STARK FOUNDATIONS

4400 NE 77th Ave, Suite 275
Vancouver, WA 98662
P: 360.566.7343
E: starkd@starkfdn.com

STRUCTURAL CALCULATIONS

PREPARED FOR

TERRAFIRMA

FOR

BREWER RESIDENCE

FOUNDATION REPAIR

5739 SW DOWNS VIEW CT

PORTLAND, OREGON

PROJECT NUMBER: 20.163.TFS (WO #: 36888)

DATE: August 31, 2020

PROJECT MANAGER: DANIEL STARK, P.E.

EXPIRES: 06/30/22

20-188312 RS

City Of Portland
REVIEWED FOR CODE COMPLIANCE
Date: 10/28/20
Permit #: 20-188312-000-00-RS

STARK FOUNDATIONS

4400 NE 77th Ave, Suite 275
Vancouver, WA 98662
P: 360.566.7343
E: starkd@starkfdn.com

August 31, 2020

Project No.: 20.163.TFS (WO #: 36888)

Clint Griffith
TerraFirma
13110 SW Wall Street
Portland, Oregon 97223

RE: Foundation repair - 5739 SW Downs View Ct, Portland, Oregon

PROJECT BACKGROUND

We understand that the structure is a single-family residence and has experienced settlement at the rear elevation of the structure. A recent floor level survey (attached) indicates as much as ~1" of differential settlement may have occurred. It is our understanding that (5) 2 7/8 inch diameter push piers have been proposed to provide additional foundation support.

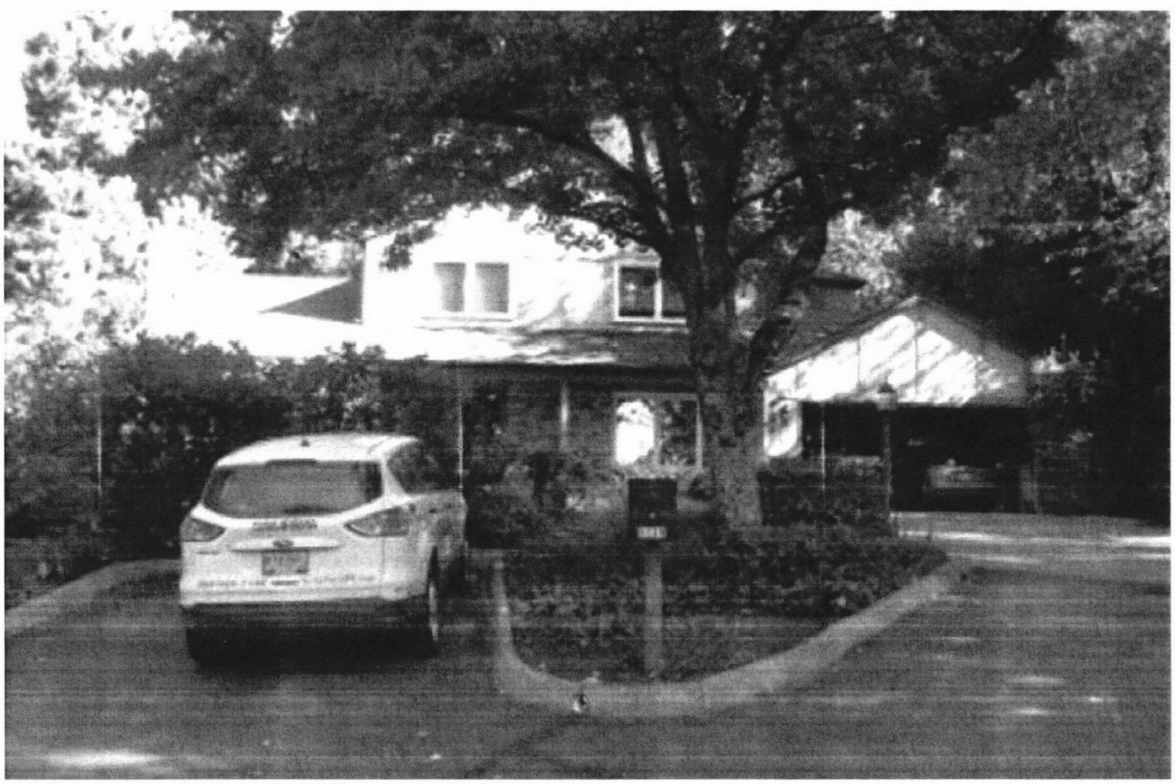


Image 1: Front Elevation

STARK FOUNDATIONS

4400 NE 77th Ave, Suite 275
Vancouver, WA 98662
P: 360.566.7343
E: starkd@starkfdn.com

GEOLOGIC SETTING AND SITE DATA

The existing structure is located in Portland, Oregon. The geologic structure in the area is comprised of silty loam (FIG 1) and the site is relatively flat. It is our opinion that the localized settlement is a result of improper foundation drainage, improperly compacted fill, and/or undersized footings.

According to the Geologic Map of the State of Oregon Department of Geology and Mineral Industries, the site is underlain by Willamette Group of the Pliocene/Pleistocene Age, which consist of Fluvial mudstone, sandstone and conglomerate and older fluvial terraces (FIG 2). Estimated depth to groundwater is approximately 100-200 feet below existing grade according to the USGS Scientific Investigations Report 2009-5059 (Estimated Depth to Ground Water in the Portland Area).

The structure is located in/near a low risk area for seismic-induced liquefaction (FIG 3) and the landslide potential for the area is very high (existing landslide) (FIG 4).

