



Certified Installers/Exclusive Dealers - CA, NV, AZ

Design and Technical Service Manual

-- Ninth Edition --

By: Donald J. Clayton, PE



Certified Installers/Exclusive Dealers - CA, NV, AZ

From the author:

This manual was written and configured with reader in mind. The goal was to present the technical theories and equations in a simple, understandable way. This manual is not a rigorous text on soil mechanics and engineering theory. The intent was to produce a manual that distilled the theory down to make it easy to understand and to reach an answer or a solution in a timely manner. The technical information provided herein can help the engineer with a basic understanding of foundation support to delve deeper into the subject. Unlike some other technical manuals, there is nothing left out of this *ECP Design and Technical Service Manual* that would prevent the reader from performing an analysis and arriving at a solution without calling to the manufacturer or an engineer for assistance.

Engineers were in mind when the theoretical explanations, the assumptions, and equations to arrive at solution were written. It is the goal to provide sufficient technical data and guidance necessary to design typical foundation support or tieback systems. This book is not intended to be a thorough analysis of the subject area but rather a handbook for solutions to typically encountered situations in the field.

The book also has been written for non-engineers such as project managers, estimators, contractors; and foundation repair company owners, office supervisors and field superintendents in the business of installing foundation support systems. The dry, technical theory is there if the reader is interested in learning the subject matter more thoroughly, but the extensive use of tables and graphs in this edition reduces the need to master the theory and the need to go into difficult equations to get a solution.

New to this edition is our “Quick and Rough” estimating methods. These “Quick and Rough” methods are presented throughout the book. “Quick and Rough” estimating allows the non-engineer to arrive at a solution to a foundation support problem with a minimum of time and only a small amount of mathematics. Most of the design examples presented in this manual are solved using both methods. The results from both methods have shown reasonably comparable results from the same design example.

The manual is divided into three distinct sections; Helical Screw Products, Resistance Piers, and Corrosion Considerations. The divisions can clearly be determined from the tab markings on the right edge of the book. While some topics overlap, an attempt to make each section stand alone so that the reader can concentrate on only the subject of interest at the time.

This manual not intended to replace professional engineering input and judgment. It is highly recommend that you seek professional engineering input on any critical projects. It is also considered good practice to incorporate a minimum factor of safety of 2.0 into each and every preliminary design, to perform a field load test on any heavily loaded foundation element or on any critical projects; and to seek professional engineering input when in doubt or when available information is incomplete or confusing.

Finally, special thanks to a friend and colleague, Mr. Aaron Grayham, for his help, suggestions, constructive criticisms and vision for this manual. His suggestions have helped to transform the previous editions of the *ECP Design and Technical Service Manual* into the more detailed and user friendly book that you hold in your hand.

DJC/September 2013



Certified Installers/Exclusive Dealers - CA, NV, AZ

Table of Contents

-- Ninth Edition --

Section I – Torque Anchors

Chapter 1 – Helical Torque Anchors Technical Design Manual	1
Introduction	2
ECP Torque Anchors	2
Torque Anchor Components	2
Product Benefits	3
Product Limitations	3
ECP Torque Anchor Product Designations	4
Capacities of ECP Helical Torque Anchors	4
Product Descriptions	5
Symbols Used In This Chapter	15
Design Criteria	15
Preliminary Design Guidelines	16
Soil Behavior	16
Cohesive Soil (Clays & Silts)	17
Cohesionless Soil (Sands and Gravels)	18
Mixed Soils	20
Effects of Water Table Fluctuations and Freeze-Thaw Cycle	21
Budgetary Capacity Estimates by “Quick and Rough” Method	21
Torque Anchor Holding Capacity	25
Installation Torque	25
Helical Torque Anchor Design Considerations	26
Projected Areas of Helical Torque Anchor Plates	26
Allowable Helical Plate Capacities	26
Relationship Between Installation Torque and Torque Anchor Capacity	26
Plate Embedment in Tension Applications	28
Preventing “Punch Through”	28
Tieback Design Considerations	28
Placement of Tiebacks	29
Hydrostatic Pressure	29
Basement Tieback Applications	29
Simple Retaining Wall Tieback Applications	30
Simple Retaining Wall Tieback Applications With Soil Surcharge	30
Ultimate Tieback Capacity Selection	30
Horizontal embedment Length – “ L_0 ”	31
Installation Angle – “ α ”	31
Critical Embedment Depth – “D”	31
Torque Anchor Installation Limits	31
Shaft Strength	31
Shaft Stiffness	32
Buckling Loads in Weak Soils	32
Allowable Compressive Loads – Pile in Air	33

