Soil Quality around Corroded Steel Piles

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Abstract: Soil corrosivity around steel pile was quantified by investigating the physico-chemical characteristics of the soil around the piles. The soil parameters examined in the study are; pH (6.5.6-8.1), moisture content (9.3-55.3%), resistivity (1825-4498 ohm-cm) and redox potential (-19.7 to -47.3 mV). Corrosivity of the soil samples were also evaluated using the American Water Works Association (AWWA) 105 numerical scale. A total summed maximum index of 8 was obtained which indicated that the soil tested were not corrosive and did not represent the condition observed in the field.

1. Introduction

Soil is a porous three phase of material. Steel piles buried in soil corrode at the exposed soil-pile interface by complex electrochemical processes because of the presence of air, water and soil electrolytes. Other factors that influence corrosion in soil are soil type, soil resistivity, soluble ion content, soil pH, oxidation-reduction (redox) potential and microbial activity in soil. It is widely recognized that the corrosion of carbon steel in soil is accounted for by the following anodic reaction and cathodic reactions in the presence of oxygen (Decker et al. 2008). Steel is used extensively in construction and repair of waterfront facilities due to availability, cost, ease of fabrication, physical and mechanical properties, and the extensive design experience with it. Structural steel and cast or fabricated steel are used in all areas of the waterfront (USACE, 2001). The corrosion of steel is a process of electrochemical cell corrosion with the soil and pore fluid acting as an electrolyte, while the metal acts as the anode at one location and cathode at another location due to variations in soil conditions along the metal surface. (Decker et al, 2008)

2. **Objectives:** The overall objective was to investigate the role of soils on the corrosion of steel piles by comparing the corrosivity of the site condition to the AWWA C105 standard.

3. Materials and methods

The American Water Works Association (AWWA) developed a numerical soil corrosivity scale, applicable to cast iron alloys. The severity ranking by assigning points for different variables. When the points total of a soil in the AWWA scale equals ten (or higher), corrosion protective measures (such as cathodic protection) have been recommended for cast iron alloys. The point system for predicting soil corrosivity according the AWWA C-105 Standard.

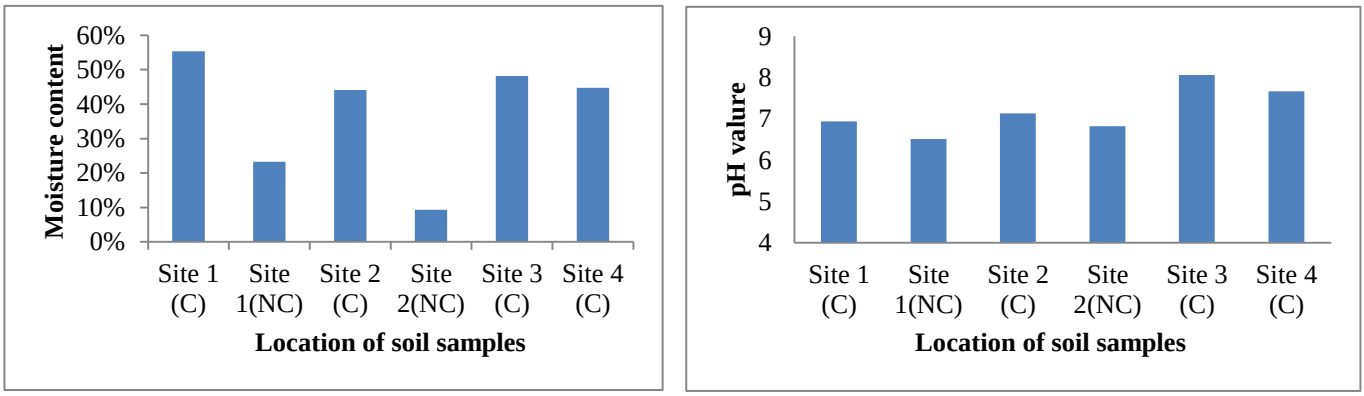

Figure 1. (a) Moisture content and (b) pH value of soil samples
(C: close to the pile NC: not close to the pile)

