Grip-Tite®
Foundation Pier System

HELIX PIER SYSTEM TECHNICAL REPORT

Grip-Tite® MANUFACTURING CO., INC.
P.O. BOX 111 • WINTERSET, IOWA 50273-0111 • TEL (515) 462-1313 • FAX (515) 462-3465

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HISTORY AND BACKGROUND

Grip-Tite Manufacturing Company has been manufacturing earth anchoring products for over 70 years. In the 1930's, Grip-Tite anchors were used to secure highway guard cables, then used extensively for guying oil well derricks and oil pipelines.

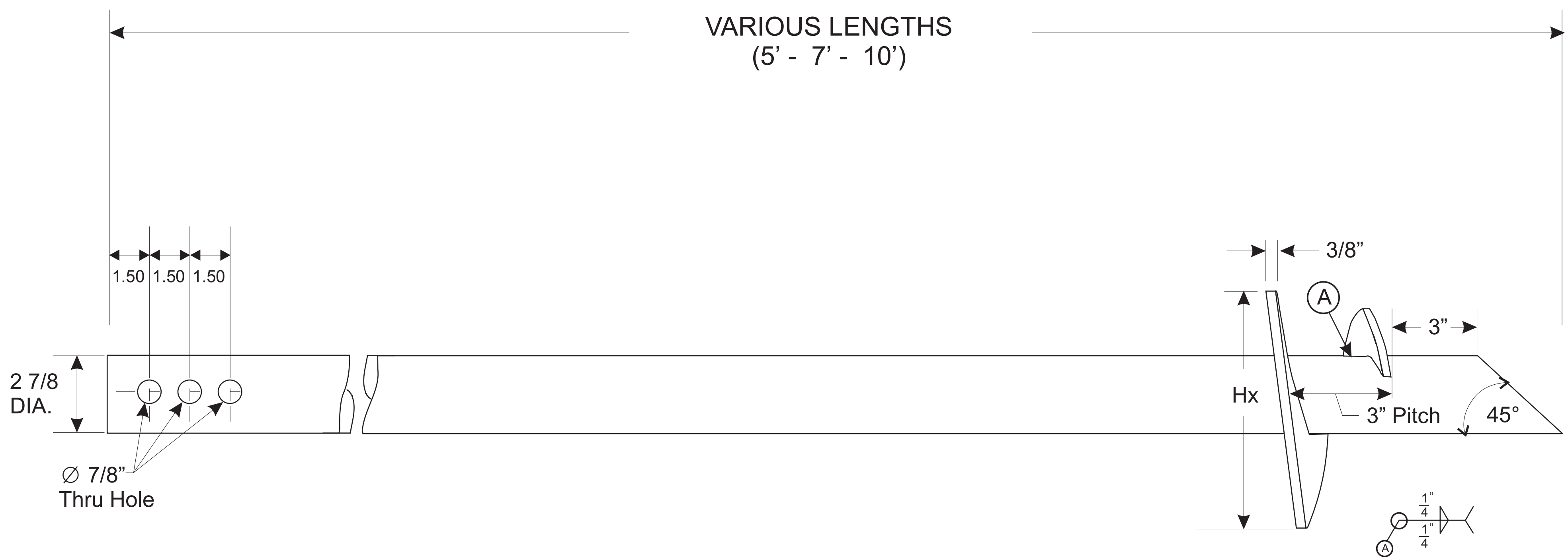
Following World War II, Grip-Tite developed anchors for the rapidly growing rural electrification network of overhead lines. Since that time, Grip-Tite has been manufacturing and supplying earth anchoring products for overhead electric and telephone lines -- serving electric and telephone utilities such as Verizon, Bell Operating Companies, Westinghouse Electric, POW-COM, Kabar Canada, and others coast to coast and abroad too numerous to mention. Grip-Tite continues as one of the leading earth anchor manufacturers for the electric and telephone industry.

Several years ago, Grip-Tite recognized the tremendous need for a product to simply and effectively secure and stabilize cracked and bowed foundation walls without replacement of the walls. After extensive development effort and using a modified earth anchor Grip-Tite originally produced for the electrification of the Island of Madagascar in the Indian Ocean, the Grip-Tite® Wall Anchor System became a reality -- a process unique enough to earn U.S. Patent number 4,189,891. Hundreds of thousands of our Wall Anchor Systems have been installed across the U.S. and Canada and continue to give confidence and peace of mind to the property owners involved.

Recently, Grip-Tite recognized the need for improvement in the foundation piering industry. Grip-Tite brought their expertise to bear on the problem of settling foundations, providing the sophisticated engineering and cost effective solutions you've come to expect.

Represented by over 50 certified dealers across the U.S. and Canada, Grip-Tite continues as your answer to all residential, commercial, and industrial foundation problems.

