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ESR-2997

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Reissued 05/2018
Revised 01/2019
This report is subject to renewal 05/2020.

DIVISION: 31 00 00—EARTHWORK

SECTION: 31 63 00—BORED PILES

REPORT HOLDER:

MAGNUM PIERING, INC.

EVALUATION SUBJECT:

MAGNUM HELICAL FOUNDATION SYSTEMS

"2014 Recipient of Prestigious Western States Seismic Policy Council (WSSPC) Award in Excellence"

A Subsidiary of INTERNATIONAL CODE COUNCIL

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

REPORT HOLDER:

MAGNUM PIERING, INC.

EVALUATION SUBJECT

MAGNUM HELICAL FOUNDATION SYSTEMS

1.0 EVALUATION SCOPE

Compliance with the following codes:

2018, 2015, 2012 and 2009 *International Building Code®* (IBC)

Properties evaluated

Structural and geotechnical

2.0 USES

The Magnum Piering, Inc. (MAGNUM) helical foundation systems are used to form deep foundations for new structures and are designed to resist axial compression and tension loads from the supported structures.

3.0 DESCRIPTION

3.1 General:

The MAGNUM helical foundation systems consist of three helical pile types, including; two round shafts MH325BG and MH325BRG, and one square shaft MS150BG. All helical piles are made up of a central shaft (lead section) with one or more helical-shaped steel bearing plates (or helices), extension shaft(s), couplings that connect multiple shaft sections, and a bracket that allows for attachment to the supported structures. The shafts with helix bearing plates are 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 bracket is then installed to connect the pile to the concrete foundation of the supported structure.

The Magnum helical pile lead sections consist of one or more (up to three) helical-shaped circular steel plates factory-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 couplings, to form one, continuous steel pile. Extension sections also can have one or more helical-shaped circular steel plates factory-welded to the central steel shaft.

3.2 Round Shaft-Helical Pile System:

The two round shafts, MH325BG and MH325BRG, differ only by the coupling mechanism between shaft sections. There are seven different brackets that can be attached to these piles: the MHC1300-3K55BG and the MHC1300-3M6565BR2G; the MHC1080-31024B and the MHC1080-31024BR2; the MP1001-3, the MP1002-3 and the MP1005-3. The MHC-1300 brackets are both Type B Direct Load Brackets, the MHC1080 brackets are both Type D- Tension Load Brackets, and the MP brackets are all Type A Side Load Brackets, for attachment to structures. All Magnum helical piles and brackets are manufactured with zinc-galvanized steels.

The central steel shaft of lead sections and extension sections is a round, 3-inch (76.2 mm) minimum outside diameter, $^{1}/_{4}$-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS3.000×0.250).

Each steel helical bearing plate (helix) is $^{3}/_{8}$-inch (9.5 mm) thick and has spiral edge geometry with an outer diameter of 8, 10, 12 or 14 inches (203, 254, 305 or 356 mm). The helix pitch, which is the distance between the leading and trailing edges, is 3 inches (76.2 mm). The lead helix is located at about 4 inches (101.6 mm) from the tip (bottom end) of the shaft lead section. For multiple helix installation, the helical bearing plates are spaced at $25^{1}/_{2}$ inches (647.7 mm) on-center, alternating the lower edge side to side, along the central shaft. Typically, the smallest diameter helical bearing plate is placed near the tip (bottom) of the lead section and the largest diameter helical bearing plate is placed nearest the top (trailing end) of the lead section or on an extension section.

The coupling for MH325BG pile consists of a round, $5^{1}/_{8}$-inch-long (130.2 mm), $3^{5}/_{8}$-inch (92 mm) nominal outside diameter, $^{1}/_{4}$-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS3.625×0.250) outer sleeve, and one $^{7}/_{8}$-inch-diameter (22.2 mm), 4.5-inch-long (114.3 mm), hex headed bolt, and one matching hex nut, for attachment. The HSS sleeve is factory-welded to the lower end of the extension section. Both the HSS sleeve and the upper end of the lead section have holes that allow the sleeve and the shaft lead section to be through bolted together during the installation. Figure 1 illustrates the typical construction of a Magnum helical pile MH325BG.

The coupling for MH325BRG pile consists of a round, 7$^1/_8$-inch- (181.0 mm) long, 3$^3/_4$-inch (95.2 mm) nominal outside diameter, $^5/_{16}$-inch (7.9 mm) minimum wall thickness, hollow structural section (HSS3.750×0.3125) outer sleeve; a round, 6-inch-long (152.4 mm), 2$^1/_2$-inch (63.5 mm) maximum outside diameter, $^1/_4$-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS2.500×0.250) inner sleeve; and one 1-inch-diameter (25.4 mm), 5.0-inch-long (127.0 mm), hex headed bolt, and one matching hex nut, for attachment. The HSS outer sleeve is factory-welded to the lower end of the extension section. The HSS inner sleeve is snug fitted into the inside of the top end of the lead section. All three HSSs (outer sleeve, inner sleeve and the upper end of the shaft section) have holes that allow them to be through bolted together during the installation. Figure 2 illustrates the typical construction of a Magnum helical pile MH325BRG.

3.3 Square Shaft- Helical Pile System:

The square shaft MS150BG has three different brackets that can be attached; the MSC1300-150M55BG, the MSC1080-150824BG and the MP1030-150G. The MSC1300 bracket is a Type B Direct Load Bracket, the MSC1080 bracket is a Type D Tension Load Bracket, and the MP bracket is a Type A Side Load Bracket, for attachment to structures. All Magnum helical piles and brackets are manufactured with zinc galvanized steel.

The central shaft of lead sections and extension sections is a round corner square (RCS) steel bar, 1½-inch (76. 2 mm) square outside dimension.

Each steel helical bearing plate (helix) is $^3/_8$-inch (9.5 mm) thick and has spiral edge geometry with an outer diameter of 8, 10, 12 or 14 inches (203, 254, 305 or 356 mm). The helix pitch, which is the distance between the leading and trailing edges, is 3 inches (76.2 mm). The lead helix is located at about 4 inches (101.6 mm) from the tip (bottom end) of the shaft lead section. For multiple helix installation, the helical bearing plates are spaced at 25½ inches (647.7 mm) on-center, alternating the lower edge side to side, along the central shaft. Typically, the smallest diameter helical bearing plate is placed near the tip (bottom) of the lead section and the largest diameter helical bearing plate is placed nearest the top (trailing end) of the lead section or on an extension section.

The coupling for MS150BG pile consists of cast square coupling, 3-inch (130.2 mm) long, 2$^7/_{16}$-inch (92 mm) square nominal outside dimension, 0.35-inch (8.9 mm) minimum wall thickness and one $^7/_8$-inch-diameter (22.2 mm), 3-inch-long (114.3 mm) hex headed bolt, with matching hex nut, for attachment. The coupling is cast on the lower end of the extension section, Both the coupling and the upper end of the lead section have pre-drilled holes that allow the coupling and the shaft lead section to be through bolted together during installation. Figure 3 illustrates the typical construction of a Magnum helical pile MS150BG.

3.4 Brackets:

3.4.1 MHC1300-3K55BG Type B Direct Load Bracket: The Magnum MHC1300-3K55BG bracket consists of a round, 5$^1/_8$-inch-long (130.2 mm), 3$^5/_8$-inch (92 mm) nominal outside diameter, $^1/_4$-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS3.625×0.250) outer sleeve; a $^3/_8$-inch-thick (9.5 mm) by 5-inch (127 mm) square steel cap plate; and one $^7/_8$-inch-diameter (22.2 mm), 4.5-inch-long (114.3 mm), hex headed bolt, and one matching hex nut, for attaching the bracket to a MH325BG shaft. The HSS outer sleeve is factory-welded to the steel cap plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have one $^{15}/_{16}$-inch (23.8 mm) through-bolt hole located 2$^1/_{16}$ inches (52.4 mm) from end of pile shaft so as to allow the bracket sleeve and the pile shaft section to be through bolted together during the bracket installation. This bracket is intended to be embedded in cast-in-place concrete foundations. This bracket is used to support axial compressive loads that are concentric with the longitudinal axis of the shaft. Figure 4 illustrates the typical construction of a Magnum MHC1300-3K55BGG direct load bracket and its attachment to concrete structures. Refer to footnotes in Table 1 for requirements of concrete cover and end/edge distance.

3.4.2 MHC1300-3M6565BR2G Type B Direct Load Bracket: The Magnum MHC1300-3M6565BR2G bracket consists of a round, 10$^1/_8$-inch-long (257.1 mm), 3$^3/_4$-inch (95.2 mm) nominal outside diameter, $^5/_{16}$-inch (7.9 mm) minimum wall thickness, hollow structural section (HSS3.75×0.375) outer sleeve; a $^5/_8$-inch-thick (15.9 mm) by 6$^1/_2$-inch (165.1 mm) square steel cap plate; and two 1-inch-diameter (25.4 mm), 5.0-inch-long (127.0 mm), hex headed bolts, and two matching hex nuts, for attaching the bracket to a MH325BRG shaft. The HSS outer sleeve is factory-welded to the steel cap plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have two 1$^1/_{16}$-inch (27.0 mm) thru bolt holes located 3 inches (76.2 mm) from end of pile shaft and 3 inches (76.2 mm) on-center so as to allow the bracket sleeve and the pile shaft section to be through-bolted together during the bracket installation. This bracket is intended to be embedded in cast-in-place concrete foundations. This bracket is used to support axial compressive loads that are concentric with the longitudinal axis of the shaft. Figure 5 illustrates the typical construction of a Magnum MHC1300-3M6565BR2G direct load bracket and its attachment to concrete structures. Refer to footnotes in Table 1 for requirements of concrete cover and end/edge distance.

