ICC EVALUATION SERVICE®

ICC-ES Evaluation Report

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

REPORT HOLDER:

AMERICAN EARTH ANCHORS, INC.

EVALUATION SUBJECT:

PENETRATOR™ GROUND SCREW FOUNDATION SYSTEMS—PE36, PE46 AND PE46-HEX8

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018 and 2015 *International Building Code®* (IBC)

Properties evaluated:

- Structural
- Geotechnical

2.0 USES

The Penetrator™ Ground Screw Foundation Systems are used to transfer axial compression, axial tension and lateral loads from the supported structures to the surrounding soil.

3.0 DESCRIPTION

3.1 General:

The Penetrator™ Ground Screw Foundation Systems consist of cast aluminum ground screws. The ground screws are screwed into the ground by application of torsion and simultaneously-applied downward pressure until the desired depth is reached. The ground screws come in three lengths and two head configurations. The PE36 is a 38-inch long ground screw, the PE46 is a 48-inch ground screw and PE46-Hex8 is a 54-inch long ground screw. The PE36 and PE46 have the same socket head configuration. The PE46-Hex8 has a deeper socket head configuration. See Figure 1 for product descriptions.

3.2 PE36, PE46 and PE46-Hex8 Penetrator™ Ground Screws:

The PE36, PE46 and PE46-Hex8 ground screws are composed of a solid cast aluminum tapered screw body with integrated screw threads and socket head. The screw body root diameter tapers from 1.81-inch-diameter (46 mm) at the top of the screw to a pointed tip at the bottom of the screw. The thread diameter tapers from 3 inches at the top of the screw to the pointed tip at the bottom of the screw. The top of the PE36 and PE46 ground screws come with an integrated cast aluminum socket hexagonal head measuring 2 inches (51 mm) wide by 2 inches (51 mm) high. The top of the socket head is tapped to receive a ¾-10 UNC threaded bolt used to attach supported structures. The side of the socket head also includes a $^3/_8$-inch-diameter (9.5 mm) predrilled hole through the body of the socket head. The top of the PE46-Hex8 ground screw has an integrated cast aluminum 8-inch-high (203 mm) cylindrical sleeve composed of a 1.875-inch-high (47.6 mm) by 1.732-inch (44 mm) hexagonal socket head and a solid round sleeve measuring 2 inches (51 mm) diameter by 6 inches (152 mm) high. The top sleeve comes with two $^3/_8$-inch-diameter (9.5 mm) predrilled through holes used to attach supported structures.

3.2.1 Top Connection of Ground Screws:

The supported structures are connected to the top of the ground screws using approved fasteners. The connection of the supported structures to the top of the ground screw is outside the scope of this report, and must be determined by registered design professional.

3.3 Material Specifications:

3.3.1 Ground Screws: The cast aluminum ground screws comply with ASTM B26 A356 T6 specification having a minimum yield strength of 24 ksi (165 MPa) and a minimum ultimate tensile strength of 34 ksi (235 MPa).

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: Engineering calculations (analysis and design) and drawings, prepared by a registered design professional, must be submitted to and approved by the code official for each project, and must be based on accepted engineering principles as described in IBC Section 1604.4. The engineering analysis must address ground screw system performance related to structural and geotechnical requirements. The calculations must address the ability (considering strength and stiffness) of the supported structure to transmit the applied loads to the Ground Screw Foundation System and the ability of the ground screws and surrounding soils to support the loads applied by the supported structure. The design method for the cast aluminum components is Allowable Strength Design (ASD), described in IBC Section 1602 and Section B3 of the 2015 Aluminum Design Manual (ADM). The design method for soils is ASD as prescribed in IBC Sections 1801.2 and 1602.

