Screw Piles

MBOA

19 October 2016

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Overview

- What are screw piles?
- How do screw piles work?
- How are screw piles used?
- Building inspector considerations
- Discussion

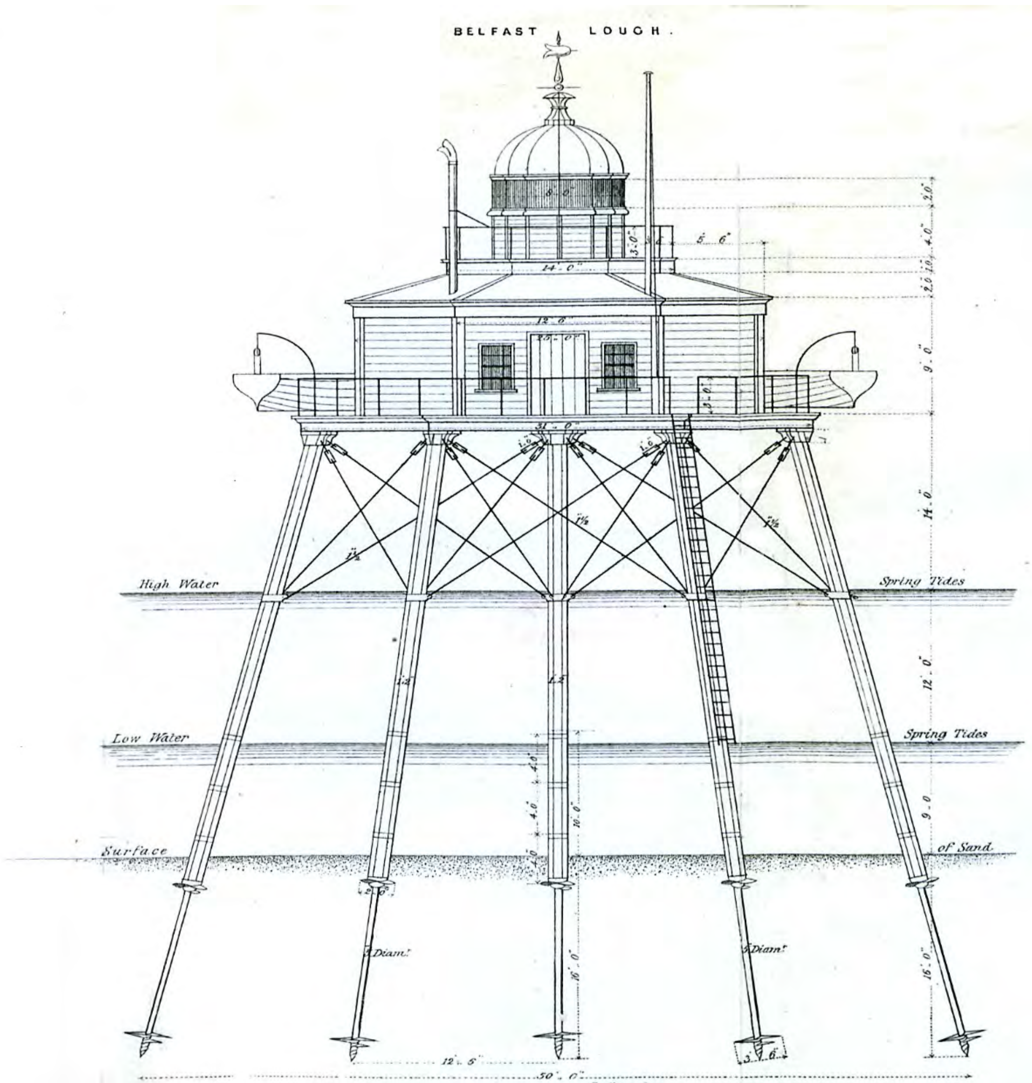
What are screw piles?