GRIP-TITE® Helix Pier Lead Section



Hx = Helix diameter - 8"; 10"; 12"; or 14"

Shaft shall consist of round structural ERW tubing per ASTM A500-03a Grade C - 2.875" OD x .262 wall

Helix: ASTM A36 - minimum yield: 36,000 / tensile: 58,000

Weld: Minimum tensile 70,000 psi

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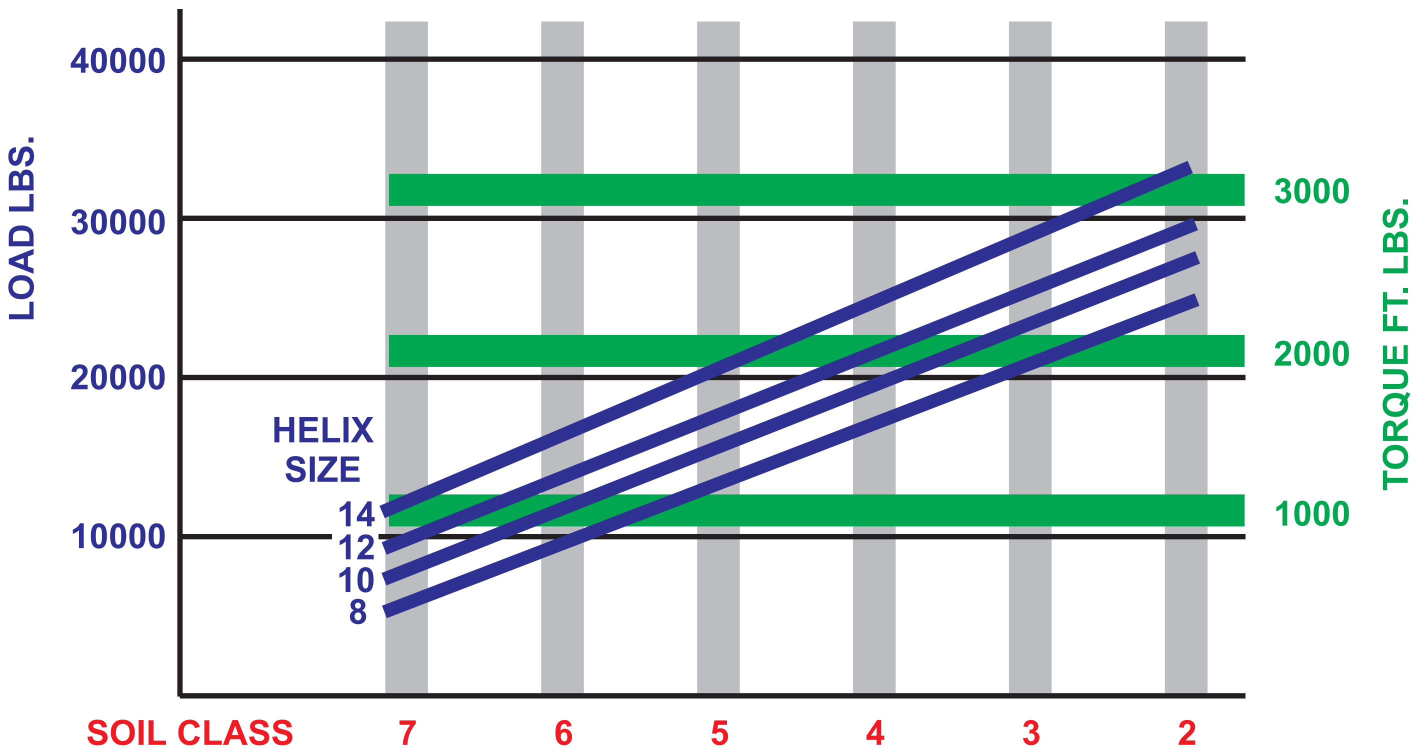
TYPICAL HOLDING CAPACITY FOR SINGLE HELIX



SOIL CLASS DESCRIPTION: 2-Dense sand, hard silts, coarse grave 3-Compact clay and gravel mixed, shale, broken rock, hardpan 4-Compacted sand, claypan, compacted gravel 5-Loose sand, gravel and clay, compacted coarse sand 6-Clay loam, damp clay, compacted sand fines, loose coarse sand 7-Silt loam, loose sand fines, wet clay, miscellaneous fill

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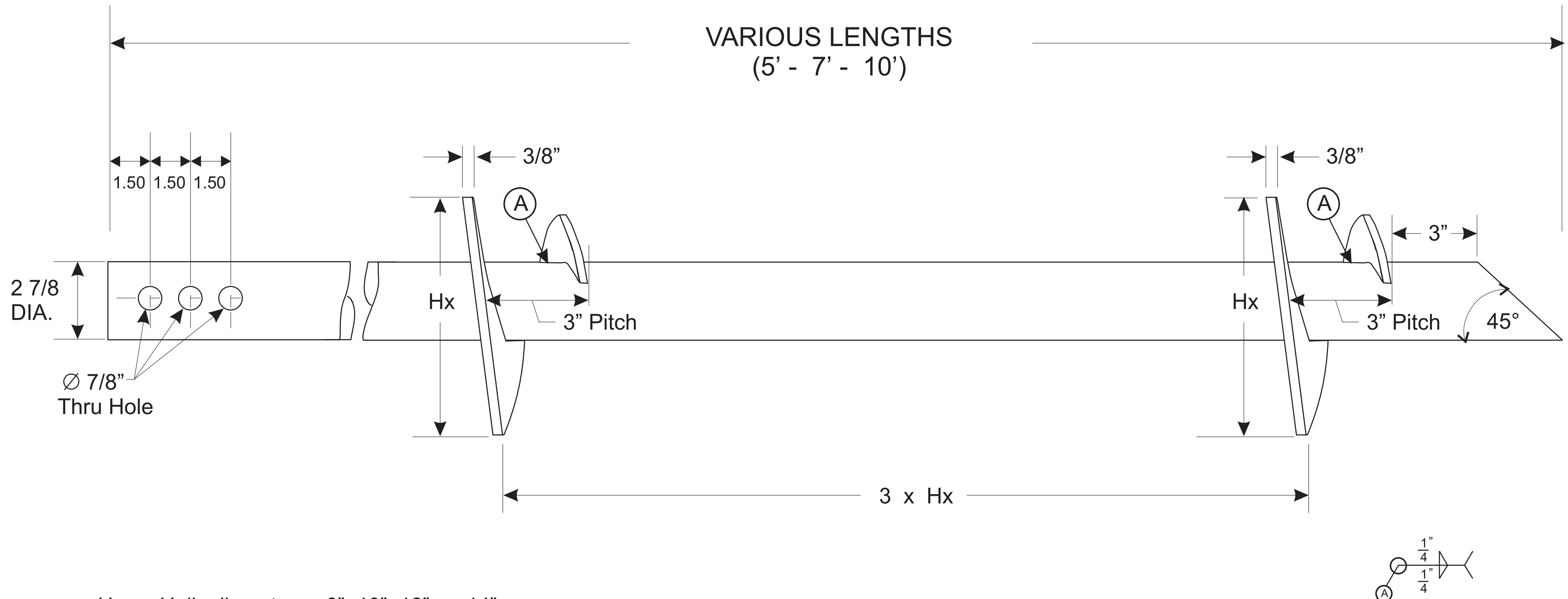
GRIP-TITE® Double Helix Pier Lead Section



