# CORROSION CONTROL IN METALLIC STRUCTURES AND ITS ENVIRONMENTAL IMPACTS APPLIED TO SHIELDING PHENOMENON

By

**Eng. Eman Mohamed Saad Eldeen Noamy**

B.Sc. in Mechanical Power Engineering, Zagazig University, 1988
Diploma in Environmental Engineering, Institute of Environmental Studies and Researches, Ain Shams University, 2002

A Thesis Submitted in Partial Fulfillment

of the Requirements for the Master Degree

in

**Environmental Sciences (Engineering)**

**ENGINEERING DEPARTMENT**
**INSTITUTE OF ENVIRONMENTAL STUDIES AND RESEARCHES - AIN SHAMS UNIVERSITY**

**2005**

## APPROVAL SHEET

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| **Prof. Dr. Salah Mahmoud El-Haggar**<br>Professor of Mechanical Power Engineering,<br>American University in Cairo | ..... |
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## Under the supervision of:

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# DEDICATION

**To the sole of my father**

# ABSTRACT

The work described in this thesis is carried out to investigate cathodic protection of steel plates (simulation of sheet pile walls). Efficiency of protection was studied in the case when applied from one side only or from both sides. The environmental harmful emissions associated with the intensive use of energy in the iron and steel industry is also highlighted, besides the problem of corroded metals disposal.

Corrosion was studied on three identical steel sheet plates; nominated X, Y and Z. Plate-X without protection (as a reference plate), Plate-Y with cathodic protection applied for only one side and Plate-Z with protection applied for both sides.

Plate potentials for the two protected plates (Y & Z) were always kept above conventional protection levels (-1.1 Volt). Metal loss was measured for the three plates and it was found that Plate-X was heavily corroded as might be expected, Plate-Y suffered substantial corrosion but less than Plate-X while Plate-Z was almost free of corrosion. Shielding phenomenon was clearly observed at plate edges in Plate-Y and Plate-Z.

Metal loss rate was also indicated by using coupons fixed on both sides of each plate surface to illustrate the corrosion distribution patterns. 3-D bar diagrams, surfaces and contours plots for the mass loss rates of the coupons and plates. The electrolyte/plate potential difference for Plate-Y fro both sides and its relation to the metal loss rate are also included.

Electronic photography and components spectrum using X-ray have been used to determine the effects of the cathodic protection on the surfaces of the three plates at the end of the experimental work.

# Summary

This thesis is concerned with the assessment of the cathodic protection of steel sheet pile walls from only one side and the harmful environmental emissions associated with the intensive use of energy in the iron and steel industry, besides the problem of corroded metals disposal.

The thesis contains thorough and intensive review of published local and international literatures and text books related to the subject of the present research concerning the corrosion of structures in general and the methods and means of protection applied to the iron and steel structures, in particular. Further, design and maintenance of cathodic protection systems have been also considered.

The thesis includes intensive review of the environmental impacts of the steel structures corrosion and the harmful environmental emissions of the iron and steel industry. Direct and indirect effects of the harmful emissions associated with the corrosion of metallic structures are also included with particular emphasis placed on the international treaties related to the global environment protection from the increase of $CO_2$ the green house phenomenon. A brief mention to the application of clean energy is highlighted.

The thesis include a detailed description of the experimental set up conducted to carry out the experimental work to study the effects the cathodic protection on three identical steel sheet plates of the same material and dimensions (800×800×1.5 mm) and measure the amount of mass loss during approximately 6 months period immersed in salient water with 2.5% weight concentration. Each plate was placed in a separate basin. The three basins were of the same dimensions and insulated against water leakage and placed in the same environmental

conditions. The first plate was immersed and no cathodic protection was applied, the second plate was protected from only one side, while the third plate was protected from the two sides. Plate potentials for the two protected Plates (Y & Z) were always kept at -1.1 Volts which is above the known conventional protection level of -0.85 Volts.

Points of electrolyte/plate potential differences during the test period are also included with the description of the measuring equipment used to obtain the experimental results.

The thesis contains the daily and periodical results of the electrolyte/plate potential differences during the test period. Metal loss in the coupons, plates and anodes are also measured. Metal loss rates are calculated and the results are presented in the forms tables and detailed diagrams with sound scientific analysis of the obtained results. The results showed the distribution of metal loss rate of the plates and its relation the electrolyte/plate potential difference of the plate protected from one side, which included 2-D, 3-D surfaces and contours plots.

The thesis contains electronic photography and components spectrum using X-ray of samples taken from the three plates at the end of the test period. The electronic photography showed that Plate-X suffered heavy corrosion with obvious pitting on its surface. Plate-Y behaved somehow similar to Plate-X if not worse in some areas, particularly on the unprotected side. On the other hand, Plate-Z which is protected from both sides shows very small corrosion with no signs of pitting.

The thesis concluded that cathodic protection of steel sheet pile walls from only one side is not sufficient and shall corrode similar to the unprotected walls if not worse.

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