Definition

- A screw pile (also helical pile or helical screw pile) is a foundation component consisting of a helical bearing plate attached to a shaft. The pile is installed by slowly turning the shaft with a high-torque, low-speed drive head.

History of Screw Piles

- Screw Piles have been used since the early 1800s. First use of screw piles were as foundations for lighthouses in southern England. First patented by Alexander Mitchell in 1833.
- Over 100 lighthouses on the eastern seaboard of the United States were founded on screw piles from the 1850s to 1890s.



Plan from the late 1840s of Mitchell's lighthouse in Belfast Lough

Current Use of Screw Piles

- Currently, screw piles are used for a wide range of applications, ranging from DIY installations (“Groundhogs”) for sunrooms and decks to large screw piles with capacities in excess of 100 tons for large commercial installations.

Scope of this Presentation

- Screw pile installations for large commercial projects (Part 3) are designed, monitored, and approved by design engineers.
- Scope of this presentation will focus on smaller (Part 9) projects – most typically residential and limited small commercial.

Components of a Screw Pile

- Tube
- Helical Bearing Plate
- Top attachment


19/06/2012

Screw Pile Tube

- Typically heavy-wall pipe Ø3”+
- Bottom end is cut at an angle (~45°)
- Top end has hole or other provision for mating to:
    - Driving head, and/or
    - Extensions


16/06/2011

Helical Bearing Plate

- “Flighting”
- Usually plate heavier than ¼”
- Shaped in a helix (screw) to allow insertion in soil
- Some piles may have more than one bearing plate, spaced along the pile (4’+ spacing common)

How do screw piles work?

- Screw Piles are installed using a high-torque, low-speed driver head (hydraulic gearmotor).
- There is a correlation between drive torque and bearing capacity in certain types of soils.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How do screw piles work?

- If required bearing capacity is not achieved, extensions can be added to the pile to achieve greater depth until capacity is achieved.
- Other options for additional capacity are selecting a larger diameter bearing plate, or selecting a pile with additional bearing plates.

Governing Regulations

- MBC(2010):
  - 4.2.3 Materials Used in Foundations
    - 4.2.3.7 Steel
      1) Steel used in foundations or in support of soil or rock shall conform with the appropriate requirements of Subsections 4.3.3. or 4.3.4., unless otherwise specified in this Section
    - 4.2.3.8 Steel Piles
      1) Where steel piles are used in deep foundations and act as permanent load-carrying members, the steel shall conform with one of the following standards:
         a) ASTM A 252, "Welded and Seamless Steel Pipe Piles,"
         b) ASTM A 283/A 283M, "Low and Intermediate Tensile Strength Carbon Steel Plates,"
         c) ASTM A 1008/A 1008M, "Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable,"
         d) ASTM A 1011/A 1011M, "Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength," or
         e) CAN/CSA-G40.21, "General Requirements for Rolled or Welded Structural Quality Steel."

Governing Regulations (cont'd)

- 4.2.3.10. Corrosion of Steel
  1) Where conditions are corrosive to steel, adequate protection of exposed steel shall be provided.

- 4.3.4.1. Design Basis for Structural Steel
  1) Buildings and their structural members made of structural steel shall conform to CSA S16, "Design of Steel Structures."

Governing Regulations (cont'd)

- Other Regulations
  - ASTM D 1143-81 (1994), "Standard Test Method for Piles Under Static Axial Compressive Load"
  - ASTM D 3689-90 (1995), "Standard Test Method for Individual Piles Under Static Axial Tensile Load"
  - ASTM D 3966-90, "Standard Test Method for Piles Under Lateral Loads"

Corrosion

- Propensity to corrosion is related to soil chemistry
- Coatings:
  - Zinc
  - Powder coating
  - Powder coating over zinc