Hx = Helix diameter - 8"; 10"; 12"; or 14"

Distance between helixes is 3 helix diameters

Shaft shall consist of round structural ERW tubing per ASTM A500-03a Grade C 2.875 OD x .262 wall

Helix: ASTM A36 - minimum yield: 36,000 / tensile: 58,000

Weld: Minimum tensile 70,000 psi

One, two, or three helixes may be used, spaced at 3 helix diameters apart.

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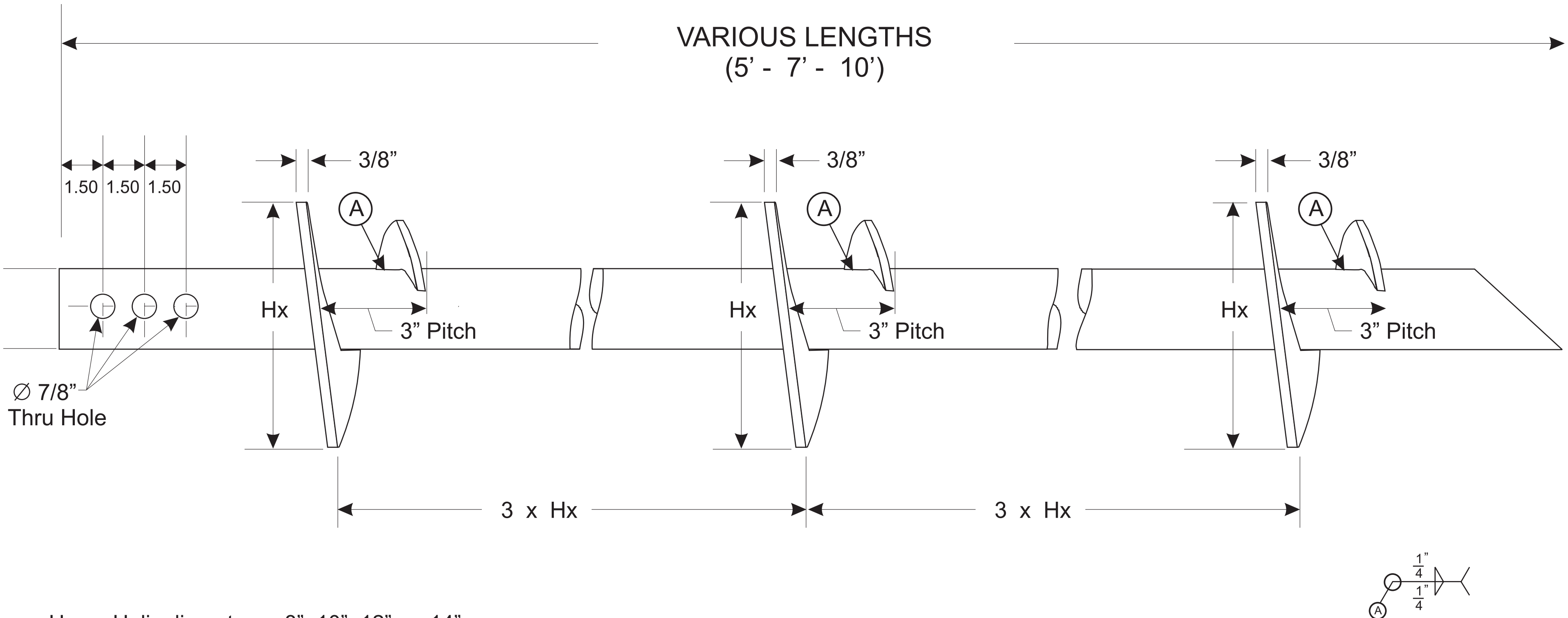
GRIP-TITE® Triple Helix Pier Lead Section



Hx = Helix diameter - 8"; 10"; 12"; or 14"

Distance between helixes is 3 helix diameters

Shaft shall consist of round structural ERW tubing per ASTM A500-03a Grade C 2.875 OD x .262 wall

Helix: ASTM A36 - minimum yield: 36,000 / tensile: 58,000

Weld: Minimum tensile 70,000 psi

One, two, or three helixes may be used, spaced at 3 helix diameters apart.