3.4.3 MHC1080-31024BG Type D Tension Load Bracket: The Magnum MHC1080-31024BG bracket consists of a round, 5$^1/_8$-inch-long (130.2 mm), 3$^5/_8$-inch (92 mm) nominal outside diameter, $^1/_4$-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS3.625×0.250) outer sleeve; a $^5/_8$-inch-thick (15.9 mm) by 4¼-inch (108 mm) diameter steel plate with a 1¼-inch (32 mm) hex nut; and one $^7/_8$-inch-diameter (22.2 mm), 4.5-inch-long (114.3 mm), hex headed bolt, and one matching hex nut, for attaching the bracket to a MH325BG shaft. The HSS outer sleeve and 1¼-inch (32 mm) hex nut is factory-welded to the steel cap plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have one $^{15}/_{16}$-inch (23.8 mm) through-bolt hole located 3 inches (76 mm) from end of pile shaft so as to allow the bracket sleeve and the pile shaft section to be through bolted together during the bracket installation. This bracket is intended to be used with No. 10 Magnum threaded rebar and plate with 1¼-inch (32 mm) hex nut to tie-back structural elements, thus loading the pile axially in tension along the longitudinal axis of the shaft. Figure 6 illustrates the typical construction of a Magnum MHC1080-31024BG tension load bracket and its attachment to structures.

3.4.4 MHC1080-31024BR2G Type D Tension Load Bracket: The Magnum MHC1080-31024BR2G bracket consists of a round, $10^1/_8$-inch-long (257 mm), $3^3/_4$-inch (95 mm) nominal outside diameter, $^5/_{16}$-inch (7.9 mm) minimum wall thickness, hollow structural section (HSS3.75×0.3125) outer sleeve; a $^5/_8$-inch-thick (15.9 mm) by 4¼-inch (108 mm) diameter steel plate with a 1¼-inch (32 mm) hex nut; and two 1-inch-diameter (25.4 mm), 5-inch-long (127 mm), hex headed bolts, and two matching hex nuts, for attaching the bracket to a MH325BRG shaft. The HSS outer sleeve and 1¼-inch (32 mm) hex nut is factory-welded to the steel cap plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have two $1^1/_{16}$-inch (27 mm) through-bolt holes located 3 inches (76 mm) from end of pile shaft and 3 inches (76 mm) on center so as to allow the bracket sleeve and the pile shaft section to be through bolted together during the bracket installation. This bracket is intended to be used with No. 10 Magnum threaded rebar and plate with 1¼-inch (32 mm) hex nut to tie-back structural elements, thus loading the pile axially in tension along the longitudinal axis of the shaft. Figure 7 illustrates the typical construction of a Magnum MHC1080-31024BR2G tension load bracket and its attachment to structures.

3.4.5 MP1001-3G Type A Side Load Bracket: The Magnum MP1001-3G bracket consists of a round, 8-inch-long (203 mm), $3^7/_8$-inch (98 mm) nominal outside diameter, $^3/_8$-inch (9.5 mm) minimum wall thickness, hollow structural section (HSS3.875×0.375) outer sleeve; a $^3/_8$-inch-thick (9.5 mm) by 8-inch (203 mm) by 21-inch (533 mm) steel plate and one to three $^3/_4$-inch-diameter (19.0 mm), 1¼-inch-long (32 mm), hex headed bolts, for attaching the bracket to a MH325BG or MH325BRG shaft. The HSS outer sleeve is factory-welded to the steel plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have one to three $^{11}/_{16}$-inch (17.5 mm) bolt holes located 2 inches (51 mm) from the end of the pile shaft and 2 inches (51 mm) on-center so as to allow the bracket sleeve and the pile shaft section to be bolted together during the bracket installation. This bracket is intended to be anchor-bolted to existing concrete foundations. This bracket is intended to support axial compressive loads. Figure 8 illustrates the typical construction of a Magnum MP1001-3G side load bracket and its attachment to concrete structures. Refer to footnotes in Table 3 for requirements of anchor bolts.

3.4.6 MP1002-3G Type A Side Load Bracket: The Magnum MP1002-3 bracket consists of a round, 8-inch-long (203 mm), $3^7/_8$-inch (98 mm) nominal outside diameter, $^3/_8$-inch (9.5 mm) minimum wall thickness, hollow structural section (HSS3.875×0.375) outer sleeve; a ½-inch-thick (12.7 mm) by 8-inch (203 mm) by 8-inch (203 mm) by 24-inch-long (610 mm) steel angle and one to three $^3/_4$-inch-diameter (19.0 mm), 1¼-inch-long (32 mm), hex headed bolts, for attaching the bracket to a MH325BG or MH325BRG shaft. The HSS outer sleeve is factory-welded to the steel angle. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have one to three $^{11}/_{16}$-inch (17.5 mm) bolt holes located 2 inches (51 mm) from the end of the pile shaft and 2-inches (51 mm) on-center so as to allow the bracket sleeve and the pile shaft section to be bolted together during the bracket installation. This bracket is intended to be anchor-bolted to existing concrete foundations. This bracket is intended to support axial compressive loads. Figure 9 illustrates the typical construction of a Magnum MP1002-3G side load bracket and its attachment to concrete structures. Refer to footnotes in Table 3 for requirements of anchor bolts.

3.4.7 MP1005-3G Type A Side Load Bracket: The Magnum MP1005-3G bracket consists of a round, 8-inch-long (203 mm), $3^7/_8$-inch (98 mm) nominal outside diameter, $^3/_8$-inch (9.5 mm) minimum wall thickness, hollow structural section (HSS3.875×0.375) outer sleeve; a ½-inch-thick (12.7 mm) by 8-inch (203 mm) by 8-inch (203 mm) by 12-inch-long (305 mm) steel angle and one to three $^3/_4$-inch-diameter (19.0 mm), 1¼-inch-long (32 mm), hex headed bolts, for attaching the bracket to a MH325BG or MH325BRG shaft. The HSS outer sleeve is factory-welded to the steel angle with gusset plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have one to three $^{11}/_{16}$-inch (17.5 mm) bolt holes located 2 inches (51 mm) from the end of the pile shaft and 2-inches (51 mm) on-center so as to allow the bracket sleeve and the pile shaft section to be bolted together during the bracket installation. This bracket is intended to be anchor-bolted to existing concrete foundations. This bracket is intended to support axial compressive loads. Figure 10 illustrates the typical construction of a Magnum MP1005-3G side load bracket and its attachment to concrete structures. Refer to footnotes in Table 3 for requirements of anchor bolts.

3.4.8 MSC1300-150M55BG Type B Direct Load Bracket: The Magnum MSC1300-150M55BG bracket consists of a round, 4-inch-long (102 mm), 2½-inch (64 mm) nominal outside diameter, $^1/_4$-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS2.5×0.250) outer sleeve; a ½-inch-thick (12.7 mm) by 5-inch (127 mm) square steel cap plate; and one $^7/_8$-inch-diameter (22.2 mm), 3-inch-long (76 mm), hex headed bolt, and one matching hex nut, for attaching the bracket to a MS150BG shaft. The HSS outer sleeve is factory-welded to the steel cap plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have one $^{15}/_{16}$-inch (23.8 mm) through-bolt hole located $1^1/_8$ inches (29 mm mm) from end of pile shaft so as to allow the bracket sleeve and the pile shaft section to be through bolted together during the bracket installation. This bracket is intended to be embedded in cast-in-place concrete foundations. This bracket is used to support axial compressive loads that are concentric with the longitudinal axis of the shaft. Figure 11 illustrates the typical construction of a Magnum MSC1300-150M55BG direct load bracket and its attachment to concrete structures. Refer to footnotes in Table 1 for requirements of concrete cover and end/edge distance.

3.4.9 MSC1080-150824BG Type D Tension Load Bracket: The Magnum MSC1080-150824BG bracket consists of a round, 4-inch-long (102 mm), 2½-inch (64 mm) nominal outside diameter, $^1/_4$-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS2.5×0.250) outer sleeve; a $^5/_8$-inch-thick (15.9 mm) by 3-inch (76 mm) diameter steel plate with a 1-inch (25.4 mm) hex nut; and one $^7/_8$-inch-diameter (22.2 mm), 3-inch-long (76 mm), hex headed bolt, and one matching hex nut, for attaching the bracket to a MS150BG shaft. The HSS outer sleeve and 1-inch (25.4 mm) hex nut is factory-welded to the steel cap plate. After helical pile installation and cut-off, the upper end of the shaft section must be field drilled to have one $^{15}/_{16}$-inch (23.8 mm) through-bolt hole located $1^1/_8$ inches (29 mm) from end of pile shaft so as to allow the bracket sleeve and the pile shaft section to be through bolted together during the bracket installation. This bracket is intended to be used with No. 8 Magnum threaded rebar and plate with 1-inch (25.4 mm) hex nut to tie-back structural elements, thus loading the pile axially in tension along the longitudinal axis of the shaft. Figure 12 illustrates the typical construction of a Magnum MSC1080-150824BG tension load bracket and its attachment to structures.

3.4.10 MP1030-150G Type A Side Load Bracket: The Magnum MP1030-150G bracket consists of two $^{3}/_{8}$-inch-thick (9.5 mm) gussets; a $^{3}/_{8}$-inch-thick (9.5 mm) by 8-inch (203 mm) by 8-inch (203 mm) by 14-inch-long (356 mm) formed steel angle; a 3-inch (76 mm) square tube, $^{3}/_{8}$-inch (9.5 mm) minimum wall thickness cross-member, and two $^{7}/_{8}$-inch threaded bars with two hex nuts per bar; a round 18-inch–long (457 mm), 3-inch (76 mm) nominal outside diameter, ¼-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS3x0.25) outer sleeve with a round 6-inch-long (152 mm), 2½-inch (64 mm) nominal outside diameter, ¼-inch (6.4 mm) minimum wall thickness, hollow structural section (HSS2.5x0.25) inner sleeve for receipt of MS150BG shaft. The gussets are factory-welded to the formed angle, the threaded bar is attached to the gussets and the cross-member slides over the two threaded bars to rest on the outer sleeve. The HSS outer sleeve is factory-welded to the inner sleeve. After helical pile installation and cut-off, the outer sleeve and inner sleeve slide over the pile shaft so as to allow cross-member to bear on the end of the pile shaft. This bracket is intended to be anchor bolted to existing concrete foundations. This bracket is used to support axial compressive loads. Figure 13 illustrates the typical construction of a Magnum MP1030-150G side load bracket and its attachment to concrete structures. Refer to footnotes in Table 3 for requirements of anchor bolts.

