ICC-ES Evaluation Report

ESR-4892

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DIVISION: 31 00 00—EARTHWORK Section: 31 63 00—Bored Piles	REPORT HOLDER: MASCORE INC.	EVALUATION SUBJECT: M1, M2 AND M3 HELICAL PILES	

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2024, 2021 and 2018 *International Residential Code®* (IRC)

Properties evaluated:

- Structural
- Geotechnical

2.0 USES

Under the IRC, the M1, M2, and M3 Helical Piles may be used as an alternate foundation system supporting light-frame construction, exterior porch deck, elevated walkway and stairway construction, and accessory structures assigned to Seismic Design Categories (SDCs) A, B, and C. The helical piles are designed to transfer compression loads from the supported structure to suitable soil bearing strata.

3.0 DESCRIPTION

3.1 System Components:

The helical pile consists of a lead shaft section; extension shaft section(s), couplings that connect multiple shaft sections; and a pile cap that allows for attachment to the supported foundation or grade beam. The lead shaft is screwed into the ground by application of torsion and the shaft is extended until a desired depth or a suitable soil or bedrock bearing stratum is reached. The lead shaft is connected to the extension shaft(s) by couplings, as described in Section 3.1.3. The helical pile shaft is connected to the pile cap, as described in Section 3.1.4.

3.1.1 Helical Pile Lead Shafts and Extensions: The helical pile lead shaft consists of one, two or three helical-shaped circular steel plates (helices), factory-welded to the central steel shaft.

Helical Pile	Lead Shaft with Single Helix	Lead Shaft with Two Helices	Lead Shaft with Three Helices
M1	M11	M12	M13
M2	M21	M22	M23
M3	M31	M32	M33

The helices allow advancement into the soil as the pile rotate. The depth of the helical piles in soil is typically extended by adding one or more extension shafts that are mechanically connected by couplers to form one continuous steel pile. The extensions do not include helical bearing plates. Configurations and dimensions of the lead shafts and extensions for M1, M2, and M3 Helical Piles are included in Figure 1.

3.1.2 Helix Plates: The helix is split from the center to the outside edge with spiral edge geometry. It is formed to a clockwise downward spiral with all radial sections normal to the shaft's longitudinal axis and with a 3-inch (76.2 mm) nominal pitch for M1 and M2 Helical Piles and 6-inch (152.4 mm) nominal pitch for M3 Helical Pile. The pitch is the distance between the leading and trailing edges. The helices are fillet-welded to the pile shaft on both sides. Dimensions of helical plated for M1, M2, and M3 Helical Piles are included in Figure 1.

3.1.3 Couplings: Each extension shaft has a 7-inch (178 mm) long coupler pipe sleeve, which is factory fillet welded to the bottom end of the extension shaft. The coupler has two $^3/_4$-inch (19 mm) bolt holes to allow for bolting the lower end of the extension to the upper end of other extension or lead shaft. Two $^5/_8$-inch (16 mm) diameter bolts and matching nuts and washers are supplied with each extension shaft. Dimensions of the coupler pipe sleeve for M1, M2, and M3 Helical Piles are shown in Figure 1.

3.1.4 Pile Caps: Pile caps are available for use in supporting new construction. They are used to transfer axial compressive loading from structure to helical piles. The pile caps are available in two models as shown in Figure 2. The Flat Plate Pile Cap consists of a square plate that is fillet welded to a short section of pipe (sleeve). The U-Shaped Pile Cap consists of a U-shaped plate that is fillet welded to a short section of pipe (sleeve). The maximum hole diameter in the pile cap for fastener installation to the shaft is $^5/_8$-inch (15.88 mm). A maximum of two holes (one on each side) is allowed. Dimensions of pile caps are provided in Figure 2.

3.2 Material Specifications:

3.2.1 General: Components of the M1, M2, and M3 Helical Piles are manufactured from hot-dip galvanized carbon steel in accordance with ASTM A123. The minimum zinc-coated thickness must be 64 µm (1.486 oz/ft^2 = 455 g/m^2).

3.2.2 Helical Pile Lead Shafts and Extensions: Pipe sections used to manufacture lead shafts and extension shafts must comply with the requirements of ASTM A252 Grade 3 or ASTM A500 Grade C. The steel must have a minimum yield stress of 50 ksi (345 MPa) and a minimum tensile strength of 62 ksi (425 MPa).

3.2.3 Helix Plates: Each helical plate is press formed from steel plate complying with CSA G40.20/G40.21 Grade 44W (300W for metric units) with minimum yield stress of 44 ksi (303 MPa) and minimum tensile strength of 65 ksi (448 MPa). The welding electrodes that are used between the helix plate and the shaft comply with the requirements of CSA W48.1 and AWS 5.1 Class E7018). The weld's tensile strength is 78 ksi (538 MPa).

3.2.4 Shaft Coupling: The couplers are manufactured from carbon steel complying with the requirements of ASTM A252 Grade 3 or ASTM A500 Grade C. The steel must have a minimum yield stress of 50 ksi (345 MPa) and a minimum tensile strength of 62 ksi (425 MPa). The welding electrodes that are used between the coupler and the pipe shaft comply with the requirements of CSA W48.1. The weld's minimum tensile strength is 69.6 ksi (480 MPa).

3.2.5 Pile Cap: The pile caps' square plate and U-shaped plate are made from ASTM A252 Grade 3 or ASTM A500 Grade C with a minimum yield stress of 50 ksi (345 MPa) and a minimum tensile strength of 62 ksi (425 MPa). The pile cap's sleeve is made from the same material. The welding electrodes that are used between the plate and the sleeve comply with the requirements of CSA W48.1. The weld's minimum tensile strength is 69.6 ksi (480 MPa).

3.2.6 Bolts, Washer, and Nuts: All connection bolts for couplers must comply with ASTM F3125 Grade A325, Type 1 or SAE J429 Grade 5 having a minimum tensile strength of 120,000 psi (827 MPa) with matching flat circular washers and nuts. The bolts, washers, and nuts are hot-dip galvanized in accordance with ASTM A153.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: The registered design professional shall determine the helical pile system and devices, including the pile cap/bracket, used as a foundation element and the applied loads shall not exceed the capacity of the helical pile system. The registered design professional shall determine the design forces in accordance with IRC Section R301. Engineering calculations and drawings of the helical pile system and devices, prepared by a registered design professional, must be submitted to, and approved by the code official for each project, and must be based on accepted engineering principles. The engineering analysis must address helical foundation system performance related to structural and geotechnical requirements. The calculations must address the ability (considering strength and stiffness) of the supported foundation and structure to transmit the applied loads to the helical foundation system and the ability of the helical piles and surrounding soils to support the loads applied by the supported foundation and structure. The design method for the steel components is either the Load and Resistance Factor Design (LRFD), or the Allowable Stress

Design (ASD), described in AISC 360 Section B3. The design method for the concrete components is the strength Design (also called LRFD) described in ACI 318, and must comply with Section 3.7.1.2 of AC358 in order to utilize the ASD capacities described in this evaluation report.

The structural analysis must consider all applicable internal forces (axial forces, shear, bending moment and torsional moment, if applicable) due to applied loads, eccentricity between applied loads and reactions acting on the pile-supported structure, the forces/moments exerted on the foundation or grade beam by the pile caps, and the design span(s) between helical foundations. The result of this analysis and the structural capacities must be used to select a helical foundation system.

