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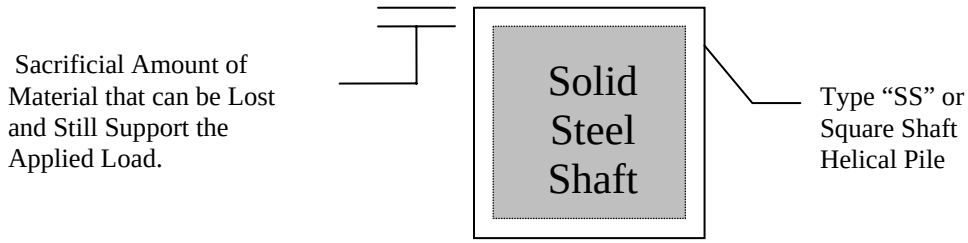
CORROSION EVALUATION FOR CHANCE® Civil Construction HELICAL PILES IN SOIL

PROJECT: Texas A&M University – MSC & University Center Complex Renovations – College Station, Texas

METHODOLOGY FOR THE ESTIMATION OF SERVICE LIFE OF HELICAL PILE SHAFTS:

The purpose of these calculations is to estimate the service life of CHANCE Type SS5 Round Cornered Square (RCS) Helical Piles in soil conditions as reported by CME Testing and Engineering, Inc. for the subject project. The soils report is based on soil samples taken near soil retention pier No. 16.

Service life will be defined by allowable sacrificial loss. This method of determining service life is based on the amount of shaft material required to resist the applied load, and then determine how much time it will take for the excess (sacrificial) material to be corroded based on loss rates from soils with similar corrosion characteristics.



GIVEN:

CHANCE® Type SS5 1-1/2" Square Shaft Solid Steel Helical Piles galvanized to ASTM A153 (Minimum Zinc Coating = 1.8 oz/ft.^{2})

Soil Description: assumed shaly clay with silt and bentonite deposits based on soil description in boring B-5.

Resistivity: 280 to 610 ohm-cm at three depths as reported in March 17, 2010 letter from CME Testing and Engineering, Inc. (Project No. 29095, Report No. 96).
pH: 8.6 to 8.9 at three depths as reported in March 17, 2010 letter from CME Testing and Engineering, Inc. (Project No. 29095, Report No. 96).

ASSUMPTIONS:

It is assumed that the material loss rates will be similar to the loss rates found at test sites with similar pH and resistivity levels as given in Melvin Romanoff's Underground Corrosion from The National Bureau of Standards (NBS) Circular #579, 1957, P.19, Table 6.

In Circular #579, site #15 is indicated as having a resistivity of 489 ohm-cm and a pH of 7.5. This soil is "Houston Black Clay" and is located near San Antonio, TX. In addition, Site #51 is indicated as having a resistivity of 234 ohm-cm and a pH of 8.8. This is "Lake Charles Clay" and is located near League City, TX. The corrosion rates for these two sites will be used to estimate the life of Type SSS helical anchor/pile shaft material. These two sites were selected because they have similar resistivity values as the project site. Site #51 has similar pH values as the project site. Site #15 is more neutral (pH of 7.5), but was used because its resistivity value was similar to the average resistivity taken at the project site.

From documents provided by Helical Concepts, Inc. the required ultimate capacity for the helical piles is 20 kip.

The yield strength of CHANCE Type SS5 material is 70 ksi and the cross sectional area of the shaft is 2.2 in^2.

AREA OF STEEL REQUIRED TO SUSTAIN ULTIMATE CAPACITY:

Based on the loss of material not required to resist the applied load. The corrosion is assumed to be uniform, and from the outside in. The remaining material is assumed to be square in section (as shown in the figure on the bottom of the first page). The allowable yield strength is 0.67(Fy), which is a factor of safety of 1.5. In addition, the ultimate capacity is used, and in this case the factor of safety is 2 against the applied working load per pile. Thus, the total factor of safety is 2 x 1.5 = 3.

For Type SS5: (20,000)/70,000(0.67) = 0.43 in^2, or 20% of available area. The remaining section is SQRT(0.43 in^2) = 0.66 in. Available thickness loss = (1.5 in -0.66 in)/2 = 0.42 in.