3.5 Material Specifications:

3.5.1 Round HSSs: The round HSSs, which are used for central shafts (lead and extension sections), of both MH325BG and MH325BRG piles, and the inner sleeve for the MH325BRG coupling, as well as sleeves of MSC1300-150M55BG direct load, MSC1080-150824BG tension load and MP1030-150G side load brackets, comply with ASTM A513, Type 1a, except with minimum yield and tensile strengths of 65 ksi and 80 ksi (448 and 551 MPa), respectively. The round HSSs, which are used for coupling sleeves of both MH325BG and MH325BRG piles, as well as sleeves of MHC1300-3K55BG and MHC1300-3M6565BR2G direct load, MHC1080-31024BG and MHC1080-31024BR2G tension load, and MP1030-150G MP1001-3G, MP1002-3G and MP1005-3G side load brackets, comply with ASTM A513, Type 5, DOM, with minimum yield and tensile strengths of 70 ksi and 80 ksi (483 and 551 MPa), respectively. All round HSSs have a coating grade 75, hot-dipped, galvanized coating complying with ASTM A123.

3.5.2 Round Corner Square Bar: The round corner square bar, which is used for the central shaft (lead and extension sections), of MS150BG, comply with ASTM A29, with minimum yield and tensile strengths of 90 ksi and 120 ksi (620 and 827 MPa), respectively.

3.5.3 Steel Plates: The steel plates, which are used for helical bearing plates, and cap plates of MHC1300-3K55BG, MHC1300-3M6565BR2G and MSC1300-150M55BG direct load, MHC1080-31024BG, MHC1080-31024BR2G and MSC1080-150824BG tension load, and MP1030-150G, MP1001-3G, MP1002-3G and MP1005-3G side load brackets, comply with ASTM A 36, with minimum yield and tensile strengths of 36 ksi and 58 ksi (248 and 400 MPa), respectively. All steel plates have a coating grade 75, hot-dipped, galvanized coating complying with ASTM A123.

3.5.4 Threaded Bolts and Nuts: The threaded bolts, which are used in couplings for MH325BG piles and with MHC1300-3K55BG direct load, MP1030-150BG side load and MHC1080-31024BG tension load brackets, comply with SAE J429, Grade 5, with a minimum yield strength of 92 ksi (634 MPa) and a tensile strength of 120 ksi (827 MPa), and have a coating that complies with ASTM F1941, coating designation Fe/Zn 5B. The corresponding nuts conform to SAE J995, Grade 5, and have a coating that complies with ASTM F1941, coating designation Fe/Zn 5B.

The threaded bolts, which are used for MH325BRG and MS150BG piles and with MHC1300-3M6565BR2G and MSC1300-150M55BG direct load, MHC1080-31024BR2G and MSC1080-150824BG tension load, and MP1001-3G, MP1002-3G and MP1005-3G side load brackets, comply with SAE J429, Grade 8, with a yield strength of 130 ksi (896 MPa), and a minimum tensile strength of 150 ksi (1034 MPa), and have a coating that complies with ASTM F1941, coating designation Fe/Zn 5B. The corresponding nuts conform to SAE J995, Grade 8, and have a coating that complies with ASTM F1941, coating designation Fe/Zn 5B.

The threaded rods, which are used for MHC1080-31024BG, MHC1080-31024BR2G and MSC1080-150824BG, and MP1030-150G side load brackets, comply with ASTM A615, with a minimum yield strength of 75 ksi (517 MPa), and a minimum tensile strength of 100 ksi (689 MPa), and have hot-dipped, galvanized coating complying with ASTM A123. The corresponding nuts conform to ASTM A108 made with steel having a minimum yield strength of 75 ksi (517 MPa) and minimum ultimate tensile strength of 100 ksi (689 MPa) and have a coating that complies with ASTM A123.

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 be subjected to the approval of 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 IBC Section 1810. The design method for the steel components is Allowable Strength Design (ASD), described in IBC Section 1602 and AISC 360 Section B3.4. The engineering analysis must address helical foundation system performance related to structural and geotechnical requirements.

The structural analysis must consider all applicable internal forces (shears, bending moments and torsional moments, if applicable) due to applied loads, structural eccentricity and maximum span(s) between helical foundations. The result of this analysis and the structural capacities must be used to select a helical foundation system.

The MAGNUM direct load and tension load brackets exert a force 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 bracket 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 pile by the foundation.

The minimum embedment depth of piles for various loading conditions must be included based on the most stringent requirements of the following: engineering analysis, tested conditions described in this report, the site specific geotechnical investigation report, and site specific load tests, if applicable.

The allowable strengths (allowable capacities) of the steel components of the MAGNUM helical foundation systems are described in Table 1, 2 and 3 (for brackets, P1); Table 4(a) (for shafts, P2); and Table 5 (for helical bearing plates, P3). The soil capacities, or capacities related to pile-soil interactions, (P4), are described in Section 4.1.5 and Table 6.

The overall capacity of the MAGNUM helical foundation systems depends upon the analysis of interaction of shafts, helical plates and soils, and must be based on the least of the following conditions (P1, P2, P3 and P4), in accordance with IBC Section 1810.3.3.1.9:

- P4: Allowable load predicted by the individual helix bearing method (or Method 1) 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.
- P4: 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.
- P2: Allowable capacities of the shaft and shaft couplings. See Section 4.1.3 of this report.
- P3: Sum of the allowable axial capacity of helical bearing plates affixed to the pile shaft. See Section 4.1.4 of this report.
- P1: Allowable axial load capacity of the bracket. See Section 4.1.2 of this report.

A written report of the geotechnical investigation must be submitted to the code official as part of the required submittal documents, prescribed in IBC Section 107, at the time of the permit application. The geotechnical report must include, but not be limited to, all of the following information:

- A plot showing the location of the soil investigation.
- A complete record of the soil boring and penetration test logs and soil samples.
- A record of soil profile.
- Information on ground-water table, frost depth and corrosion related parameters, as described in Section 5.5 of this report.
- Soil properties, including those affecting the design such as support conditions of the piles.
- 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 IBC Section 1810.2.1.
- Confirmation of the suitability of MAGNUM helical foundation systems for the specific project.
- Recommendations for design criteria, including but not be limited to: mitigations of effects of differential settlement and varying soil strength; and effects of adjacent loads.
- Recommended center-to-center spacing of helical pile foundations, if different from Section 5.14 of this report; and reduction of allowable loads due to the group action, if necessary.
- Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity when required).
- Load test requirements.
- Any questionable soil characteristics and special design provisions, as necessary.
- Expected total and differential settlement.
- The axial compression, axial tension and lateral load soil capacities for allowable capacities that cannot be determined from this evaluation report.
- Minimum helical pile depth, if any, based on local geologic hazards such as frost, expansive soils, or other condition.

4.1.2 Bracket Capacity (P1): Tables 1, 2 and 3 describes the allowable axial compression and tension capacities of the MHC1300-3K55BG, MHC1300-3M6565BR2G and MSC1300-150M55BG Type B Direct Load Brackets; the MHC1080-31024BG, MHC1080-31024BR2G and MSC1080-150824BG Type D Tension Load Brackets: and the MP1001-3G, MP1002-3G, MP1005-3G and MP1030-150G Type A Side Load Brackets, respectively. The connections of the building structure to the helical pile brackets must be designed and included in the construction documents. Only localized limit states of supporting concrete including 2-way punching shear and concrete bearing have been evaluated in this evaluation report. The concrete foundation must be designed and justified to the satisfaction of the code official with due consideration to the eccentricity of applied loads, including reactions provided by the brackets, acting on the concrete foundation. Refer to item 5.3 of this report for bracing requirement.

4.1.3 Shaft Capacity (P2): Table 4(a) describes the allowable axial compression and tension loads of the shafts (MH325BG, MH325BRG and MS150BG). Table 4(b) describes the mechanical properties of the shafts (MH325BG, MH325BRG and MS150BG), which are based on a 50-year corrosion effect in accordance with Section 3.9 of AC358. The top of shafts must be braced as prescribed in IBC Section 1810.2.2, and the supported foundation structures such as concrete footings are assumed to be adequately braced such that the supported foundation structures provide lateral stability for the pile systems. In accordance with IBC Section 1810.2.1, 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 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. The shaft capacity of the helical foundation systems with an unbraced length more than zero must be determined by a registered design professional using parameters in Table 4(b), with due consideration of lateral support provided by the surrounding soil and/or structure.

The elastic shortening of the pile shaft will be controlled by the strength and section properties of the shaft sections 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: Δ_{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 4(b), $in.^2$ (mm^2).

E = Young's modulus of the shaft, see Table 4(b), ksi (MPa).

For each coupler of MH325BG piles, an elastic shortening of 0.004 inch (0.102 mm) is estimated at allowable shaft load, and a slip of 0.131 inch (3.327 mm) is estimated at allowable shaft load. For each coupler of MH325BRG piles, an elastic shortening of 0.005 inch (0.127 mm) is estimated at allowable shaft load, and a slip of 0.193 inch (4.902 mm) is estimated at allowable shaft load. For each coupler of MS150BG piles, an elastic shortening of 0.002 inch (0.051 mm) is estimated at allowable shaft load and a slip of 0.093 inch (2.362 mm) is estimated at allowable shaft load.

4.1.4 Helix Capacity (P3): Table 5 describes the allowable axial compression loads for helical bearing plates. For helical piles with more than one helix, the allowable helix capacity, P3, for the helical foundation systems and devices, may be taken as the sum of the least allowable capacity of each individual helix.

4.1.5 Soil Capacity (P4): Table 6 describes the geotechnical related properties of the piles (MH325BG, MH325BRG and MS150BG). The allowable compressive soil capacity (P4) 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 (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 axial load capacities predicted by the torque correlation method must be equal to or greater than what is predicted by Method 1 or 2, described above.

The individual bearing method is determined as the sum of the individual areas of the helical bearing plates times the ultimate bearing capacity of the soil or rock comprising the bearing stratum for helix plates.

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

With the torque correlation method, the ultimate axial soil capacity (P_{ult}) of the pile and the allowable axial soil capacity (Pa) of the pile are predicted as follows:

$$P_{ult} = K_t \times T \qquad \text{(Equation 1)}$$

$$Pa = 0.5\, P_{ult} \qquad \text{(Equation 2)}$$

where:

P_{ult} = Ultimate axial compressive capacity (lbf or N) of helical pile, which must be limited to the maximum ultimate values noted in Table 6.