The structural analysis must consider all applicable internal forces (axial forces, shears, bending moments and torsional moments, if applicable) due to applied loads; eccentricity between applied loads and reactions acting on the screw-supported structure; the loading exerted on the supported structure by the top connection devices; and the design span(s) between ground screws. The loading exerted by the supported structure to the top of the ground screw should be equal in magnitude and opposite in direction to the force in the ground screw. A small lateral force is developed at the supported structure if the ground screw is not perfectly plumb but within the permitted inclination from vertical of ±1 degree. The result of this analysis and the structural capacities must be used to select a ground screw foundation system.

The ground screw embedment into the soil is based on the ground screw length and must be selected based on the project specific requirements.

For Ground Screw Foundation Systems subject to combined lateral and axial (compression or tension) loads, the allowable strength of the ground screw under combined loads must be determined using the interaction prescribed in Chapter H of the 2015 ADM.

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

A site-specific geotechnical report is required for proper application of ground screw foundation systems, unless exempted by the building official in accordance with IBC Section 1803.2. When required, geotechnical investigations shall be conducted in accordance with IBC Section 1803.2 and reported in accordance with IBC Section 1803.6. The geotechnical report must include, but not be limited to, the following information:

1. A plot showing the location of the soil investigation.
2. A complete record of the soil boring and penetration test logs and soil samples.
3. A record of the soil profile.
4. Information on groundwater table, frost depth and corrosion-related parameters, as described in Section 5.4 of this report.
5. Soil design parameters as shown in Table 4 of this report.
6. Confirmation of the suitability of ground screw systems for the specific project.
7. Recommendations for design criteria, including but not limited to, mitigation of effects of differential settlement and varying soil strength; and effects of adjacent loads.
8. Recommended center-to-center spacing of ground screws, if different from spacing noted in Section 5.0 of this report; and reduction of allowable loads due to the group action, if necessary.
9. Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity, when required).
10. Load test requirements.
11. Any questionable soil characteristics and special design provisions, as necessary.
12. Expected total and differential settlement.
13. The axial compression, axial tension and lateral load soil capacities if values cannot be determined from this evaluation report.

There are four primary structural/geotechnical elements associated with the ground screw foundation system: top of ground screw connection capacity, ground screw capacity, ground screw thread capacity and ground screw soil capacity, which are described in Sections 4.1.2, 4.1.3, 4.1.4, and 4.1.5, respectively. The allowable capacity of overall ground screw foundation system is described in Section 4.1.6.

4.1.2 Top of Ground Screw Connection:

The allowable load capacities of the top of ground connection are shown in Table 1 of this report. The supported structural element and its connection to the top of the ground screw must be designed by a registered design professional and must not exceed the published values in Table 1 of this report.

4.1.3 Ground Screw Capacity: The allowable load capacities of the screw are shown in Table 2 of this report.

4.1.4 Ground Screw Thread Capacity: The allowable load capacities of the ground screw threads are shown in Table 3 of this report.

4.1.5 Soil Capacity: The allowable load capacity of the ground screws installed in specified soils is shown in Table 4 of this report. The soil capacity of the ground screws shall be determined by a registered design professional for soil conditions that substantially differ from those shown in the table. Soil conditions shall be determined by a site-specific geotechnical report, as described in Section 4.1.1.

4.1.6 Ground Screw Foundation System: The overall allowable load capacity of the Ground Screw Foundation System depends upon the analysis of interaction of connection to the top of the gound screw (Section 4.1.2), ground screw shafts (Section 4.1.3), ground screw threads (Section 4.1.4) and ground screw soil capacity (Section 4.1.5), and must be based on the lowest value of those for top connection device capacity, ground screw shaft capacity, ground screw thread capacity and ground screw soil capacity. The applied load from the supported structure must not exceed the overall allowable load capacity of the Ground Screw Foundation System.

4.2 Installation:

4.2.1 General: The Penetrator™ Ground Screw Foundation Systems must be installed in accordance with this section (Section 4.2), the site-specific approved construction documents (engineering plans and specifications), and the manufacturer's written installation instructions. In case of a conflict, the most stringent requirement governs.