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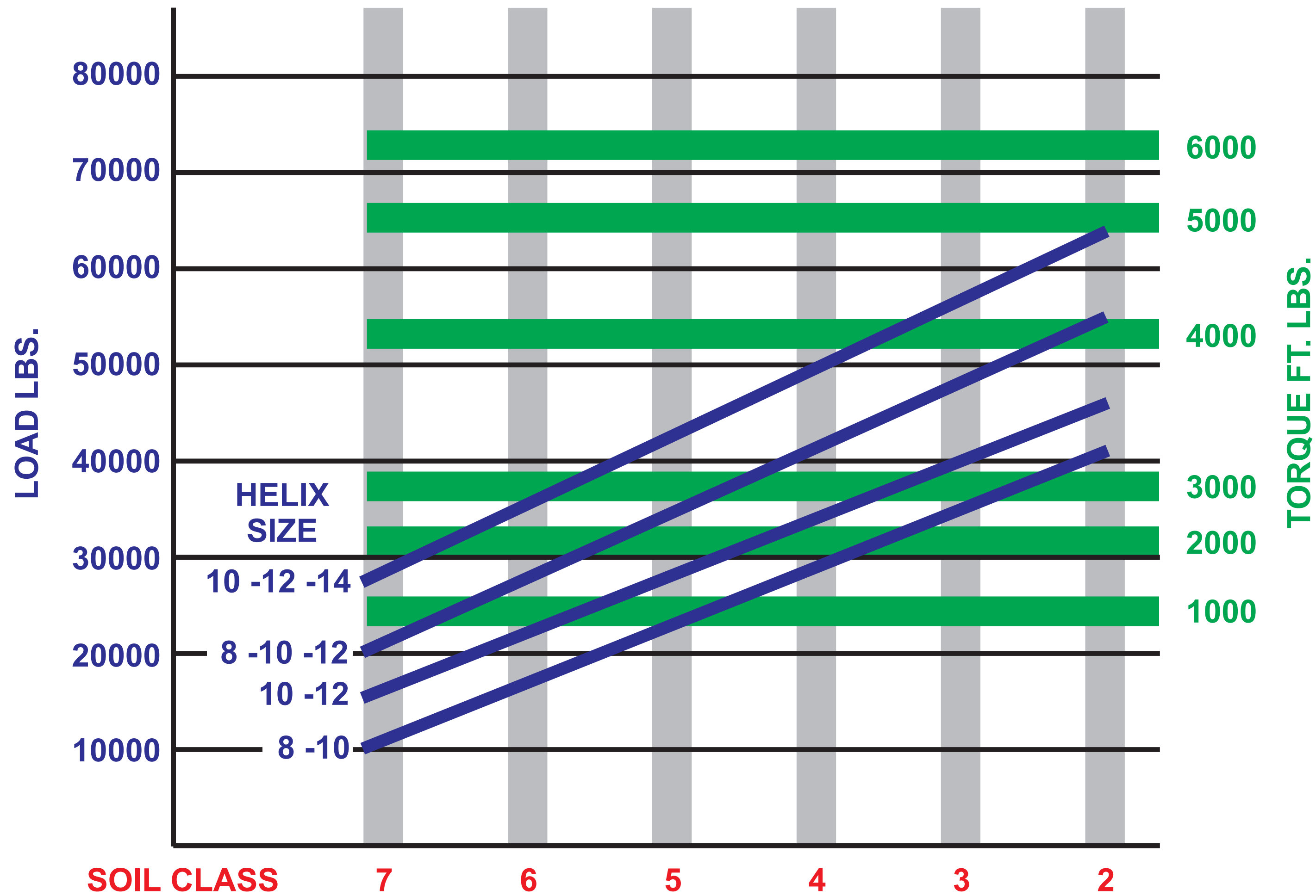
SOIL HOLDING TORQUE DATA



SOIL CLASS DESCRIPTION: 2-Dense sand, hard silts, coarse grave 3-Compact clay and gravel mixed, shale, broken rock, hardpan 4-Compacted sand, claypan, compacted gravel 5-Loose sand, gravel and clay, compacted coarse sand 6-Clay loam, damp clay, compacted sand fines, loose coarse sand 7-Silt loam, loose sand fines, wet clay, miscellaneous fill