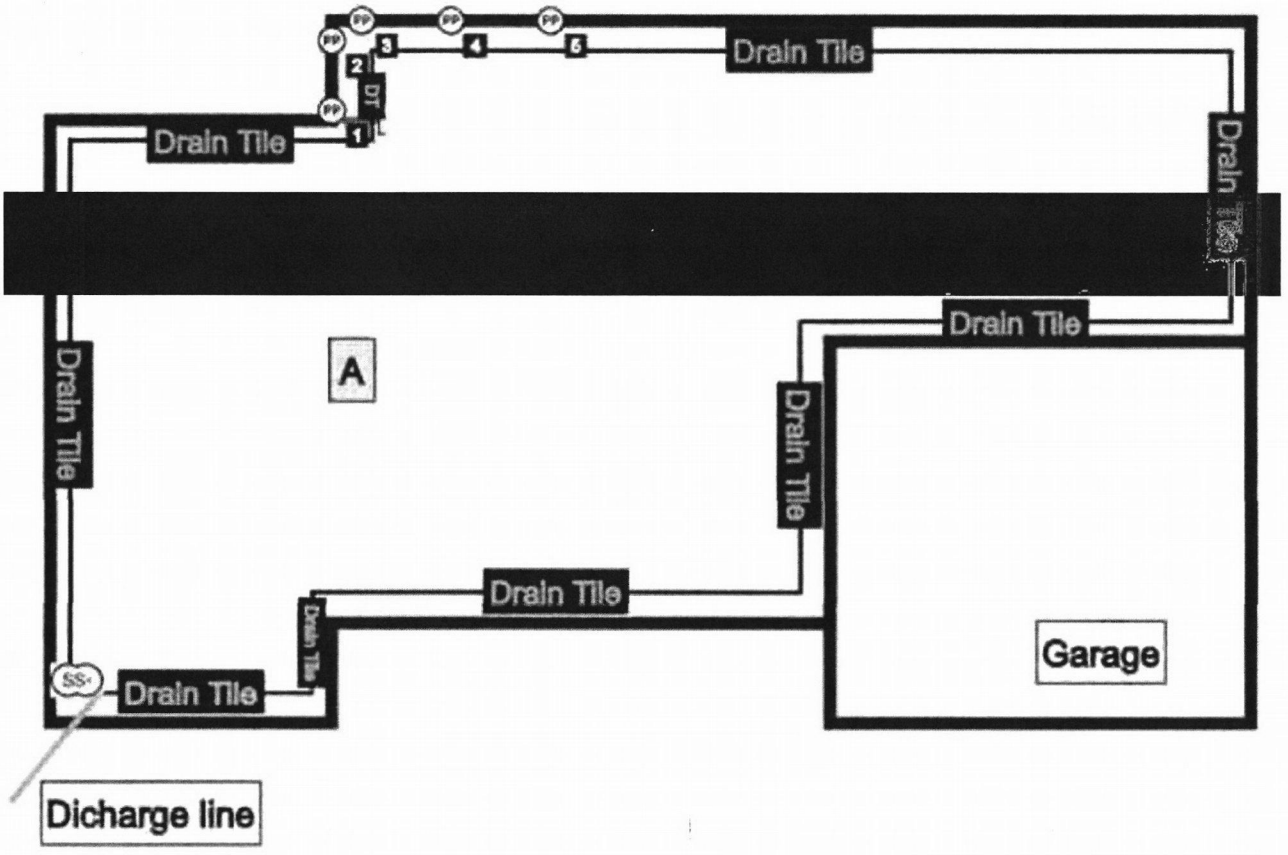
SUMMARY

The ultimate load requirement for the push piers is 20000 lbs, and based on the geologic setting, we expect the piers to achieve adequate capacity at approximately 8 – 25 feet. We recommend that the piers with a 2 7/8 inch shaft and be installed to a minimum depth of 8 feet and a minimum installation pressure of 2100 psi, or refusal, using a 9.62 square inch hydraulic ram.

Regards,

Daniel Stark, P.E.
Stark Foundations

EXPIRES: 06/30/22


PP
PP
PP
PP
3
4
5
2
DT
1
Drain Tile
Drain Tile
Drain Tile
A
Drain Tile
Drain Tile
Drain Tile
Drain Tile
Drain Tile
SS
Garage
Dicharge line

Engineering Properties–Multnomah County Area, Oregon														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
8C—Cascade-Urban land complex, 8 to 15 percent slopes														
Cascade	50	C	0-8	Silt loam	ML	A-4	0-0-0	0-0-0	85-93-100	80-90-100	80-90-100	70-80-90	25-30-35	NP-5-10
			8-27	Silt loam, silty clay loam	ML	A-4, A-6	0-0-0	0-0-0	95-98-100	95-98-100	95-98-100	80-85-90	25-33-40	NP-8-15
			27-60	Silt loam, silty clay loam	ML	A-4	0-0-0	0-0-0	100-100-100	100-100-100	95-98-100	85-90-95	25-30-35	NP-5-10

Figure 1: Engineering Soil Properties
Reference: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

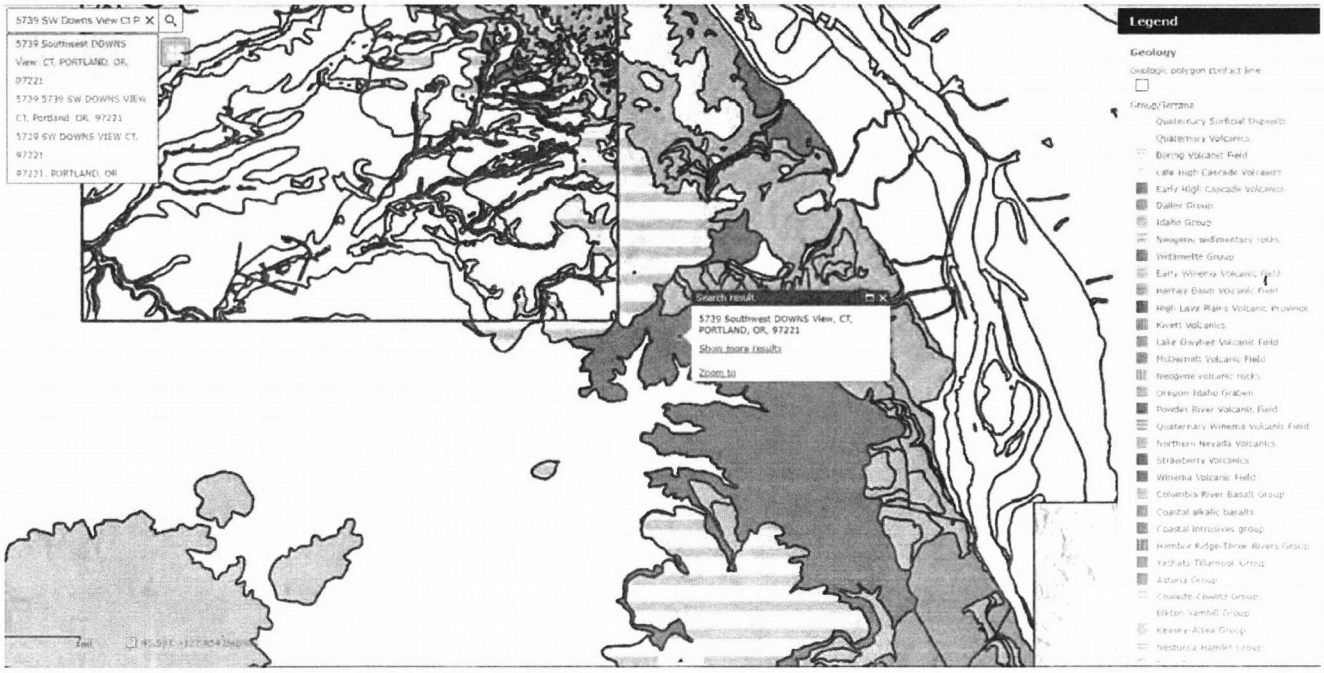


Figure 2: Geologic Map
Reference: https://gis.dogami.oregon.gov/maps/geologicmap/