Pile caps exert a force and, in some cases, may be allowed to exert a moment on the footing or grade beam in which they are embedded. The force is equal in magnitude and opposite in direction to the force in the pile. A small lateral force is developed at the pile cap embedment if the pile shaft is not perfectly plumb but within the permitted inclination from vertical of ±1°. The lateral shear is equal to sin(1°) or 0.0175 x the axial force exerted on the pole by the foundation. The allowable moment is zero for pile caps used with helical piles embedded in soft soil under all conditions of concrete strength and pile head fixity.

The minimum pile embedment into soil for various loading conditions must be determined based on the most stringent requirements of the following: engineering analysis; tested conditions described in this report, specified minimum pile embedment described in this report; the site-specific geotechnical investigation report; and site-specific load tests, if applicable.

The geotechnical analysis must address the suitability of the helical foundation system for the specific project. It must also address the center-to-center spacing of the helical pile, considering both effects on the supported foundation and structure and group effects on the pile-soil capacity. The analysis must include estimates of the axial compression capacities of the helical piles, whatever is relevant for the project, and the expected total and differential foundation movements due to single pile or pile group, as applicable.

A written report of the geotechnical investigation may be submitted to the code official as part of the required submittal documents, at the time of the permit application. If not submitted, the soil capacity of the helical pile (P4) must be established in accordance with Equation 4 in Section 4.1.5 of this report with the factor of safety equals to 2.5. The geotechnical report must include, but not be limited to, the following information:

1. A plot showing the location of the soil investigation.
2. A complete record of the soil boring and penetration test logs and soil samples.
3. A record of soil profile.
4. Information on groundwater table, frost depth and corrosion-related parameters, as described in Section 5.4 of this report.
5. Soil properties, including those affecting the design such as support conditions of the piles.
6. Soil design parameters, such as shear strength parameters as required by Section 4.1.5; soil deformation parameters; and relative pile support conditions as defined in Section 4.1.3.
7. Confirmation of the suitability of the Mascore helical foundation system for the specific project.
8. Recommendations for design criteria, including but not limited to: mitigations of effects of differential settlement and varying soil strength; and effects of adjacent loads.
9. Recommended center-to-center spacing of helical pile foundations, if different from Section 5.8 of this report; and reduction of allowable loads due to the group action, if necessary.
10. Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity when required).
11. Load test requirements.
12. Any questionable soil characteristics and special design provisions, as necessary.
13. Expected total and differential settlement.
14. The axial compression soil capacity for allowable capacities that cannot be determined from this evaluation report.
15. Minimum helical pile depth, if any, based on local geologic hazards such as frost, expansive soils, or other conditions.

4.1.2 Pile Cap Capacity (P1): The supported structure (e.g., foundation or beam) and connection between the pile cap and the supported structure are outside the scope of this evaluation report and must be designed and justified to the satisfaction of the code official, with due consideration to all applicable limit states and the direction and eccentricity of applied loads, including reactions provided by the pile cap, acting on the foundation/beam. The design must be included in the construction documents. Refer to Table 1 for the pile cap capacities. Flat and U-Shape Plate Pile Caps are limited to compression loads only and must be used to support structures that are laterally braced.

4.1.3 Pile Shaft Capacity (P2): Table 2 describes the mechanical properties of the shaft which are based on a 50-year corrosion effect in accordance with Section 3.9 of AC358. Table 3 describes the allowable capacities of the shaft (including coupler capacity). The shaft capacity and the coupler deflection of the helical foundation systems, where there is one or more couplers within the unbraced length of the shaft, are outside the scope of this evaluation report. For capacities not reported in Table 3, they must be determined by a registered design professional.

The top of shafts must be braced, and the supported foundation structures such as concrete pile caps are assumed to adequately braced such that the supported foundation structures provide lateral stability for the pile systems (the lateral restraint for the shaft is equal to or greater than 0.4 percent of the allowable axial compression load of the helical pile system).

Soil conditions in Table R401.4.1 of the IRC are deemed to afford sufficient lateral support to prevent buckling of the helical pile systems that are braced, and the unbraced length is defined as the length of piles that is standing in air, water or in fluid soils plus additional 5 feet (1524 mm) when embedded into firm soil or additional 10 feet (3048 mm) when embedded into soft soil. Firm soils shall be defined as any soil with a Standard Penetration Test blow count of five or greater. Soft soil shall be defined as any soil with a Standard Penetration Test blow count greater than zero and less than five. Fluid soils shall be defined as any soil with a Standard Penetration Test blow count of zero [weight of hammer (WOH) or weight of rods (WOR)]. Standard Penetration Test blow count shall be determined in accordance with ASTM D1586.

For each pile, the shaft capacity including maximum installation torque is the lowest capacity of its components, which include a lead section, one or more extension sections, and couplings connecting lead section to extension section, or connecting two extension sections together.

For purposes of this report, shaft support conditions for resisting axial compressive loads are classified into the following two categories: (1) Fixed Condition, where the top of the pile is fully restrained against rotation and translation by the concrete foundation; and (2) Pinned Condition, where the top of the pile is fully restrained against translation, but not against rotation, by the concrete foundation. For both conditions, no portion of the pile may stand in air, water or fluid soils; the top of piles must be braced as noted above; and piles must be embedded at least 5 feet (1524 mm) into stiff soil, and 10 feet (3048 mm) into soft soil. See Table 3 for shaft capacities.

The elastic shortening of the pile shaft will be controlled by the strength and section properties of the shaft sections (See Table 2) and coupler(s). For loads up to and including the allowable load limits found in this report, the elastic shortening of shaft can be estimated as: $\Delta_{shaft} = P\ L/(A\ E)$

where:

Δ_{shaft} = Length change of shaft resulting from elastic shortening, in (mm).

P = applied axial load, lbf (N).

L = effective length of the shaft, in. (mm).

A = cross-sectional area of the shaft, see Table 2, in.^{2} (mm^2).

E = Young's modulus of the shaft, see Table 2, ksi (MPa).

For each galvanized coupler, a slip of 0.260 inch (6.60 mm) is estimated at allowable shaft load.

4.1.4 Helix Plate Capacity (P3): The helix compression load capacities are listed in Table 4.

4.1.5 Soil Capacity (P4): Table 5 describes the geotechnical related properties of the piles. The allowable axial compressive load capacities of helical piles based on soil resistance (P4) must be determined by a registered design professional in accordance with:

- Method 1: Helix bearing based on a site-specific geotechnical report (considering smallest helix plate only), or
- Method 2: Field loading tests conducted under the supervision of a registered design professional as required in IRC Section R401.4. The allowable load is predicted by dividing the ultimate capacity from load tests by a safety factor of at least 2.0.

For either Method 1 or Method 2, the predicted axial load capacities must be confirmed during the site-specific production installation, such that the axial load capacities predicted by the torque correlation method must be equal to or greater than the predicted by Method 1 or 2, described above.

4.1.5.1 Method 1: With the helix bearing method, the nominal axial load capacity of the helical pile is determined as the area of the smallest helical bearing plate times the ultimate bearing capacity of soil or rock comprising the respective bearing strata for the plate, as follows:

$Q_{tot} = A_h q_u$ (Equation 1)

where,

Q_{tot} = Predicted nominal axial compressive capacity of the helical pile, lbf (N).