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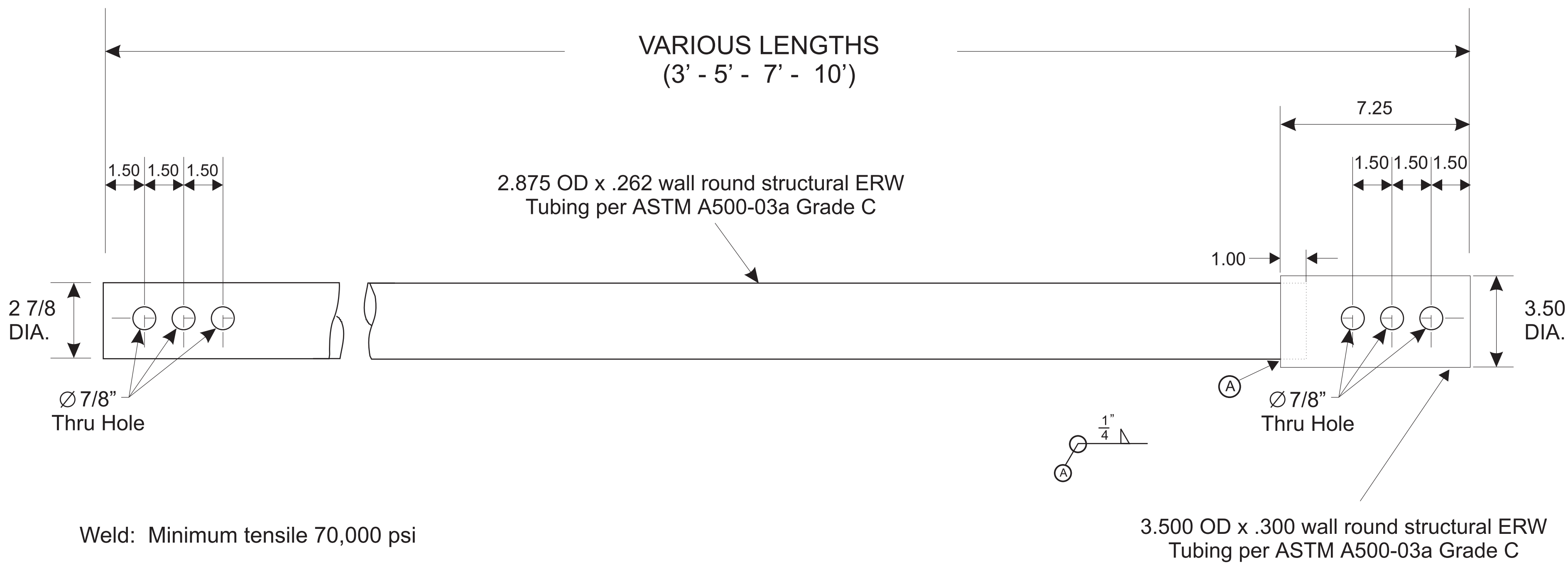
GRIP-TITE® Helix Pier Shaft Extension



Weld: Minimum tensile 70,000 psi

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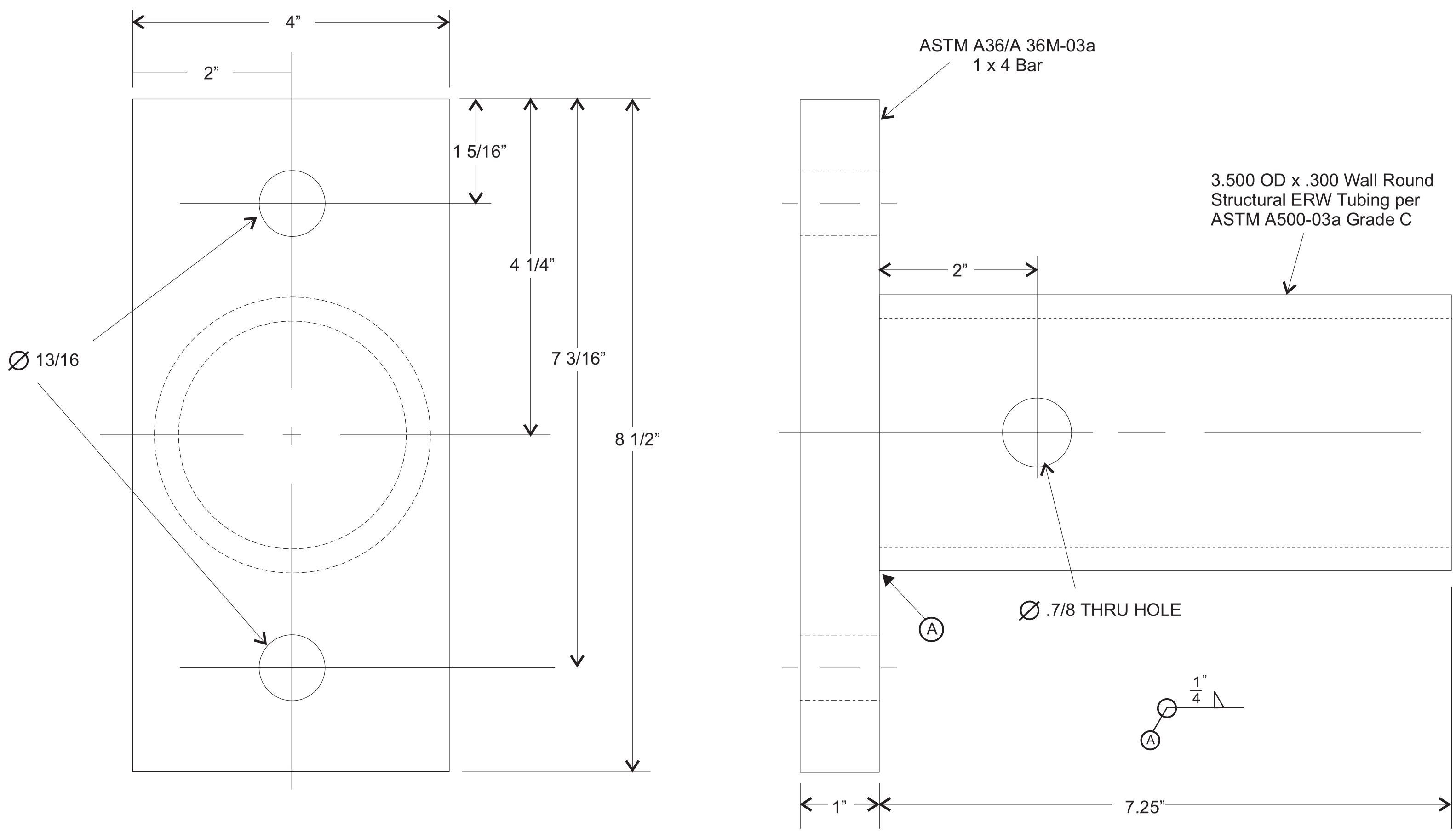
GRIP-TITE® Helix Pier New Construction Top Cap