Figure 3: Seismic-Induced Liquefaction
Reference: https://gis.dogami.oregon.gov/maps/hazvu/

Figure 4: Landslide Hazard Map
Reference: https://gis.dogami.oregon.gov/maps/hazvu/

STARK FOUNDATIONS

PROJECT

Foundation Underpinning
5739 SW Downs View Ct
Portland, Oregon

Date: 31-Aug-20
Designed by: NDS

Project No.: 20.163.TFS (WO #: 36888)

Design Criteria

Code(s):

International Building Code (IBC) 2015/2018
ASCE 7-10

Design Loads:

Dead:

Roof =	15	psf
Chimney =	45	psf
Third Floor =	15	psf
Second Floor =	15	psf
First Floor =	15	psf
Walls =	8	psf
8" Foundation Wall =	100	psf
Soil =	110	psf

Live:

Roof (snow) =	25	psf
Third Floor =	40	psf
Second Floor =	40	psf
First Floor =	40	psf

Soil:

Allow Lateral Bearing Pressure =	100	psf/ft
Active Pressure =	60	psf/ft

Wind: (not applicable)

Exposure =	C	
Wind Speed, V =	120	mph
Gust Effect Factor, G =	0.85	
Internal Pressure Coefficient, GC_{pi} =	-0.18	
External Pressure Coefficient, C_p =	0.8	

Risk Category =	II	
K_{zt} =	1.0	
K_d =	0.85	
K_z =	0.98	
Height, h_z =	30	ft

Design Wind Pressure:

where: $p_w = q_z (GCp - GC_{pi})$

$q_z = 0.00256 K_z K_{zt} K_d V^2$

Therefore:

q_z =	30.7	psf
p_w =	26.4	psf
Factored Wind Pressure, p'_w =	15.8	psf (say 16 psf)

Design Load Combo = D + 0.6W

$\omega = 0.6$

STARK FOUNDATIONS

PROJECT

Foundation Underpinning
5739 SW Downs View Ct
Portland, Oregon

Date: 31-Aug-20
Designed by: NDS

Project No.: 20.163.TFS (WO #: 36888)

Push Pier Design - Worst Case

Vertical Design Loads:

Tributary Widths:

Roof =	4	ft	------->	60	plf
Third Floor =	0	ft	------->	0	plf
Second Floor =	8	ft	------->	120	plf
First Floor =	8	ft	------->	120	plf
Walls =	16	ft	------->	128	plf
Foundation Wall (height) =	3	ft	------->	300	plf
Soil (height) =	2	ft	------->	220	plf
			ΣDL =	948	plf

Live:

Roof (snow) =	4	ft	------->	100	plf
Third Floor =	0	ft	------->	0	plf
Second Floor =	8	ft	------->	320	plf
First Floor =	8	ft	------->	320	plf
			ΣLL =	740	plf

Max Pier Spacing or Trib = 6 ft

Pier Working Loads:

P_{DL} =	5688	lbs
0.75*P_{LL} =	3330	lbs
Working Load, P_{TL} =	10000	lbs
Ultimate Load, P_{ULT} =	20000	lbs

Pier Design:

Pier Type: Push Pier

Bracket: FS288BL Bracket Cap = 25300 lbs Therefore ok Reference ICC report (attached)

Shaft Diameter: 2.875"

Installation Pressure, P:

$Q_{ult} = 2 (P_{TL})$

20000 lbs

$Q_{ult} = A_{cyl} (P)$ where A_{cyl} = working area of the dual bore installation cylinder

A_{cyl} = 9.62 in^2

Therefore, $P_{REQ} = Q_{ult} / A_{cyl}$

2100 psi

STARK FOUNDATIONS

PROJECT

Foundation Underpinning
5739 SW Downs View Ct
Portland, Oregon

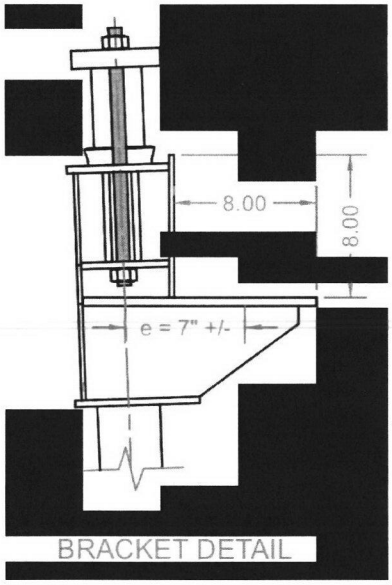
Date: 31-Aug-20
Designed by: NDS

Project No.: 20.163.TFS (WO #: 36888)

Push Pier Analysis - PP288 System

Vertical Design Loads:

Working Load, P_{TL} =	9.02	kips
Min Installation Depth, L =	10	ft
Unbraced Length, L_U =	1	ft (assumed fully braced)
Eccentricity, e =	7	in
Concrete-steel coif of friction =	0.45	
Friction Factor of Safety =	2.0	
Normal Surface Force, F_n =	4.51	
Eccentric moment, $M_e = P_{TL} \times e$ =	63.13	in-kip
Friction moment, M_f =	14.20	in-kip
Design moment, M_T =	48.92	in-kip



Sleeve Section Properties:

Sleeve Length =	48	in
Sleeve OD =	3.485	in
Wall thickness, t_w =	0.201	in
Sleeve ID =	3.083	in
A =	2.072	in^2
I =	2.804	in^4
S =	1.609	in^3
Z =	2.169	in^3
r =	1.163	in
E =	29000	ksi
F_y =	50	ksi

Pier Section Properties:

Pier OD =	2.839	in
Wall thickness, t_w =	0.117	in
Sleeve ID =	2.605	in
A =	1.001	in^2
I =	0.928	in^4
S =	0.654	in^3
Z =	0.867	in^3
r =	0.963	in
k =	2.1	
E =	29000	ksi
F_y =	50	ksi