4.2.2 Ground Screw Installation:

1. The ground screws must be located and installed in accordance with the site-specific approved construction documents.
2. The equipment used to install the ground screws must be in accordance with the manufacturer's published installation instructions.
3. During installation the rotation of the ground screw must be accompanied by downward pressure (crowd) to advance the screw one thread pitch per rotation.

4. Ground screws must be installed vertically plumb into the ground with a ±1 degree of tolerance. The torque induced within the ground screws depends on the density of surrounding soils. The ground screw maximum installation torque capacities are provided in Table 2 and must not be exceed during ground screw installation.
5. Torque must be measured by torque wrench or meter.
6. The final depth must equal the length of the ground screws, except for head protruding from the ground surface. The length of the ground screw chosen must meet the minimum depth required for frost protection.
7. In order to avoid group effect for lateral loading, the center-to-center spacing of ground screws in the direction of lateral force must be at least eight times the ground screw outside diameter 3 inches (76 mm).
8. In order to avoid group effect for axial loading, the center-to-center spacing of ground screws must be at least three times the ground screw outside diameter 3 inches (76 mm).
9. The eccentricity between the applied vertical load by supported structures and the center of the ground screw shaft must not exceed 5 percent of the shaft maximum diameter of 3 inches (76 mm).

4.2.3 Top of Ground Screw Connection: Once the ground screw has been installed, the supported structure must be connected to the top of the ground screw in accordance with the approved plans as determined by registered design professional.

4.3 Special Inspections:

Special inspection in accordance with Section 1705.1.1 of the IBC must be performed during the installation of the Ground Screw Foudation Systems. Items to be recorded and confirmed by the special inspector include, but are not limited to, the following:

1. Verification of the product manufacturer.
2. Product configuration and identification (including catalog numbers) for ground screws.
3. Installation equipment used.
4. Written installation procedures.
5. Inclination and position of ground screws.
6. Verification that the maximum installation torque noted in Tables 2 is not exceeded. Verification that the ground screw soil embedment complies with Table 4, as applicable.
7. Compliance of the installation with the approved construction documents and this evaluation report, including conditions and limitations described in the footnotes to the tables in this report.

5.0 CONDITIONS OF USE

The Penetrator™ Ground Screw Foundation Systems described in this report comply with, or are suitable alternatives to what is specified in, those codes noted in Section 1.0 of this report, subject to the following conditions:

5.1 The Penetrator™ Ground Screw Foundation Systems are manufactured, identified and installed in accordance with this report, the approved construction documents (engineering drawings and specifications), and the manufacturer's written installation instructions, which must be available at the jobsite at all times during installation. In case of a conflict, the most stringent requirement governs.

5.2 The Penetrator™ Ground Screw Foundation Systems have been evaluated for support of structures assigned to Seismic Design Categories A and B and Site Classes A through D in accordance with IBC Section 1613. Ground screw foundation systems that support structures assigned to Seismic Design Category C, 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 Ground screw foundation systems are limited to support structures constructed from steel. aluminum or wood materials.

5.4 Use of the ground screw foundation systems in exposure conditions that are indicative of potential pile deterioration or corrosion situations as defined by the following: (1) soil resistivity less than 1,000 ohm-cm; (2) soil pH less than 5.5; (3) soils with high organic content; (4) soil sulfate concentrations greater than 1,000 ppm; (5) soils located in a landfill, or (6) soil containing mine waste is beyond the scope of the evaluation report.

5.5 Supported structures in contact with ground screws must comply with the provisions for dissimilar materials in Section M7 of the 2015 Aluminum Design Manual. Fasteners used to connect supported structure elements to the ground screws must also comply with the dissimilar materials provisions in Section M7 of the 2015 Aluminum Design Manual.

5.6 The ground screws must be installed vertically into the ground, with a maximum allowable angle of inclination of ±1 degree.