P_a = Allowable axial compression capacity (lbf or N) of helical piles, which must be limited to the maximum allowable values noted in Table 6.

K_t = Torque correlation factor per Table 6.

T = Final installation torque defined as the last torque reading taken when terminating the helical pile installation; which must not exceed the maximum installation torque rating noted in Table 6 of this report.

Lateral capacities were not evaluated in this report at this time and should be determined by a registered design professional on a project by project basis and subjected to approval of the code official.

4.2 Installation:

4.2.1 General: The MAGNUM helical foundation systems must be installed by MAGNUM trained and authorized installers. The MAGNUM helical foundation systems must be installed in accordance with this section (Section 4.2), 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 conflict, the most stringent requirement governs.

4.2.2 Helical Piles (MH325BG, MH325BRG and MS150BG): The helical piles must be installed according to a preapproved plan of placement. Installation begins by attaching the helical pile lead section to the torque motor using a drive tool and drive pin. Next, crowd must be applied to force the pilot point into the ground at the proper location, inclination and orientation, as described in the placement plan. Then the pile must be rotated into the ground in a smooth, clockwise, continuous manner while maintaining sufficient crowd to promote normal advancement. Installation continues by adding extension sections as necessary. Refer to Sections 3.2.1 and 3.3.3 of this report and the approved construction documents for type, grade, size and number of bolts and nuts that are required to connect the shaft sections. Inclination and alignment shall be checked and adjusted periodically during installation. Connection bolts between shaft sections shall be snug-tightened as defined in Section J3 of AISC 360. Care shall be taken not to exceed the maximum installation torque rating (shown in Table 6) of the helical piles during installation. Helical piles must be advanced until 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.

4.2.3 Direct Load Brackets (MHC1300-3K55BG, MHC1300-3M6565BR2G and MSC1300-150M55BG): After helical pile installation is complete, the pile shaft is cut off to the planned elevation of the structure. Tolerances for final pile head elevation are typically +1 inch (+25 mm) to -$^1/_2$ inch (-12.7 mm) unless otherwise specified. New holes must be drilled through the helical pile shaft in the field to match the bracket sleeve. A mag-drill template is available from MAGNUM to improve safety and accuracy during hole drilling. The holes must match the diameter and minimum edge distances of the bracket round HSS sleeve. Torch cut holes are not permitted. After hole drilling, the MHC1300-3K55BG, MHC1300-3M6565BR2G or MSC1300-150M55BG bracket is installed over the MH325BG, MH325BRG or MS150BG helical pile shaft, respectively, and through bolted with bolts/nuts described in Sections 3.4and 3.5.4 of this report. The bolted connection between shaft section and the brackets must conform to snug-tightened joint as defined in Section J3 of AISC 360. The concrete foundation is cast around the bracket.

4.2.4 Tension Load Brackets (MHC1080-31024BG, MHC1080-31024BR2G and MSC1080-150824BG): After helical pile installation is complete, the pile shaft is cut off to the planned elevation of the structure. Tolerances for final pile head elevation are typically +1 inch (+25 mm) to -$^{1}/_{2}$ inch (-12.7 mm) unless otherwise specified. New holes must be drilled through the helical pile shaft in the field to match the bracket sleeve. A mag-drill template is available from MAGNUM to improve safety and accuracy during hole drilling. The holes must match the diameter and minimum edge distances of the bracket round HSS sleeve. Torch cut holes are not permitted. After hole drilling, the MHC1080-31024BG, MHC1080-31024BR2G or MHC1080-150824BG bracket is installed over the MH325BG, MH325BRG or MS150BG helical pile shaft, respectively, and through bolted with bolts and nuts described in Sections 3.4 and 3.5.4 of this report. The bolted connection between shaft section and the brackets must conform to snug-tightened joint as defined in Section J3 of AISC 360. The bracket is then connected to the structure using a plate washer and nut.

4.2.5 Side Load Brackets (MP1030-150G, MP1001-3G, MP1002-3G and MP1005-3G): For use with helical piles, following completion of pile installation, the bracket is slid over the helical pile shaft. For angle side load brackets a ½-inch (12.7 mm) minimum grout bed of high-strength, fast-setting, non-shrink grout is applied to the lower face of the angle, and the bracket is pushed up into position against the existing foundation. The bracket is then attached to the concrete structure using the specified Hilti KB3 carbon steel stud expansion anchors, to be installed per ICC-ES evaluation report ESR-2302. Then, new holes must be drilled in the helical pile shaft in the field to match the bracket sleeve for the MP1001-3G, MP1002-3G and MP1005-3G. The holes must match the diameter and minimum edge distances of the bracket round HSS sleeve. Torch cut holes are not permitted. After hole-drilling, the specified bolts are impacted through the bracket into the pile shaft in single shear. The length of the shaft extending through the top of the bracket can be cut-off a few inches above the bracket.

4.3 Special Inspection:

Special inspections in accordance with 2018, 2015 and 2012 IBC Section 1705.9 (2009 IBC Section 1704.10), must be performed continuously during installation of MAGNUM helical foundation systems (piles and brackets). Items to be recorded and confirmed by the special inspector must include, but are not limited to, the following:

1. Verification of the product manufacturer, and the manufacturer's certification of installers.
2. Product identification including lead sections, couplings, extension sections, brackets, bolts and nuts, as specified in the construction documents and this evaluation report.
3. Installation equipment used.
4. Written installation procedures.
5. Tip elevations, the installation torque and final depth of the helical foundation systems.
6. Inclination and position/location of helical piles.
7. Tightness of all bolted connections.
8. Verification that direct load bracket cap plates are in full contact with the top of the pile shaft.
9. Compliance of the installation with the approved construction documents and this evaluation report.

5.0 CONDITIONS OF USE

The MAGNUM helical foundation systems, described in this report, comply with or are suitable alternatives to what is specified in, the code listed in Section 1.0 of this report, subject to the following conditions:

5.1 The MAGNUM helical foundation systems are manufactured, identified and installed in accordance with this report, the site-specific approved construction documents (engineering plans and specifications), IBC Section 1810.4.11, and the manufacturer's written installation instructions. In case of conflict, the most stringent requirement governs.

5.2 The MAGNUM helical foundation systems have been evaluated for support of structures assigned to Seismic Design Categories A, B and C 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 IBC Section 1810.2.2. Shaft couplings must be located within firm or soft soil as defined in Section 4.1.3.

5.4 Installations of helical foundation systems are limited to regions of concrete members where analysis indicates no cracking at service load levels.

5.5 Use of the MAGNUM helical foundation systems or devices 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 landfill, or (6) soil containing mine waste, is beyond the scope of this evaluation report.

5.6 Zinc-coated steel and bare steel components must not be combined in the same system. All helical foundation components must be galvanically isolated from concrete reinforcing steel, building structural steel, or any other metal building components.

5.7 The helical piles must be installed vertically into the ground with the maximum allowable angle of inclination of 1 degree.

5.8 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, prepared by a registered design professional, are provided to, and are approved by, the code official.

5.9 The adequacy of the concrete structures that are connected to the MAGNUM brackets must be verified by a registered design professional, in accordance with applicable code provisions, such as Chapter 13 of ACI 318-14 under the 2018 and 2015 IBC (Chapter 15 of ACI 318 under the 2012 and 2009 IBC) and Chapter 18 of IBC, and subject to the approval of the code official.

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

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

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

5.14 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.

5.15 Requirements described in footnotes of tables in this report must be satisfied.

5.16 Evaluation of compliance with IBC Section 1810.3.11.1 for buildings assigned to Seismic Design Category (SDC) C, and with IBC Section 1810.3.6 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.

5.17 Settlement of helical piles is beyond the scope of this evaluation report and must be determined by a registered design professional as required in IBC Section 1810.2.3.

5.18 The MAGNUM helical foundation systems are manufactured at the Magnum Piering, Inc. facility located at 156 Circle Freeway Drive, Cincinnati, Ohio 45246, 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 September 2017 (editorially revised September 2018).

7.0 IDENTIFICATION

7.1 The Magnum Piering, Inc. (MAGNUM) helical foundation systems (including lead shafts, extension shafts, brackets and boxed hardware) are identified by a label bearing the name of Magnum Piering, Inc., the address of the manufacturing facility, the product number, the evaluation report number (ESR-2997), and an order number.

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

MAGNUM PIERING, INC.
156 CIRCLE FREEWAY DRIVE
CINCINNATI, OHIO 45246
(800) 822-7437
www.magnumpiering.com
hperko@magnumpiering.com

TABLE 1—BRACKET CAPACITY (P1) FOR DIRECT LOAD BRACKETS[1,2,3]

BRACKET TYPE	SHAFT TYPE	(P1) ALLOWABLE CAPACITY (kips) 2,500 psi Concrete Minimum		
		Compression	Tension	Lateral
MHC1300-3K55BG	MH325BG	33.3	NE[4]	NE[4]
MHC1300-3M6565BR2G	MH325BRG	57.0	NE[4]	NE[4]
MSC1300-150M55BG	MS150BG	44.6	24.0	NE[4]

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

[1]Only localized limit states of supporting concrete including bearing and 2-way punching shear have been evaluated. Refer to Sections 5.4 and 5.9 of this report for additional requirements.
[2]Refering to Figures 4a and 5a and 11a, 2-way punching shear in concrete footing is not a concern when the applied load by the supported post above the concrete footing and the reaction afforded by the helical pile below the concrete footing are concentric; otherwise 2-way punching shear in concrete is a concern, and the minimum concrete cover/edge distance must conform to Figures 4b and 5b and 11b, as applicable.
[3]Allowable capacities include an allowance for corrosion over a 50-year service life and presume the supported structure is braced in accordance with IBC Section 1810.2.2.
[4]NE = Not evaluated at this time.

TABLE 2—BRACKET CAPACITY (P1) FOR TENSION LOAD BRACKETS[1,2,3]

BRACKET TYPE	SHAFT TYPE	(P1) ALLOWABLE CAPACITY (kips)[3] 2,500 psi Concrete Minimum		
		Compression	Tension	Lateral
MHC1080-31024BG	MH325BG	NE[4]	38.2	NE[4]
MHC1080-31024BR2G	MH325BRG	NE[4]	67.3	NE[4]
MSC1080-150824BG	MS150BG	NE[4]	37.1	NE[4]

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

[1]The reported value represents the mechanical capacity of the bracket. Refer to Sections 5.4 and 5.9 of this report for additional requirements.
[2]Allowable capacities include an allowance for corrosion over a 50-year service life and presume the supported structure is braced in accordance with IBC Section 1810.2.2.
[3]Connection to structure must be designed by registered design professional.
[4]NE = Not evaluated at this time.