PP288 Capacity

kl/r =	26.2	in	
F_c =	327	ksi	
$4.71 (E / F_y)^{0.5}$	113		
F_{cr} =	46.9	ksi	
P_n =	46.9	kips	
FS =	1.67		
Allowable Axial Load, P_n / FS	28.1	kips	
Actual Axial Load, P_{TL} =	9	kips	Therefore ok
Pier OD / t_{wp} =	24.3		Therefore < 0.45E / Fy - OK
M_p =	152	in-kip	
FS =	1.67	ksi	
Allowable Flexural Load, M_n / FS =	90.9	in-kip	
Actual Flexural Load, M_T =	48.92	in-kip	Therefore OK
Combined Axial & Flexural Check =	0.86		Therefore OK

EVALUATION REPORT **Number: 289**

Originally Issued: 01/16/2015 **Revised: 01/30/2020** **Valid Through: 01/31/2021**

SUPPORTWORKS, INC.
11850 VALLEY RIDGE DRIVE
PAPILLION, NEBRASKA 68046
www.supportworks.com
jkortan@supportworks.com

SUPPORTWORKS PP288 AND PP237 PUSH PIER SYSTEMS

CSI Section:
31 62 00 Driven Piles

1.0 RECOGNITION

Supportworks, Inc. Models PP288 and PP237 push pier systems recognized in this report have been evaluated for use as support foundations. The structural performance and geotechnical properties of the Supportworks, Inc. push pier systems comply with the intent of the provisions of the following codes and regulations:

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

2.0 LIMITATIONS

Use of Models PP288 and PP237 push pier foundation systems recognized in this report is subject to the following limitations:

2.1 The push pier foundation systems are manufactured, identified and installed in accordance with this report, approved construction documents (engineering drawings and specifications), and the manufacturer's published installation instructions. In case of conflicts, the more restrictive governs.

2.2 The push pier foundation systems have been evaluated for support of structures assigned to Seismic Design Categories A, B, and C in accordance with IBC Section 1613. Push pier foundation systems that support structures assigned to Seismic Design Category D, E or F, or are located in Site Class E or F, are outside the scope of this report.

2.3 Installations of the push pier foundation systems are limited to regions of concrete members where analysis indicates no cracking occurs at service load levels or due to the effects of restrained shrinkage.

2.4 The push pier brackets shall be used only to support structures that are laterally braced as defined in Section 1810.2.2 of the IBC.

2.5 The push pier foundation systems have not been evaluated for use in soil conditions that are indicative of a potential pier deterioration or corrosion situation 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.

2.6 Zinc-coated steel and bare steel components shall not be combined in the same system, except where the sacrificial thickness (T_s) for the zinc-coated components is taken as that given for bare steel components. All push pier foundation components shall be galvanically isolated from concrete reinforcing steel, building structural steel, or any other metal building components.

2.7 The push pier shafts shall be installed at a maximum angle of 3.0 ± 1.0-degrees from the vertical.

2.8 Special inspection is provided in accordance with Section 3.4 of this report.

2.9 Engineering calculations and drawings, in accordance with recognized engineering principles, as described in IBC Section 1604.4, prepared by a registered design professional, are provided to, and are approved by the code official.

2.10 The adequacy of the concrete structures that are connected to the brackets shall be verified by a registered design professional, in accordance with applicable code provisions, such as Chapter 15 of ACI 318 and Chapter 18 of IBC, and subject to the approval of the code official.

2.11 A geotechnical investigation report for each project site shall be provided to the code official for approval in accordance with Section 3.2.1 of this report.

2.12 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 (including Chapter 18) or the referenced standards are prohibited.

2.13 Evaluation of compliance with Section 1810.3.11.1 of the IBC for buildings assigned to Seismic Design Category C, and with Section 1810.3.6 of the IBC for all buildings, is outside the scope of this evaluation report. Such compliance shall be addressed by a registered design professional for each site, and the work of the design professional shall be subjected to approval of the code official.

2.14 Settlement of push piers is beyond the scope of this evaluation report and shall be determined by a registered design professional in accordance with Section 1810.3.2 of the IBC.

2.15 The Model PP288 push pier foundation system components are manufactured at the following facilities: Behlen Technology & Manufacturing Company, Omaha, Nebraska; Behlen Manufacturing Company, Columbus, Nebraska; PowerBrace, Des Moines, Iowa; and TSA Manufacturing, Omaha, Nebraska. The Model PP237 push pier foundation system components are manufactured at the following facilities: Behlen Technology & Manufacturing Company, Omaha, Nebraska; Behlen Manufacturing Company, Columbus, Nebraska; and TSA Manufacturing, Omaha, Nebraska.

3.0 PRODUCT USE

3.1 General: Supportworks, Inc. Models PP288 and PP237 push pier systems are used to support foundations of existing structures or to provide additional axial compression capacity to existing foundation systems. The systems are alternatives to driven piles described in IBC Section 1810.3.1.4.

3.2 Design: Structural calculations (analysis and design) and drawings, prepared by a registered design professional, shall be approved by the code official for each project, and shall be based on accepted engineering principles as described in IBC Section 1604.4, and shall conform to IBC Section 1810. The design methods for the steel components are Allowable Strength Design (ASD), described in the IBC and AISC 360 Section B3.4. The structural analysis shall consider all applicable internal forces due to applied loads, structural eccentricity and maximum span(s) between push pier foundations. The structural analysis, the IBC, and this report shall be used to select an appropriate push pier system.

The ASD capacities of push pier system components are indicated in Table 2 of this report. The geotechnical investigation shall address the suitability of the push pier system for the specific project. The requirements for deep foundations in IBC Section 1803.5.5 shall be considered. In addition, effects on the supported foundation and structure and group effects on the pile-soil capacity shall be considered. The investigation shall provide estimates of the axial compression capacities for the push piers, and the expected total and differential settlements due to single pier or pier group, as applicable.

3.2.1 A written report of the geotechnical investigation shall be submitted to the code official as one of the required submittal documents, prescribed in IBC Section 107, at the time of the permit application. The geotechnical report shall comply with provisions in IBC Section 1803.6 and also include, but need not be limited to, the following information:

1. Information on groundwater table, frost depth and corrosion-related parameters, as described in Section 2.5 of this report.
2. Soil properties, including those affecting the design such as support conditions for the piers.
3. Recommendations for design criteria.
4. Any questionable soil characteristics and special design provisions, as necessary.

