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ESR-3418

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This report is subject to renewal 11/2018.

DIVISION: 31 00 00—EARTHWORK

SECTION: 31 63 00—BORED PILES

REPORT HOLDER:

TECHNO-PIEUX INC.

1700 SETLAKWE STREET
THETFORD MINES, QUEBEC G6G 8B2
CANADA

EVALUATION SUBJECT:

TECHNO METAL POST HELICAL FOUNDATION SYSTEMS

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ICC-ES Evaluation Report

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DIVISION: 31 00 00—EARTHWORK
Section: 31 63 00—Bored Piles

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EVALUATION SUBJECT:

TECHNO METAL POST HELICAL FOUNDATION SYSTEMS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2015, 2012, 2009 and 2006 *International Building Code®* (IBC)
- 2013 *Abu Dhabi International Building Code* (ADIBC)†

†The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.

Properties evaluated:

- Structural
- Geotechnical

2.0 USES

The Techno Metal Post helical foundation systems are used either to underpin foundations of existing structures or to form deep foundations for new structures; and are designed to transfer axial compression, axial tension, and lateral loads from the supported structures to suitable soil-bearing strata.

3.0 DESCRIPTION

3.1 General:

The Techno Metal Post helical foundation systems consist of a helical pile and a bracket that allows for attachment to the supported structures. Each helical pile, consisting of a lead section and one or more extension sections (optional), is screwed into the ground, by application of torsion, to a depth that conforms to project requirements for avoidance of unsatisfactory subsurface conditions and that ensures a suitable soil- or bedrock-bearing stratum has been reached. The bracket is then installed to connect the pile to the supported structure.

3.2 System Components:

3.2.1 Lead and Extension Shafts: The Techno Metal Post helical pile lead sections consist of single or multiple (two or three) helical-shaped circular steel plates (helix plates) welded to a central steel shaft. The depth of the helical piles in soil is typically extended by adding one or more steel shaft extensions that are mechanically connected together by welded steel couplings, to form one continuous steel pile. The extensions do not include helical bearing plates. Both the lead section and the extension sections are round hollow structural steel sections, HSS3.500x0.216, or HSS3.500x0.300, measuring 7 feet (2134 mm), 10.5 feet (3200 mm) or 14 feet (4267 mm) long and having a $3^1/_2$-inch (88.9 mm) outside diameter and a 0.216-inch (5.5 mm) or 0.300-inch (7.6 mm) nominal wall thickness. The leading end of a lead section is cut to a 45° ± 5° angle from the shaft longitudinal axis. Figures 1A, 1B and 2 illustrate a typical helical pile lead section and an extension, respectively. Table 1A provides a description and allowable soil capacities for the pile lead section. Tables 1B and 1C describes the mechanical properties of 3.5-inch-diameter helical shafts. Table 2A provides a description and allowable soil capacities of the extension sections.

3.2.2 Helix Plates: Each circular, helical, steel bearing plate (helix) is split from the center to the outside edge with spiral edge geometry. Each helix is formed to a clockwise downward spiral with all radial sections normal to the shaft's central longitudinal axis ± 5° and with a 3 ± 0.25-inch (76.2 ± 6.4 mm) pitch. The pitch is the distance between the leading and the trailing edge. The helix plates for the Techno Metal Post helical piles are 0.5 inch (12.7 mm) thick and have an outer diameter of 8, 10, or 12 inches (203.2, 254.0, 304.8 mm). For single helix piles, the helix is factory fillet-welded to the leading end of lead sections. See Table 1A and Figure 1A for helical pile configurations. For multiple helical pile combinations, two or three helices are welded to the lead sections. Helix spacing along the shaft shall be between 2.4 to 3.6 times helix diameter. Helix plates are arranged along the shaft such that they track the same path as the leading helix. The leading helix must be of an equal or smaller diameter than the helix immediatly on top of it. See Figure 1B.

3.2.3 Couplings: If needed, a coupling or a reinforced coupling can be factory-welded to the top end of the lead section or to the top end of an extension section in order to receive an extension section so as to extend the helical pile. The coupling consists of a 3.5-inch-long (88.9 mm), round HSS4.000x0.226, with an outside diameter of 4.0 inches (101.6 mm), and a 0.226-inch nominal wall thickness. Figure 3A and Table 3 illustrate the coupling. The reinforced coupling consists of a 9-inch-long (88.9 mm), round HSS4.000x0.226, with an outside diameter of 4.0 inches (101.6 mm), and a 0.226-inch

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nominal wall thickness. Two holes are drilled in the reinforced coupling and these holes are aligned with the two holes drilled in the lead section or extension. Figure 3B and Table 3 illustrate the reinforced coupling. The coupling or reinforced coupling must be field-welded to the extension shafts using fillet welds. The weld size must be a minimum of 0.226 inch (5.7 mm), and the weld length must match the full perimeter length of the cross section of the extension shaft that is field-welded to the coupling or reinforced coupling.

3.2.4 Brackets: The Techno Metal Post brackets are Type B (direct load) brackets as defined in Section 3.10.2 of AC358. Corresponding to the material and configuration of the supported structures, four types of Techno Metal Post brackets are available, which are described in Sections 3.2.4.1 through 3.2.4.5.

3.2.4.1 Brackets Embedded in Concrete Foundations (PC5, PC6 and PC8): These brackets are used to support new concrete foundations, and are for attaching to helical piles that support axial compression, axial tension and lateral loads. Each concrete bracket consists of one steel cap plate and one steel tube sleeve, which are factory-welded together to form the bracket. The cap plates of PC5, PC6 and PC8 brackets are, respectively, $^3/_8$ inch (9.5 mm) thick and 5 inches (127.0 mm) square, $^1/_2$ inch (12.7 mm) thick and 6 inches (152.4 mm) square, $^3/_4$ inch (19.0 mm) thick and 8 inches (203.2 mm) square. The tubular sleeves of PC5, PC6 and PC8 brackets are round HSS4x0.226, measuring 4 inches (101.6 mm) long and having a 4-inch (101.6 mm) outside diameter and a 0.226-inch nominal wall thickness. The steel sleeve has two $^9/_{16}$-inch-diameter (14.3 mm) holes that are shop-manufactured in diametrically opposite walls of the sleeve, allowing the sleeve and the top of the shaft section (which has two $^9/_{16}$-inch-diameter [14.3 mm] holes that are field-fabricated in diametrically opposite walls of the top of the shaft) to be through-bolted together during the field installation. Each bracket sleeve through-bolted connection must be made with one, $^1/_2$-inch-diameter (12.7 mm), heavy hex, structural steel bolt, one matching $^1/_2$-inch (12.7 mm) heavy hex, steel nut, and two matching $^1/_2$-inch (12.7 mm) circular or square, hardened steel washers supplied by the pile manufacturer. Figure 4A and Table 4A provide bracket specifications. Tables 4B and 4C provide bracket allowable capacities and requirements for the attached concrete foundations. The concrete covers, including dimensions and concrete strength, must comply with what is prescribed in Table 4C.

3.2.4.2 Welded U Brackets Attached to Wood Beams (PU4 and PU5): These brackets are used to support wood beams in new or existing construction, and are for helical piles that support axial compression and axial tension loads. The brackets are U-shaped steel bent plates that are typically field-welded to the top of a pile shaft using fillet welds. The weld size must be a minimum of $^1/_4$ inch (6.4 mm) and the weld length must match the full circumferential length of the cross section of the shaft that is welded to the bracket. Each bracket has two shop-drilled, $^1/_4$-inch-diameter (6.4 mm) holes, on each vertical plate (side plate), to allow the attachment of wood screws into the supported wood beam. Both PU4 and PU5 bend plates are $^3/_8$ inch (9.5 mm) thick and $4^1/_2$ inches (114.3 mm) long, with the bracket length measured in the beam length direction. The PU4 bent plate has an out-to-out width of $4^3/_8$ inches (111.1 mm), an inside width of $3^5/_8$ inches (92.0 mm), and a height of $2^5/_8$ inches (66.7 mm). The PU5 bent plate has an out-to-out width of $6^3/_8$ inches (161.9 mm), an inside width of $5^5/_8$ inches (142.9 mm), and a height of $3^1/_4$ inches (82.6 mm). Figure 5A and Table 5A illustrate bracket constructio screw fasteners used to attach the bracket supported wood beam must be four, No. 14 rolle wood screws, with minimum screw lengths of 2 (50.8 mm) and 3 inches (76.2 mm), respectively, and PU5 brackets. See Table 5B and Figure 5A.