TABLE 3—BRACKET CAPACITY (P1) FOR SIDE LOAD BRACKETS[1,2,3,4]

BRACKET TYPE	SHAFT TYPE	(P1) ALLOWABLE CAPACITY (kips)[3]		
		Compression	Tension[5]	Lateral[5]
MP1001-3G	MH325BG/MH325BRG	39.3	NE	NE
MP1002-3G	MH325BG/MH325BRG	38.0	NE	NE
MP1005-3G	MH325BG/MH325BRG	35.0	NE	NE
MP1030-150G	MS150BG	20.2	NE	NE

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

[1]Load capacity based on full scale load tests per AC358 with an installed 5'-0" unbraced pile length having a maximum of one coupling per IBC Section 1810.2.1. Repair brackets must be centrally loaded and bracket plate must be fully engaged with bottom of concrete foundation, where applicable. Only localized limit states such as mechanical strength of steel components and concrete bearing and connection of bracket to concrete have been evaluated. Minimum specified compressive strength of unreinforced concrete used for this evaluation is 2500 psi for the MP1005-3G and MP1030-150G brackets; and 5000 psi for the MP1001-3G and MP1002-3G brackets. Different capacities may be achieved on reinforced concrete, but must be evaluated through additional engineering or proof testing.

[2]Allowable capacities include an allowance for corrosion over a 50-year service life and presume the supported structure is braced in accordance with IBC Section 1810.2.2.

[3]For use with ½-inch-diameter Hilti KB3 carbon steel stud anchors having a minimum embedment of 3.562 inches, installed per ICC-ES evaluation report ESR-2302. The number of anchor bolts used must comply with the following: MP1001-3G use ten bolts (see Figure 8); MP1002-3G use six bolts (See Figure 9); MP1005-3G use four bolts (see Figure 10); MP1030-150G use four bolts (see Figure 13). For MP1001-3G, MP-1002-3g and MP1005-3G, connection of bracket sleeve to top of shaft requires three ¾-inch bolts as described in Section 3.5.4.

[4]Connection to structure must be designed by registered design professional.

[5]NE- Not evaluated at this time.

TABLE 4(A)—SHAFT ALLOWABLE CAPACITY (P2)[1]

SHAFT TYPE	UNBRACED SHAFT LENGTH (FT)	(P2) ALLOWABLE CAPACITY (KIPS)				
		COMPRESSION[2,3]			TENSION	LATERAL
		0 Coupler	1 Coupler	2 Couplers		
MH325BG	0	60	35.8	22.8	38.2	NE[4]
MH325BRG	0	60	60	51.1	63.8	NE[4]
MS150BG	0	47.3	47.3	NE[4]	44.4	NE[4]

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

[1]Allowable capacities include an allowance for corrosion over a 50-year service life.

[2]Allowable capacities are based on fully braced conditions where effective length (KL) of piles equals to zero and pile tops are fully braced, which require the pile head to be fully braced laterally and rotationally and no portion of shaft is in air, water, or fluid soils. Refer to Section 4.1.3 of this report for the determination of unbraced length, L.

[3]Shaft capacity of helical foundations with an unbraced length more than zero must be determined by a registered design professional.

[4]NE = Not evaluated at this time.

TABLE 4(B)—SHAFT MECHANICAL PROPERTIES AFTER CORROSION LOSS[1]

MECHANICAL PROPERTIES	HELICAL PILE SHAFT	
	MH325BG and MH325BRG	MS150BG
Corroded Shaft Outside Diameter (inch)	2.994	1.494 square
Corroded Shaft Inside Diameter (inch)	2.504	N/A
Corroded Design Wall Thickness (inch)	0.245	N/A
Corroded Gross Cross Section Area ($inch^2$)	2.11	2.177
Corroded Moment of Inertia, I ($inch^4$)	2.01	0.389
Corroded Radius of Gyration, r (inch)	0.98	0.423
Corroded Section Modulus, S ($inch^3$)	1.34	0.393
Corroded Plastic Modulus, Z ($inch^3$)	1.85	0.786
Minimum Steel Yield Strength, F_y (ksi)	65	90
Minimum Steel Ultimate Strength, F_u (ksi)	80	120
Modulus of Elasticity of Steel (ksi)	29,000	29,000

For **SI:** 1 inch = 25.4 mm, 1 kip = 4.448 kN, 1 psi = 6.895 kPa. N/A- not applicable.

[1]Geometrical properties of the cross section are based on the design wall thickness of HSSs and have been adjusted for a 50-year corrosion effect in accordance with Section 3.9 of AC358.

TABLE 5—HELICAL BEARING PLATE CAPACITY (P3) – AXIAL COMPRESSION/TENSION[1,2]

HELIX DIAM. (IN)	SHAFT TYPE	HELIX THICKNESS (IN)	HELIX PITCH (IN)	ALLOWABLE CAPACITY[3] (P3) (KIPS)
8	MH325BG / MH325BRG	0.375	3.0	45.6
10	MH325BG / MH325BRG	0.375	3.0	49.3
12	MH325BG / MH325BRG	0.375	3.0	50.8
14	MH325BG / MH325BRG	0.375	3.0	51.1
8	MS150BG	0.375	3.0	36.7
10	MS150BG	0.375	3.0	39.6
12	MS150BG	0.375	3.0	34.6
14	MS150BG	0.375	3.0	37.1

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

[1]For helical piles with more than one helix, the allowable helix capacity, P3, for the helical foundation systems, may be taken as the sum of the least allowable capacity of each individual helix.
[2]As described in Section 3.2.1 of this report, all helical bearing plates are made from same material, and have the same edge geometry, thickness and pitch.
[3]Allowable capacities include an allowance for corrosion over a 50-year service life.

TABLE 6—SOIL CAPACITY (P4) – AXIAL COMPRESSION AND TENSION[1]

GEOTECHNICAL RELATED PROPERTIES	HELICAL PILE MODELS		
	MH325BG	MH325BRG	MS150BG
Mechanical Torsion Rating (ft-lbs)[3]	8,900	12,475	7379
Maximum Torque Per Soil Tests (ft-lbs)[4]	7,300	13,000	7360
Maximum Installation Torque Rating (ft-lbs)[5]	7,300	12,475	7360
Torque Correlation Factor, K_t (ft^{-1})	8	8	10
Maximum Ultimate Soil Capacity / Maximum Allowable Soil Capacity (P4) from Torque Correlations (kips)[2]	58.4/29.2 (for compression)	99.8/49.9 (for compression) 95.0/47.5 (for tension)	73.6/36.8 (for compression and tension)

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 report.
[2]Maximum ultimate soil capacity is determined from $P_{ult} = K_t \times T$ based on the corresponding maximum installation torque rating for the specific pile model. Allowable soil capacity is determined from $Pa = P_{ult} /2.0$ based on the corresponding maximum installation torque rating for the specific pile model. See Section 4.1.5 for additional information.
[3]Mechanical torsion rating is the maximum torsional resistance of the steel shaft.
[4]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.
[5]Maximum Installation Torque rating is the lower of the “mechanical torsion rating” and the “maximum torque per soil tests”.