Design for Corrosion

- Sacrificial thickness is the amount of thickness lost to corrosion over the design life.
- Corrosion can be accounted for in design by reducing the thickness of helical pile shafts, helical bearing plates, and other components by the sacrificial thickness over the design life in structural calculations.
- Four methods are commonly used to compute sacrificial thickness:
  - International Code Council (ICC) Evaluation Services Document AC358
  - American Association of State Highway and Transportation Officials (AASHTO) (2004) Section 11.10.6.4.2a
  - 98th Percentile life expectancy
  - King method

Table 11.2 Life Expectancy of 0.25-inch- [6-mm-] Thick-wall Tubular Helical Piles (Perko, 2004)

Soil Resistivity (Ohm-cm)	Corrosivity Category	Example Soils	(Minimum) **98% Probability** *(Average)* Helix Foundation Life Expectancy	
			Bare Metal	Galvanized
0–2,000	**Severe**	Soil in marine environments; organic soils and peat; soft, wet silts and clays; wet shales	(15) **30** *(80)*	(40) **75** *(200)*
2,000–10,000	**High**	Stiff, moist clays; medium-dense silts and loams; wet clayey to silty sand; wet sandstone	(55) **70** *(135)*	(140) **170** *(340)*
10,000–30,000	**Moderate**	Dry to slightly moist clays; dry silts and loams; sand and gravel; limestone	(50) **55** *(140)*	(125) **140** *(350)*
>30,000	**Low**	Dry shales; dry sandstone; clean and dry sand and gravel; slate and granite	(345) **325** *(555)*	(865) **810** *(1385)*

Design Uses

- Use of screw piles is similar to other pile or pier elements like friction piles or pad & pier.
- Screw piles are not recommended for:
  - Very rocky soil with few fines (ie. pit-run gravel)
  - Excessive shale
  - Extremely dense or stiff soils.

Lateral Resistance

- A single screw pile, installed vertically, has poor ability to resist horizontal loads.
- If horizontal loading is a concern, options include:
  - Installing screw piles at a slight angle from vertical, alternating the direction of the angle.
  - Installing screw piles in multiples, tying the tops of the piles together in a screw cap or equivalent.

Usage Considerations

- Cost
- Suitability of structure to point supports
  - Point loads vs. continuous loading
  - Presence of very large point loads
  - Lateral support


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Building Inspector Considerations

- Screw piles appear deceptively simple.
- Often appear to be a “magic solution”.

Some Screw Pile Design Factors

- Suitability of the site
- Soil conditions
- Requirements of the structure
- Design of the helical screw pile
- Construction of the pile
- Installation to design requirement?
- Other factors…

Many factors are Part 4 issues.

Some Typical Plan Review and Inspection Concerns:

- Manufacturing process
- Substitution for other foundation types
- Method and success of installation
- Need for professional design

Manufacturing Process

- Material certification
- Welding certification
- Provisions for corrosion prevention

Substitutions for Other Foundation Types

- Proper spacing and sizing of screw piles.
- How are point loads supported?
- What are the lateral loads? How does the proposed installation resist these loads?
- Is the basement floor also supported on screw piles? Garage floor? Steps and decks?