Weld: Minimum Tensile 70,000 psi

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ULTIMATE COMPONENT CAPACITIES

CATALOG NUMBER	COMPONENT (PRODUCT) DESCRIPTION	ULTIMATE CAPACITY (pounds)
FP3BA	3" PIER BRACKET ASSEMBLY	96,700
HPLS	2 7/8" DIA. HELIX LEAD SECTION	96,100
HPE	2 7/8" DIA. HELIX EXTENSION	96,100

General Notes:

1. Test data by Stork (December 1999 and July 2000)
2. Actual Capacities may vary based on bracket assembly position against the foundation system and pier tube inclination.
3. Working and/or Allowable Capacities should be based on appropriate Safety Factors in accordance with standard design practices.

PROJECT NUMBER: 3618 200-8742.1

DATE: July 20, 2000

Patzig Testing Laboratories
3922 Delaware Avenue
Des Moines, Iowa 50313-2597

REPORT OF LOAD TESTING

Prepared for:
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Timothy B. Cox, P.E.
Product Service Manager
Mechanical/Metallurgical Dept.

The test results contained in this report pertain only to the samples submitted for testing and not necessarily to all similar products.

INTRODUCTION:

This report presents the results of load tests performed on house support piers. This work was requested by Mike Johnson of Grip-Tite Manufacturing Co., Inc. The samples were received on June 22, 2000 with the work conducted on July 19, 2000.

SAMPLE DESCRIPTION:

A total of 1 sample was received. The sample was described as an all-steel pier bracket for 3" tube (new design-robotically welded). Major design details consist of 0.5-inch X 8 X 8-inch flat plate bent 90° as the bracket and 0.75-inch thick top plate with a 1.0-inch thick cap plate. Threaded rod to hold cap to top plate was ¾-10 grade 7 with 3/4 inch grade 8 nuts.

TESTING PROCEDURE:

The sample was attached to a fixture inverted from its normal position. A three inch diameter solid round bar was used to apply the load directly to the cap at a rate of approximately 12,000 to 24,000 lbs./minute with inspections and data recorded at 20,000, 30,000, and finally at the point when the samples would no longer accept additional loads. Deflection readings were taken from a dial indicator measuring the relative travel between the ram and the crosshead. (Some of the deflection may have been movement of the fixture rather than the sample)

TEST RESULTS:

LOAD OF CAP AT 4" BETWEEN PLATES		
INCHES OF DEFLECTION	**DESCRIPTION OF FAILURE**	**PEAK LOAD (LBS)**
0.130	None	20,000
0.155	None	30,000
Not recorded	Bolt stretch	96,700

NOTE – The bolt stretch for sample = 0.24" RIGHT and 0.24" LEFT.

DISPOSITION OF SAMPLES:

Samples were returned to Mike Johnson at completion of testing.

Design Guidelines For Screw Anchors

CHESTER A. CARVILLE, P.E.
and ROBERT W. WALTON

The following article, Design Guidelines for Screw Anchors, has been made available courtesy of the U.S. Federal Highway Administration, Washington, D.C. and the authors. It originally was presented at the International Conference on Design and Construction of Deep Foundations held in Orlando, FL., in December of 1994. *CHESTER A. CARVILLE, P.E. is associated with Forensic Consultants, 40631 Deluz Murrieta Road, Fallbrook, CA 92028. ROBERT W. WALTON is an Engineering Contractor with Walton Property Services, 4154 Datcho Drive, San Diego, CA 92117.*

ABSTRACT

The screw anchor is a deep foundation member consisting of a steel shaft with helical plates welded to the shaft. Screw anchors are installed into the soil using mechanical rotational force by adding extensions as the assembly advances. Once installed, the anchor has bearing capacity in both tension and compression. For over 70 years, screw anchors have been used by the utility industry for power pole guying, transmission tower foundation underpinning and pipeline supports. Today, the general construction industry is discovering and using screw anchors for a much wider variety of applications. This paper provides information about screw anchor installation criteria as they relate to screw anchor design. It is intended that this discussion will provide the engineers with important insights so that they can work more effectively with contractors in the evaluation, design and implementation of screw anchor projects.

INTRODUCTION

The screw anchor consists of a helical steel plate or series of helical steel plates fixed to a steel shaft. The shaft is directed toward the soil and mechanically rotated, advancing the screw anchor into the soil. The soil around the shaft remains relatively undisturbed. Once installed, the anchor has bearing capacity in both tension and compression in the subsurface by transferring the structure's load to the bearing stratum. The anchor installation angle can range from horizontal (0°) to vertical (90°).

When installing screw anchors, the lead section anchor can be driven to greater depths by adding shaft extensions. The bearing capacity of the anchor increases with increasing magnitude of applied installation torque. The theoretical ultimate capacity which can be achieved is limited by the torsional strength of the anchor shaft and the single helix load limit. The final extension shaft is connected to the supported structure by an appropriate termination device.