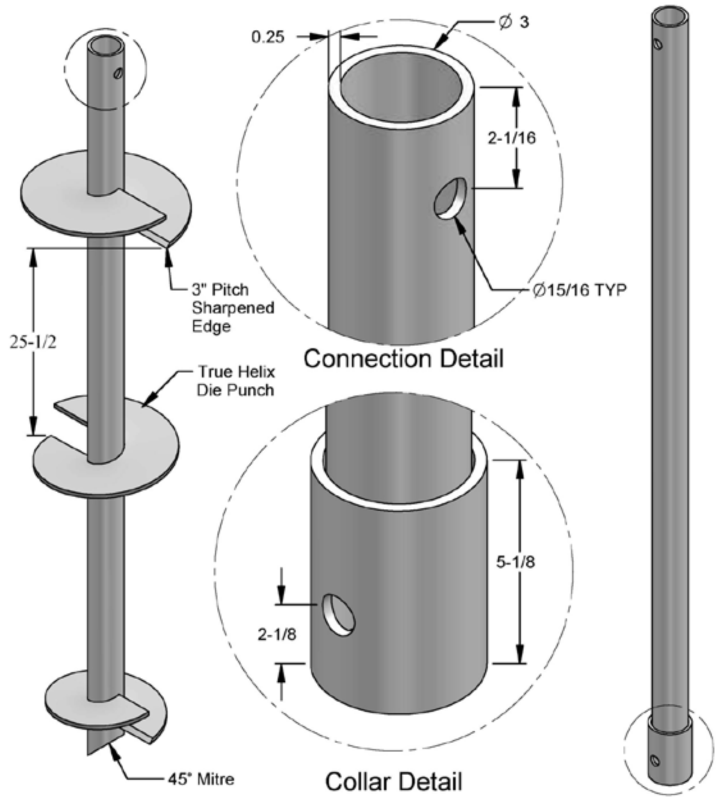


FIGURE 1—MAGNUM HELICAL PILE MH325BG

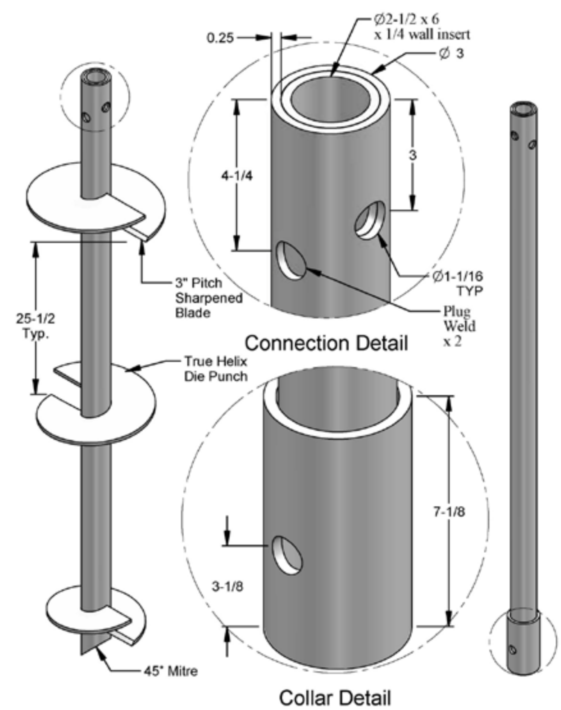


FIGURE 2—MAGNUM HELICAL PILE MH325BRG

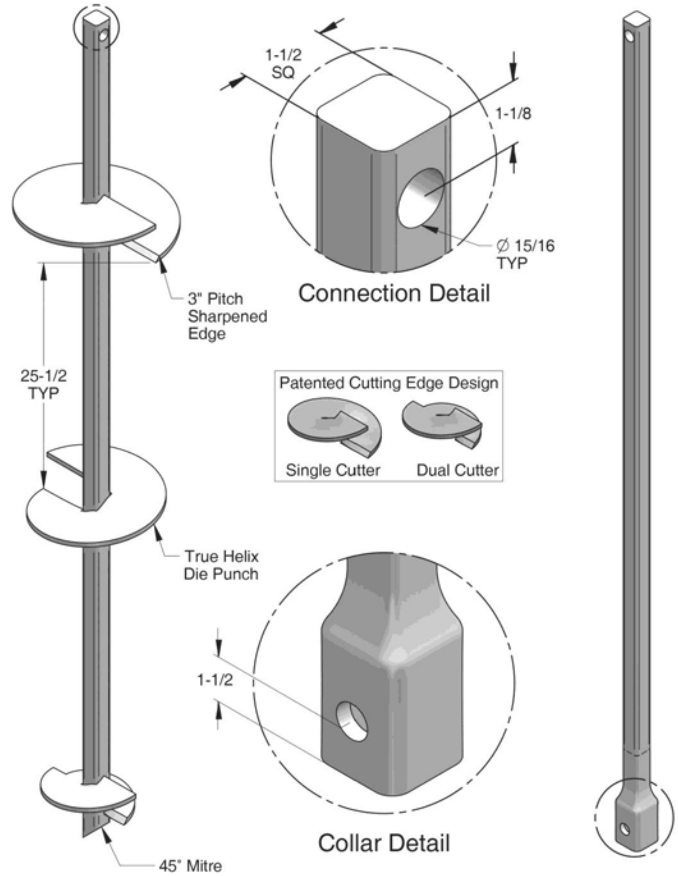
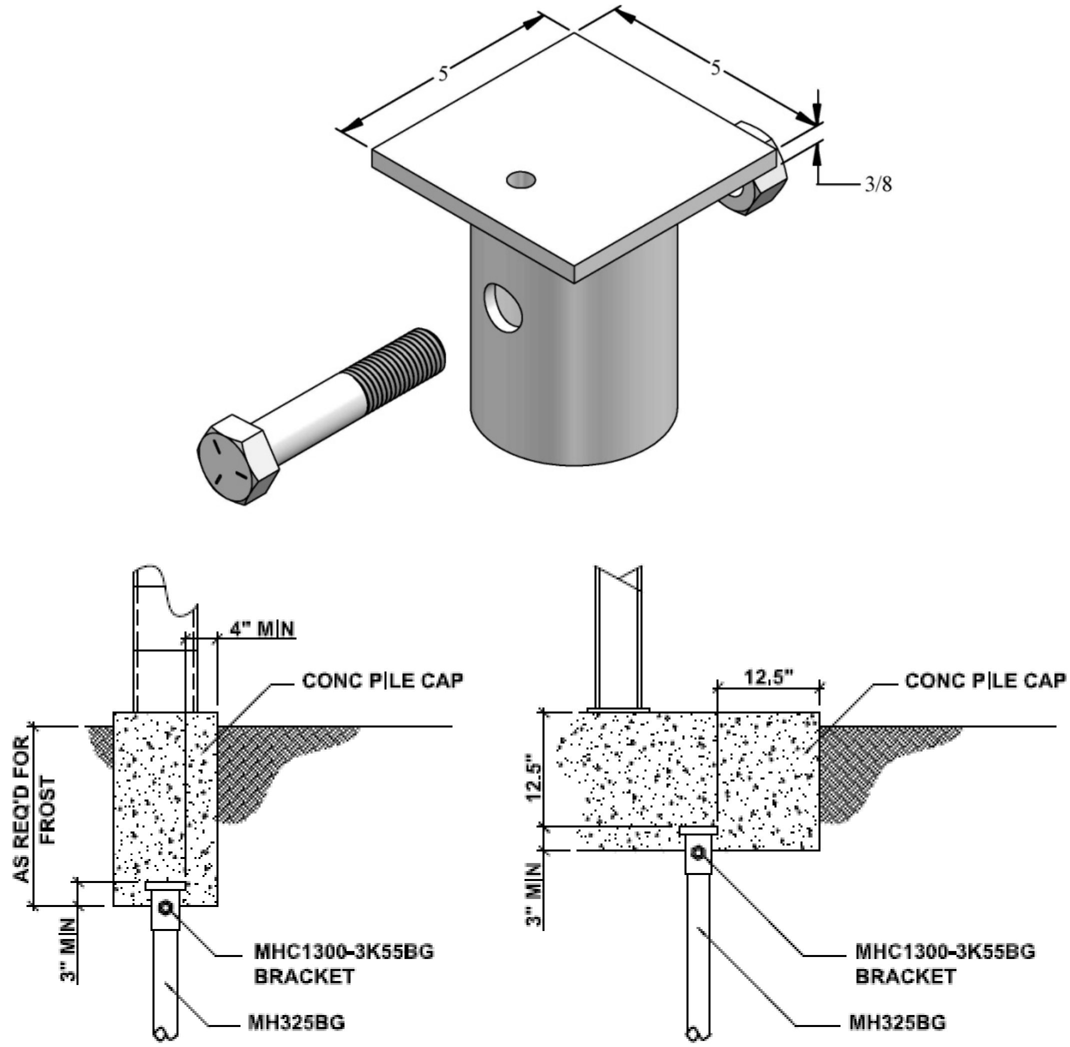