Method and Success of Installation

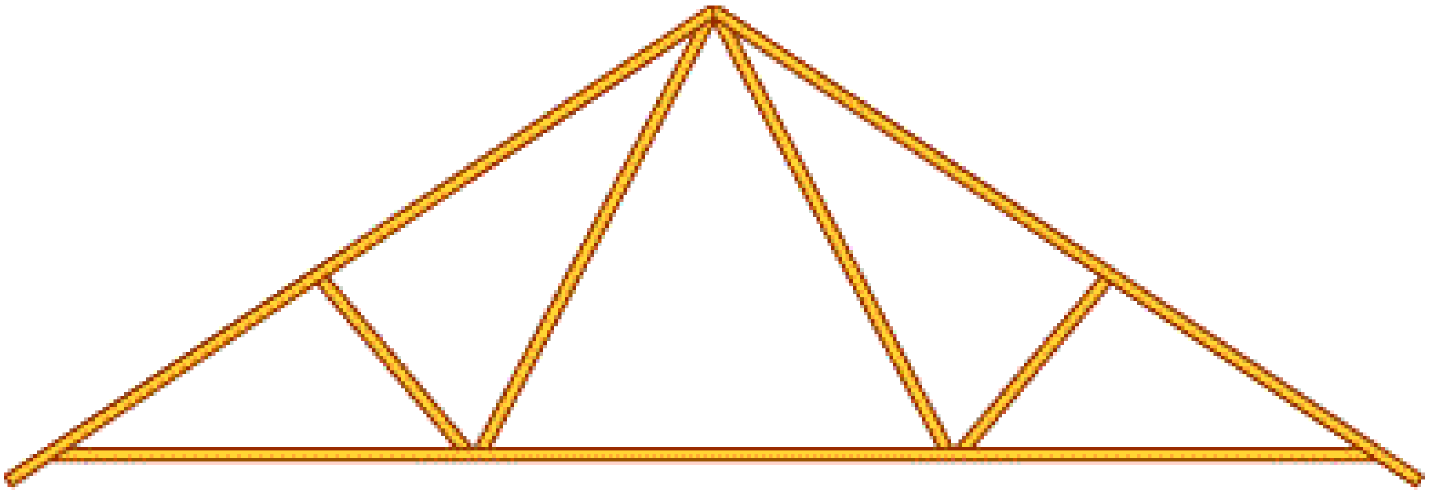
- What is the speed of the install? If the installation occurs above a threshold RPM (usually only 1 – 3 RPM), screw pile capacity will not be achieved (ie. instead of installing a screw pile, the installer drove in a hole auger)
- Were the required loadings obtained? If so, how were the loadings confirmed? Did the installer monitor the install motor torque (oil pressure on a hydraulic gearmotor)?

Need for Professional Design

- To ensure a proper screw pile installation, a Part 4 analysis should be performed
  - Load identification and quantification
  - Determination of possible risk factors
  - Design features to account for risk factors
    - Lateral loads
    - Changing loads
    - Multi-pile sets to reduce need for large piles.

Example

Consider the engineered roof truss:



Engineered Roof Truss

- Comes in all sizes and shapes, for use in all sorts of applications
- Is constructed of commonly-available dimensional lumber
- Easy to replicate?

Comparison of Truss and Screw Pile

- Both appear to be a simple assembly
- Both encourage copying
- Both are similar to an iceberg – much of the value/danger is unseen

