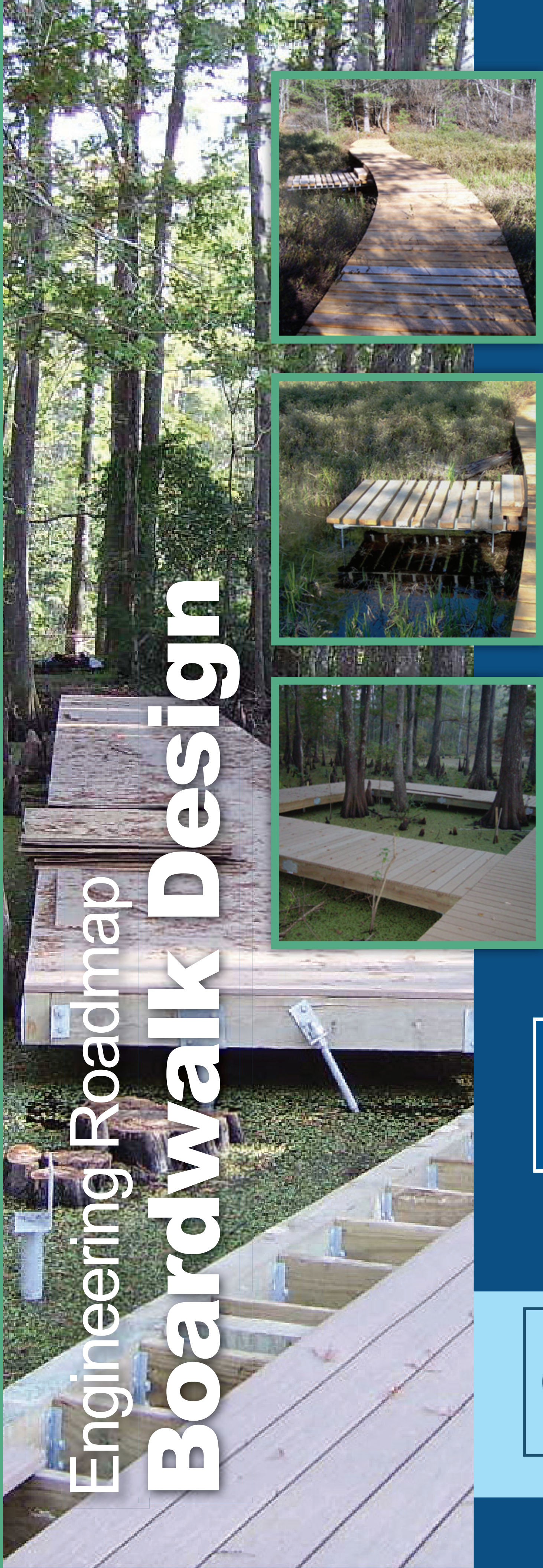
Engineering Roadmap
Boardwalk Design



The Leading Edge In Helical Foundations

MacLean Dixie HFS™

Building Solid Foundations

ISO 9001:2008
QSR-938

DEEP FOUNDATIONS INSTITUTE

Load Calculations

Establish each load component for the structure that you are designing.

In the event that multiple load concerns exist, typically the greatest load requirement shall dictate the design of the pile. However, adequate strength for the other load conditions should be verified.

What are the Compressive Loads?
What are the Tension Loads?
What are the Lateral Load Capacities?
Are there Seismic Load Concerns?

Has a factor of safety been established for the design? Typical industry standard for factor of safety is 2:1. The engineer of record is responsible for designating the factor of safety to be utilized for installation purposes.

(Design / Working Load) x Factor of Safety = Ultimate Load

Example

A boardwalk design is specified for 10 kips ultimate compression load and 7 kips ultimate tension load. In most cases the pile can be designed for 10 kip of compression load and, in doing so, the 7 kip tension load will be satisfied. Nonetheless, the tension capacity should be double checked with the selected pile configuration.

Pile Spacing Design / Selection

The allowable boardwalk span between adjacent piles is determined by a combination of several of the following factors:

1. The design of the pre-manufactured boardwalk section.
2. The reach of the installation equipment
3. The lateral load requirements of the piling system.
4. The anticipated unsupported pile length from the ground surface, pond bottom, creek embankment, etc.
5. Environmental concerns that may limit the access of the installation equipment.
6. The balance between number of piles and size of piles as determined by the project economy.