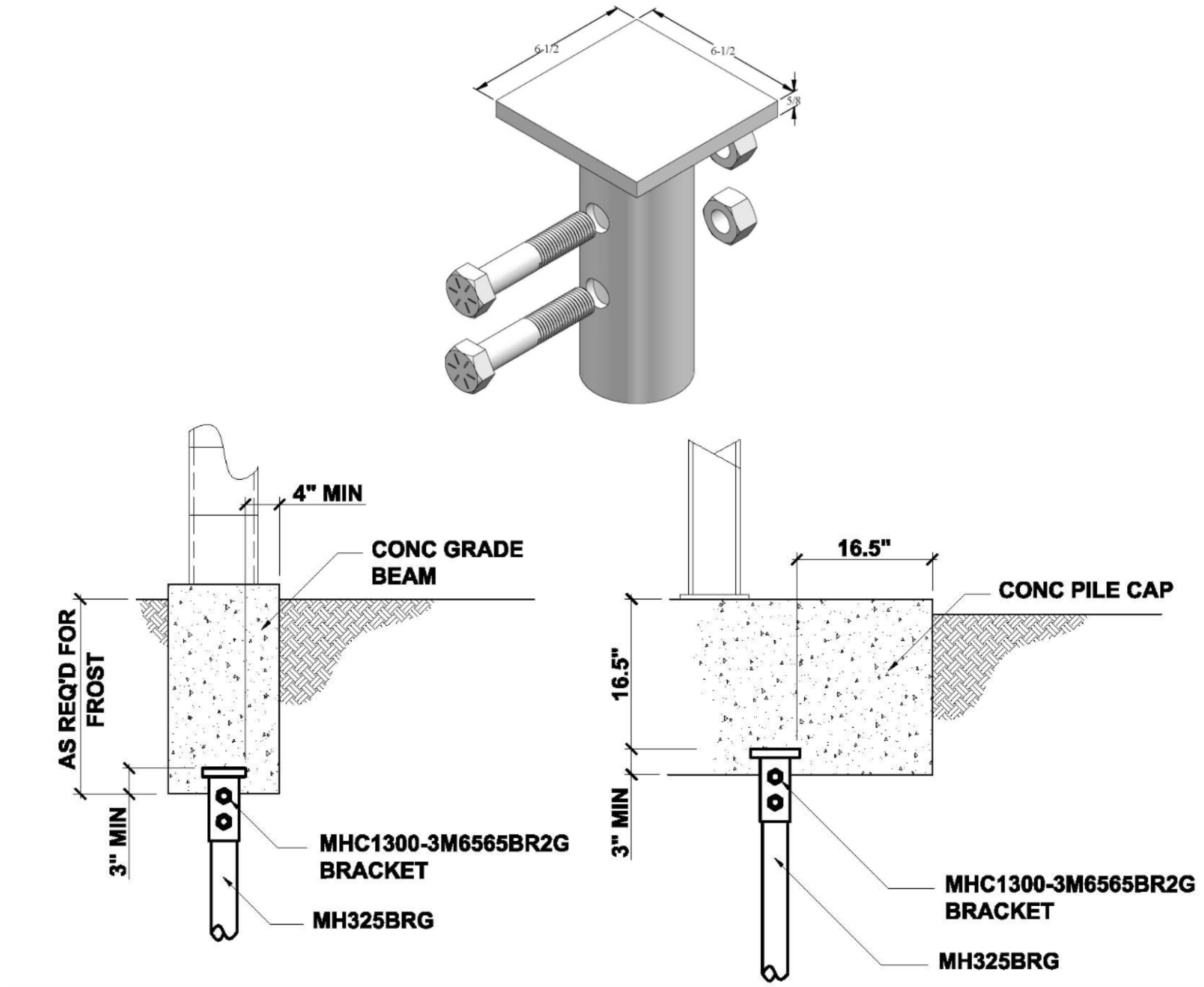
FIGURE 3—MAGNUM HELICAL PILE MS150BG



a) TYPICAL APPLICATION UNDER DIRECT LOADS WHEN 2-WAY CONC PUNCHING SHEAR IS NOT A CONCERN

b) TYPICAL APPLICATION IN MULTI-PILE CAP WHEN 2-WAY CONC PUNCHING SHEAR IS A CONCERN

FIGURE 4—MAGNUM MHC1300-3K55BG DIRECT LOAD BRACKET



a) TYPICAL APPLICATION UNDER DIRECT LOADS WHEN 2-WAY CONC PUNCHING SHEAR IS NOT A CONCERN

b) TYPICAL APPLICATION IN MULTI-PILE CAP WHEN 2-WAY CONC PUNCHING SHEAR IS A CONCERN

FIGURE 5—MAGNUM MHC1300-3M6565BR2G DIRECT LOAD BRACKET

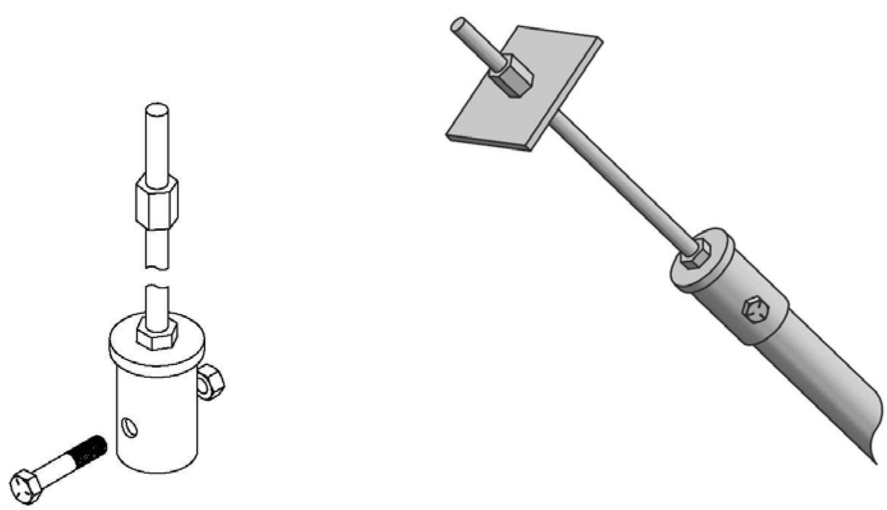


FIGURE 6—MAGNUM MHC1080-31024BG TENSION LOAD BRACKET

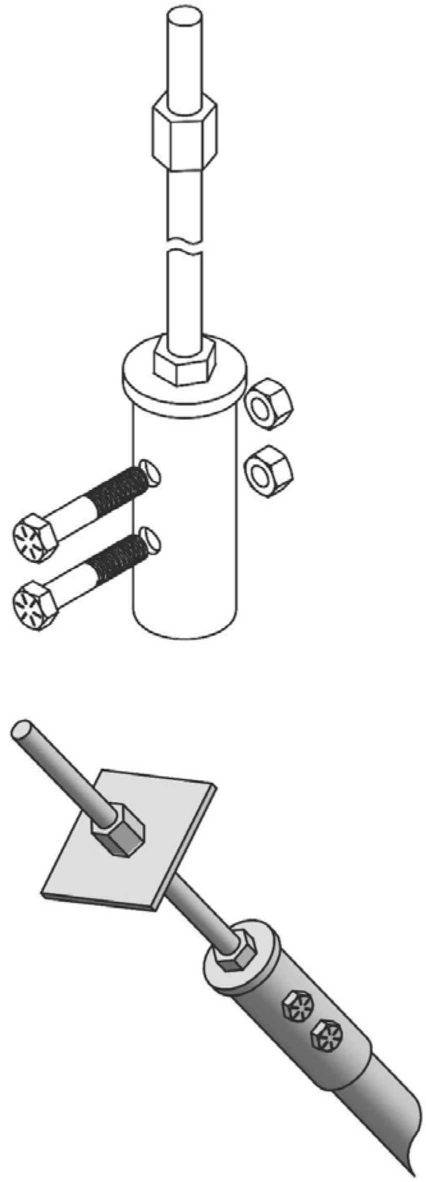


FIGURE 7—MAGNUM MHC1080-31024BR2G TENSION LOAD BRACKET

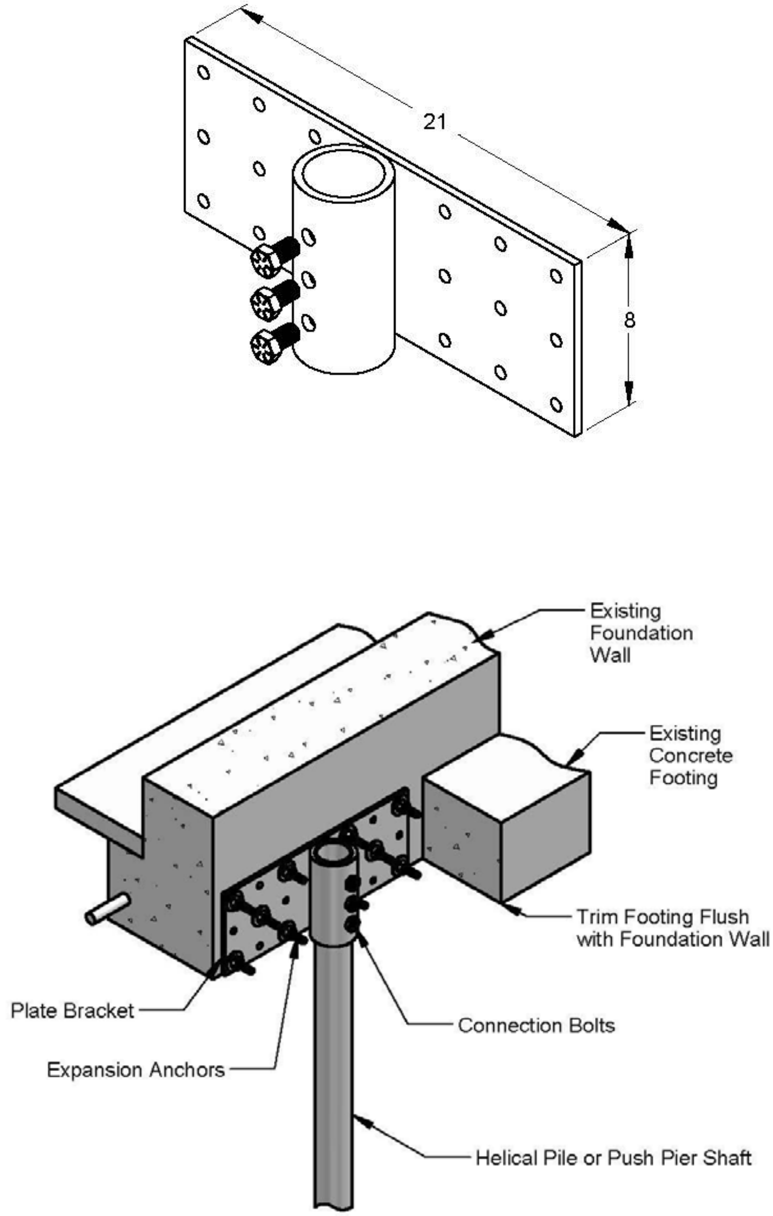


FIGURE 8—MAGNUM MP1001-3G SIDE LOAD BRACKET

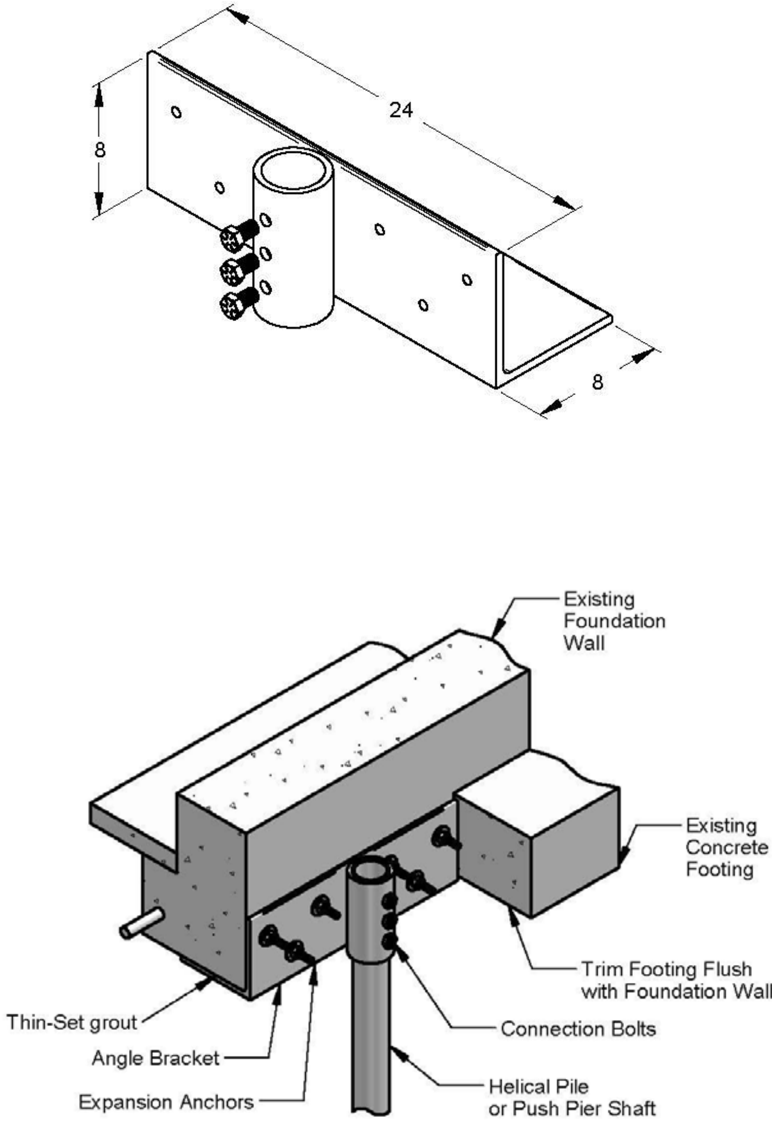
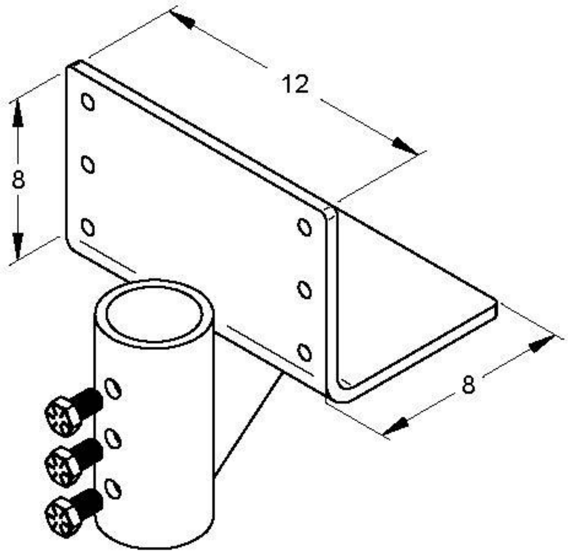