3.2.4.3 Bolted U Brackets Attached to Wood Beams (PU4B and PU5B): These brackets serve the same purpose as the PU4 and PU5. Each bracket consists of a U-shaped steel bent plate that is shop-welded to a round HSS sleeve. The U-shaped bent plates for the PU4B and PU5B are identical to those of the PU4 and PU5, respectively. The sleeve and the connection between the sleeve and the top of the shaft are the same as those of the concrete brackets described in Section 3.2.4.1. Figure 5B and Table 5A provide specifications of the bracket and bolted connection that must be used to attach the bracket sleeve with the supporting shaft. The screw fasteners used to attach PU4B and PU5B brackets to the supported wood beam must be as required for the PU4 and PU5, respectively. See Table 5B and Figure 5B.

3.2.4.4 Brackets Attached to Steel Columns (PSC5, PSC6 and PSC8): These brackets are used to support pipe and round HSS steel columns in new or existing construction, and are for helical piles that support axial compression and axial tension loads. The PSC5, PSC6 and PSC8 brackets are identical to, respectively, the PC5, PC6 and PC8, except that each PSC bracket cap plate has four, shop-drilled or field-fabricated, $^9/_{16}$-inch-diameter (14.3 mm) holes which are used for a bolted connection to the base plate of the supported column. The bracket must be field-attached to a column base plate, using a minimum of four, $^1/_2$-inch-diameter (12.7 mm), heavy hex, structural steel bolts, matching $^1/_2$-inch (12.7 mm) heavy hex, steel nuts, and matching $^1/_2$-inch (12.7 mm) circular, hardened steel washers. As a minimum, the column base plate must have the same horizontal dimensions as those of the attached bracket plate, and the thickness of column base plate must be at least 1.5 times the bracket cap plate thickness. See Figure 6 and Table 6A.

3.2.4.5 Brackets Attached to Steel I-Beams (PIB5, PIB6 and PIB8): These brackets are used to support steel I-beams in new or existing construction, and are for helical piles that support axial compression and axial tension loads. The PIB5, PIB6 and PIB8 brackets are identical to, respectively, the PC5, PC6 and PC8, except that the PIB bracket cap plates are field-welded to the supported steel wide flange beams. The bracket width must be sufficiently greater than the beam bottom flange width so that the welds between them can be placed. Figure 7 and Table 7A provide specifications for bracket and welding connections. The bracket must be field-welded to the steel beam using fillet welds at each side of the beam bottom flange. The weld size must be a minimum of $^1/_4$ inch (6.4 mm), and the length must match the full length of the bracket.

3.3 Material Specifications:

3.3.1 Lead and Extension Shafts: The shaft lead and extension sections are carbon steel round HSS conforming to ASTM A500, Grade C, except having a minimum yield strength of 51 ksi (352 MPa) and a minimum tensile strength of 62 ksi (427 MPa). The shaft finish is either plain steel or hot-dip galvanized in accordance with ASTM A123.

3.3.2 Helix Plates: The helix plates are carbon steel conforming to ASTM A36, having a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (400 MPa). The helix plates and the

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shafts to which they are factory-welded are either plain finish or hot-dipped galvanized as assemblies in accordance with ASTM A123.

3.3.3 Couplings: The couplingand reinforced couplingare carbon steel round HSS sections conforming to ASTM A500, Grade C, except having a minimum yield strength of 51 ksi (352 MPa) and a minimum tensile strength of 62 ksi (427 MPa). The field-applied welds must comply with AISC 360 prequalified welded joint requirements and must be made with an E70XX electrode. The coupling and reinforced coupling finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

3.3.4 Brackets: The cap plates of the PC, PSC, and PIB brackets, and the bent plates of the PU4, PU5, PU4B and PU5B, are carbon steel conforming to ASTM A36, having a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (400 MPa). The tubular sleeves of the PC, PU4B, PU5B, PSC, and PIB brackets are carbon steel round HSS conforming to ASTM A500, Grade C, except having a minimum yield strength of 51 ksi (352 MPa) and a minimum tensile strength of 62 ksi (427 MPa). For the through-bolted connection between a bracket sleeve and a pile shaft as required for the PC, PU4B, PU5B, PSC, and PIB brackets, the bolt must comply with ASTM A490, Type 1 or 3, with a minimum tensile strength of 150 ksi (1034 MPa); the nut must comply with ASTM A563, Grade DH or DH3; and the washers must comply with ASTM F436, Type 1 or 3. The finish of the ASTM A490 bolt, nut and washer is plain steel as required by AISC 348. All field-applied welds must comply with AISC 360 prequalified welded joint requirements and must be made with an E70XX electrode. The bracket finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

3.3.4.1 PC5, PC6 and PC8: The minimum specified concrete strength at 28 days, and the concrete cover dimensions, must comply with what is prescribed in Table 4C.

3.3.4.2 PU4 and PU5: The screw fasteners used to attach the bracket to the supported wood beam must comply with what is prescribed in Section 3.2.4.2 and Table 5B. The screw connections must comply with the end-use conditions and limitations noted in the footnotes to Table 5E.

3.3.4.3 PU4B and PU5B: See Section 3.3.4.2.

3.3.4.4 PSC5, PSC6 and PSC8: As a minimum, for the bolted connection between the bracket cap plate and the base plate of a supported column, the bolts must comply with ASTM A490, Type 1 or 3, with a minimum tensile strength of 150 ksi (1034 MPa); the nuts must comply with ASTM A563, Grade DH or DH3; and the washers must comply with ASTM F436, Type 1 or 3.

3.3.4.5 PIB5, PIB6 and PIB8: See Section 3.3.4 for welding requirements.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: Engineering calculations (analysis and design) and drawings, 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 as described in IBC Section 1604.4, and must conform to Section 1810 of the 2015, 2012 and 2009 IBC (Section 1808 for the 2006 IBC). The engineering analysis must address helical foundation system performance related to structural and geotechnical requirements. The calculatior address the ability (considering strength and stiff the supported foundation and structure to trans applied loads to the helical foundation system ability of the helical piles and surrounding soils to the loads applied by the supported foundation and structure. The design method for the steel components is Allowable Strength Design (ASD), described in IBC Section 1602 and AISC 360 Section B3. The design method for the concrete components is Strength Design (also called LRFD) as described in IBC Section 1602 and 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 design method for soils is ASD as prescribed in IBC Sections 1801.2 and 1602.

The structural analysis must consider all applicable internal forces (axial forces, shears, bending moments and torsional moments, if applicable) due to applied loads; eccentricity between applied loads and reactions acting on the pile-supported structure; the loading exerted on the supported structure by the connection brackets; and the design span(s) between helical foundations. The loading exerted on the supported structure by the connection bracket is equal in magnitude and opposite in direction to the force in the pile. A small lateral force is developed at the supported structure if the pile shaft is not perfectly plumb but within the permitted inclination from vertical of ±1°. The lateral force is equal to 0.0175 times the axial force in the pile, and must be resisted by the supported structure or other structures that are connected to the supported structure. The result of this analysis and the structural capacities must be used to select a helical foundation system.

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 and specified minimum pile embedment described in this report; the site-specific geotechnical investigation report; and site-specific load tests, if applicable.

For helical foundation systems subject to combined lateral and axial (compression or tension) loads, the allowable strength of the shaft under combined loads must be determined using the interaction prescribed in Chapter H of AISC 360.

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 tension, axial compression and lateral 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 must be submitted to the code official as part of the required submittal documents, prescribed in Section 107 of the 2015, 2012 and 2009 IBC (Section 106 for the 2006 IBC), at the time of the permit application. 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 the soil profile.

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4. Information on groundwater table, frost depth and corrosion-related parameters, as described in Section 5.0 of this report.
5. Soil design parameters, such as shear strength, soil bearing pressure, unit weight of soil, deformation characteristics and other parameters affecting pile-support conditions as defined in Section 1810.2.1 for the 2015, 2012 and 2009 IBC (Section 1808.2.9 for the 2006 IBC).
6. Confirmation of the suitability of helical foundation systems for the specific project.
7. Recommendations for design criteria, including but not limited to, mitigation of effects of differential settlement and varying soil strength; and effects of adjacent loads.
8. Recommended center-to-center spacing of helical pile foundations, if different from spacing noted in Section 5.0 of this report; and reduction of allowable loads due to the group action, if necessary.
9. Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity, when required).
10. Load test requirements.
11. Any questionable soil characteristics and special design provisions, as necessary.
12. Expected total and differential settlement.
13. The axial compression, axial tension and lateral load soil capacities if values cannot be determined from this evaluation report.