3.2.2 Bracket Capacity (P1): Only localized limit state of concrete bearing strength in compression has been evaluated in this evaluation report for compliance with IBC Chapter 19 and ACI 318. All other structural requirements in IBC Chapter 19 and ACI 318 applying to the concrete foundation, such as those limit states described in ACI 318 (anchorage per Appendix D, punching (two-way) shear, beam (one-way) shear, and flexural (bending) related limit states), have not been evaluated in this evaluation report. The concrete foundation shall be designed and justified to the satisfaction of the code official with due consideration to structural detailing, applicable limit states, and the direction and eccentricity of applied loads, including reactions provided by the brackets, acting on the concrete foundation.

3.2.3 Shaft Capacity (P2): The top of shafts shall be braced as prescribed in Section 1810.2.2 of the IBC. In accordance with Section 1810.2.1 of the IBC, any soil other than fluid soil shall be deemed to afford sufficient lateral support to prevent buckling of systems that are braced. When piers are standing in air, water or fluid soils, the unbraced length is defined as the length of piers that is standing in air, water or fluid soils plus an additional 5 feet (1524 mm) when embedded into firm soil or an additional 10 feet (3048 mm) when embedded into soft soil. Firm soils shall be defined as any soil with a Standard Penetration Test (SPT) blow count of five or greater. Soft soil shall be defined as any soil with a SPT blow count greater than zero and less than five. Fluid soils shall be defined as any soil with a SPT blow count of zero [weight of hammer (WOH) or weight of rods (WOR)]. The SPT blow counts shall be determined in accordance with ASTM D1586. For fully braced conditions where the pier is installed in accordance with Section 1810.2.2 of the IBC, and piers do not stand in air, water, or fluid soils, the shaft capacities shall not exceed the ASD shaft compression capacities shown in Table 2 of this report. Shaft capacities of push pier foundation systems in air, water or fluid soils, shall be determined by a registered design professional.

The elastic shortening/lengthening of the pier shaft will be controlled by the variation of applied loads from the pier lock-off load and the mechanical and geometrical properties of the $2^{7}/_{8}$- and $2^{3}/_{8}$-inch-diameter (73 mm and 60 mm) round structural tubing. The shaft elastic shortening may be determined from equation Eq.-1:

$$\Delta_{shaft} = \frac{\Delta P \times L}{A \times E} \qquad \text{(Eq. 1)}$$

Where:

Δ_{shaft} = change in shaft length due to elastic shortening (inches/mm)
ΔP = change in load between the applied load and the pier lock-off load (lbf/N)
L = pier shaft length (inches/mm)
A = shaft cross-sectional area (in^2/mm^2) (taken from Table 1 of this report)
E = shaft steel modulus of elasticity (29,000,000 psi/199,900 MPa)

3.2.4 Soil Capacity (P4): For determination of allowable soil capacity in axial compression, a minimum factor of safety of 2.0 shall be applied to the final drive force. The final drive force shall not exceed the maximum drive force rating of the applicable PP288 or PP237 push pier system as listed in Table 2 (Note #4) of this report.

3.2.5 System Capacity: The ASD allowable capacity of the push pier foundation system in compression depends upon the analysis of interaction of brackets, shafts, and soils; and shall be the lowest value of P1, P2, and P4 as shown in Table 2 of this report.

3.3 Installation:

3.3.1 Installation General: The push pier foundation systems shall be installed by trained and certified installers. The push pier foundation systems shall be installed in accordance with this section (Section 3.3 of this report), site-specific approved construction documents (engineering drawings and specifications), and the manufacturer's written installation instructions. In case of conflicts, the more restrictive governs.

3.3.2 Retrofit Bracket Installation:

1. An area shall be excavated approximately 3 feet (914 mm) square and to a depth approximately 9 to 13 inches (229 to 330 mm) below the bottom of footing at the push pier location. The soil shall be removed below the bottom of footing to about 9 inches (229 mm) from the footing face in the area where the bracket bearing plate will be placed. The vertical and bottom faces of the footing shall, to the extent possible, be smooth and at right angles to each other for the mounting of the support bracket. The concrete surfaces shall be free of all soil, debris and loose concrete so as to provide a full and firm contact of the retrofit bracket.

2. Notching of the footings may be needed to place the retrofit bracket directly under the wall/column. Notching shall be performed, however, only with the acceptance of the registered design professional and the approval of the code official.

3. The bracket shall be placed under the footing and raised into position with the horizontal and vertical bearing plates in full contact with the concrete surfaces. The bracket shall be temporarily held in place using wood cribbing or other mechanical means. The under-footing brackets do not require mechanical anchorage to the concrete foundation.

4. The external sleeve shall be placed over the starter tube and both the external sleeve and starter tube shall be inserted through the bracket from the top. Care shall be taken that the sleeve and starter are properly aligned and extend past both the top and bottom plates of the bracket.

5. The drive stand shall be secured to the bracket, the hydraulic drive cylinder attached to the drive stand and connected to the hydraulic operating system.

6. The drive stand shall be aligned by activating the hydraulics and extending the drive cylinder rod to make slight contact with the starter tube section. A digital level, protractor or other device shall be used to check alignment of the drive stand, sleeve, starter and bracket. The alignment shall be adjusted as necessary to allow a 3.0 ±1.0-degree installation angle. Temporary cribbing may be used between the drive stand and the foundation wall to set the correct installation angle while advancing the starter tube and external sleeve.

7. The external sleeve and starter tube shall be driven together until the end of the sleeve is seated at the top of the bracket. Pier tubes shall then be coupled and pushed through the external sleeve. When the maximum cylinder stroke has been reached, the cylinder shall be retracted, a drive tube tool shall be set in place, and the push shall be completed to the top of the bracket or external sleeve.

8. The drive pressure at the final stroke of each pier tube section shall be recorded. This process shall continue until the pre-determined drive pressure (final drive force) is achieved or the structure starts to lift. After reaching the final drive force, the pressure shall be released from the hydraulic system and the drive stand and drive cylinder shall be removed from the bracket. The drive process shall be repeated at each of the proposed pier locations. The final drive force shall not exceed the maximum drive force rating of the push pier system as listed in Table 2 (Note #4) of this report.

9. A lift cylinder shall be connected to each retrofit bracket assembly to lift the structure to the desired elevation and/or transfer the designated portion of the foundation loads to the push pier system.