A_h = Area of the smallest helix bearing plate, in.^{2} (mm^2).

q_u = Ultimate unit bearing capacity of soil or rock comprising the bearing stratum for the helix bearing plate, psi (MPa).

The unit bearing capacity of the bearing stratum for the helix plate is determined based on IRC Section R401.4.1 or calculated using the bearing capacity equation for deep foundation as follows:

$q_u = cN_c + q'N_q$ (Equation 2)

where,

c = Undrained shear strength parameter, considering the effect of soil disturbance due to the helix pile installation, psi (MPa).

N_c = Bearing capacity factor.

q' = Effective overburden pressure at helix plate foundation depth, psi (MPa)

N_q = Bearing capacity factor.

The bearing capacity factors N_c and N_q and the undrained shear strength of soils must be taken from the site-specific geotechnical report.

The design allowable axial load must be determined by dividing the total ultimate axial load capacity predicted by wither Method 1 or 2, above, by a safety factor of at least 2.

4.1.5.2 Torque Correlation Method: The Foundation Design Documentation (see Section 4.1.8) must include documentation of the derivation of the design allowable capacity and the minimum effective torsional resistance pile termination criterion, derived using the torque correlation method. With the torque correlation method, the total ultimate axial load capacity of the helical pile is predicted as follows:

$Q_{ult} = K_t T$ (Equation 3)

$Q_{all} = Q_{ult} / F.S.$ (Equation 4)

where:

Q_{ult} = Ultimate axial compressive capacity (lbf or N) of the helical pile, which must be limited to the maximum ultimate values in Table 5.

Q_{all} = Allowable axial compressive capacity (lbf or N) of the helical pile, which must be limited to the maximum allowable values noted in Table 5.

The maximum ultimate and allowable axial compressive capacities, predicted by torque-correlation method are less than or equal to those axial verification test results. The smaller of the torque-correlation predicted maximum axial capacities (ultimate and allowable) and the axial verification test results are provided in Table 5, on soil capacities.

K_t = Torque correlation factor of 10 ft^{-1} (32.8 m^{-1}) for the M1 Helical Pile, 8 ft^{-1} (26.2 m^{-1}) for the M2 Helical Pile, and 7 ft^{-1} (23.0 m^{-1}) for the M3 Helical Pile.

T = Effective torsional resistance, which is defined as the installation torque measured when the pile reaches its final tip embedment. The minimum effective torsional resistance pile termination criterion is calculated as:

F.S. = An appropriate factor of safety for the project, not less than 2.0. F.S. shall not be less than 2.5 if site-specific geotechnical information is not available.

$T_{req} = F.S. \times Q_{all}/K_t$ (Equation 5)

where,

T_{req} = Minimum effective torsional resistance pile termination criterion, in lbf-ft or N-m.

4.1.6 Foundation System: The overall allowable capacity of the helical pile system in compression depends upon the analysis of interaction of pile caps, shafts, helical plates, and soils, and must be the lowest value of:

- P1: Allowable axial capacity of the pile cap. See Section 4.1.2 of this report.
- P2: Allowable axial capacities of the shaft and shaft couplings as described in Section 4.1.3 of this report.
- P3: Allowable axial capacity of helical bearing plate affixed to the pile shaft. See Section 4.1.4 of this report.
- P4: Allowable load predicted by Method 1 or Method 2 as described in Section 4.1.5 of this report.
- P4: Allowable load predicted by the torque correlation method described in Section 4.1.5 of this report.

4.1.7 Settlement Analysis: The pile head vertical movement at allowable load of the helical pile may be estimated as the sum of the following: the movement at helix plates due to soil deformation and helix plate deflection, the shaft elastic shortening, and coupler(s) slip. The corresponding equation is described below:

$$\Delta_{total} = \Delta_{helix} + \Delta_{shaft} \quad \text{(Equation 6)}$$

where,

Δ_{total} = Total pile head vertical movement, in. (mm).

Δ_{helix} = Movement of helix plate within soil, in. (mm).

Δ_{shaft} = Shaft elastic shortening and coupler(s) slip, in. (mm).

The reliability of foundation system capacity and settlement predictions may be improved by performing full-scale field tests at the construction site using piles of same configuration as the intended production piles.

4.1.7.1 Shaft Elastic Shortening: Elastic shortening of helical pile shaft may be a significant contributor to overall pile head movement under load for long piles. For loads up to and including the allowable load limits found in the tables of this report, the length change can be estimated as:

$$\Delta'_{shaft} = P\,L / (E\,A) \quad \text{(Equation 6)}$$

where,

Δ'_{shaft} = Length change of shaft resulting from elastic shortening, in. (mm).

P = Applied axial load, lbs (N).

L = Effective length of the shaft, in. (mm). It may be approximated as the distance from the point of load application to the helix plate.

A = Cross-sectional area of the shaft, in.^{2} (mm^2). See Table 2.

E = Young's modulus of elasticity of the shaft, may be taken as 29,000 ksi (200,000 MPa)

For shafts, elastic shortenings of 0.005, 0.006 and 0.008 inch per foot for M1, M2 and M3 shafts (0.167 mm/m), respectively, are estimated at allowable shafts loads.

4.1.7.2 Helix Movement: The evaluation of helix movement due to helix deformation, soil deformation, and helix-soil interaction, is beyond the scope of this evaluation report. It is recommended that the user of this report consult with the helical pile manufacturer (Mascore Inc.).

4.1.7.3 Coupler Slip: The slip of the helical pile coupler is 0.260 inch (6.60 mm) for the M1, M2, and M3 Helical Piles at the allowable load per coupling.

4.1.8 Foundation Design Documentation: The foundation design documentation, which is part of the approved construction documents and prepared by a registered design professional, must include at least the following for each pile placement:

1. The manufacturer, helical pile configuration and catalog numbers of structural attachments, as appropriate.
2. Minimum pile tip embedment and minimum effective torsional resistance termination criteria. There must be an explanation that the minimum effective torsional resistance is to be calculated as the final torsional resistance for the helix pile loaded in compression.
3. Maximum pile tip embedment, if appropriate.
4. Construction details for pile cap connections to structures, prescriptively specifying at least the following (as applicable):
   a. Type and condition of the structure to be supported.
   b. Bracing is required for all structures to be supported by any of the New Construction Pile Caps.
   c. Surface preparation.
   d. Drill holes, bolts and washer plates.
   e. Field welding.
   f. Edge distance.

g. Concrete reinforcement.

h. Leveling grout.

i. The permissible angles of inclination for installation for the helical pile foundation systems (shafts and pile caps) are 0° ± 1°.

5. Construction details must also indicate that materials with different corrosion protection coatings must not be combined in the same system and that the helical foundation systems must not be placed in electrical contact with structural steel, reinforcing steel or any other metal building components.