There are four primary structural/geotechnical elements associated with the helical foundation system: bracket capacity, pile shaft capacity, helix plate capacity and soil capacity, which are described in Sections 4.1.2, 4.1.3, 4.1.4, and 4.1.5, respectively. The allowable capacity of overall helical foundation system is described in Section 4.1.6.

4.1.2 Bracket Capacity:

4.1.2.1 Brackets Embedded in Concrete Foundations (PC5, PC6 and PC8): The concrete foundations must be designed and justified to the satisfaction of the code official. Only localized limit states related to interaction of the bracket and concrete foundations have been evaluated for this evaluation report. Figure 4B and Table 4C provide requirements for concrete strength and concrete cover dimensions. Refer to Table 4B for bracket allowable axial compression, axial tension and lateral load capacities.

4.1.2.2 Welded Brackets Attached to Wood Beams (PU4 and PU5): The wood beams must be designed and justified to the satisfaction of the code official. For brackets resisting axial tension (uplift) loading, the connection between wood screws and wood beam must be designed and detailed to provide additional mechanical reinforcement capable of transmitting all of the stresses that would otherwise need to be transmitted through tension perpendicular to grain within the wood members. Additionally, provisions of 2015 and 2012 NDS Section 3.4.3.3 apply to the screw connections. Only localized limit states related to interaction of the bracket and wood beams have been evaluated for this evaluation report. The design assumptions and limitations for the wood screw connections are described in the footnotes under Table 5E. Each wood beam must be attached to the bracket with four wood screws described in Table 5B, through the holes on the bracket side plates. F Table 5C for allowable axial compression capac the PU4, PU4B, PU5 and PU5B. Tables 5D anc the allowable axial tension capacities for the P PU4B, and PU5 and PU5B, respectively, which ar on the specific gravity of sawn lumber or the equivalent specific gravity of an engineered wood beam.

4.1.2.3 Bolted Brackets Attached to Wood Beams (PU4B and PU5B): The screw connection between bolted brackets (PU4B and PU5B) and a supported wood beam is identical to that between the welded brackets (PU4 and PU5, respectively) and the corresponding wood beam. The capacity related to the bolted connection between a bracket sleeve and a pile shaft is included in this evaluation report. See Section 4.1.2.2 for additional explanation regarding bracket capacities and design requirements.

4.1.2.4 Brackets Attached to Steel Columns (PSC5, PSC6 and PSC8): The steel column, the weld between the column and its base plate, the base plate, and the interaction (including prying action) between the base plate and bolts, must be designed and justified to the satisfaction of the code official. The bolted connection between a base plate and the bracket must comply with the minimum requirements prescribed in Tables 6A and 6B and must comply with AISC 360 for a pretensioned connection, or a slip-critical connection, as prescribed in the approved construction document. The allowable capacities listed in Table 6B include consideration of the interaction (including prying action) between the bracket plate and bolts and the assumptions described in Sections 3.2.4.4 and 3.3.4.4 and Tables 6A and 6B. If the assumptions are not valid, the interaction (prying action) between the bracket plate and bolts must be evaluated by the registered design professional and must be justified to the satisfaction of the code official. Table 6B lists the allowable axial compression and allowable axial tension capacities, for PSC5, PSC6 and PSC8 brackets attached to steel columns.

4.1.2.5 Brackets Attached to Steel I-Beams (PIB5, PIB6 and PIB8): The steel beams must be designed and justified to the satisfaction of the code official. Only localized limit states related to interaction of the bracket and steel beams have been evaluated for this evaluation report. Each steel beam must be attached to the bracket with the welds along each side of the beam bottom flange, as prescribed in Figure 7 and Table 7A. Tables 7B and 7C list the allowable axial compression capacities, and allowable axial tension capacities, respectively, for the PIB5, PIB6 and PIB8 attached to specific I-beams.

4.1.3 Shaft Capacity: The top of the shafts must be braced, as prescribed in Section 1810.2.2 under the 2015, 2012 and 2009 IBC (Section 1808.2.5 for the 2006 IBC), and the supported structures such as concrete footings, steel columns, steel beams and wood beams are assumed to be adequately braced such that the supported structures provide lateral stability for the pile systems. In accordance with Section 1810.2.1 of the 2015, 2012 and 2009 IBC (Section 1808.2.9 for the 2006 IBC), any soil other than fluid soil must be deemed to afford sufficient lateral support to prevent buckling of the systems that are braced, and the unbraced length is defined as the length of piles standing in air, water, or in fluid soils plus an additional 5 feet (1524 mm) when embedment is into firm soil, or an additional 10 feet (3048 mm) when embedment is into soft soil. Firm soils are defined as soils with a Standard Penetration Test (SPT) blow count of five or greater. Soft soils are defined as soils with an SPT blow count greater than zero and

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less than five. Fluid soils are defined as soils with an SPT blow count of zero [weight of hammer (WOH) or weight of rods (WOR)]. Standard Penetration Test blow count must be determined in accordance with ASTM D1586. The shaft capacity of the helical foundation systems in air, water, or fluid soils must be determined by a registered design professional for support conditions, including effective unbraced lengths of shafts (those are not addressed in Table 8 of this report). The following are the allowable stress design (ASD) shaft capacities:

- Allowable compression capacity: Reference Table 8
- Allowable tension capacity: Reference Table 9
- Allowable lateral shear capacity: Reference Table 9
- Allowable bending capacity: Reference Table9
- Torque rating: Reference Tables 1A and 2A

The elastic shortening/lengthening of the pile shaft will be controlled by the strength and section properties of the $3^1/_2$-inch-diameter (88.9 mm) shaft sections and the 4-inch-diameter (101.6 mm) coupler(s), as applicable. The elastic deflection of the piling will be limited to 0.000241 inch per lineal foot of shaft length per kips of axial load (0.00451 mm per lineal meter of shaft length per kN of axial load) plus 0.0000589 inch per coupler per kips of axial load (0.000336 mm per coupler per kN of axial load). The mechanical properties of the shaft sections are shown in Tables 1B and 1C and can be used to calculate the anticipated settlements due to elastic shortening/lengthening of the pile shaft.

4.1.4 Helix Plate Capacity: Up to three plates can be placed on a single helical pile. The helical plates are spaced in accordance with Section 3.2.2 of this report. For helical plates with more than one helix, the allowable helix capacity for the helical foundation system may be taken as the sum of the least allowable capacity of each individual helix. The helix allowable axial compression and tension capacities are listed in Table 10.

4.1.5 Soil Capacity: The design axial compressive and tensile load capacities of helical piles based on soil resistance must be determined by a registered design professional in accordance with a site-specific geotechnical report, as described in Section 4.1.1, combined with the individual helix bearing method (Method 1), or from field loading tests conducted under the supervision of a registered design professional, as applicable (Method 2). For either Method 1 or Method 2, the predicted axial load capacities must be confirmed during the site-specific production installation, such that the allowable axial load capacities predicted by the torque correlation method must be equal to or greater than that predicted by Method 1 or 2, described above.

With the individual helix bearing method, the nominal axial load capacity of the helical pile is determined as the area of the helical bearing plate times the ultimate bearing capacity of the soil or rock bearing strata for the plate.

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

With the torque correlation method, the ultimate and allowable axial load capacities of the helical pile are predicted as follows:

$$Q_{ult} = K_t T \quad \text{(Eq. 1)}$$

$$Q_{all} = 0.5\, Q_{ult} \quad \text{(Eq. 2)}$$

where:

Q_{ult} = Ultimate axial tensile or comp capacity (lbf or N) of the helical pile.

Q_{all} = Allowable axial tensile or comp capacity (lbf or N) of the helical pile.

K_t = Torque correlation factor of 7 ft^{-1} (23.0 m^{-1}) in compression and of 7 ft^{-1} (19.7 m^{-1}) in tension for the $3^1/_2$-inch-outside-diameter (88.9 mm) round shaft.

T = Final installation torque in ft-lbf or N-m, which must not exceed the maximum installation torque prescribed in Tables 1A and 2A.

The maximum ultimate and maximum allowable axial compression and tension capacities predicted by the 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 Tables 1A and 2A, on soil capacities.

The lateral capacity of the pile referenced in Table 11 of this report is based on field testing of the P3-8 helical pile with an 8-inch-diameter single helix plate installed in a very stiff clay soil with a minimum SPT blow count of 26 at a minimum embedment of 18 feet (5.5 m). For soil conditions other than very stiff clay, the lateral capacity of the pile must be determined by a registered design professional.