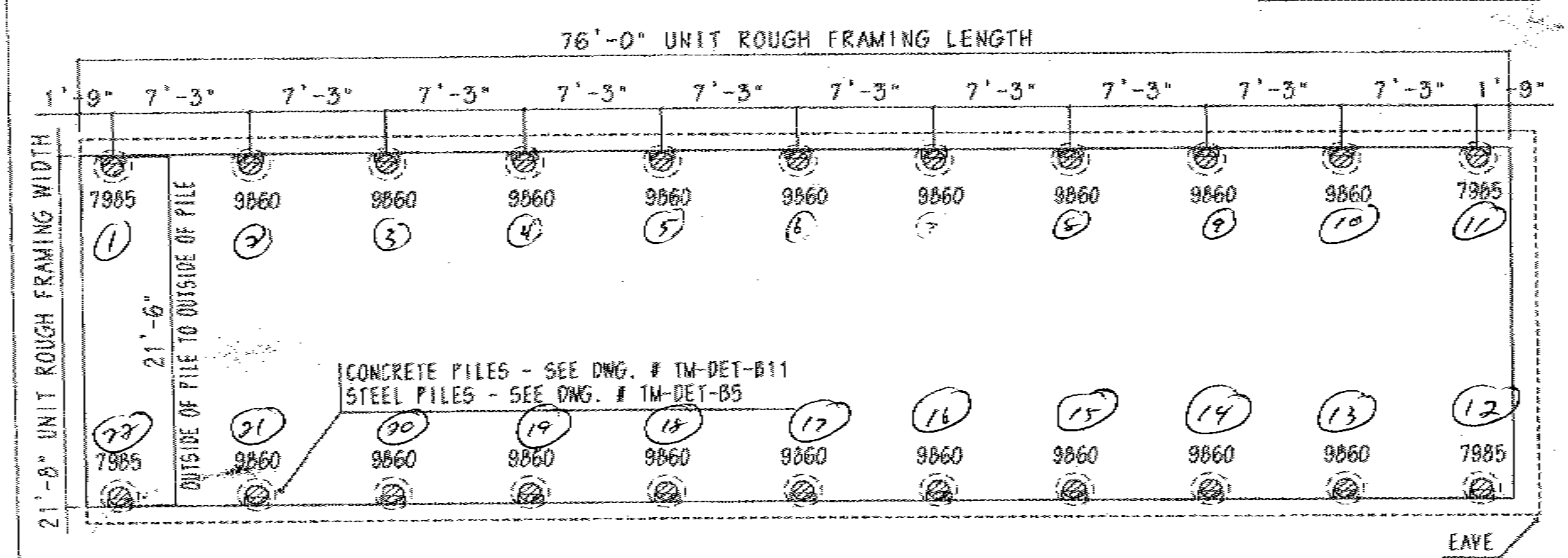
CCMC-tested Screw Piles

- Some of the risk can be reduced by using CCMC-tested screw piles.
- If a certified installer, working from a engineer-certified load sheet, is able to achieve the torques/loads required by the design, they should be able to produce a installation report documenting their install.

Allowable loads

(in granular soil or silt)

AUGER DRIVER		Allowable Loads			
		Compression		Tension	
Hydraulic pressure (psi)	Applied Torque (lbf)	kN	LB	kN	LB
750	788	15.8	**3 555**	-	-
800	850	17.1	**3 852**	-	-
850	913	18.4	**4 149**	-	-
900	975	19.8	**4 445**	1.6	360
950	1038	21.1	**4 742**	2.8	630
1000	1100	22.4	**5 038**	4.0	900
1050	1163	23.7	**5 335**	5.3	1 184
1100	1225	25.0	**5 631**	6.5	1 467
1150	1288	26.3	**5 928**	7.8	1 751
1200	1350	27.7	**6 225**	9.0	2 034
1250	1413	29.0	**6 521**	10.3	2 318
1300	1475	30.3	**6 818**	11.6	2 601
1350	1538	31.6	**7 114**	12.5	2 824
1400	1600	32.9	**7 411**	13.5	3 046
1450	1663	34.3	**7 708**	14.5	3 269
1500	1725	35.6	**8 004**	15.5	3 491
1550	1788	36.9	**8 301**	16.5	3 714
1600	1850	38.2	**8 597**	17.8	3 997
1650	1913	39.5	**8 894**	19.0	4 281
1700	1975	40.8	**9 191**	20.3	4 564
1750	2038	42.2	**9 487**	21.5	4 848
1800	2100	43.5	**9 784**	22.8	5 131
1850	2163	44.8	**10 080**	24.1	5 415
1900	2225	46.1	**10 377**	25.3	5 698
1950	2288	47.4	**10 674**	26.6	5 982
2000	2350	48.8	**10 970**	27.8	6 265
2050	2413	50.1	**11 267**	29.1	6 549
2100	2475	51.4	**11 563**	30.4	6 832
2150	2538	52.7	**11 860**	31.4	7 055
2200	2600	54.0	**12 156**	32.3	7 277
2250	2663	55.3	**12 453**	33.3	7 500
2300	2725	56.7	**12 750**	34.3	7 722
2350	2788	58.0	**13 046**	35.3	7 945
2400	2850	59.3	**13 343**	36.3	8 168
2450	2913	60.6	**13 639**	37.3	8 390
2500	2975	61.9	**13 936**	38.3	8 613
2550	3038	63.3	**14 233**	39.3	8 835
2600	3100	64.6	**14 529**	40.3	9 058
2650	3163	65.9	**14 826**	41.2	9 280
2700	3225	67.2	**15 122**	42.2	9 503
2750	3288	68.5	**15 419**	43.2	9 725
2800	3350	69.8	**15 716**	44.2	9 948
2850	3413	71.2	**16 012**	45.2	10 170
2900	3475	72.5	**16 309**	46.2	10 393
2950	3538	73.8	**16 605**	47.2	10 616
3000	3600	75.1	**16 902**	48.2	10 838