FIGURE 9—MAGNUM MP1002-3G SIDE LOAD BRACKET



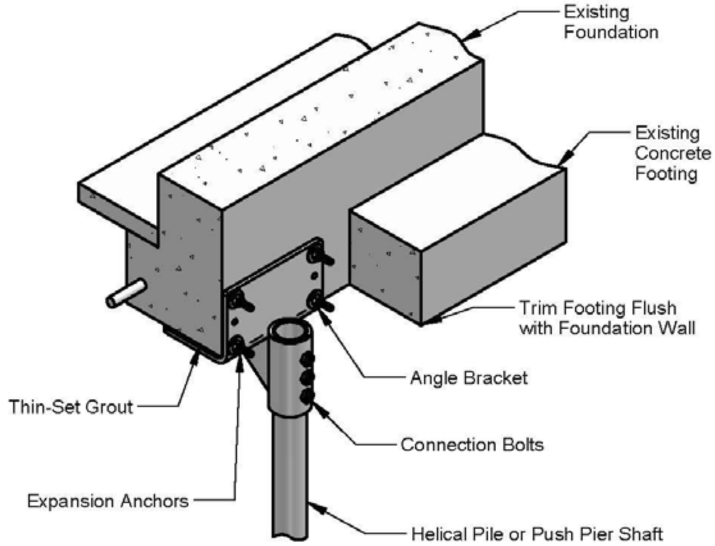


FIGURE 10—MAGNUM MP1005-3G SIDE LOAD BRACKET

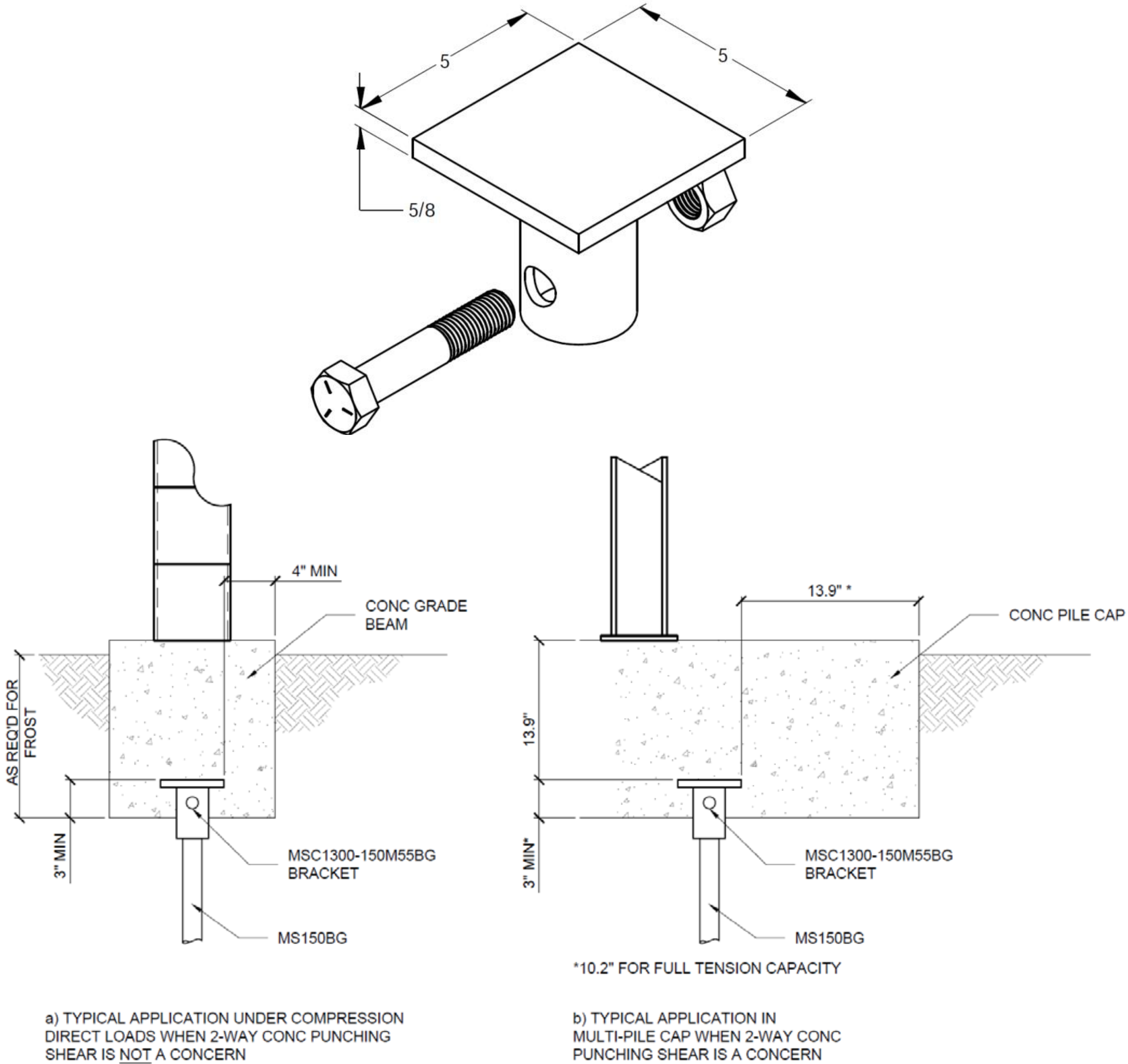


FIGURE 11- MAGNUM MSC1300-150M55BG DIRECT LOAD BRACKET

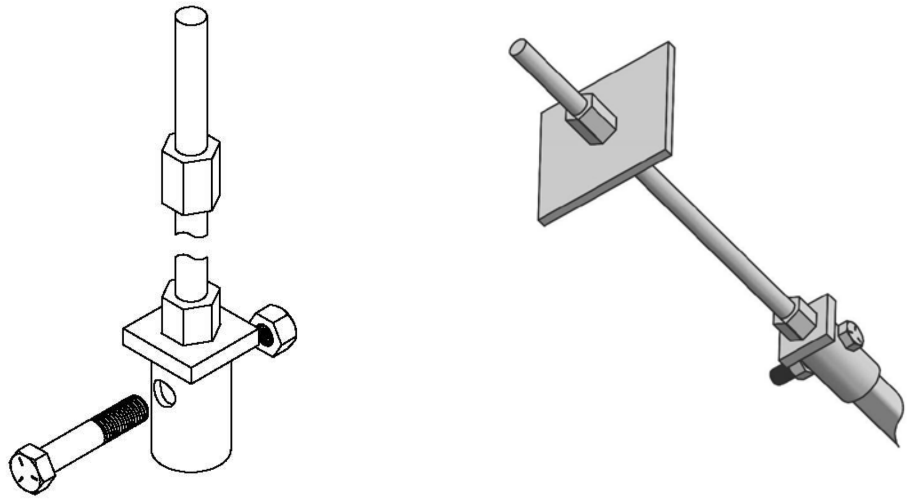


FIGURE 12- MAGNUM MSC1080-150824BG TENSION LOAD BRACKET

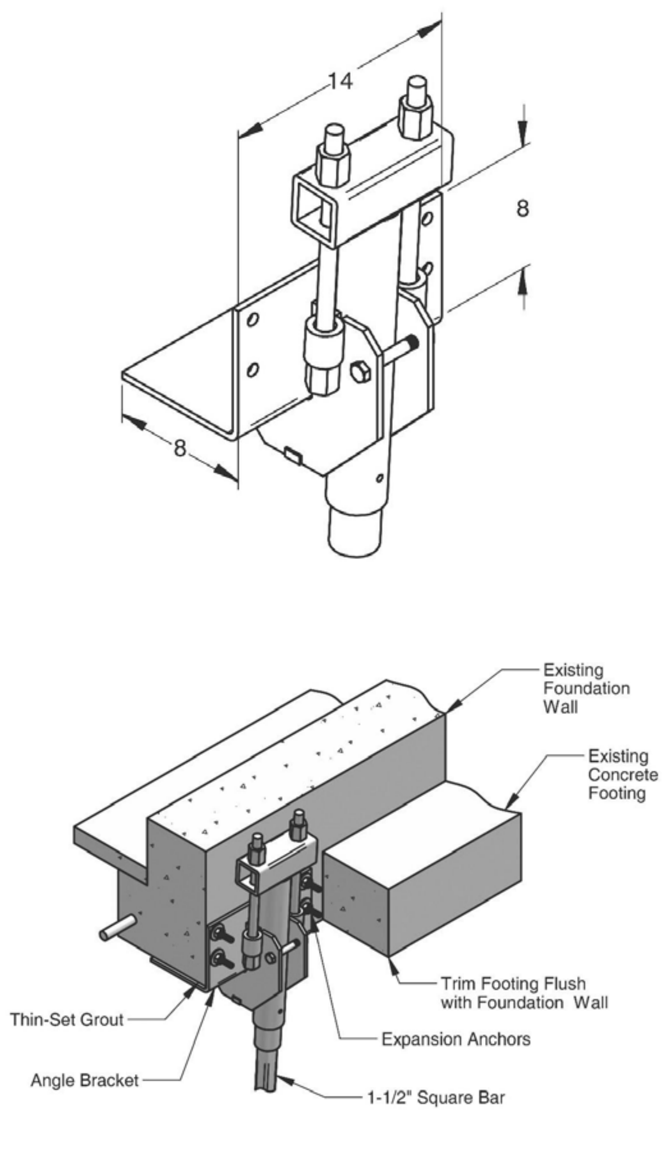


FIGURE 13- MAGNUM MP1030-150G SIDE LOAD BRACKET