Chapter 2 – Helical Torque Anchors - Installation Guidelines and Testing Procedures 35	
Hydraulic Torque Motors	36
Installation Torque	36
Soil Efficiency Factor – “k”	36
Determining Installation Torque	37
Converting Motor Pressure Differential to Shaft Torque	38
ECP Smart Anchor Monitor (SAM) and Assembly Configuration	40
ECP Hydraulic Torque Motor Performance Curves	40
Structural Compressive Pile and/or Tensile Helical Anchor Installation Procedure	44
Field Test Procedures for Static Axial Compression and Tensile Loads	47
Basic Procedure for Quick Tension or Compression Tests	48
Chapter 3 – Helical Torque Anchors - Design Examples	51
Design Example 1 – Heavy Weight New Construction – Cohesionless Soil	52
Design Example 1A – Heavy Weight New Construction - “Quick and Rough” Method	54
Design Example 1B – Heavy Weight New Construction –Weak Soil	56
Design Example 2 – Light Weight New Construction – Cohesive Soil	58
Design Example 2A – Light Weight New Construction – “Quick and Rough” Method	60
Design Example 3 – Basement Wall Tieback Anchor – Cohesive Soil	62
Design Example 3A – Basement Wall Tieback Anchor – “Quick and Rough” Method	65
Design Example 4 – Retaining Wall Tieback Anchor – Cohesionless Soil	67
Design Example 5 – Foundation Restoration – Cohesive Soil	69
Design Example 5A – Foundation Restoration – “Quick and Rough” Method	72
Design Example 6 – Motor Output Torque	75
Design Example 6A – Motor Output Torque – “Quick and Rough” Method	76
Design Example 7 – Ultimate Capacity from Field Data	77
Design Example 7A – Ultimate Capacity from Field Data - “Quick and Rough” Method	77
Chapter 4 – Torque Anchors - Introduction to Helical Soil Nails	79
Introduction	80
ECP Soil Nail Components	81
Product Benefits	81
Product Descriptions – Square Shaft Soil Nails	82
Product Limitations	83
Capacities of ECP Soil Nails	83
Mechanics of Soil Nail Installation	84
Shotcrete	86
Field Documentation	86