Determine which products have the mechanical capacity to meet the project's load requirements.
Please reference Table 12-2 Rated Maximum Design Loads of MacLean Dixie Engineering Reference Manual – Based on Installation Torque.

Description	Designation	Kt	Torsional Capacity (ft-lbs)	Max Design Tension (lbs)	Max Design Compression (lbs)	Ultimate Tension (lbs)	Ultimate Compression (lbs)
1.50" RCS	D6	10	5,500	30,000	27,500	60,000	55,000
1.50" RCS (High strength)	D7	10	7,000	35,000	35,000	70,000	35,000
1.75" RCS	D10	10	10,000	50,000	50,000	100,000	100,000
2.00" RCS	D15	10	15,000	75,000	75,000	150,000	150,000
2.875" O.D. Pipe (0.203" wall)	P28	8	7,500	40,000	30,000	80,000	60,000
2.875" O.D. Pipe (0.276" wall)	P28H	8	9,000	50,000	36,000	100,000	72,000
3.500" O.D. Pipe (0.216" wall)	P35	7	11,400	50,000	40,000	100,000	80,000
3.500" O.D. Pipe (0.300" wall)	P35H	7	15,000	70,000	52,500	140,000	105,000
4.500" O.D. Pipe (0.237" wall)	P45	6	20,000	70,000	60,000	140,000	120,000
4.500" O.D. Pipe (0.337" wall)	P45H	6	26,000	100,000	78,000	200,000	156,000
8.625" O.D. Pipe (0.1875" wall)	P8	5	44,500	120,000	100,000	240,000	200,000

Column Buckling Considerations

In general, the axial loads applied to a helical pile shaft in a boardwalk application will be sufficiently small that column buckling considerations will not be an obstacle to design. However, since the pile shafts will often have significant unbraced lengths due to the nature of boardwalk construction (i.e., piles will often be installed in swamps, marshes, over small streams, etc.), it is prudent to ensure that the reduced compression capacity of the pile shaft due to buckling concerns is still sufficient to support the required compression load.

The Euler equation is used to determine the "critical buckling" load of the shaft and it is provided below for convenience:

$$P_{cr} = \frac{IE\pi^2}{(kL)^2}$$

Where:

P_{cr} = Reduced capacity of the pile due to bucking concerns (pounds)

I = Moment of inertia of the pile section (inches^4)

E = Modulus of elasticity of steel (29,000,000 psi)

k = End support condition (2 for a boardwalk)

L = Unsupported /un-braced length of pile shaft (inches)

When the reduced capacity due to buckling is insufficient to carry the ultimate compression load, the designer could use a larger pile shaft or install cross-bracing to reduce the unsupported length.

Where buckling is a major concern, please consult the MacLean Dixie Engineering Reference Manual for more information about buckling.

Design Requirements

Based on soil boring logs, what zone(s) of unsuitable soil are present within the boardwalk footprint? Identify the unsuitable soil zones in order to develop a minimum tip embedment of the pile. Be sure to utilize only the soil boring log(s) that are located within the boardwalk's footprint.

Refer to geotechnical or site condition reports to review for significant wetted zone depths in order to specify a sufficient embedment to penetrate the wetted zone and extra load bearing strata that is unaffected by seasonal wetting and drying. Ensure that the installed depth of the helices is sufficiently beneath the scour depth defined by local building codes.

Helical Pile design requires the piles to be embedded an additional distance equal to 3 times the largest helix diameter once the soil resistance / installation torque has been achieved in order to seat the helices in the load bearing strata.

The test anchor installation log should include torque measurements at 1foot intervals and a record of any underground obstructions encountered.

Example: For helical piles with multiple helices such as a 10"-12"-14" configuration, the largest helix shall determine the additional pile embedment length. In this example the pile must be embedded an additional 3.5 feet.

