Ain Shams University
Faculty of Engineering
Structural Engineering Department

CORROSION RATE EVALUATION OF STEEL REINFORCEMENT IN STRESSED R.C. BEAMS SUBJECTED TO AGGRESSIVE ENVIRONMENT

A Thesis
Submitted in Partial Fulfillment of the Requirements for
the Degree of Doctor of Philosophy in Civil Engineering

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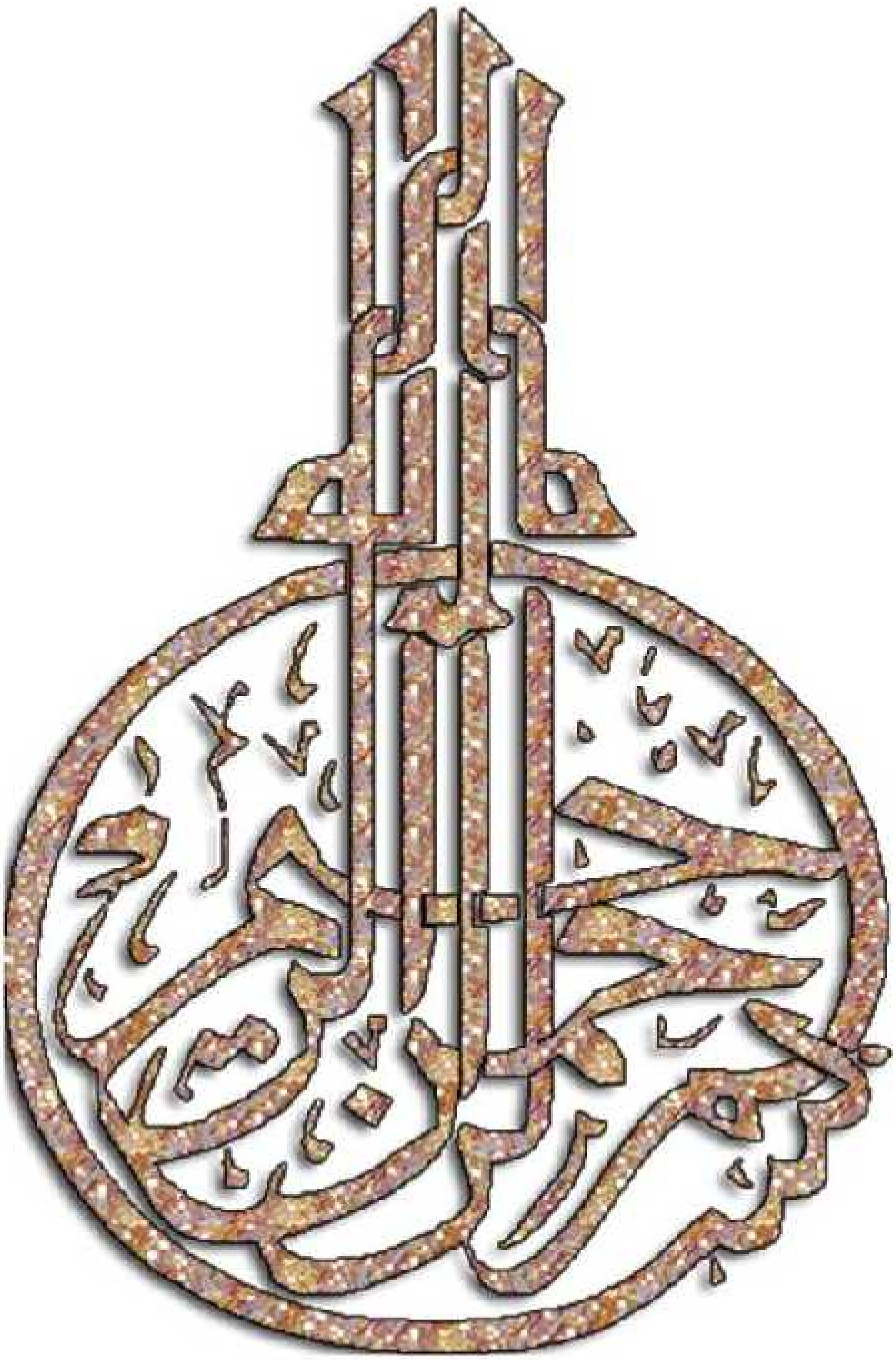

In the Name of Allah, the Mast Gracious, the Most Merciful

<u>Statement</u>

This thesis is submitted to Ain Shams University for the degree of Doctor of Philosophy in civil engineering (structural engineering).

No part of this thesis has been previously submitted for obtaining a degree or a qualification before.

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Doctor of Philosophy, 2010
Eng. Ibrahim Abdel-Latif Yousef
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ABSTRACT

Corrosion of the steel reinforcement plays a vital role in the determination of durability and service life of concrete structures. Corrosion of reinforcing steel is an economically expensive problem since it leads to unanticipated, premature degradation of concrete structures. In most cases, water-soluble chlorides induce the corrosion of the reinforcing steel. As the corrosion of the reinforcing steel continues, the products formed due to chemical reactions exert enormous stresses on the surrounding concrete leading to cracking followed by spalling of the concrete cover. Extensive research work has been done on the corrosion behavior of the embedded steel reinforcement and also on the different protective measures that are available for corrosion control. However, little work has been done to identify the performance and predict the behavior of the stressed steel subjected to corrosive environment with time.

Modern research in materials modeling, which addresses complex behavior, such as ductile yielding, micro-cracking, brittle fracture, localization and softening, aims to develop mathematical models used to describe the relationship between stresses and strains and possibly include some non-local effects. The modeling process in this research work was done using the Artificial Neural Networks (ANNs) technique. This technique is known by its ability to learn from experience and examples and then from a model that adapts with changing situations.

The main aim of this research work is to study the problem of corrosion of stressed steel in concrete subjected to corrosive environment both experimentally and mathematically.

The experimental part includes different tests carried out on about 60 loaded and non loaded reinforced concrete beams. These beams were used to study the effect of some important parameters affecting the corrosion rate such as concrete cover, bar diameter, exposure time and chloride concentration. Corrosion rate was measured using three different techniques (Corrosion Potential – Concrete Resistivity – Corrosion Current Density). These measurements were taken for specimens corroded that were either by accelerating techniques or that were naturally corroded.

The mathematical part includes modeling of the corrosion rate of stressed steel in R.C. beams. The input data of the model was concrete cover, bar diameter, chloride concentration, exposure time and corrosion current while the output data of the model was the *corrosion rate*. The used mathematical model was based on the aforementioned concept of ANNs.

The main result of this research work ,based on both experimental and mathematical studies, was a proposed technique to evaluate the corrosion rate of R.C. structures subjected to corrosive environments taking into consideration the actual concrete cover, bar diameter, chloride concentration and the exposure time.

The corrosion rate measurements obtained by the proposed technique were verified by testing additional R.C. loaded concrete beams. The accuracy of results obtained from the proposed technique was more than 95%.

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