ASSESSMENT OF STEEL CORROSION PERFORMANCE OF CONCRETE MIXTURES MADE OF EGYPTIAN BLENDED CEMENTS

By

Mohamed Atef Ibrahim Reyad

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

In

STRUCTURAL ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

ASSESSMENT OF STEEL CORROSION PERFORMANCE OF CONCRETE MIXTURES MADE OF EGYPTIAN BLENDED CEMENTS

Key Words:
Slag Cement; Fly Ash; Impressed Current; Accelerated Corrosion technique; Lollipop; Water Permeability; Rapid Chloride Penetration; Pull-Out

Summary:
Manufacturing of Blast Furnace Slag Cement (CEM III/A) has boomed since it was specified in the Egyptian Cement Standard ESS 4756:2006. However, corrosion protection efficiency of the Egyptian (CEM III/A) cement has been rarely investigated. Therefore, in this research work corrosion performance was investigated for different concrete mixtures made of Egyptian manufactured (CEM III/A 42.5N), (CEM III/A 42.5N) partially replaced with fly ash and Ordinary Portland cement (CEM I). A total of 432 reinforced concrete (i.e. lollipop) specimens were exposed to impressed current accelerated corrosion technique. In addition to the binder types, the corrosion influence of the concrete mixture water/binder (w/b) ratio and binder content were assessed as well as the impact of reinforcement cover and exposure duration on reinforced concrete specimen's corrosion performance. The corrosion protection was assessed by the corrosion current and it was quantified by measuring the rebar diameter loss. In addition, corrosion performance is correlated with pull-out test results. The chloride ion penetrability, water permeability and measured corrosion current were significantly reduced by replacing (CEM I) with either (CEM III/A) or (CEM III/A+FA) cements specially for large reinforced concrete cover having optimum cement content (400kg/m^3) and minimum w/b ratio with suitable workability.

ACKNOWLEDGMENT

Thanks are due to Almighty ***Allah*** for enabling me to complete this research as best as I can and peace be upon his Prophet Mohamed. I hope that this thesis results will be useful for me and whoever will follow me.

I would like to express my deepest appreciation to my family ***"my mother, my wife, my brothers, and my lovely children Omar, and Lily***" for their strong support along my life and their life, also to ***my father spirit***.

I would like to express my utmost gratitude to my thesis supervisors: ***Professor Dr. Osama A. Hodhod,*** and ***Professor Dr. Mohamed M. El-Attar,*** for their encouragement, supervision, precious remarks and guidance throughout the planning and execution of this thesis.

Special thanks and gratitude to my non-official supervisor: ***Associate professor Dr. Alaa El-Din M. Sharkawi.*** The role of Dr. Sharkawi in this thesis is invaluable. Dr. Sharkawi provided the Rapid Chloride penetration apparatus and helped with the design of the accelerated corrosion set up. Discussions with Dr. Sharkawi along this study course have enriched the research work, enhanced the published papers extracted from this study and contributed to the completed form of this thesis.

With all my love and respect

Eng. Mohamed Atef Ibrahim

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Abstract

Although it has been used worldwide for decades, manufacturing of Blast Furnace Slag Cement (CEM III/A) has boomed since it was specified in the Egyptian Cement Standard ESS 4756 on 2006. However, corrosion protection for reinforced concrete structures efficiency of the Egyptian (CEM III/A) cement has rarely investigated.

The research methodology is to investigated the influence of different concrete mixtures cast with Egyptian manufactured cement (CEM III/A 42.5N), (CEM III/A 42.5N) partially replaced with locally fly ash class F - and Ordinary Portland cement (CEM I) against corrosion exposure.

A total of 432 reinforced concrete (i.e. lollipop) specimens were exposed to accelerated corrosion by impressed current technique. In addition to the binder types, the corrosion influence of the concrete mixture, water/binder (w/b) ratio and binder content were assessed as well as the impact of reinforcement cover thickness and accelerated corrosion duration on reinforced concrete lollipop specimen's corrosion performance.
The corrosion protection was assessed by the corrosion current and it was quantified by measuring the rebar diameter loss. In addition, corrosion performance is correlated with pull-out test results

The study results assess the durability role of replacing (CEM I) with (CEM III/A) or (CEM III/A +20% FA) was remarkably dependent on the concrete mixture binder content and water/binder ratio. Optimum blended cement content and minimum water/binder (w/b) ratio, with suitable workability, provided the least concrete water permeability and chloride ion penetrability. Therefore, 400kg/m^3 -of either proposed blended cements- accompany with w/b ratio of 0.45 achieved the best concrete durability characteristics, with advantage to the (CEM III/A +20% FA) cement. Hence, it's clear that the highest blended cement content is not always the optimum content, as commonly specified, to achieve the least concrete permeability and chloride penetrability as well as the best corrosion protection. Therefore, it's possible to reduce the content of the proposed blended cements and the w/b ratio (i.e. paste content) without sacrificing the desired workability, compressive strength and durability