Screw anchors are constructed of very high-strength materials and when sufficient installation torque is applied, particularly with a small helix or helices, they will advance well into firm formational soils. The screw anchor is designed to obtain its capacity in soil or soft rock and not in solid rock. A knowledge of the depth and characteristics of formational bedrock is an important aspect of screw anchor design. Where subsurface conditions include the prospect of an encounter with dense formational soil or solid rock, screw anchor testing can help to avoid soil or helix failure during production. For example, if a test anchor penetrates formational soils and grinds on solid rock, the helix surface area may be increased and/or the minimum required installation torque may be decreased. If the adjustment is made properly, the screw anchor will reach its designed installation torque and required ultimate capacity before it begins grinding on solid rock.

SCREW ANCHOR DESIGN

In screw anchor engineering, it is just as important to avoid over-design as under-design. To obtain a good installation it is necessary to penetrate the undesirable soil and establish capacity in the suitable bearing strata. Instead of seeking maximum anchor depth, one should seek capacity in the suitable bearing strata, by using optimum helix configuration at optimum depth, for maximum economic benefit. The best solution is to conduct screw anchor exploration and testing. After reviewing available subsurface information, select a reasonable helix configuration for testing. Drive the anchor to the low range of the anticipated installation torque. Perform a pull out test to failure and record the capacity achieved. The load at which the anchor begins to fail is the ultimate capacity of the anchor at the given installation torque. *A compression test is seldom necessary since the compression capacity is normally greater.*

Using the test results, an empirical torque factor, (Kt) is found according to the following formula:

$$Kt = Qt/T$$

Where T = Average installation Torque (ft-kips) recorded from the installation machine, Qt = Ultimate Anchor Capacity (kips) achieved during load testing and Kt Empirical Torque Factor (1/ft).

Repeating the installation at the same as well as slightly higher and/or lower installation torque values will allow the engineer to select a value for Kt to be used in the design of the production anchors. For a group of tests conducted within the same depth range and soil type, the lowest of the calculated values for Kt should be used.

It should be noted that testing of production anchors should not exceed the mechanical helix load limit recommended by the manufacturer. The single helix load limit for most square shaft anchors is between 30 and 40 kip. Therefore at higher capacities, it is not advisable to test the anchor to failure.

In the case where a minimum Qt has been predetermined, testing of a proposed production anchor need only verify that the minimum ultimate capacity has been achieved at a given installation torque. Testing of the anchor to failure would not be necessary.

As an example of underpinning a building with screw anchors, we know from a subsurface investigation that suitable strata occurs at a depth of 12 feet and below. We also know that each anchor must have a working capacity of 15 kip with a factor of safety of 2.0. We select a two helix anchor assembly with one 8-inch helix and one 10-inch helix, and drive it to a depth of 15 feet where an installation torque of 2.0 ft-kip is achieved. We then perform a load test and find that the anchor fails at 24 kip. We then drive the same anchor to a depth of 20 feet where an installation torque of 4.0 is achieved. The anchor does not fail under a load of 35 kip. The testing is repeated at two other locations with similar results.

The ultimate capacity for production anchors is to be 30 kip (15 kip working capacity x 2.0 factor of safety). Based upon the above formula, Kt = 24 kip/2.0 ft-kip = 12/ft. Therefore an anchor installed to 4.0 ft-kip has a theoretical ultimate capacity of 12 x 4.0 = 48 kip > 30 kip. Also installing a production anchor to 4.0 ft-kip we have verified a minimum ultimate capacity of 35 kip > 30 kip. Therefore, the proposed production anchor is acceptable providing it is driven to a minimum depth of 15 feet and a minimum installation torque of 4.0 ft-kip.

Several studies have been documented to verify the use of the empirical torque factor. The method of predicting screw anchor capacity, which yields the most consistent result, is the installation torque correlation method (Hoyt and Clemence, 1989). Their referenced value for square shaft anchors is Kt=10. One study (Mitsch and Clemence, 1985) obtained a range from Kt=12 to Kt=26. Dixie Electrical Manufacturing (Alumaform, Inc., 1988) publishes guidelines which suggest a range from Kt=12 to Kt=17 for their multi-helix anchors. A.B. Chance Company (1989) recommends a value of 10. A paper by Rupiper and Edwards, 1989 states that the common Kt used by practitioners today is 10. These authors commonly commence a project with a KT of 10 and adjust based on test and production field conditions.

It is important to understand that the value for Kt is a combination of soil and anchor properties, primarily relating to friction during installation. Therefore Kt for dense dry sand would normally be less than for a hard wet clay. The factors become more complex when an anchor is driven through a wet clay material into a dense sandy material. The wet clay provides lubrication to the helix surfaces, permitting them to advance further into the dense sand. Also, the shape and size of the anchor shaft and the method of coupling can be a significant factor. The factor for pipe anchors, such as the A.B. Chance 3.5 inch HS is recommended to be around 7 for most soils. This factor is lower because the pipe anchors create significantly more drag as they are installed due to their larger diameter and three bolt connection. We have not found any clear consensus as to the impact of variations in size and number of helices on the value for Kt. In general, it appears that the value remains the same since an increasing helical surface area results in a corresponding increase in anchor capacity. Crouch, Stephenson and Clemence (1993) provides a detailed discussion of the factors which must be evaluated in predicting screw anchor installation torque.

Once the design has been approved and the project is underway, the engineer should maintain flexibility and be prepared to respond to possible unexpected subsurface conditions encountered by the contractor. This would include being able to change screw anchor locations, modify load distribution plans, adjust estimates of soil design parameters and modify requirements for screw anchor configurations, depth and minimum installation torque.