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

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

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

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

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

5.12 In order to avoid the group effects on lateral load behavior, the minimum center-to-center spacing of ground screws in the direction of lateral force must be at least eight times the ground screw shaft outside diameter; and to avoid the group effects on axial load behavior, the center-to-center spacings of the ground screws must be at least three times the ground screw shaft outside diameter.

5.13 Settlement of helical piles is beyond the scope of this evaluation report and must be determined by a registered design professional.

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

5.15 The ground screw foundation systems are manufactured in Woonsocket, Rhode Island under a quality control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

6.1 Report of soil load tests conducted in accordace with ASTM D1143, ASTM D3689 and ASTM D3966.

6.2 Report of axial compression and tension tests of ground screws.

6.3 Report of torsion tests of ground screws.

6.4 Report of thread capacity tests.

6.5 Quality documentation in accordance with the ICC-ES Acceptance Criteria for Quality Control Documentation (AC10).

7.0 IDENTIFICATION

7.1 The Penetrator™ Ground Screw Foundation Systems described in this report must be identified with a tag or label with the following information: report holder name and address; product model number and batch number and the ICC-ES evaluation report number (ESR-4496).

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

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TABLE 1—PE36, PE46 AND PE46-HEX8 GROUND SCREWS TOP CONNECTION ALLOWABLE CAPACITY[1,2]

Ground Screw Model	Allowable Load Capacity (kips)		
	Axial Tension[3]	Axial Compression	Lateral
PE36	11.8[3]	7.486[3]	0.422[3]
PE46	11.8[3]	7.486[3]	0.422[3]
PE46-HEX8	13.6[4]	7.486[4]	0.422[4]

For **SI:** 1 inch= 25.4 mm; 1 kip=1000 lbf= 4.45 kN.

[1] Tabulated allowable load capacities include corrosion losses of 0.036-inch over a 50-year service life. Fasteners attached to ground screws must comply with the provisions in Section M7 of the 2015 Aluminum Design Manual.
[2]Tabuluated allowable load values are based on internal strength properties of integrated cast aluminum socket head. Connection capacity of socket head to supported structural element must be determined by registered design professional.
[3]Tabulated load capacities are based on the load applied through a ¾-inch-diameter bolt with full thread engagement to the top of the integrated cast aluminum socket head. Other applicable limit states must be determined by registered design professional.

[4]Tabulated load capacities are based on the load applied through a 2-inch Schedule 40 steel pipe sleeve complying with ASTM A53 Grade B installed over the integrated cast aluminum socket head with two 3/8-inch diameter hex head bolts complying with SAE J429 Grade 8 and matching nuts complying with SAE J995. Other applicable limit states must be determined by registered design professional

TABLE 2—PE36, PE46 and PE46-Hex8 GROUND SCREW MODEL SHAFT ALLOWABLE CAPACITY

Ground Screw Model No.	Ground Screw Overall Length (inches)	Allowable Load Shaft Capacities[1]				
		Axial Tension (kips)	Axial Compression[2] (kips)	Lateral		Maximum Torque (ft-lbf)
				Bending (kip-ft)	Shear (kips)	
PE36	38	11.8	7.486	0.422	0.422	1051
PE46	48	11.8	7.486	0.422	0.422	1051
PE46-Hex8	54	13.6	7.486	0.422	0.422	1051

For **SI:** 1 inch= 25.4 mm; 1 kip=1000 lbf= 4.45 kN; 1 ft-lb= 1.36 N-m.

[1]Tabulated allowable load capacities include corrosion losses of 0.036-inch over a 50-year service life.

TABLE 3—PE36, PE46 and PE46-Hex8GROUND SCREWS SCREW THREADS ALLOWABLE CAPACITY[1]

Maximum Allowable Torsion (ft-lb)	Axial Tension/Compression Thread Capacity (kips)
1051	22.8

For **SI:** 1 inch= 25.4 mm; 1 kip=1000 lbf= 4.45 kN; 1 ft-lb= 1.36 N-m.