ALLOWABLE STEEL LOSS:

SS5: Based on the loss of 0.42 inches of thickness of shaft, the weight loss in terms of weight per unit area is:

(0.42 in)*(0.283 lb./in^3)*(16 oz./lb.) = (1.902 oz./in^2)*(144 in^2/$ft.^2$) = **273.9 oz./ft^2**

AVERAGE METAL LOSS PER YEAR:

From Romanoff Site #15: (HOUSTON BLACK CLAY)

DURATION OF EXPOSURE, (YEARS)	LOSS IN WEIGHT (OZ./FT.^{2})	LOSS PER YEAR (OZ./FT.^{2})
2.0	2.1	1.05
4.0	3.2	0.80
5.9	5.4	0.91
8.0	5.5	0.69
12.0	7.8	0.65
17.6	10.4	0.59

The average loss per year is 0.78 oz./ft.^{2}. Note that as the duration of exposure increases, the material loss per year generally decreases.

HELICAL PILE SHAFT LIFE:

To determine the shaft life (SL), the allowable steel loss is divided by the average loss per year.

For the SS5 helical pile shaft, SL = (273.9 oz./ft.^{2})/(0.78 oz./ft.^{2}) = ***351.2 years***

TOTAL ZINC COAT LOSS:

From Romanoff NBS Circ. #579, P. 110, Table 65, gives the following average loss rates for Site 15 soils.

DURATION OF EXPOSURE, (YEARS)	LOSS IN WEIGHT (OZ./FT.^{2})	LOSS PER YEAR (OZ./FT.^{2})
10.06	0.37	0.037

Estimated Life of Zinc = 1.8 oz/ft.^{2} / 0.037 oz/ft.2 = 48.6 *years*.

Total Estimated Service Life of SS5 Helical Pile Shaft = **351.2 + 48.6 = 399.8 yrs.**

From Romanoff Site #51: (LAKE CHARLES CLAY)

DURATION OF EXPOSURE, (YEARS)	LOSS IN WEIGHT (OZ./FT.^{2})	LOSS PER YEAR (OZ./FT.^{2})
2.0	4.0	2.0
5.4	13.9	2.57
7.5	21.0	2.8
9.4	28.8	3.06
14.4	35.2	2.44

The average loss per year is 2.57 oz./ft.^{2}. Note that as the duration of exposure increases, the material loss per year generally increases.

HELICAL PILE SHAFT LIFE:

To determine the shaft life (SL), the allowable steel loss is divided by the average loss per year.

For the SS5 helical pile shaft, SL = (273.9 oz./ft.^{2})/(2.57 oz./ft.^{2}) = ***106.6 years***

TOTAL ZINC COAT LOSS:

From Romanoff NBS Circ. #579, P. 112, Table 66, gives the following average loss rates for Site 51 soils.

DURATION OF EXPOSURE, (YEARS)	LOSS IN WEIGHT (OZ./FT.^{2})	LOSS PER YEAR (OZ./FT.^{2})
12.7	9.0	071

Estimated Life of Zinc = 1.8 oz/ft.^{2} / 0.71 oz/ft.2 = 2.5 *years*.

Total Estimated Service Life of SS5 Helical Pile Shaft = **106.6 + 2.5 = 109.1 yrs.**

Thus, a rough estimate of material loss in 50 years is 0.2 in per side.

Summary:

	Estimated Service Life (years) Based on Romanoff Sites	
Type SS Shaft	**Site #15**	**Site #51**
SS5	399.8	109.1

These calculations are estimated allowable sacrificial loss from either solid square shaft steel, and are based upon loss rates obtained from Romanoff's disturbed soil sites. This is considered to be a conservative estimate because helical piles and anchors are normally installed into undisturbed soil.

However, it is generally accepted that the majority of any corrosion will occur at or near the surface. Hence, it is very likely that shaft metal loss will control the design. The following reference is submitted as evidence of this:

"… The data indicate that undisturbed soils are so deficient in oxygen at levels a few feet below 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." - *from National Bureau of Standards Monograph 127 by Romanoff.*

If your office has any questions regarding the information presented, please contact me.

Sincerely,

Gary L. Seider, P.E.
CHANCE Civil Construction