INSTALLATION EQUIPMENT

A high torque, tight access driver is used to install screw anchors for foundation underpinning. The unit may be used for repair or new construction whenever deep foundation or anchoring is required. High installation torque is often required to achieve the desired capacities.

CONCLUSION

Screw anchors can provide a simple and effective way to deal with a wide variety of foundation requirements. What is most valuable to the engineer is the inherent quality control system. Once the minimum required depth is established, each anchor installation must advance until the established minimum torque is achieved. In this way, unforeseen and unsuitable subsurface conditions are automatically detected and immediately apparent to the engineer. In most cases, these unforeseen conditions are self-correcting as the screw anchor assembly continues to advance into the suitable strata.

REFERENCES

CHANCE A.B. Design Examples of Helical Anchors; Centralia, MO 1989.

ALUMAFORM, INC. Dixie Anchors; Birmingham, Alabama, 1988.

CROUCH L. K., STEPHENSON R.W. and CLEMENCE S.P. Installation Torque and Uplift Capacity of Helical Soil Anchors in Sand. ASCE, 1993.

HOYT R. and CLEMENCE S. Uplift Capacity of Helical Anchors in Soil. International Conference on Soil Mechanics and Foundation Engineering. Rio de Janeiro, Brazil, 1989.

MITSCH M. and CLEMENCE S. The Uplift Capacity of Helix Anchors in Sand. Uplift Behavior of Foundations in Soil. ASCE Detroit, Michigan, 1985.

RUPIPER S. and EDWARDS W. Helical Bearing Plate Foundations for Underpinning. Foundation Engineering Proceedings Congress. SCE, Evanston, Illinois, 1989

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CORROSION INFORMATION

The United States Department of Commerce/National Bureau of Standards book entitled **NBS PAPERS ON UNDERGROUND CORROSION OF STEEL PILINGS** states the following in part:

Background

Data obtained by the National Bureau of Standards on the corrosion performance of steel piles driven into the ground in a wide variety of soil environments show that the strength and useful life of steel piles are not significantly affected by corrosion. These findings are in sharp contrast to those of earlier corrosion studies in which iron and steel specimens, such as pipe, that are buried under "disturbed" soil conditions exhibit varying amounts of corrosion.

Summary

Steel pilings which have been in service in various underground structures for periods ranging between 7 and 40 years were inspected by pulling piles at 8 locations and making excavations to expose pile sections at 11 locations. The conditions at the sites varied widely, as indicated by the soil types which ranged from well-drained sands to impervious clays, soil resistivities which ranged from 300 ohm-cm to 50,200 ohm-cm, soil *p*H which ranged from 2.3 to 8.6.

The data indicate that the type and amount of corrosion observed on the steel pilings driven into undisturbed natural soil, regardless of the soil characteristics and properties, is not sufficient to significantly affect the strength or useful life of pilings as load-bearing structures.

Moderate corrosion occurred on several piles exposed to fill soils which were above the water table level or in the water table zone. At these levels the pile sections are accessible if the need for protection should be deemed necessary.

It was observed that soil environments which are severely corrosive to iron and steel buried under disturbed conditions in excavated trenches were not corrosive to steel pilings driven in the undisturbed soil. The difference in corrosion is attributed to the differences in oxygen concentration. The data indicate that undisturbed soils are so deficient in oxygen at levels a few feet below the ground line or below the water table zone, that steel pilings are not appreciably affected by corrosion, regardless of the soil types or the soil properties. Properties of soils such as type, drainage, resistivity, *p*H or chemical composition are of no practical value in determining the corrosiveness of soils toward steel pilings driven underground. This is contrary to everything previously published on specimens exposed in disturbed soils and do not apply to steel pilings which are driven in undisturbed soils.

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The National Association of Engineers (N.A.C.E.) publications titled "Corrosion Basics" makes these statements pertaining to corrosion and coatings:

NACE page 213	An obvious method of controlling corrosion is that of interposing a barrier between the threatened metal surface and the corrosive medium, *i.e.* some kind of coating. Since corrosion always requires the presence of an electrolyte (moisture) in contact with the metal, if a metal could be coated with a material which was absolutely waterproof and absolutely free from holes, all attack would be stopped. The coating, it should be noted, would not only need these two properties when it was applied, but the two properties would have to be permanent the coating would have to remain perfect in both respects.
NACE page 216	An important difference with steel piling is that a few pits or even holes have little effect on its structural strength. Consequently, much more corrosion can be tolerated than with pipelines. Piling is almost always bare, vertical, and hence subject to the same kinds of cells that attach oil well casings. Bonding often may be a problem because individual piles may not be interconnected electrically, a condition that makes both investigation and protection a problem.
NACE page 216	Galvanized steel is not normally installed underground. The thin zinc coating is quickly dissipated by galvanic action with any exposed steel.
NACE page 238	As soon as a pore or bare spot appears, the corrosion of the bare metal is accelerated.
NACE page 266	A coating may fail as a result of a large number of potentially adverse conditions. Some of these can be defined as mechanical, as when abrasion or impact removes the coating.

The above information shows clearly that coatings on steel piers does not effectively increase its life expectancy. It may in fact, due to abrading that can occur in coatings of steel drive piers, actually decrease its life expectancy. Please refer to the N.A.C.E. and N.B.S. publications for additional information.