4.1.6 Helical Pile Foundation System: The overall allowable axial capacity of the Techno Metal Post helical foundation system (in axial tension and axial compression) depends upon the analysis of interaction of brackets, shafts, helical plates and soils, and must be the lowest value of those for bracket capacity, shaft capacity, helical bearing plate capacity and allowable soil capacity. The overall allowable axial capacity and allowable lateral capacity must be limited to no more than 60 kips (266.9 kN) and 6 kips (26.7 kN), respectively, as required by Section 3.8 of AC358. The overall allowable lateral capacity of the Techno Metal Post helical foundation system depends upon the analysis of interaction of brackets, shafts, and soils, and must be the lowest value of those for bracket capacity, shaft capacity, and allowable soil capacity.

4.1.7 Foundation System (under the 2015, 2012 and 2009 IBC): Under the 2015, 2012 and 2009 IBC, the additional requirements noted in this section (Section 4.1.7) must be satisfied. For all design methods permitted under Section 4.1.1 of this report, the allowable axial compressive and tensile load of the helical pile system must be based on the least of the following conditions in accordance with 2015, 2012 and 2009 IBC Section 1810.3.3.1.9:

- Allowable load predicted by the individual helix bearing method (or Method 1) described in Section 4.1.5 of this report.
- Allowable load predicted by the torque correlation method described in Section 4.1.5 of this report.
- Allowable load predicted by dividing the ultimate capacity determined from load tests (Method 2 described in Section 4.1.5) by a safety factor of at least 2.0. This allowable load will be determined by a registered design professional for each site-specific condition.
- Allowable capacities of the shaft and shaft couplings. See Section 4.1.3 of this report.

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- Sum of the allowable axial capacity of helical bearing plates affixed to the pile shaft. See Section 4.1.4 of this report.
- Allowable axial load capacity of the bracket. See Section 4.1.2 of this report.

4.2 Installation:

4.2.1 General: The helical pile systems must be installed in accordance with this section (Section 4.2), 2015, 2012 and 2009 IBC Section 1810.4.11, the site-specific approved construction documents (engineering plans and specifications), and the manufacturer's written installation instructions. In case of a conflict, the most stringent governs. The Techno Metal Post helical foundation systems must be installed only by Techno Metal Post trained and certified installers. All installers' training is provided at the Techno Metal Post headquarters located in Thetford Mines, Quebec, Canada. All Techno Metal Post installers receive a certificate which states that the installer has received the required training.

4.2.2 Pile Installation:

1. The helical piles must be located and installed in accordance with the site-specific approved construction documents.
2. The hydraulic installation equipment is placed about 3 feet (914 mm) away from where the pile is to be installed.
3. A rotating head is attached to the pile top end using a $^{3}/_{4}$-inch-diameter steel bolt.
4. The pile must be positioned in a perfect plumb line by using the hydraulic equipment's remote control mechanism.
5. The pile shaft is screwed into the ground by applying a constant vertical downward force using the hydraulic equipment.
6. Helical piles must be installed vertically plumb into the ground with a ±1 degree of tolerance. The torque induced within the shaft depends on the density of surrounding soils. The shaft maximum installation torque capacities are provided in Tables 1A and 2A, and cannot be exceeded during pile installation.
7. The helical piles must be installed at a constant and continuous pace, at a rate of less than 25 revolutions per minute.
8. The pile shaft must be checked at close time intervals to ensure that the pile is vertically plumb with a ±1 degree of tolerance from the vertical and that the pile location is as prescribed in the approved plans with a maximum tolerance of $^{1}/_{2}$ inch (12.7 mm). Adjustment may be necessary in order to maintain the prescribed plumb and position tolerance.
9. The gauge pressure must be checked at close time intervals in order to confirm the density of the soil.
10. The gauge pressures and final depth must be recorded. The final pressure (final torque) must be an average of pressure/torque values within the last 2 feet (610 mm) of the pile installation.
11. The final depth must comply with the approved construction documents, if applicable, such as minimum depth required for frost protection.
12. Using the torque correlation formula describe evaluation report, the allowable axial tens compression capacities are estimated.
13. If required, extensions can be installed in c the helix plate to reach a suitable soil-bearing stratum. Extensions must be selected based on approved plans as specified per the site conditions by a registered design professional. When the lead shaft is almost completely driven into the ground, an extension is aligned vertically over the lead shaft. The connection between the lead section and the extension is facilitated by a coupling or reinforced coupling device (as required by the approved construction document), which is already factory-welded on the top end of the lead or extension section when it is manufactured. The extension is welded by the installer to the coupler located at the top of the shaft. The field-welding must comply with Sections 3.2.3 and 3.3.3 of this report, AISC 360 and the IBC. After the extension is welded to the lead section, it is driven into the ground in the same manner as the lead section. Every additional extension needed is installed and welded to the preceding extension in the same way.
14. In order to avoid group effect for lateral loading, the center-to-center spacing of helical piles in the direction of lateral force must be at least eight times the pile shaft outside diameter, and the spacing between helical plates must not be less than 3D, where D is the diameter of the largest helical plate measured from the edge of the helical plate to the edge of the adjacent helical pile plate, and 4D, where the spacing is measured from the center to the center of the adjacent helical pile plates.
15. In order to avoid group effect for axial loading, the center-to-center spacing of helical piles must be at least three times the diameter of the largest helix plate at the depth of bearing.
16. In tension applications, the helical pile shall be installed such that the minimum depth from the ground surface to the helix is 12D, where D is the diameter of the helix.
17. When the pile has reached the required depth, the rotary head is removed from the shaft, and the surrounding soils must be consolidated.
18. When the helical pile is installed to the required and appropriate depth as determined in accordance with the approved construction document by a registered design professional, the top of the last extension, which exceeds the elevation needed for fitting with the supported structure, may be cut to the appropriate elevation.
19. The required bracket per the approved plans must be attached by the installer to the top of the shaft by a bolted and/or welded connection in accordance with Sections 3.2 and 3.3 of this report.
20. The field cutting, bolting and welding must be in accordance with the most restrictive requirements described in this evaluation report, IBC, AISC 360, and the manufacturer's written instructions. As a minimum, field-welds must be fillet welds having a minimum size of $^{1}/_{4}$ inch (6.4 mm), and weld length must match the full interface length of connected steel elements. The welds must be made with E70xx filler metal and the welded joint must be an AISC 360 prequalified welded joint.

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21. The installer must affix the product label, which is provided by the report holder, to the top of the shaft. The label must comply with the requirements noted in Section 7.0 of this report.

4.2.3 Bracket Installation: In addition to requirements in Section 4.2.2, the bracket installation must comply with the applicable requirements noted in Section 4.2.3. For PC, PU4B, PU5B, PSC, and PIB brackets, as a minimum, the bolts used to connect the bracket sleeve and the pile shaft must be tightened to achieve a snug-tight condition as defined in Section J3 of AISC 360.

4.2.3.1 PC5, PC6 and PC8: The installation must comply with requirements prescribed in Sections 3.2.4.1, 3.3.4 and 3.3.4.1, and Tables 4A, 4B and 4C.

4.2.3.2 PU4 and PU5: The installation must comply with requirements prescribed in Sections 3.2.4.2, 3.3.4, and 3.3.4.2, and Tables 5A through 5E.

4.2.3.3 PU4B and PU5B: The installation must comply with requirements prescribed in Sections 3.2.4.3, 3.3.4 and 3.3.4.3, and Tables 5A through 5E. The connections between the bracket and a wood beam are identical to those for PU4 and PU5 brackets.

4.2.3.4 PSC5, PSC6 and PSC8: The installation must comply with requirements prescribed in Sections 3.2.4.4, 3.3.4 and 3.3.4.4, and Tables 6A and 6B. The bolted connection between a base plate and the bracket cap plate must meet the minimum requirements prescribed in Tables 6A and 6B and must meet AISC 360 for a pretensioned connection, or a slip-critical connection, as prescribed in the approved construction document.

4.2.3.5 PIB5, PIB6 and PIB8: The bracket installation must comply with the applicable requirements prescribed in Sections 3.2.4.5 and 3.3.4, Figure 7, and Tables 7A through 7C.

4.2.4 Quality Control Inspection: A quality control inspection must be provided by the pile installer for every project. For heavy residential (A heavy residential project is defined as a project in which a pile supports an ASD axial load that is larger than 9.5 kips), commercial and industrial projects, an engineer employed by Techno Metal Post must supervise all helical pile installations. As a minimum, the quality control inspection must include verifying the following: helical pile depth; space between helical piles; inclination and position of each helical pile; installation torque and depth of each helical pile; the allowable soil capacities for tension and compression through correlations with final installation torques; and the appropriateness of the installed brackets. If the pile installer is uncertain about any aspect of the installation, he must contact the Techno Metal Post engineering team. For all projects, the installer must provide a field report, signed and sealed by a registered design professional, to the project owner or his designated representative, and to the code official. A sample of a field report, including the minimum required information to be included, can be obtained from the report holder.