The moisture content (MC) of soil samples close to the piles at Site 1, 2, 3 and 4 were more than 40% (Figure 1(a)). Except Site 1(NC) and Site 2(NC), other samples were corrosive. The pH of Site 2(C), Site 3(C) and Site 4(C) were more than 7 (Figure 1(b)). According to numerical corrosivity AWWA Scale, severity ranking by assigning points for MC and pH value shown was zero. It shown there is no corrosivity affected by pH. According to the points given by resistivity, Site 1(C) and Site3(C) indicated a little corrosive, other samples were not corrosive. For redox potential summarized in Table 2, the samples had negative potential and showed high corrosivity.

Table 1. Resistivity of soil samples

No.		Site 1		Site 2		Site 3	Site 4
Location		Site 1 (C)	Site 1(NC)	Site 2 (C)	Site 2(NC)	Site 3 (C)	Site 4 (C)
Resistance(R,Ω)	Saturated	1347	2541	2432	10020	1270	3130
	Not saturated	–	2832	–	18900	–	2970
Resistivity(ρ,Ω-cm)	Min	1935.5	3651.2	3494.6	14398.1	1824.9	4498
	Max	–	4069.4	–	27158.0	–	4268
AWWA Points		1	0	0	0	1	0

Table 2. Redox potential of soil samples

No.	Site 1		Site 2		Site 3	Site 4
Location	Site 1 (C)	Site 1 (NC)	Site 2 (C)	Site 2 (NC)	Site 3 (C)	Site 4 (C)
Redox potential	-37.9	-22.4	-19.7	-43.3	-47.3	-33
AWWA Points	5	5	5	5	5	5

4. Result and Discussion

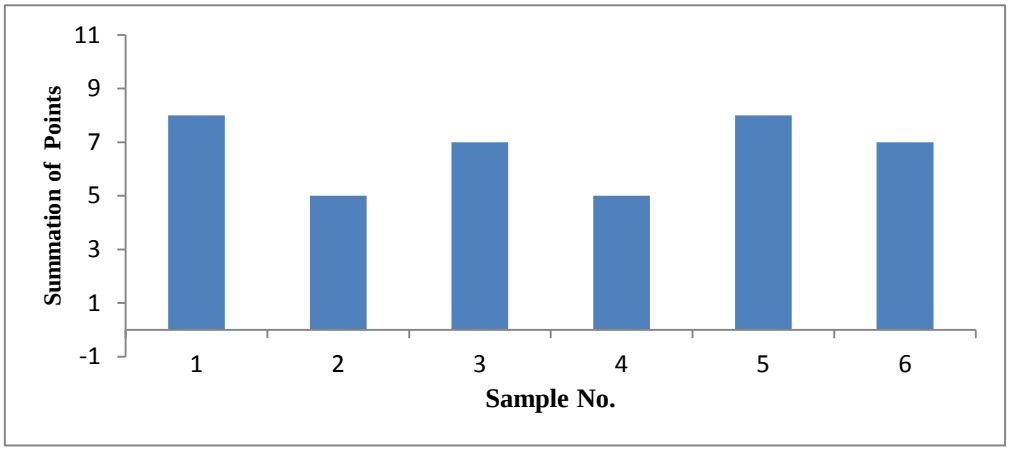

Figure 2. Evaluation of corrosivity

The final corrosivity index are shown in Figure 2. According to the AWWA C105 standard, an index of 10 or more indicates that the soil tested is corrosive whereas an index below 10 suggests that the soil samples were not corrosive and hence AWWA standard did not correlate well with the field condition.

5. Acknowledge

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6. Reference

American Water Works Association, Standard for Determining Corrosivity of Soils (AWWA) C-105

Decker, J. B., Rollins, K. M. and Ellsworth, J. C. (2008). "Corrosion Rate Evaluation and Prediction for Pile Based on Long-Term Field Performance." Geotechnical and Geoenvironmental Engineering, 341-351.

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