[1]Tabulated allowable load capacities include corrosion losses of 0.036-inch over a 50-year service life.

TABLE 4—PE36, PE46 AND PE46-HEX8 GROUND SCREWS ALLOWABLE SOIL CAPACITY[4]

Ground Screw Model No.	Ground Screw Overall Length (inches)	Ground Screw Soil Embedment Depth (inches)	Axial Tension (lbf)		Axial Compression (lbf)		Lateral (lbf)[3]	
			Soil Classification					
			Silty Sand[1]	Sandy Clay[2]	Silty Sand[1]	Sandy Clay[2]	Silty Sand[1]	Sandy Clay[2]
PE36	36	36	655	1285	1842	3792	422	313
PE46	48	46	1963	2417	1842	3792	422	313
PE46-Hex8	54	46	1963	2417	1842	3792	422	313

For **SI:** 1 inch= 25.4 mm; 1 lbf= 4.45 N.

[1]Silty sand classified soil has a blow count of 13.
[2]Sandy clay classified soil has a blow count of 30.
[3]Lateral load applied 12 inches above ground surface.
[4]Maximum installation torque must not exceed the maximum torque values in Table 3 of this report.

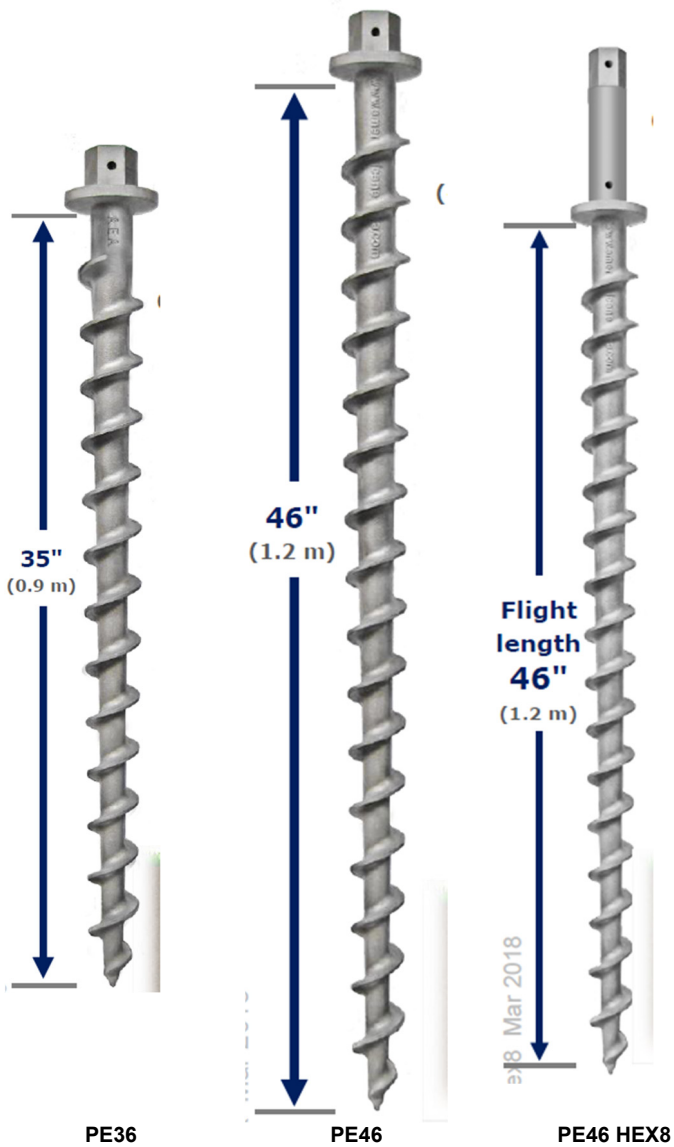

FIGURE 1—PENETRATOR™ GROUND SCREWS