4.2 Installation:

4.2.1 General: The helical piles must be installed by individuals who are trained and certified by Mascore Inc.

4.2.2 Lead and Extension shafts: The helical piles are typically installed using portable or machine-mounted rotary hydraulic motors capable of exerting a torsional moment at least 10 percent higher than the maximum installation torque reported in Table 5 for the pile model being installed. The pile is rotated into the ground in a smooth, clockwise, continuous manner, while maintaining an axial downward force sufficient to cause the pile to penetrate the earth at a uniform rate of approximately 3 inches (76 mm) per revolution. Installation speed ranges from 5 to 20 revolution per minute (RPM). Installation continues by adding extension sections as necessary. Refer to Section 3 for specifications of bolts and nuts that are required to connect the shaft sections. Bolts must be snug tightened as defined in Section J3 of AISC 360. Inclination and alignment must be checked and adjusted periodically during installation. Equipment capable of measuring the torsional resistance experienced by the pile during installation must be utilized for installation quality control. Care must be taken not to exceed the maximum installation torque rating as shown in Table 5. Helical piles must be advanced until the axial capacity is verified by achieving the required final installation torque as indicated by the torque correlation method described in Section 4.1.5, and the minimum depth, if any, as specified by the geotechnical report Section 4.1.1. The foundation piles must be aligned both vertically and horizontally as specified in the approved plans.

4.2.3 Pile Cap: The pile caps must be placed over the top of the helical piles. The top of the pile elevation must be established and must be consistent with the specified elevation. If necessary, the top of the pile may be cut off level to the required length in accordance with the manufacturer's instructions and AISC 360 requirements so as to ensure full, direct bearing contact between the top of the pile shaft and the pile cap. Bolts and nuts as described in Sections 3.1.4 and 3.2.6 of this report must be used for installing the pile cap to the helical pile. The bolts must be snug-tightened, as defined in Section J3 of AISC 360.

5.0 CONDITIONS OF USE:

The M1, M2, and M3 Helical Piles described in this report complies with, or is a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 The helical piles must be manufactured, identified, and installed in accordance with this report, the site-specific approved construction documents (engineering plans and specifications), and the manufacturer's published installation manual, which must be always available at the jobsite during installation. In the event of a conflict between these documents, the most restrictive requirements govern.

5.2 The helical piles have been evaluated for support of structures assigned to Seismic Design Categories (SDCs) A, B and C in accordance with IRC Section R301. Use of the systems to support structures regulated under the IRC and assigned to SDCs D_0, D_1, D_2 and E; are outside the scope of this report, and are subject to the approval of the code official based upon submission of a design in accordance with the code by a registered design professional.

5.3 Engineering calculations and drawings, in accordance with recognized engineering principles, and complying with Section 4.1 of this report, must be prepared by a registered design professional and submitted to the code official for approval.

5.4 Use of the helical pile system in soil conditions that are indicative of potential pile deterioration or corrosion situations is outside the scope of this report. Soil conditions that are indicative of potential pile deterioration or corrosion situations include the following: (1) soil resistivity less than 1,000 ohm-cm; (2) soil pH less than 5.5; (3) soil with high organic content; (4) soil sulfate concentrations greater than 1,000 ppm; (5) soils located in landfills; or (6) soils containing mine waste.

5.5 All helical pile system components must be galvanically isolated from concrete reinforcing steel, building structural steel, or any other metal building components.

5.6 The helical piles must be installed vertically into the ground with a maximum allowable angle of inclination of 1 degree from vertical.

5.7 The applied loads on the helical pile must not exceed the allowable capacities described in Section 4.1 of this report.

5.8 The minimum helical pile center-to-center spacing upon which this evaluation report is based is four times the average helical bearing plate diameters. For piles with closer spacing, the pile allowable load reductions due to pile group effects must be included in the geotechnical report, described in Section 4.1.1 of this report, and must be considered in the pile design by a registered design professional, and subject to the approval of the code official.

5.9 The superstructure must be designed to resist the effects of helical pile mislocation.

5.10 Settlement of the helical pile is outside the scope of this report and must be determined by a registered design professional based upon shaft (including coupling) information prescribed in this evaluation report and in consultation with the pile manufacturer.

5.11 The M1, M2, and M3 Helical Piles components are manufactured by Mascore Inc in Ontario, Canada under a quality-control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Helical Pile Systems and Devices (AC358), dated June 2020 (editorially revised February 2024).

7.0 IDENTIFICATION

7.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-4892) along with the name, registered trademark, or registered logo of the report holder (Mascore Inc.) must be included in the product label.

7.2 In addition, the label shall include the product name and model [M1 (M11, M12 or M13), M2 (M21, M22 or M23), or M3 (M31, M32 or M33) Helical Piles].

7.3 The report holder's contact information is the following:

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TABLE 1─PILE CAP ALLOWABLE CAPACITIES (ASD), P1 [1,2,3]

PILE CAP	HELICAL PILE	COMPRESSION CAPACITY (lbs)
Flat Plate	M1	4256
	M2	10587
	M3	13957
U-Shape Plate	M1	4256
	M2	10587
	M3	13957

For **SI**: 1 inch = 25.4 mm, 1 kip = 4.448 kN.

[1]Allowable capacities are based on the mechanical strength of the steel pile cap. The connection between pile cap and the foundation or supported structure is outside the scope of this evaluation report and must be designed by a registered design professional.
[2]Listed allowable capacities assume the pile foundation system is sidesway braced.
[3]Allowable capacities are based on zinc-coated steel losing 0.013-inch steel thickness as indicated in Section 3.9 of AC358 for a 50-years service life.

TABLE 2─SHAFT MECHANICAL PROPERTIES AFTER CORROSION LOSS[1]

CHARACTERISTIC	SHAFT OUTER DIAMETER		
	M1: $2^3/_8$-inch	M2: 3-inch	M3: 3.5 inch.
Steel Yield Stress, F_y (ksi)	50		
Steel Tensile Strength, F_y (ksi)	62		
Modulus of Elasticity, E (ksi)	29,000		
Nominal Wall Thickness (inch)	$^5/_{32}$	$^3/_{16}$	$^7/_{32}$
Design Wall Thickness (inch)	0.13	0.162	0.188
Design Outside Diameter (inch)	2.362	2.987	3.487
Design Inside Diameter (inch)	2.102	2.663	3.111
Gross Cross-sectional Area, A ($inch^2$)	0.911	1.437	1.947
Moment of Inertia, I ($inch^4$)	0.569	1.438	2.658
Radius of Gyration, r (inch)	0.79	1.0	1.168
Section Modulus, S ($inch^3$)	0.482	0.963	1.525
Plastic Section Modulus, Z ($inch^3$)	0.648	1.294	2.048

For **SI**: 1 inch = 25.4 mm, 1 ksi = 6.89 MPa.

[1]Dimensional properties are based on zinc-coated steel losing 0.013-inch steel thickness as indicated in Section 3.9 of AC358 for a 50-years service life in addition to the 0.07 thickness reduction in accordance with Section B4.2 of AISC 360.

TABLE 3─SHAFT ALLOWABLE CAPACITY (ASD), P2 [2,3,4,5]

Helical Pile	Maximum Installation Torque (lb.ft)	No of Couplers within L_u	COMPRESSION (lbs)		
			kL_u = 0 ft [1]	kL_u = 5 ft	kL_u = 10 ft
M1	2000	0	10,210	6,850	3,780
M2	4160		20,930	13,930	8,720
M3	6730		35,800	22,330	14,120

For **SI**: 1 inch = 25.4 mm, 1 ft = 0.305 m, 1 kip = 4.448 kN.