4.3 Special Inspections:

Special inspection in accordance with Section 1705.9 of the 2015 and 2012 IBC (Section 1704.10 for the 2009 IBC, and Section 1704.9 for the 2006 IBC) must be performed continuously during the installation of the Techno Metal Post helical foundation systems (piles and brackets). Where on-site cutting, bolting or welding is required, inspection in accordance with IBC Section 1705.2 of the 2015 and 2012 IBC (Section 1704.3 for the 2009 and 2006 IBC) is also required. Items to be recorded and confirmed by the special inspector but are not limited to, the following:

1. Verification of the product manufacturer a manufacturer's certification of installers.
2. Product configuration and identification (including catalog numbers) for lead sections, extension sections, and brackets.
3. Installation equipment used.
4. Written installation procedures.
5. Wood screws, bolts, nuts and washers as specified in the approved construction documents and this evaluation report.
6. Fielding cutting, bolting and welding as specified in the approved construction documents and this evaluation report.
7. Weld filler metal compliance with the specifications; weld filler metal identification; qualification of welders; use of appropriate welding materials; storage conditions of welding materials; welding joint preparations; weld size, length and location; conformance of welding procedure with the appropriate AISC 360 and AWS D1.1 requirements; fabrication tolerance.
8. Fasteners (bolt, nut and washer): manufacturer's certifications available for fastener materials; fasteners marked in accordance with ASTM requirements; proper bolting procedure selected for joint detail; connecting elements, including the appropriate faying surface condition and hole preparation, if specified, meet applicable requirements; pre-installation verification testing by installation personnel observed and documented for fastener assemblies and methods used; proper storage provided for bolts, nuts, washers and other fastener components; joint brought to the snug-tight condition prior to the pretensioning operation; fasteners are pretensioned in accordance with the AISC 360 and RCSC Specification and Sections 4.1.2.4 and 4.2.3.4, as applicable.
9. Inclination and position of helical piles.
10. Tip elevations, installation torque and depth of helical piles.
11. Compliance of the installation with the approved construction documents and this evaluation report, including conditions and limitations described in the footnotes to the tables in this report.

5.0 CONDITIONS OF USE

The Techno Metal Post helical foundation systems described in this report comply with, or are suitable alternatives to what is specified in, those codes noted in Section 1.0 of this report, subject to the following conditions:

5.1 The Techno Metal Post helical foundation systems are manufactured, identified and installed in accordance with this report, the approved construction documents (engineering drawings and specifications), and the manufacturer's written installation instructions, which must be available at the jobsite at all times during installation. In case of a conflict, the most stringent requirement governs.

5.2 The Techno Metal Post helical foundation systems have been evaluated for support of structures assigned to Seismic Design Categories A, B and C

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in accordance with IBC Section 1613. Helical foundation systems that support structures assigned to Seismic Design Category D, E or F, or that are located in Site Class E or F, 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 All brackets must be used only to support structures that are laterally braced as defined in Section 1810.2.2 of the 2015, 2012 and 2009 IBC (Section 1808.2.5 for the 2006 IBC). Shaft couplings must be located within firm or soft soil as defined in Section 4.1.3.

5.4 The helical foundation systems must not be used in conditions that are indicative of potential pile deterioration or corrosion situations as defined by the following: (1) soil resistivity less than 1,000 ohm-cm; (2) soil pH less than 5.5; (3) soils with high organic content; (4) soil sulfate concentrations greater than 1,000 ppm; (5) soils located in a landfill, or (6) soil containing mine waste.

5.5 Zinc-coated steel and bare steel components must not be combined in the same system, except that plain ASTM A490 bolts can be used with galvanized brackets since the sacrificial thickness for the zinc-coated components is taken as that given for bare steel components as permitted by Section 3.9 of AC358, and a 50-year corrosion life has been considered for all steel components under this evaluation report. All helical foundation 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.

5.7 To comply with requirements found in Section 1810.3.1.3 of the 2015, 2012 and 2009 IBC (Section 1808.2.8.8 for the 2006 IBC), the superstructure must be designed to resist the effects of helical pile eccentricity.

5.8 Special inspection is provided in accordance with Section 4.3 of this report.

5.9 Engineering calculations and drawings, in accordance with recognized engineering principles as described in IBC Section 1604.4, and complying with Section 4.1 of this report, are prepared by a registered design professional and approved by the code official.

5.10 The adequacy of the supported structures that are connected to the brackets must be verified by a registered design professional in accordance with applicable code provisions, and subjected to the approval of the code official.

5.11 A geotechnical investigation report for each project site must be provided to the code official for approval in accordance with Section 4.1.1 of this report.

5.12 The load combinations prescribed in IBC Section 1605.3.1 or 1605.3.2 must be used to determine the applied loads. When using the alternative basic load combinations prescribed in IBC Section 1605.3.2, the allowable stress increases permitted by material chapters of the IBC or the referenced standards are prohibited.

5.13 For lateral load, the minimum center-to spacing of helical piles in the direction of late must be at least eight times the pile shaft diameter; and the spacing between helica must not be less than 3D, where D is the diar the largest helical plate measured from the edge of the helical plate to the edge of the adjacent helical pile plate, and 4D, where the spacing is measured from the center to the center of the adjacent helical pile plates. For axial load, the minimum center-to-center spacing of helical piles must not be less than three times the diameter of largest helix plate at the depth of bearing. 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. Load reductions are subject to the approval of the code official.

5.14 In tension applications, the helical pile must be installed such that the minimum depth from the ground surface to the helix is 12D, where D is the diameter of the helix.

5.15 Settlement of helical piles is beyond the scope of this evaluation report and must be determined by a registered design professional as required in Section 1810.2.3 of the 2015, 2012 and 2009 IBC (Section 1808.2.12 of the 2006 IBC) upon consultation with the report holder.

5.16 The applied loads must not exceed the allowable capacities described in Section 4.1 of this report.

5.17 Evaluation of compliance with Section 1810.3.11.1 of the 2015, 2012 and 2009 IBC (Section 1808.2.23.1.1 of the 2006 IBC) for buildings assigned to Seismic Design Category (SDC) C, and with IBC Section 1810.3.6 of the 2015, 2012 and 2009 IBC (Section 1808.2.7 of the 2006 IBC) for all buildings, is outside of the scope of this evaluation report. Such compliance must be addressed by a registered design professional for each site, and is subject to approval by the code official.

5.18 Requirements set forth in Tables 1A through11, including footnotes, must be satisfied.

5.19 The Techno Metal Post helical foundation systems are manufactured at Techno Metal Post facility located in Thetford Mines, Québec, 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 2013 (editorially revised September 2014).

7.0 IDENTIFICATION

Every helical pile and bracket of the Techno Metal Post helical foundation systems described in this report is identified with a serial number (tracking number) engraved in the metal of the shaft and bracket. Additionally, a product label is installed on the jobsite by the installer to the top of each shaft, and includes the report holder's name (Techno-Pieux Inc.) and address, the product catalog number and description, the ICC-ES evaluation report number (ESR-3418).

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FIGURE 1A—TYPICAL HELICAL PILE LEAD SECTIONS (SINGLE HELIX)

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FIGURE 1B—TYPICAL HELICAL PILE LEAD SECTIONS (TWO OR THREE HELICES)

TABLE 1A—DESCRIPTION AND AXIAL SOIL CAPACITY OF PILE LEAD SECTIONS[1,2,3]

	Product name.	Length (A)	Outside Diameter (B)	Nominal Shaft Thickness	Helix Outside Diameter (C)	K_t	Installation Torque	Max. Ultimate Capacity	Max. Allowable Capacity	Helix Specification	Shaft Specification	Helix Thickness (T)
		(feet)	(inches)	(inches)	(inches)	(ft^{-1})	(lb-ft)	(kips)	(kips)			(inches)
Compression	P3-8	Section 3.2.1	Section 3.2.1	Section 3.2.1	8	7	11000	74.1	37.1	Section 3.3.2	Section 3.3.1	Section 3.2.2
	P3-10				10							
	P3-12				12							
	P3-8,10				8 and 10							
	P3-8,12				8 and 12							
	P3-10,12				10 and 12							
	P3-8,10,12				8, 10 and 12							
Tension	P3-8	Section 3.2.1	Section 3.2.1	Section 3.2.1	8	7	11000	77	38.5	Section 3.3.2	Section 3.3.1	Section 3.2.2
	P3-10				10							
	P3-12				12							
	P3-8,10				8 and 10							
	P3-8,12				8 and 12							
	P3-10,12				10 and 12							
	P3-8,10,12				8, 10 and 12							

For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 kip = 4.448 kN, 1lbf-ft = 1.356 N-m, 1 ft^{-1} = 3.2808 m^{-1}.