Certified Installers/Exclusive Dealers - CA, NV, AZ

Section II –Steel Piers

Chapter 5 – Steel Piers - Technical Design Manual	89
Introduction	90
Features and Innovations	90
Product Benefits	91
Pier Installation Sequences	91
PPB Utility Bracket Installation	92
PPB Utility Bracket Components	92
PPB 166 Slab Jack Installation	93
ECP Steel Pier Product Configurations	94
“Suitable Load Bearing Stratum”	95
Why Determine Structural Loads?	95
Simplified Tables of Structural Foundation Loads	96
Estimating Structural Loads	97
Benefits of Estimating Foundation Loads	97
“Quick and Rough” Structural Load Estimating	98
Estimating Commercial Building Loads	99
Determining Pier Spacing	99
Pier Spacing Based Upon <u>Pier Strength</u>	99
Pier Spacing Based Upon <u>Footing Strength</u>	99
Pier Installation, Load Testing & Project Documentation	102
Pier Installation	102
Proof Testing and Project Documentation	103
Buckling Loads on the Pier Shaft in Weak Soil	103
Allowable Compressive Loads – “P” in Air	104
Pier Sleeves	105
“Quick and Rough” Buckling Load Estimates	106
ECP Steel Pier Model 350 Utility Bracket System, ECP TA-150 Torque Anchor and Model 350-TA Tieback Adapter Assembly	106
Chapter 6 – Steel Piers - Resistance Pier Design Examples	107
Design Example 1 – Calculate Foundation Load – Two Story Brick with Full Basement	108
Design Example 1A – Calculate Foundation Load – “Quick and Rough” Method” Two Story Brick with Full Basement	109
Design Example 2 – Calculate the Maximum Pier Spacing for Design Example 1	110
Design Example 2A – Adjust for Pier Buckling in Weak Soil	110
Design Example 3 – Calculate Foundation Load – Single Story Slab on Grade	111
Design Example 3A – Calculate Foundation Load – “Quick and Rough” Method” Single Story Slab on Grade	112
Design Example 4 – Calculate the Maximum Pier Spacing for Design Example 3	113
Design Example 5 – Calculate the Foundation Load and Determine Pier Spacing Three Story Office Building	114
Design Example 5A – Estimate the Drive Cylinder and Lifting Ram Pressures – “Quick and Rough” Method for Design Example 5	117
Design Example 6 – Determine Force Applied to Pier from Field Data	118
Design Example 6A – Determine Force Applied to Pier – “Quick and Rough” Method”	118



Certified Installers/Exclusive Dealers - CA, NV, AZ

Section III – Corrosion Considerations

Chapter 7 – Corrosion Life of Steel Foundation Products	119
Corrosion Considerations	120
Steel Underground – How Long Does It Last?	120
Difference in Electrical Potential	120
Electrolyte	120
Aeration	120
Controlling Factors for Corrosion	120
Soil Resistivity	120
Soil pH	121
Corrosion Test Results	122
Zinc Galvanizing for Corrosion Protection	122
Oxygen Availability	122
Estimating Corrosion Potential	123
Special Corrosion Conditions	124
Methods of Corrosion Control	125
Passive Control	125
Active Control	126
Corrosion Life Analysis	127
“Quick and Rough” Corrosion Life Estimating	128
Corrosion of the Torque Anchor Shafts	128
Life of Torque Anchor Galvanization	128
Corrosion Life of ECP Steel Pier	129
Results of Field Tested Galvanized Coating Life	130
Manufacturer’s Warranty	131
Chapter 8 – Torque Anchors & Steel Piers	
Corrosion Life Design Examples	133
Design Example 1 – Corrosion Life of Tubular Torque Anchor	134
Design Example 1A – Corrosion Life of Tubular Torque Anchor “Quick and Rough” Method	136
Design Example 2 – Corrosion Life of Tubular ECP Steel Pier Pipe	137
Design Example 2A – Corrosion Life of Tubular ECP Steel Pier Pipe “Quick and Rough” Method	139

Earth Contact Products, LLC reserves the right to change design features, specifications and products without notice, consistent with our efforts toward continuous product improvement. We also make changes and corrections to the technical design text consistent with the state of the art. Please check with Engineering Department, Earth Contact Products to verify that you are using the most recent design information and product specifications.

Technical Design Assistance

Earth Contact Products, LLC. has a knowledgeable staff that stands ready to help you with understanding how to prepare preliminary designs, installation procedures, load testing, and documentation of each placement when using ECP Torque Anchors. If you have questions or require engineering assistance in evaluating, designing, and/or specifying Earth Contact Products, please call us at 913 393-0007, Fax at 913 393-0008.