[1]L_u = Total unbraced pile length, including the length in air, water or in fluid soils, and the embedment length into firm or soft soil (non-fluid soil) Refer to Section 4.1.3 of this report for the determination of the unbraced length. k = effective length factor for shaft compression buckling consideration. kL_u = total effective unbraced length of the pile, kL_u = 0 represent a fully braced condition.
[2]Allowable capacities are for piling installed with a maximum 1-degree inclination and the assumption that the pile shaft is concentrically loaded. The shaft is laterally braced at the top.
[3]Allowable capacities are based on two 5/8-inch bolts with matching washers and nuts installed complying with Section 3. The bolt threads are not excluded from the connection shear plane.
[4]Allowable capacities are based on zinc-coated steel losing 0.013-inch steel thickness as indicated in Section 3.9 of AC358 for a 50-years service life in addition to the 0.07 thickness reduction in accordance with Section B4.2 of AISC 360.
[5]For other unbraced lengths and conditions, the shaft capacity of helical foundations must be determined by a registered design professional.

TABLE 4—HELICAL BEARING PLATE ALLOWABLE CAPACITY (ASD), P3 [1,2]

HELIX DIAMETER (inch)	SHAFT OUTER DIAMETER (inch)	HELICAL PILE	HELIX THICKNESS (inch)	HELIX PITCH (inch)	ALLOWABLE CAPACITY, P3 (kips)
8	$2^3/_8$	M11, M12 & M13	$^3/_8$	3	22.5
10		M12 & M13			0[3]
12		M13			0[3]
10	3	M21, M22 & M23	$^3/_8$	3	36.9
12		M22 & M23			0[3]
14		M23			0[3]
12	$3^1/_2$	M31, M32 & M33	$^3/_8$	6	42.9
14		M32 & M33			0[3]
16		M33			0[3]

For **SI**: 1 inch = 25.4 mm, 1 kip = 4.448 kN.

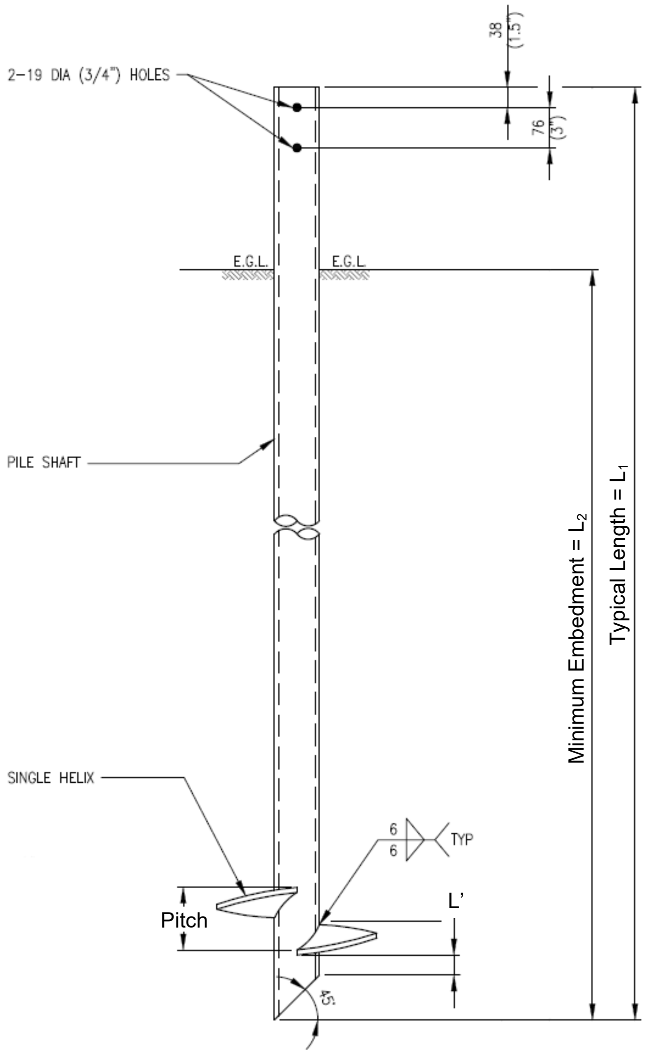
[1]All helical bearing plates are made from same material and have the same thickness.
[2]Allowable capacities are based on zinc-coated steel losing 0.03-inch steel thickness as indicated in Section 3.9 of AC358 for a 50-years service life.
3Bearing capacity of the helix plate was not evaluated and is conservatively taken zero.

TABLE 5—SOIL CAPACITY, P4 – AXIAL COMPRESSION [1]

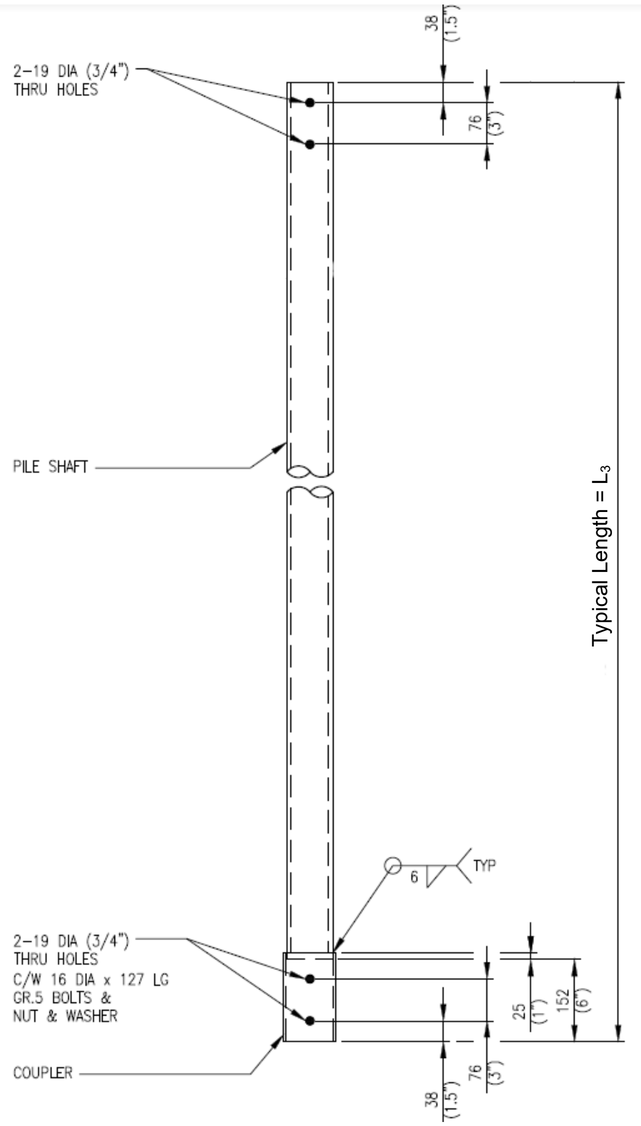
GEOTECHNICAL RELATED PROPERTIES	HELICAL PILE		
	M1 (M11, M12 or M13)	**M2 (M21, M22 or M23)**	**M3 (M31, M32 or M33)**
Mechanical Torsion Rating (ft-lbs) [2]	2,000	4,160	6,730
Maximum Torque Per Soil Tests (ft-lbs) [3]	2,950	5,000	8,500
Maximum Installation Torque Rating (ft-lbs) [4]	2,000	4,160	6,730
Torque Correlation Factor, K_t (ft^{-1})	9.5	7.5	6
Maximum Ultimate Soil Capacity / Maximum Allowable Soil Capacity (P4) from Torque Correlations (kips) [5]	19 / 9.5	31.2 / 15.6	40.4 / 20.2