[1]Refer to Figure 1 for shaft dimension designations.

[2]Refer to Section 4.1.5 for soil capacity, and Section 4.1.6 for pile system capacity.

[3]The ultimate and allowable soil capacities listed in this table are the smaller of the torque-correlation predicted maximum axial capacities and the axial verification test results.

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TABLE 1B—MECHANICAL PROPERTIES OF 3.5 INCH DIAMETER HELICAL SHAFT (HSS3.500X0.216)

Mechanical Properties	After Corrosion Loss
Steel Yield Strength, F_y	51 ksi (317 MPa)
Steel Ultimate Strength, F_u	62 ksi (427 MPa)
Modulus of Elasticity, E	29,000 ksi (200,000 MPa)
Nominal Wall Thickness	0.216 in (5.5 mm)
Design Wall Thickness	0.166 in (4.2 mm) (0.036 in [0.9144 mm] loss as per AC358 Section 3.9)
Outside Diameter	3.464 in (88.0 mm)
Inside Diameter	3.132 in (79.6 mm)
Cross Sectional Area	1.71 in^2 (1,103 mm^2)
Moment of Inertia, I	2.33 in^4 (969,819 mm^4)
Radius of Gyration, r	1.17 in (29.7 mm)
Section Modulus, S	1.35 in^3 (22,123 mm^3)
Plastic Section Modulus, Z	1.80 in^3 (29,497 mm^3)

TABLE 1C—MECHANICAL PROPERTIES OF 3.5 INCH DIAMETER HELICAL SHAFT (HSS3.500X0.300)

Mechanical Properties	After Corrosion Loss
Steel Yield Strength, F_y	51 ksi (317 MPa)
Steel Ultimate Strength, F_u	62 ksi (427 MPa)
Modulus of Elasticity, E	29,000 ksi (200,000 MPa)
Nominal Wall Thickness	0.300 in (7.6 mm)
Design Wall Thickness	0.243 in (6.17 mm) (0.036 in [0.9144 mm] loss as per AC358 Section 3.9)
Outside Diameter	3.464 in (88.0 mm)
Inside Diameter	2.978 in (75.6 mm)
Cross Sectional Area	2.459 in^2 (1,586 mm^2)
Moment of Inertia, I	3.207 in^4 (1,334,854 mm^4)
Radius of Gyration, r	1.142 in (29.0 mm)
Section Modulus, S	1.852 in^3 (30,348 mm^3)
Plastic Section Modulus, Z	2.526 in^3 (41,295 mm^3)

[1]Refer to Table 1A for shaft dimension designations.

FIGURE 2—TYPICAL SHAFT EXTENSIONS[1]

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TABLE 2A—DESCRIPTION AND AXIAL SOIL CAPACITY OF PILE EXTENSIONS[1,2,3]

	Product name	Length (A)	Outside Diameter (B)	Nominal Shaft Thickness	K_t	Max. Installation Torque	Max. Ultimate Capacity	Max. Allowable Capacity	Shaft Specification
		(feet)	(inch)	(inch)	(ft^{-1})	(ft-lb)	(kips)	(kips)	
Compression	R3N	Section 3.2.1	Section 3.2.1	Section 3.2.1	7	11000	74.1	37.1	Section 3.3.1
Tension	R3N	Section 3.2.1	Section 3.2.1	Section 3.2.1	7	11000	77	38.5	Section 3.3.1

For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 kip = 4.448 kN, 1lbf-ft = 1.356 N-m, 1 ft^{-1} = 3.2808 m^{-1}.

[1]Refer to Figure 2 for shaft dimension designations.

[2]Refer to Section 4.1.5 for soil capacity, and Section 4.1.6 for pile system capacity.

[3]The ultimate and allowable soil capacities (P4) listed in this table are the smaller of the torque-correlation predicted maximum axial capacities and the axial verification test results.

FIGURE 3A—COUPLING

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FIGURE 3B—REINFORCED COUPLING

TABLE 3—DESCRIPTION AND SPECIFICATIONS OF THE COUPLING AND THE REINFORCED COUPLING

Product Name	Coupling (UE-3) and Reinforced Coupling (UER-3)		Field Weld	
	Dimensions	Material Specification	Dimensions	Specification
UE-3 and UER-3	Section 3.2.3	Section 3.3.3	Section 3.2.3	Section 3.3.3

FIGURE 4A—PC BRACKETS EMBEDDED IN A CONCRETE FOUNDATION

TABLE 4A—PC5, PC6 AND PC8 BRACKET SPECIFICATIONS

Product Name	**Cap Plate**		**Sleeve**		**Fasteners**	
	Dimensions	**Specification**	**Dimensions**	**Specification**	**Dimensions**	**Specification**
PC5	Section 3.2.4.1	Section 3.3.4	Section 3.2.4.1	Section 3.3.4	Section 3.2.4.1	Section 3.3.4
PC6	Section 3.2.4.1	Section 3.3.4	Section 3.2.4.1	Section 3.3.4	Section 3.2.4.1	Section 3.3.4
PC8	Section 3.2.4.1	Section 3.3.4	Section 3.2.4.1	Section 3.3.4	Section 3.2.4.1	Section 3.3.4

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FIGURE 4B—ILLUSTRATION OF PC5, PC6 AND PC8 STEEL BRACKET CONCRETE COVERS

TABLE 4B—PC5, PC6 AND PC8 BRACKET ALLOWABLE AXIAL AND LATERAL LOAD CAPACITY [1]

Product Name	Axial Compression		Axial Tension		Lateral Load
	Min. Concrete Cover[2]	Full Concrete Cover[3]	Min. Concrete Cover[2]	Full Concrete Cover[3]	Min. and Full Concrete Cover[4]
	(kips)	(kips)	(kips)	(kips)	(kips)
PC5	7.3	31.17	1.22	11.38	0.67
PC6	8.2	42.46	1.43	11.38	0.79
PC8	9.8	47.10	1.84	11.38	1.03

For **SI:** 1 inch = 25.4 mm, 1 kip = 4.448 kN.
[1]Capacities include allowance for corrosion over a 50-year service life.
[2]Refer to Figure 4B and Table 4C for the code-prescribed minimum concrete cover dimensions.
[3]Refer to Figure 4B and Table 4C for the required full concrete cover dimensions such that concrete related limit states do not govern the bracket capacity.
[4]Based on the following conditions: (1) A edge distance of 4-inches; and (2) concrete cover thickness varies between the minimum cover and the full concrete cover, as described in Table 4C.

TABLE 4C—PC5, PC6 AND PC8 BRACKET CONCRETE STRENGTH AND COVERS[1]

Product Name	Concrete Specified Compressive Strength[4]	Overall Horizontal Dimension	Edge Distance	Minimum Concrete Covers[2]		Full Concrete Covers[3]			
						For Axial Compression		For Axial Tension	
		B[5]	C[5]	X1	X2	X1	X2	X1[6]	X2
	(psi)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)
PC5	2500	13	4	3	4	3	10.1	7.4	4
PC6		14				3	11.7	7.1	4
PC8		16				3	11.7	6.5	4

For **SI:** 1 inch = 25.4 mm, 1 psi = 6.895 kPa.
[1]See Figure 4B for concrete cover designations.
[2]Minimum concrete covers are prescribed in IBC Section 1810.3.11 of the 2015, 2012 and 2009 IBC (Section 1808.2.4 of the 2006 IBC).
[3]Full concrete covers are determined to ensure that concrete related limit states do not govern the bracket capacities.
[4]Concrete strength is the specified compressive strength at 28 days, see Section 3.3.4.1.
[5]Dimensions B and C apply to both bracket width and length directions.
[6]For dimension X1 determination, in accordance with Section 14.5.1.7 of ACI 318-14 under the 2015 IBC and Section 22.4.7 of ACI 318-11 and ACI 318-08 under the 2012 and 2009 IBC (Section 22.4.8 of ACI 318-05 under the 2006 IBC), concrete is assumed cast against soil, and a 2-inch extra concrete thickness is include in X1.