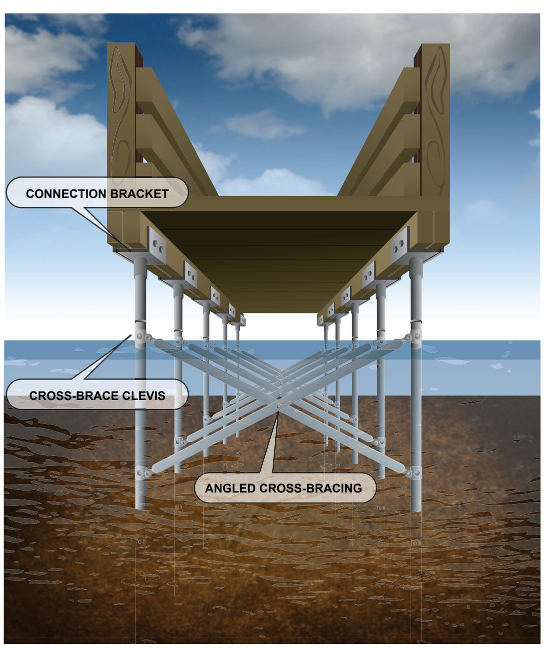
An alternative for projects that do not currently have soil boring information is to contract with a certified helical pile installation company which will complete a series of test piles in order to establish a vertical soil profile. Test anchor information that is to be recorded is as follows:

- Installation Torque by Depth in 1 foot increments
- Any underground obstructions that were encountered.

Lateral Movement Considerations

Boardwalk Designs that have extremely long sections of continuous straight segments tend to be much more susceptible to lateral movement than designs that have shorter spans with turns and rotations. The soil conditions and pile diameter will determine the available lateral reaction. Depending upon the required ultimate lateral load capacity of the piling system, it may be necessary to use larger diameter pipe piles or a cross-bracing system to achieve the required lateral load capacity.

Examples of Cross-Bracing



Helix Configuration Design

What type of soil does the bearing strata consist of? Cohesive Soil (clay)? or Granular Soil (sand)?

Upon determination of the consistency of the bearing strata, begin calculating the pile's capacity based upon the soil type.

Cohesive Soil Calculation (ANGLE OF INTERNAL FRICTION φ = 0.00 DEGS)

geotechnical capacity equation: $q_{ult(g)} = A_h \times (c \times N_c)$

Where: **Nc = 9** for clay soils of medium plasticity and with an angle of internal friction of 0.0 degrees
Ah = the sum of the areas of the helical plates
C = the cohesion of the soil

Most boring logs include blow counts N (ASTM D 1586) but often do not include cohesion or unconfined compression strength values. In this case, the following equation may be used for clays of medium plasticity to estimate their cohesion. This equation is based on empirical studies and should be used with caution.

c (ksf) = N/8

Where: **N** = Blow Count Value per ASTM D1586 Standard Penetration Test

Alternately, where unconfined compression test values are available, we recommend using the following equation to calculate the cohesion:

$c = 1/2 \times q_u)$

Where: q_u = *Unconfined Compressive Strength*

Granular Soil Calculation – Please reference MacLean Dixie Engineering Reference Manual.

geotechnical capacity equation:
$q_{ult(g)} = A_h \times (q \times N_q)$ **= Helix Ultimate Geotechnical Bearing Capacity**

Where: **q** = Effective overburden pressure is defined as the average unit weight of the soil times its depth.
Nq = Bearing Capacity Factor for Cohesionless Soil – Nq is a function of the *angle of internal friction* of the soil as previously discussed.

Additional information regarding the compression and tension design method for helical piles can be located in the MacLean Dixie Engineering Reference Manual and in the New Construction Engineering Roadmap.

Table 8.1
Angle of Internal Friction (φ) vs. Nq For Helical Foundation Piles Granular Cohesionless Soils

Φ	Nq
20	4.463
21	4.959
22	5.514
23	6.138
24	6.841
25	7.632
26	8.526
27	9.538
28	10.685
29	11.989
30	13.473
31	15.169
32	17.110
33	19.338
34	21.903
35	24.864
36	28.294
37	32.279
38	36.928
39	42.369
40	48.762
41	56.308
42	65.250
43	75.899
44	88.642
45	103.971

Corrosion Considerations

Please refer to Section 11 of the most recent MacLean Dixie Engineering Reference Manual regarding corrosion considerations of the project.

Boardwalk Bracket & Hardware

Review www.macleandixie.com for specific product information and your local MacLean Dixie HFS distributor.

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