3.4 Special Inspection: Continuous special inspection in accordance with Section 1704.8 of the 2009 IBC or Section 1705.7 of the 2012, 2015, and 2018 IBC shall be provided for the installation of foundation piers and foundation brackets. Items to be confirmed by the special inspector include, but are not limited to, the manufacturer's certification of installers, verification of the product

manufacturer, push pier bracket and component configuration and identification, inclination and position of the push piers, final drive force, push pier lock-off load, depth of the foundation piers, and compliance of the installation with the approved construction documents and this evaluation report.

In lieu of continuous special inspection, periodic special inspection as defined in IBC Section 202 is permitted, provided that all following requirements identified below, are satisfied: (1) The installers are certified by the manufacturer and the evidence of installer training and certification by the report holder are provided to the code official; (2) Structural observations in accordance with the 2009 IBC Section 1710, 2012 IBC Section 1704.5, or 2015 or 2018 IBC Section 1704.6 are provided; (3) A periodic inspection schedule, as part of the statement of special inspection, prepared by a registered design professional, is submitted to and approved by the code official. As a minimum, the periodic inspection schedule shall include, but not be limited to, the following:

1. Before the start of work: Verify manufacturer, verify installer's certification by the manufacturer, and confirm push pier and bracket configuration compliance with the approved construction documents and this evaluation report.
2. Installation of the first push pier foundation system: Verify that the location, inclination, final drive force, push pier lock-off load and depth of the push piers comply with the approved construction documents and this evaluation report. Verify that installers keep an installation log.
3. First connection to the building structure: Verify that installation of brackets complies with the approved construction documents and this evaluation report.
4. End of work: Verify that the installation log complies with requirements specified in the approved construction documents. Verify that installation of all structural connections complies with approved construction documents and this evaluation report.

4.0 PRODUCT DESCRIPTION

4.1 Product information: Models PP288 and PP237 push pier systems consist of an under-footing bracket (side load), external sleeve, starter tube with friction-reduction collar, and push pier tube sections with slip-fit couplings. The under-footing bracket is secured against and below the existing footing while pier sections are hydraulically driven (pushed) through the bracket and into the soil below using the combined structural weight and any contributory soil load as drive resistance. Pier sections are added and driven until a suitable load bearing stratum is encountered. The weight of the structure is then transferred through the foundation brackets and piers, and to firm load bearing soil or bedrock.

4.2 PP288 Material information

4.2.1 Retrofit Bracket Assemblies FS288B, FS288BL, and FS288BL2: The FS288B, FS288BL, and FS288BL2 bracket assemblies consist of an FS288B, FS288BL, or FS288BL2 bracket, an external pipe sleeve (FS288ES48), a cap plate (FS288C), two threaded rods, and matching nuts. The assemblies are illustrated in Figure 1 of this report.

4.2.1.1 FS288B, FS288BL, and FS288BL2 Brackets: The FS288B, FS288BL, and FS288BL2 brackets are constructed from factory-welded, 0.250-, 0.3125-, 0.375-, and 0.500-inch-thick (6.35 mm, 7.94 mm, 9.53 mm, and 12.7 mm) steel plates. The steel plates used in the FS288B and FS288BL brackets conform to ASTM A36, with a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (400 MPa). The steel plates used in the FS288BL2 bracket conform to ASTM A572, Grade 50, with a minimum yield strength of 50 ksi (345 Mpa) and a minimum tensile strength of 65 ksi (448 Mpa). The bracket finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

4.2.1.2 FS288ES48 External Sleeve: The external sleeve (FS288ES48) is manufactured from a 48-inch-long (1219 mm), $3^1/_2$-inch outside diameter (89 mm) and 0.216-inch (5.49 mm) nominal wall thickness pipe conforming to ASTM A500, as specified in the quality control documentation. One end of the external sleeve has a 1.00-inch long (25.4 mm) section trumpeted to a final outer diameter of 4.00 inches (101.6 mm). The sleeve finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

4.2.1.3 FS288C Cap Plate: The FS288C cap plate is manufactured from a 1-inch-thick (25.4 mm), 4-inch-wide (102 mm), 8.25-inch-long (210 mm) steel plate. The steel cap plate conforms to ASTM A572, Grade 65, having a minimum yield strength of 65 ksi (448 MPa) and a minimum tensile strength of 80 ksi (552 MPa). The cap plate assembly finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

4.2.1.4 Threaded Rod and Nuts: The cap plate is attached to the retrofit bracket with two $^3/_4$-inch-diameter by 16-inch-long (19.1 mm by 406 mm) threaded rods, and matching $^3/_4$-inch (19.1 mm) heavy hex nuts. The $^3/_4$-inch-diameter (19.1 mm) steel threaded rods conform to ASTM A193, Grade B7, having a minimum yield strength of 105 ksi (724 MPa) and a minimum tensile strength of 125 ksi (862 MPa). The matching $^3/_4$-inch-diameter (19.1 mm) steel heavy hex nuts conform to ASTM A563 Grade DH or DH3, or ASTM A194 Grade 2H. The threaded rods and nuts are zinc-coated in accordance with ASTM B633, with coating classification Fe/Zn 8.

4.2.2 PP288 Starter and Pier Tube Sections: The central steel shaft of the starter and pier tube sections are 2.875-inch outer diameter (73 mm) by 0.165-inch (4.19 mm) nominal wall thickness hollow structural section in conformance with ASTM A500 as specified in the quality control documentation. Mechanical properties are listed in Table 1 of this report. The starter tube includes a 1.00-inch-long (25.4 mm) by 3.375-inch (85.7 mm) outer diameter friction-reduction collar machined from steel conforming to ASTM A36 with a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (400 MPa). The starter tube and pier tube shaft finishes are triple coated in-line galvanized.

4.2.3 PP288 Shaft Couplings: The shaft coupling material is factory crimped or plug-welded to one end of the tube section and consists of 2.50-inch (63.5 mm) outer diameter by 0.180-inch (4.57 mm) nominal wall thickness hollow structural section in conformance with ASTM A53 Grade B, Type E & S with a minimum yield strength of 35 ksi (241 MPa) and a minimum tensile strength of 60 ksi (413 MPa). The pier tube shaft coupling finish is plain steel.

4.3 PP237 Material information

4.3.1 Retrofit Bracket Assembly FS238B: The FS238B bracket assembly consists of an FS238B bracket, an external pipe sleeve (FS238ES48), a cap plate (FS238C), two threaded rods, and matching nuts. The assembly is illustrated in Figure 1 of this report.