For **SI**: 1 foot = 0.305 m, 1 lbf = 4.448 N, 1 lbf-ft = 1.356 N-m

[1]Soil Capacity (P4) must be determined per Section 4.1.5 of this evaluation report.
[2]Mechanical torsion rating is the maximum torsional resistance of the steel shaft.
[3]Maximum torque per soil tests is the maximum torque achieved during field axial verification testing that was conducted to verify the pile axial capacity related to pile-soil interaction.
[4]Maximum installation torque rating is the lower of the "mechanical torsion rating" and the "maximum torque per soil tests".
[5]Maximum ultimate soil capacity is determined from Equation 3 based on the corresponding maximum installation torque rating for the specific pile model. Allowable soil capacity is determined from Equation 4 based on the corresponding maximum installation torque rating for the specific pile model. See Section 4.1.5 for additional information.



M11, M21 & M31 Lead Shaft

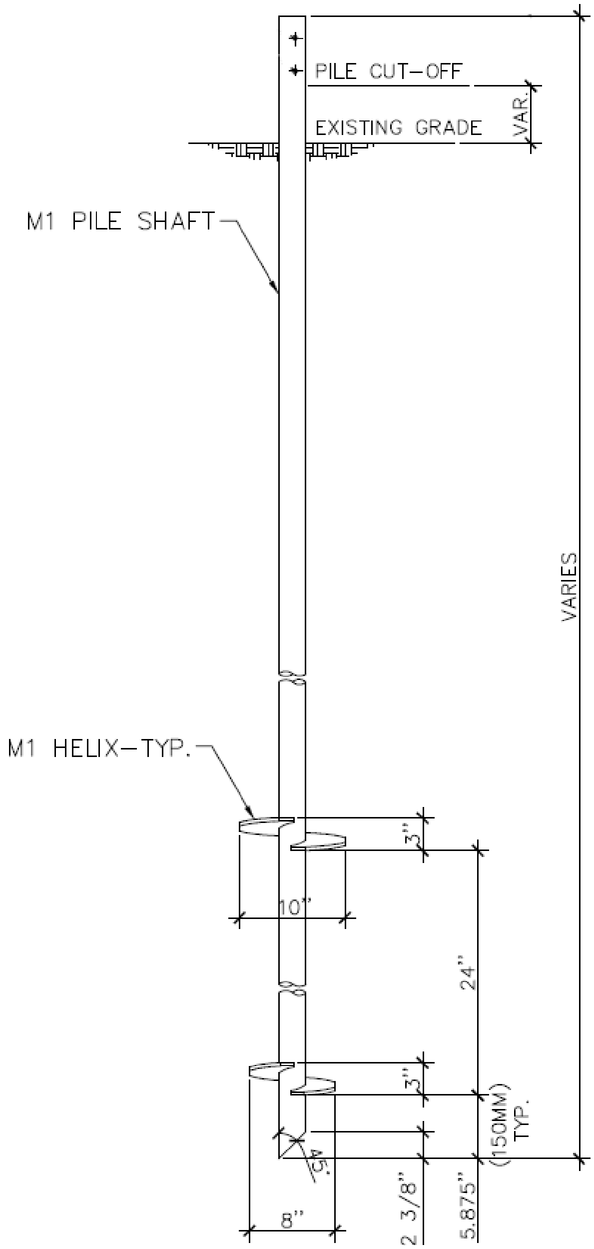


Extension for All Helical Piles

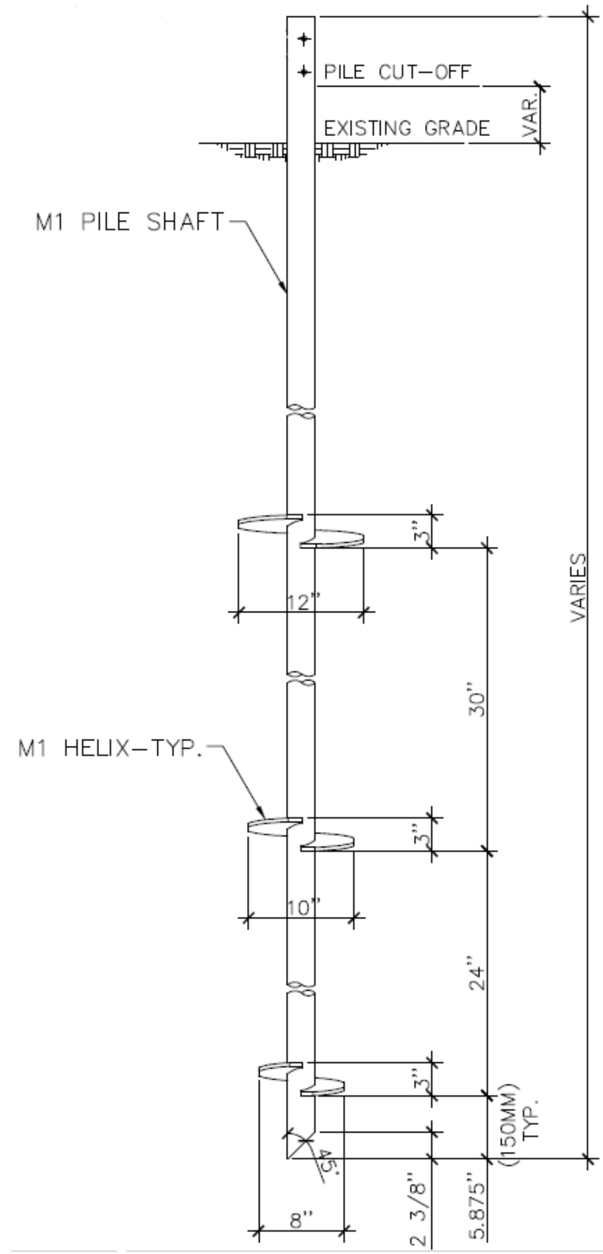
Dimensions

Helical Pile	M1 (M11, M12 & M13)	M2 (M21, M22 & M23)	M3 (M31, M32 & M33)
Shaft's Outer Diameter	$2^3/_8$"	3"	$3^1/_2$"
Shaft's Wall Thickness	$^5/_{32}$"	$^3/_{16}$"	$^7/_{32}$"
Coupler's Outer Diameter	$2^7/_8$"	$3^1/_2$"	4"
Coupler's Wall Thickness	$^3/_{16}$"	$^3/_{16}$"	$^7/_{32}$"
Helix Plate Outer Diameter	8", 10" & 12"	10", 12" & 14"	12", 14" & 16"
Helix Plate Thickness	$^3/_8$"	$^3/_8$"	$^3/_8$"
Helix Plate Pitch	3"	3"	6"
L'	$^1/_2$"	$^1/_2$"	$^3/_4$"
Typical L_1	5' – 0" to 10' – 0"	5' – 0" to 10' – 0"	5' – 0" to 10' – 0"
Typical L_2	4' – 6.8"	4' – 7.5"	4' – 7.75"
Typical L_3	5' – 6"	6' – 6"	7' – 6"