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FIGURE 5A—WELDED U BRACKETS (PU4 and PU5) ATTACHED TO WOOD BEAMS

FIGURE 5B—BOLTED U BRACKETS (PU4B and PU5B) ATTACHED TO WOOD BEAMS

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TABLE 5A—STEEL U BRACKETS (PU4, PU5, PU4B AND PU5B) AND CONNECTION SPECIFICATIONS

Product Name	U Plate		Field Weld		Sleeve		Bolt, Nut and Was	
	Dimensions	Specification	Dimensions	Specifications	Dimensions	Specification	Dimensions	Specif
PU4	Section 3.2.4.2	Section 3.3.4	Section 3.2.4.2	Section 3.3.4	NA	NA	NA	N
PU5	Section 3.2.4.2	Section 3.3.4	Section 3.2.4.2	Section 3.3.4	NA	NA	NA	NA
PU4B	Section 3.2.4.3	Section 3.3.4	NA	NA	Section 3.2.4.3	Section 3.3.4	Section 3.2.4.3	Section 3.3.4
PU5B	Section 3.2.4.3	Section 3.3.4	NA	NA	Section 3.2.4.3	Section 3.3.4	Section 3.2.4.3	Section 3.3.4

TABLE 5B—STEEL U BRACKETS (PU4, PU5, PU4B AND PU5B) SCREW FASTENER SPECIFICATIONS

Product Name	Wood Screws		Screw Length	Major Diameter	Root Diameter	Bending Yield Strength	Screw Standard
	Number of Screws	Screw Size					
			(inches)	(inches)	(inches)	(ksi)	
PU4 and PU4B	4	#14	2	0.242	0.196	70	ANSI/ASME B18.6.1
PU5 and PU5B	4	#14	3	0.242	0.196	70	ANSI/ASME B18.6.1

For **SI:** 1 inch = 25.4 mm, 1 ksi = 6.895 MPa.

TABLE 5C—PU4, PU4B, PU5 AND PU5B BRACKET ALLOWABLE COMPRESSION CAPACITY (WITH RESPECT TO WOOD REFERENCE DESIGN VALUE)[1,2]

$F_{c\perp}$[3]	PU4	PU4B	PU5	PU5B
(psi)	(kips)	(kips)	(kips)	(kips)
200	2.27	2.27	3.57	3.57
250	2.84	2.84	4.46	4.46
300	3.40	3.40	5.35	5.35
350	3.97	3.97	6.24	6.24
400	4.54	4.54	7.13	7.13
450	5.11	5.11	8.02	8.02
500	5.67	5.67	8.92	8.92
550	6.24	6.24	9.81	9.81
600	6.81	6.81	10.70	10.70
650	7.38	7.38	11.60	11.60
700	7.94	7.94	12.50	12.50
750	8.51	8.51	13.40	13.40
800	9.08	9.08	14.30	14.30
850	9.65	9.65	15.20	15.20
900	10.20	10.21	16.00	16.00

For **SI:** 1 kip = 4.448 kN, 1 psi = 6.895 kPa.

[1]Linear interpolation between wood compression perpendicular to grain values is permitted for the same bracket.

[2]See footnotes 1 and 2 under Table 5E.

[3]Reference design value of wood is compression perpendicular to grain.

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TABLE 5D—PU4 AND PU4B ALLOWABLE TENSION CAPACITY (WITH RESPECT TO WOOD SPECIFIC GRAVITY)[1]

G[2]	TENSION (lbf)	G[2]	TENSION (lbf)	G[2]	TENSION (lbf)
0.31	540	0.46	810	0.60	990
0.32	560	0.47	820	0.61	1000
0.33	590	0.48	840	0.62	1010
0.34	610	0.49	850	0.63	1030
0.35	640	0.50	860	0.64	1040
0.36	660	0.51	880	0.65	1050
0.37	680	0.52	890	0.66	1060
0.38	690	0.53	900	0.67	1070
0.39	710	0.54	910	0.68	1080
0.40	720	0.55	930	0.69	1100
0.41	740	0.56	940	0.70	1110
0.42	750	0.57	950	0.71	1120
0.43	770	0.58	970	0.72	1130
0.44	780	0.59	980	0.73	1140
0.45	790				

For **SI:** 1 lbf = 4.448 N.

[1]See footnotes 1 and 2 under Table 5E.

[2]G is the specific gravity of sawn lumber or equivalent specific gravity of engineered wood beams.

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TABLE 5E—PU5 AND PU5B ALLOWABLE TENSION CAPACITY (WITH RESPECT TO WOOD SPECIFIC GRAVITY)[1,2]

G[3]	TENSION (lbf)	G[3]	TENSION (lbf)	G[3]	TENSION (lbf)
0.31	540	0.46	810	0.60	990
0.32	560	0.47	820	0.61	1000
0.33	590	0.48	840	0.62	1010
0.34	610	0.49	850	0.63	1030
0.35	640	0.50	860	0.64	1040
0.36	660	0.51	880	0.65	1050
0.37	680	0.52	890	0.66	1060
0.38	690	0.53	900	0.67	1070
0.39	710	0.54	910	0.68	1080
0.40	720	0.55	930	0.69	1100
0.41	740	0.56	940	0.70	1110
0.42	750	0.57	950	0.71	1120
0.43	770	0.58	970	0.72	1130
0.44	780	0.59	980	0.73	1140
0.45	790				

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.448 N.

[1]The allowable tension capacities are limited by the wood screw connection capacities, which are based on the following end-use conditions and limitations:

- Actual lumber widths are 3.5 inches for PU4 and PU4B brackets, and 5.5 inches for PU5 and PU5B brackets.
- The wood beam is located at center of the bracket with respect to the bracket width dimension.
- A wet service factor of 0.67 is assumed for calculating the connection capacity.
- Wood will not experience sustained exposure to elevated temperatures such that the temperature factor is 1.0.
- Lumber is not incised such that the incising factor for the lumber is 1.0.
- A load duration factor of 1.6 is assumed for calculating the connection capacity.
- The distance between the end of the wood beam and the adjacent edge of the shaft must be greater than 3 inches (76.2 mm) such that the bearing area factor prescribed in 2015 and 2012 NDS equation (3.10-2) can be applied.
- All spacing, edge, and end distances are such that the geometry factor is 1.0.
- For brackets resisting axial tension (uplift) loading, the connection between wood screws and wood beam must be designed and detailed to provide additional mechanical reinforcement capable of transmitting all of the stresses that would otherwise need to be transmitted through tension perpendicular to grain within the wood members. Additionally, provisions of 2015, 2012 and 2005 NDS Section 3.4.3.3 apply to the screw connections. The design to address these requirements must be done by a registered design professional and is subjected to approval of the code official.
- In accordance with 2015, 2012, 2009 and 2006 IBC Section 2304.9.5, wood screws in contact with preservative-treated wood must be of hot-dipped zinc-coated galvanized steel or stainless steel.

[2]If any one of the conditions described in footnote 1, above, is not satisfied, the connection capacity must be revised based on calculations provided by a registered design professional, and the revised capacities must be subjected to the approval of the code official.

[3]G is the specific gravity of sawn lumber or equivalent specific gravity of engineered wood beams.

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FIGURE 6—PSC BRACKETS SUPPORTING STEEL COLUMNS

TABLE 6A—PSC BRACKET AND FASTENER SPECIFICATIONS [(1)(3)]

Product Name	BRACKET		BASE PLATE[2]	FASTENERS FOR SLEEVE		FASTENERS FOR BASE PLATE	
	Dimensions	Specification	Dimensions	Dimensions	Specification	Dimensions	Specification
PSC5	Section 3.2.4.4	Section 3.3.4	Section 3.2.4.4 & Footnote 2	Section 3.2.4.4	Section 3.3.4	Sections 3.2.4.4	Section 3.3.4
PSC6							
PSC8							

[1]The requirements for base plate, bolts, nuts and washers are the minimum requirements for the bracket connection. The approved engineering plans may have more stringent requirements that will take precedence over these minimum requirements. See footnote 1 in Table 6B for additional explanations.
[2]The calculations for bracket capacity assume that the base plate is stiff enough so that the compression loads are transferred directly to the wall of the shaft through direct bearing. In addition, the base plate, at a minimum, must have the same horizontal dimensions as those of the bracket cap plate, and the base plate thickness is at least 1.5 times that of the bracket cap plate. If these assumptions are not satisfied, a registered design professional must evaluate every applicable limit states along the load path from the column to the steel pile shaft, and determine the allowable compression load capacity.
[3]For bolted connection between base plate and bracket cap plate, only the limit states related to bolts and interaction between bracket and bolts are evaluated in this report. See footnote 1 in Table 6B for additional explanations.