FOUNDATION NOTES

[1]. EACH SUPPORT POINT INDICATES THE TOTAL LOAD CALCULATED AS FOLLOWS:

DEAD LOAD OF STRUCTURE........	40 LB/FT^2
FLOOR LIVE LOAD (MAXIMUM).....	40 LB/FT^2
ROOF DESIGN LOAD-- [55% GSL(68.8 LB/FT^2) + 100% RL(2.1 LB/FT^2)]........	40 LB/FT^2
CALCULATED DESIGN LOAD.........	120 LB/FT^2

[2.] MAX. CALCULATED LOAD PER SUPPORT POINT 9 860 LBS.

[3.] THIS DRAWING INDICATES FOUNDATION SIZING AND MAXIMUM SUPPORT SPACING ONLY. FOUNDATON MUST BE DESIGNED TO SUIT LOCAL CONDITIONS AND DESIGN LOADS SHOWN.

[4]. BLOCKING AND TIE-DOWNS MUST CONFORM TO THE REQUIREMENTS OF CSA-Z240.10.1-08 SITE PREPARATION, FOUNDATION, AND ANCHORAGE OF MOBILE AND MODULAR HOMES.

[5]. PROVIDE COMPACT GRAVEL BASE IF WOOD SUPPORT BLOCKING IS USED.

[6]. ALL MATERIALS AND DESIGN CRITERIA MUST CONFORM WITH PART 9 OF THE APPLICABLE BUILDING CODE.

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REVISIONS

[redacted]

PILE LOAD REPORT

Date: [redacted]

ADDRESS: [redacted]

PILE #	SIZE OF PILE	ACTUAL FEET BELOW GRADE	MINIMUM P.S.I.	MINIMUM LOAD	ACTUAL P.S.I.	ACTUAL LOAD	EXTENSIONS USED
1	3½"	13½	1500	7985	2000	10970	1 / 5'
2	3½"	13½	1850	9860	2100	11563	1 / 5'
3	3½"	8'	1850	9860	2500	13936	
4	3½"	17'	1850	9860	2000	10970	1 / 7'
5	3½"	10'	1850	9860	1900	10377	
6	3½"	8'	1850	9860	2200	12156	
7	3½"	8½'	1850	9860	2000	10970	
8	3½"	8'	1850	9860	2000	10970	
9	3½"	14'	1850	9860	2000	10970	1 / 5
10	3½"	14½'	1850	9860	1700	10377	
11	3½"	8½'	1500	7985	1700	9191	1 / 5'
12	3½"	8'	1500	7985	1600	8597	
13	3½"	8'	1850	9860	2500	13936	
14	3½"	14'	1850	9860	1900	10377	1 / 5'
15	3½"	16'	1850	9860	1850	10080	1 / 7'
16	3½"	8'	1850	9860	2200	12156	
17	3½"	8'	1850	9860	2400	13343	
18	3½"	8'	1850	9860	2500	13936	
19	3½"	8½'	1850	9860	1700	10377	
20	3½"	9	1850	9860	2200	12156	

Summary

- Screw piles are one component available to a designer
- As with all other structural components, screw piles add value for some situation, and are not appropriate for others
- The more professional design is included in the installation, the lower the risk to the AHJ.

Discussion

- Questions?