4.3.1.1 FS238B Bracket: The FS238B bracket is constructed from factory-welded, 0.250- and 0.375-inch-thick (6.35 mm and 9.53 mm) steel plates. The steel plates conform to ASTM A36, with a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (400 MPa). The bracket finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

4.3.1.2 FS238ES48 External Sleeve: The external sleeve (FS238ES48) is manufactured from a 48-inch-long (1219 mm), $2^{7}/_{8}$-inch outside diameter (73 mm) and 0.203-inch (5.16 mm) nominal wall thickness pipe with a factory-welded end ring which consists of a 0.75-inch long (19.1 mm), $3^{3}/_{8}$-inch outside diameter (85.7 mm) and 0.188-inch (4.78 mm) nominal wall thickness pipe. The external sleeve shaft and end-ring conforms to ASTM A500 and ASTM A53, respectively, as specified in the quality control documentation. The sleeve finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

4.3.1.3 FS238C Cap Plate: The FS238C cap plate is manufactured from a 0.5-inch-long (12.7 mm), $2^{7}/_{8}$-inch outside diameter (73 mm) and 0.203-inch (5.16 mm) nominal wall thickness pipe that is factory welded to a 0.75-inch-thick (19.1 mm), 3.75-inch-wide (95 mm), 5.75-inch-long (146 mm) steel plate. The steel pipe conforms to ASTM A53, Grade B, Type E and S, having a minimum yield strength of 35 ksi (241 MPa) and a minimum tensile strength of 60 ksi (413 MPa). The steel cap plate conforms to ASTM A572, Grade 50, having a minimum yield strength of 50 ksi (345 MPa) and a minimum tensile strength of 65 ksi (448 MPa). The cap plate assembly finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

4.3.1.4 Threaded Rod and Nuts: The cap plate is attached to the retrofit bracket with two $^{5}/_{8}$-inch-diameter by 14-inch-long (15.9 mm by 356 mm) threaded rods, and matching $^{5}/_{8}$-inch (15.9 mm) standard hex nuts. The threaded rods conform to ASTM A193, Grade B7, having a minimum yield strength of 105 ksi (724 MPa) and a minimum tensile strength of 125 ksi (862 MPa). The matching standard hex nuts conform to SAE J995 Grade 8. The threaded rods and nuts are zinc-coated in accordance with ASTM B633, with coating classification Fe/Zn 8.

4.3.2 PP237 Starter and Pier Tube Sections: The central steel shaft of the PP237 starter and pier tube sections are 2.375-inch outer diameter (60 mm) by 0.154-inch (3.91 mm) nominal wall thickness hollow structural section in conformance with ASTM A500 as specified in the quality control documentation. Mechanical properties are listed in Table 1 of this report. The starter tube includes a friction reduction collar factory welded to one end. The collar consists of a 1.00-inch-long (25.4 mm), $2^{7}/_{8}$-inch outside diameter (73 mm) and 0.203-inch (5.16 mm) nominal wall thickness pipe conforming to ASTM A53, Grade B, Type E and S, having a minimum yield strength of 35 ksi (241 MPa) and a minimum tensile strength of 60 ksi (413 MPa). The starter tube and pier tube shaft finishes are either plain steel or hot-dipped galvanized in accordance with ASTM A123.

4.3.3 PP237 Shaft Couplings: The PP237 shaft coupling material is factory crimped to one end of the tube section and consists of 2-inch (50.8 mm) outer diameter by 0.187-inch (4.75 mm) nominal wall thickness hollow structural section in conformance with ASTM A500 Grade C, with a minimum yield strength of 46 ksi (317 MPa) and a minimum tensile strength of 62 ksi (427 MPa). The pier tube shaft coupling finish is either plain steel or hot-dipped galvanized in accordance with ASTM A123.

5.0 IDENTIFICATION

The push pier foundation system components described in this report are identified by labels that include the report holder's name (Supportworks, Inc.); the name and address of Behlen Technology & Manufacturing Company, Behlen Manufacturing Company, PowerBrace, or TSA Manufacturing; the product name, the model number (PP288 or PP237); the part number; and the IAPMO UES evaluation report number (ER-289). The identification includes the IAPMO Uniform Evaluation Service Mark of Conformity. Either Mark of Conformity may be used as follows:

or

IAPMO UES ER-289

6.0 SUBSTANTIATING DATA

6.1 Data in accordance with IBC Section 1810.3.1.4.
6.2 Test Reports for compression loading Push Pier Foundation System
6.3 Engineering Calculations

7.0 STATEMENT OF RECOGNITION

This evaluation report describes the results of research carried out by IAPMO Uniform Evaluation Service on Supportworks, Inc. Model PP288 and PP237 Push Pier Systems to assess conformance to the codes shown in Section 1.0 of this report and serves as documentation of the product certification. Products are manufactured at locations noted in Section 2.15 of this report under a quality control program with periodic inspection under the supervision of IAPMO UES.

Brian Gerber, P.E., S.E.
Vice President, Technical Operations
Uniform Evaluation Service

Richard Beck, PE, CBO, MCP
Vice President, Uniform Evaluation Service

GP Russ Chaney
CEO, The IAPMO Group

For additional information about this evaluation report please visit
www.uniform-es.org **or email us at** info@uniform-es.org