Index of Tables and Graphs

-- Ninth Edition --

Section II –Torque Anchors

Chapter 1 – Helical Torque Anchors Technical Design Manual	1
Table 1. ECP Torque Anchor Product Designations	4
Table 2. Capacities of Torque Anchors	4
Tables of Available Standard Torque Anchor Leads and Extensions	5
How to Specify Special Order Torque Anchors	10
Tables of Available Utility Brackets, Pile Caps and Tieback Transitions	11
Table 3. Symbols Used in this Chapter	15
Table 4. Cohesive Soil Classification	17
Table 5. Properties of Cohesive Soil	17
Graph 1. Required Helical Plate Area vs. SPT, “N” – Cohesive Soils	18
Table 6. Cohesionless Soil Classification	18
Table 7. Properties of Cohesionless Soil	19
Table 8. Mixed Soil Descriptions	20
Table 9. Soil Classifications	22
Graphs 2 – 5. Torque Anchor Holding Capacity	23
Table 10. Projected Areas of Helical Torque Anchor Plates	26
Table 11. Average Ultimate Mechanical Helical Plate Capacities	26
Table 12. Soil Efficiency Factor, “k”	27
Graph 6. Motor Output Torque vs Ultimate Capacity	27
Table 13. Angular Embedment Length	31
Table 14. Torque Anchor Shaft Stiffness Comparisons	32
Graph 7. Conservative Critical Buckling Load for Budget Estimates	33
Table 15. Conservative Critical Buckling Load for Budget Estimates	33
Graph 8. Ultimate Axial Compressive Load on Piles without Lateral Soil Support	34
Chapter 2 – Installation Guidelines and Testing Procedures for Helical Torque Anchors	35
Table 16. Hydraulic Torque Motor Specifications	39
Graphs 9 – 13. Pressure at Motor vs. Motor Output Torque – Various Motors	41
Torque Anchor Installation Record – (Template)	46
Field Load Test Report – (Template)	49
Chapter 4 – Introduction to Helical Soil Nails	79
Tables of Available Standard ECP Soil Nail Leads, Extensions and Wall Plates	82
Table 17. Capacities of ECP Soil Nails	83



Section II – Steel Piers

Chapter 5 – Steel Piers Technical Design Manual	89
Table of ECP Steel Pier Product Configurations	94
Table 1. ECP Steel Resistance Pier System Ratings	95
Tables 2 – 7. Simplified Tables of Structural Foundation Loads	96
Table 8. Estimated Soil Loads on Footings	98
Graph 1. Temporary Soil Load (One Side) – W_t	98
Table 9. Estimated Snow Loads	98
Table 10. Ranges for Typical Average Residential Building Loads	98
Table 11. Weights of Building Materials	99
Graph 2. Graphs for Estimating Pier Spacing Based Upon Foundation Strength of Spread Footing or Monolithic Slab Only (No Stem Wall or Hollow Masonry Stem Walls)	100
Graph 3. Graph for Estimating Pier Spacing Based Upon Foundation Strength of Spread Footing with Short Integrally Cast Concrete Stem Walls	101
Graph 4. Cylinder Force vs Hydraulic Pressure	102
Graph 5. Maximum Compressive Load on Steel Piers Without Soil Support	104
Table 12. Steel Pier Shaft Stiffness Comparisons	104
Table 13. Conservative Critical Buckling Load for “Quick and Rough” Budgetary Estimating	106

Section III – Corrosion Considerations

Chapter 7 – Corrosion Life of Steel Foundation Products	119
Table 1. Soil Resistivity Ranges for General Soil Types	121
Table 2. Soil Resistivity and Relative Corrosivity Rating	121
Graph 1. The Effect of pH on Corrosion of Iron	122
Graph 2. The Effect of pH on Corrosion of Zinc	122
Graph 3. Corrosion Potential Estimating Graph – Underground Bare Steel Structures	123
Table 3. Numerical Corrosivity Score	124
Table 4. Soil Corrosion Potential	124
Table 5. Sample ECP Torque Anchor & Soil Nail Life Expectancy Estimates at Full Load	128
Table 6. Sample ECP Steel Pier Life Expectancy Estimates at Full Load	130
Table 7. Corrosion of Galvanized Steel Pipe in Contact with Various Soils	130

Technical Design Assistance

Earth Contact Products, LLC. has a knowledgeable staff that stands ready to help you with understanding how to prepare preliminary designs, installation procedures, load testing, and documentation of each placement when using ECP Torque Anchors. If you have questions or require engineering assistance in evaluating, designing, and/or specifying Earth Contact Products, please call us at 913 393-0007, Fax at 913 393-0008.