TABLE 6B—PSC BRACKET ALLOWABLE AXIAL COMPRESSION AND AXIAL TENSION CAPACITY FOR SUPPORTING STEEL COLUMNS [(1,2)]

Product Name	Compression	Tension
	(kips)	(kips)
PSC5	31.17	11.38
PSC6	42.46	11.38
PSC8	55.37	11.38

For **SI:** 1 kip = 4.448 kN.
[1]The allowable capacities are based on the governing limit state of bracket, the bolts attaching base plate to the bracket cap plate, and the interaction between the cap plate and high-strength bolts. All other structural components and their limit states, such as base plate, welding between base plate and supporting column, the supporting column, and interaction between base plate and the high strength bolts, are outside of the scope of this evaluation, which must be evaluated by a registered design professional for each site-specific design condition and must be subjected to approval of the code official.
[2]See footnote 2 of Table 6A.

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FIGURE 7—PIB BRACKETS SUPPORTING STEEL I-BEAMS

TABLE 7A—PIB BRACKET AND WELD SPECIFICATIONS

Product Name	Bracket		Field Weld	
	Dimensions	Specification	Dimensions	Specifications
PIB5	Section 3.2.4.5	Section 3.3.4	Section 3.2.4.5	Section 3.3.4
PIB6	Section 3.2.4.5	Section 3.3.4	Section 3.2.4.5	Section 3.3.4
PIB8	Section 3.2.4.5	Section 3.3.4	Section 3.2.4.5	Section 3.3.4

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TABLE 7B—PIB BRACKET ALLOWABLE AXIAL COMPRESSION CAPACITY FOR SUPPORTING STEEL I-BEAMS[1]

PIB5	
Beam	**Compression (kips)**
W8X10	6.17
W8X13	10.77
W8X15	10.77
W10X12	6.70
W10X15	10.77
W10X17	10.77
W10X19	10.77
W12X14	6.37
W12X16	8.48
W12X19	10.34
W12X22	10.77

PIB6	
Beam	**Compression (kips)**
W8X10	6.17
W8X13	15.31
W8X15	18.48
W8X18	15.31
W8X21	19.67
W10X12	6.70
W10X15	11.89
W10X17	13.51
W10X19	15.28
W12X14	6.37
W12X16	8.48
W12X19	10.34
W12X22	13.99
W14X22	8.59
W14X26	11.70
W16X26	9.52

PIB8	
Beam	**Compress (kips)**
W8X10	6.17
W8X13	15.31
W8X15	18.48
W8X18	15.31
W8X21	19.67
W8X24	20.05
W10X12	6.70
W10X15	11.89
W10X17	13.51
W10X19	15.28
W10X22	13.51
W10X26	17.20
W12X14	6.37
W12X16	8.48
W12X19	10.34
W12X22	13.99
W12X26	9.70
W12X30	13.99
W14X22	8.59
W14X26	11.70
W14X30	13.89
W14X34	16.31
W14X38	21.00
W16X26	9.52
W16X31	12.68
W16X36	15.65
W16X40	17.31
W18X35	14.56
W18X40	16.87
W21X44	19.78
W24X55	24.73

For **SI:** 1 kip = 4.448 kN.

[1]The I-beams must have a minimum yield strength of 50 ksi (345 MPa) and a minimum tensile strength of 65 ksi (450 MPa).

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TABLE 7C—PIB BRACKET ALLOWABLE AXIAL TENSION CAPACITY FOR SUPPORTING STEEL I-BEAMS [1,2]

PIB5	
Beam	**Tension (kips)**
W8X10	3.93
W8X13	6.08
W8X15	7.70
W10X12	4.13
W10X15	6.82
W10X17	7.70
W10X19	7.70
W12X14	4.74
W12X16	6.57
W12X19	7.70
W12X22	7.70

PIB6	
Beam	**Tension (kips)**
W8X10	3.93
W8X13	6.08
W8X15	9.28
W8X18	10.19
W8X21	10.40
W10X12	4.13
W10X15	6.82
W10X17	10.19
W10X19	10.40
W12X14	4.74
W12X16	6.57
W12X19	10.40
W12X22	10.40
W14X22	10.40
W14X26	10.40
W16X26	10.40

PIB8	
Beam	**Tensio (kips)**
W8X10	3.93
W8X13	6.08
W8X15	9.28
W8X18	10.19
W8X21	11.38
W8X24	11.38
W10X12	4.13
W10X15	6.82
W10X17	10.19
W10X19	11.38
W10X22	11.38
W10X26	11.38
W12X14	4.74
W12X16	6.57
W12X19	11.38
W12X22	11.38
W12X26	11.38
W12X30	11.38
W14X22	10.50
W14X26	11.38
W14X30	11.38
W14X34	11.38
W14X38	11.38
W16X26	11.14
W16X31	11.38
W16X36	11.38
W16X40	11.38
W18X35	11.35
W18X40	11.38
W21X44	11.38
W24X55	11.38

For **SI:** 1 kip = 4.448 kN.

[1]The I-beams must have a minimum yield strength of 50 ksi (345 MPa) and a minimum tensile strength of 65 ksi (450 MPa).

[2]The adequacy of the beam and welds between the beam and the bracket must be verified by a registered design professional and must be subjected to approval of the code official.

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TABLE 8—SHAFT ALLOWABLE COMPRESSION CAPACITY[1] (kips)

Shaft Effective Unbraced Length (KLu)[2,3,4](ft)		0	4	5	6	7	8	9	10	11	12	13	14	[illegible]
Shaft Capacities (kip)	No Coupler[5]	52.2	24.7	21.4	18.7	16.4	14.4	12.7	11.2	9.9	8.7	7.7	6.8	[illegible]
	1 or 2 Couplers[5]	33.4	20.5	18.7	17.2	15.9	14.4	12.7	11.2	9.9	8.7	7.7	6.8	6.1

For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 kip = 4.448 kN.

[1]Capacities include allowance for corrosion over a 50-year service life and presume the supported structure is braced in accordance with Section 1810.2.2 of the 2015, 2012 and 2009 IBC (Section 1808.2.5 of the 2006 IBC). Additionally, capacities account for bending stresses caused by a maximum inclination from vertical of 1 degree.
[2]Lu = total pile unbraced length in accordance with Section 1810.2.1 of the 2015, 2012 and 2009 IBC (Section 1808.2.9 of the 2006 IBC), including the length in air, water or in fluid soils, and the embedment length into firm or soft soil (non-fluid soil).
[3]K = effective length factor for shaft compression buckling consideration.
[4]KLu = Total effective unbraced length of the pile, where KLu = 0 represents a fully braced condition in that the total pile length is fully embedded in firm or soft soil and the supported structure is braced as noted in footnote 1, above.
[5]Total number of couplers within the total pile length.

TABLE 9—SHAFT ALLOWABLE CAPACITY (EXCEPT AXIAL COMPRESSION) [1,2]

PILE MODEL	COMPRESSION	TENSION	LATERAL SHEAR	BENDING MOMENT	TORQUE RATING
	(kips)	(kips)	(kips)	(kip-ft)	(lb-ft)
Single or Multi-helix leads and extensions	Table 8	33.4	13.1	2.8	Tables 1A and 2A

For **SI:** 1 inch = 25.4 mm, 1 kip = 4.448 kN, 1lbf-ft = 1.356 N-m, 1kip-ft = 1.356 kN-m.

[1]Capacities include allowance for corrosion over a 50-year service life.
[2]Capacities are based on the lower capacity of the two components that are shaft and coupling.

TABLE 10—HELIX ALLOWABLE CAPACITY FOR AXIAL TENSION AND AXIAL COMPRESSION [1]

PILE MODEL[2]	Dimensions	Specification	ALLOWABLE CAPACITY
	(in.)		(kips)
P3-8	Section 3.2.2	Section 3.3.2	63.1
P3-10	Section 3.2.2	Section 3.3.2	57.7
P3-12	Section 3.2.2	Section 3.3.2	61.9

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

[1]Capacities include allowance for corrosion over a 50-year service life.
[2] See Section 4.1.4 of this report to address helix capacity of multi-helix configurations.

TABLE 11—HELICAL PILE ALLOWABLE LATERAL SOIL CAPACITY [1,2,3]

PILE MODEL	ALLOWABLE LATERAL CAPACITY		MINIMUM INSTALLATION DEPTH	
	(lbs)	(kN)	(ft)	(m)
P3-8	1,250	5.56	18	5.50

[1]Installation must be in accordance with Sections 4.1.5 and 4.2 of this report.
[2]Intallation is limited to piles in very stiff clay with a minimum SPT of 26 (See Section 4.1.5) and used with bracket PC5, PC6 or PC8 embedded in concrete foundations.
[3]For soil conditions other than very stiff clay, the lateral capacity of the pile must be determined by a registered design professional.