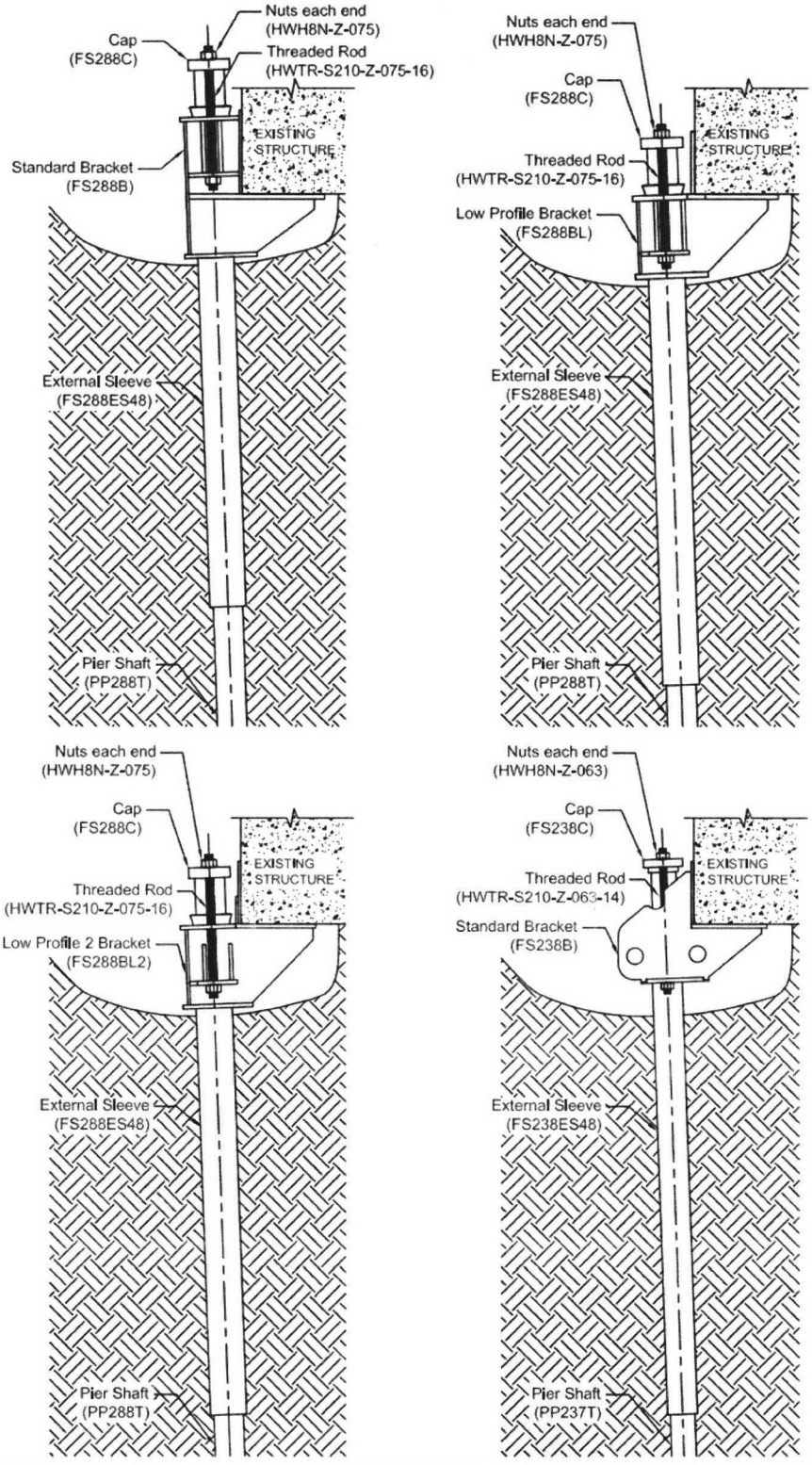


FIGURE 1 - FS288B, FS288BL, FS288BL2, and FS238B Retrofit Bracket System Components

TABLE 1 - MECHANICAL PROPERTIES OF PUSH PIER SHAFTS

Mechanical Properties	Un-corroded		After 50 Year Corrosion Loss			
	Plain Steel		Plain Steel		Hot-dip Galvanized	
	PP288	PP237	PP288	PP237	PP288	PP237
Steel Minimum Yield Strength, F_y	50 ksi	60 ksi	50 ksi	60 ksi	NA	60 ksi
Steel Minimum Ultimate Strength, F_u	55 ksi	70 ksi	55 ksi	70 ksi	NA	70 ksi
Modulus of Elasticity, E	29,000 ksi	29,000 ksi	29,000 ksi	29,000 ksi	NA	29,000 ksi
Nominal Wall Thickness	0.165 in.	0.154 in.	0.165 in.	0.154 in.	NA	0.154 in.
Design Wall Thickness	0.153 in.	0.143 in.	0.117 in.	0.107 in.	NA	0.133 in.
Outside Diameter, OD	2.875 in.	2.375 in.	2.839 in.	2.339 in.	NA	2.365 in.
Inside Diameter, ID	2.569 in.	2.089 in.	2.605 in.	2.125 in.	NA	2.099 in.
Cross Sectional Area, A	1.31 in^2	1.00 in^2	1.00 in^2	0.75 in^2	NA	0.93 in^2
Moment of Inertia, I	1.22 in^4	0.63 in^4	0.93 in^4	0.47 in^4	NA	0.58 in^4
Radius of Gyration, r	0.96 in.	0.79 in.	0.96 in.	0.79 in.	NA	0.79 in.
Elastic Section Modulus, S	0.85 in^3	0.53 in^3	0.65 in^3	0.40 in^3	NA	0.49 in^3
Plastic Section Modulus, Z	1.14 in^3	0.71 in^3	0.87 in^3	0.53 in^3	NA	0.66 in^3

For SI: 1 inch = 25.4 mm, 1 kip = 1,000 lbf = 4.448 kN

TABLE 2 - PP288 AND PP237 (WITH RETROFIT BRACKET) ASD COMPRESSION CAPACITIES

Bracket Part No.[1]	Sleeve Part No.[1]	Bracket Description	Allowable Compression Capacity (kips)			
			Bracket (P1)[2]	Shaft (P2)[3]	Soil (P4)[4]	Foundation System[5]
FS288B or FS288B-G	FS288ES48 or FS288ES48-G	PP288 Standard Bracket w/48" Sleeve	28.5	29.4	30.0	28.5
FS288BL or FS288BL-G	FS288ES48 or FS288ES48-G	PP288 Low Profile Bracket w/48" Sleeve	25.4	29.4	30.0	25.4
FS288BL2 or FS288BL2-G	FS288ES48 or FS288ES48-G	PP288 Low Profile Bracket w/48" Sleeve	24.1	29.4	30.0	24.1
FS238B	FS238ES48	PP237 2 3/8" Pier Bracket w/48" Sleeve	12.9	20.0	15.0	12.9
FS238B-G	FS238ES48-G		15.9	24.9	15.0	15.0

For SI: 1 inch = 25.4 mm, 1 kip = 1,000 lbf = 4.448 kN

[1]Part numbers with "G" suffix indicate hot-dip galvanized coating. Part numbers without a "G" suffix indicate plain steel.
[2]Bracket capacities are based on full-scale load tests and assumes a minimum concrete compressive strength (f'_c) of 2,500 psi (17.24 MPa).
[3]Shaft capacities are applicable only to foundation systems that are fully braced as described in Section 3.2.3 of this report.
[4]Soil capacities are determined by taking the final drive force during installation and dividing it by a minimum factor of safety of 2.0. Maximum drive force shall not exceed 60.0 kips for the PP288 system and 30.0 kips for the PP237 system.
[5]Foundation system allowable capacities are based on the lowest of P1, P2, and P4 listed in this table. Section 3.2.5 of this report describes additional requirements.