FIGURE 1—TYPICAL LEAD SHAFT AND EXTENSIONS AND NOMINAL DIMENSIONS (continued)

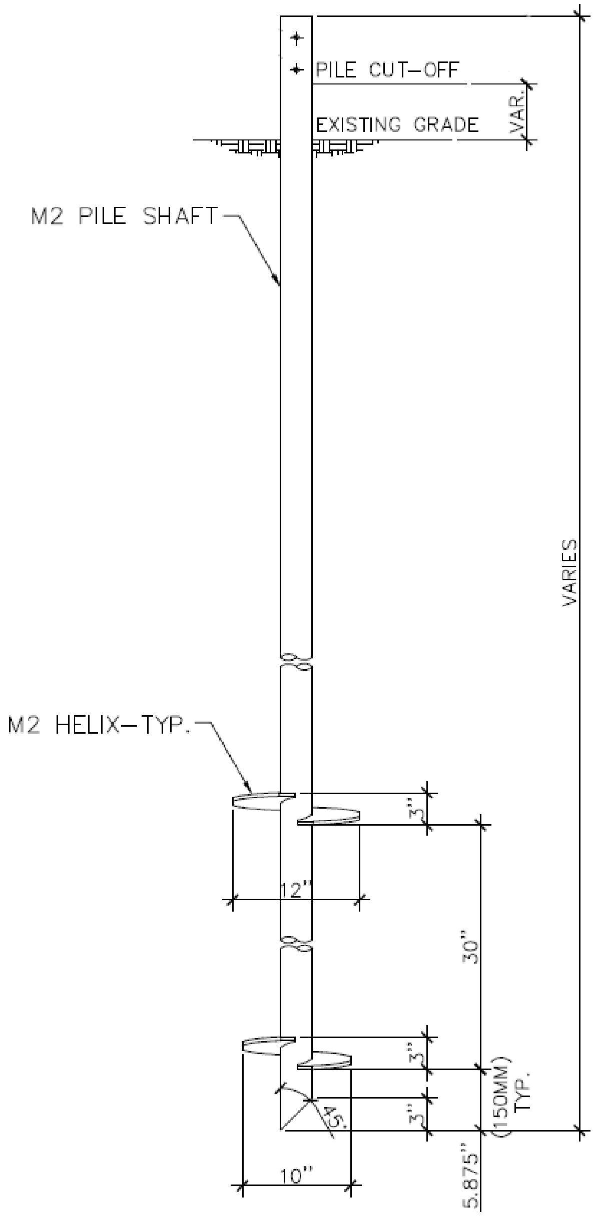


M12 Lead Shaft

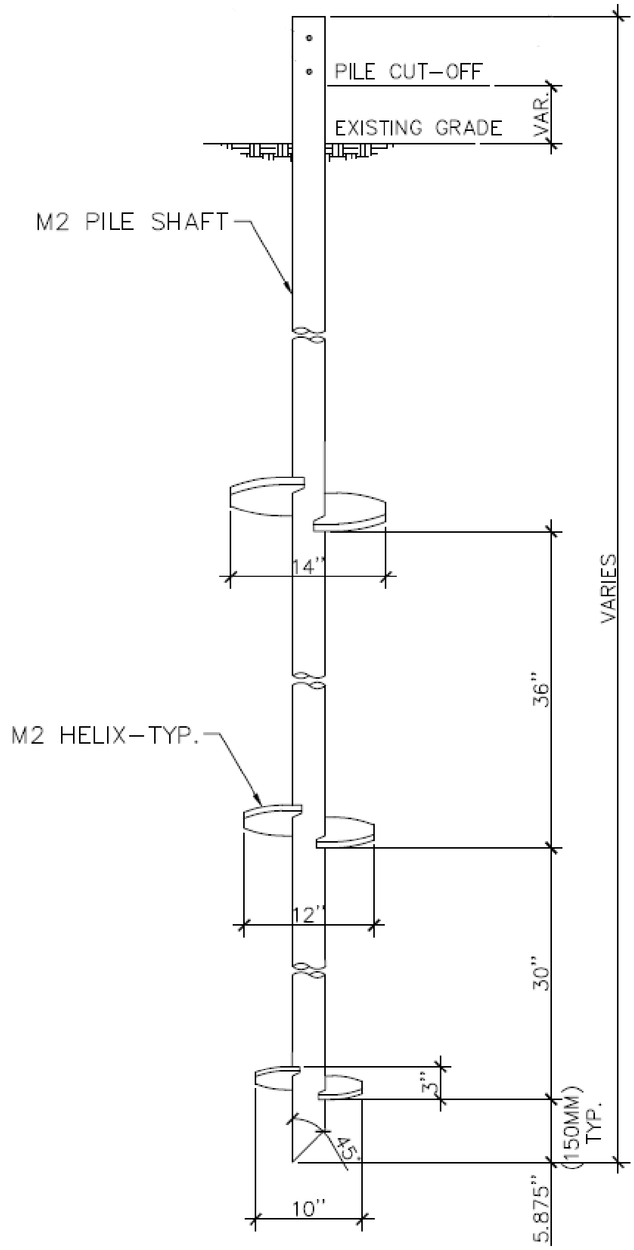


M13 Lead Shaft

FIGURE 1─TYPICAL LEAD SHAFT AND EXTENSIONS AND NOMINAL DIMENSIONS (continued)

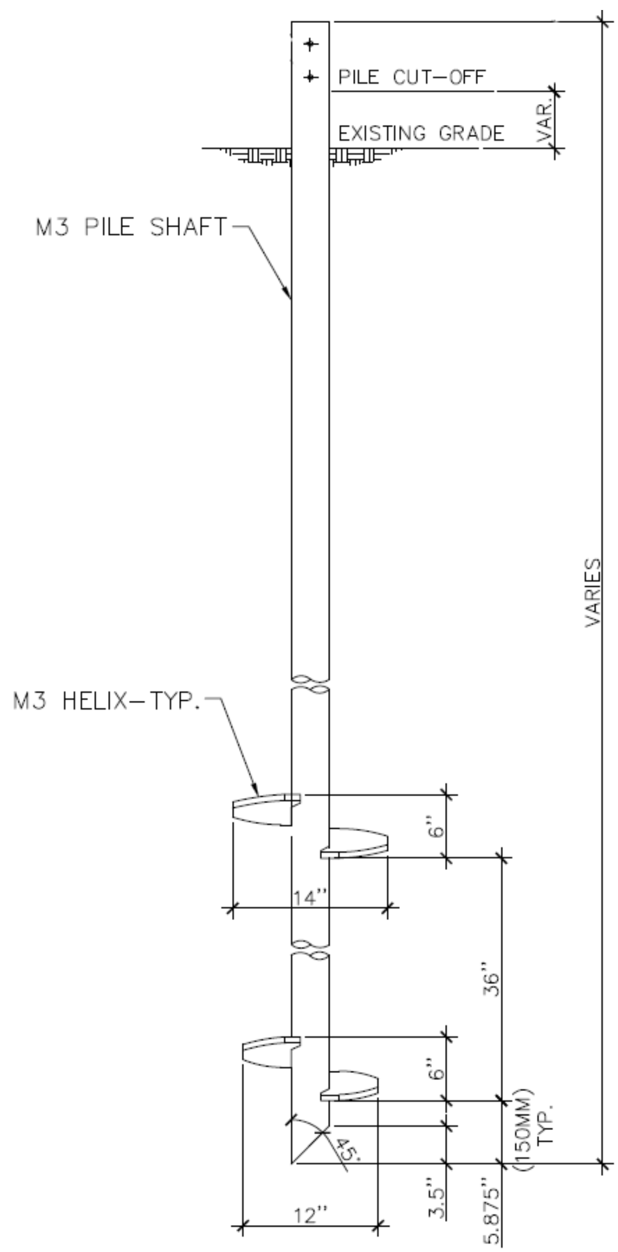


M22 Lead Shaft

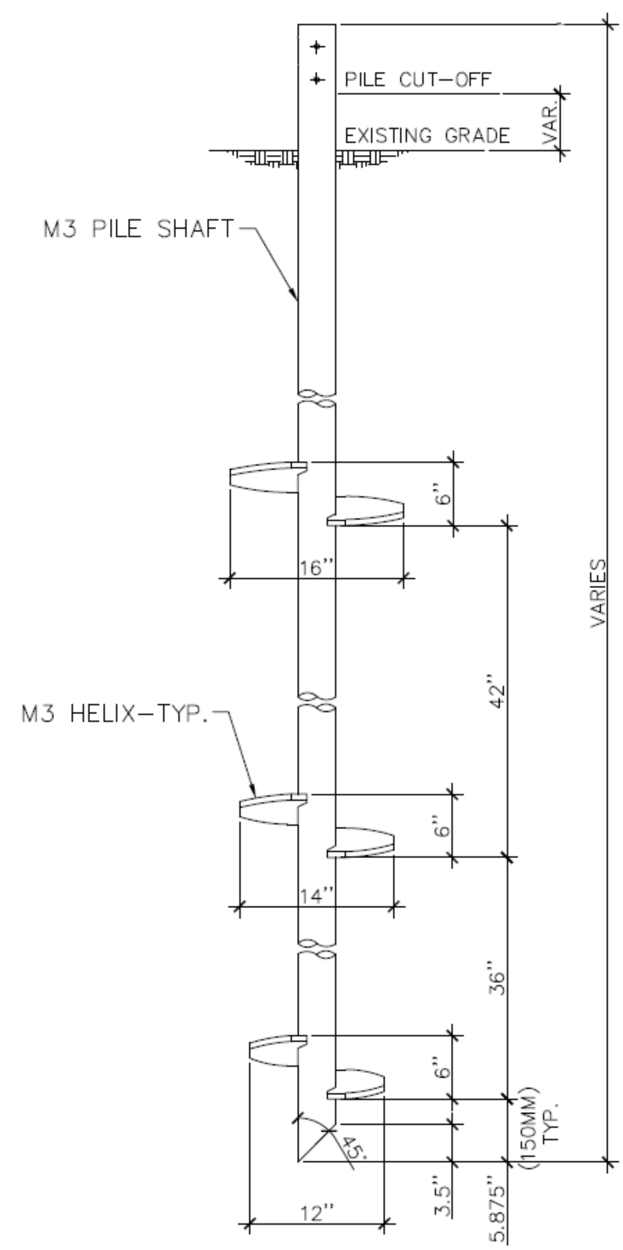


M23 Lead Shaft

FIGURE 1—TYPICAL LEAD SHAFT AND EXTENSIONS AND NOMINAL DIMENSIONS (continued)

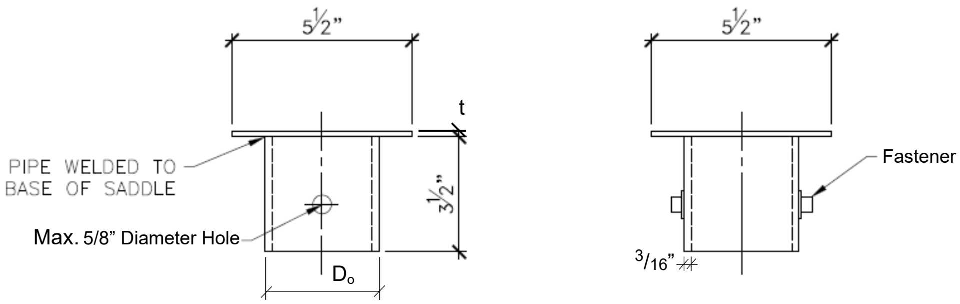


M32 Lead Shaft



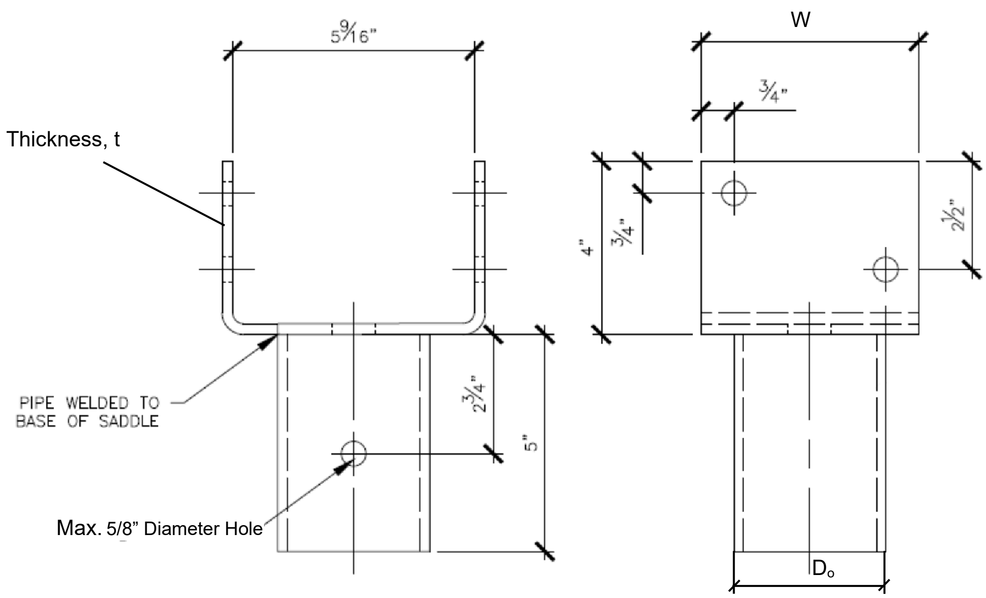
M33 Lead Shaft

FIGURE 1—TYPICAL LEAD SHAFT AND EXTENSIONS AND NOMINAL DIMENSIONS



Helical Pile	M1	M2	M3
Sleeve's Outer Dia., D_o	3"	3.5"	4"
Plate Thickness, t	3/16"	1/4"	1/4"

Flat Plate Pile Cap



Helical Pile	M1	M2	M3
D_o	3"	3.5"	4"
W	3.5"	4.5"	5.5"
Sleeve's Thickness	3/16"	3/16"	3/16"
U-Shape Plate Thickness, t	3/16"	1/4"	1/4"

U-Shape Plate Pile Cap

FIGURE 2—PILE CAPS AND NOMINAL DIMENSIONS