AIN SHAMS UNIVERSITY
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STRUCTURAL ENGINEERING DEPARTMENT

FLEXURAL BEHAVIOR OF CONCRETE BEAMS REINFORCED WITH HIGH STRENGTH AND CORROSIVE RESISTANT STEEL

Thesis

Submitted in fulfillment of the
requirements for the degree of

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In
STRUCTURAL ENGINEERING

By

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FOR MASTER OF SCIENCE
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FLEXURAL BEHAVIOR OF CONCRETE BEAMS REINFORCED WITH HIGH STRENGTH AND CORROSIVE RESISTANT STEEL

SUMMARY

The research program presented in this thesis was of multi phases to examine the mechanical characteristics of the MMFX steel, evaluate their corrosion resistance, investigate and assess their structural performance as main flexural reinforcement using typical full-scale T-section concrete beams reinforced by MMFX rebars. The research presents the experimental program carried out at the Reinforced Concrete Structures laboratory at Ain Shams University, Cairo, Egypt. A total of eight full-scale concrete beams were constructed and tested. All beams were T-section of 500 mm flange width by 80 mm thick. The web was 250 mm wide by 400 mm deep. The nominal length of all beams was 4000mm. Six beams were reinforced by MMFX rebars in the tension side while the remaining two beams were reinforced by conventional steel rebars Grade (40/60) in the tension side. The beams were equally reinforced by conventional steel rebars Grade (40/60) on the compression side except for the beam with maximum reinforcement ratio. All beams were tested under static loading conditions to failure in order to investigate the behavior during the pre-cracking, cracking, post-cracking, ultimate capacities, and modes of failure. Deformations, strains in longitudinal reinforcement, and crack pattern were recorded during the test at different loading stages. In the second phase of the research program, a comprehensive analysis of the tested specimens was conducted using cracked section analysis. The predicted behavior was compared to that observed during testing. The design recommendations and guidelines are proposed based on the results from this investigation and additional parametric study.

To fulfill the previously mentioned objectives, this research was divided into the following chapters:

- Chapter (1) is an introduction to this research. This chapter discusses the importance of the research and highlights the scope of the research program.

- Chapter (2) presents a brief review of the available literature, research findings, performance data and current practices relative to the use of MMFX steel in concrete structures.

- Chapter (3) presents the experimental program. This chapter describes the formwork, material properties, fabrication, test specimens, test setup, measurement devices, and loading scheme.

- Chapter (4) presents the test results and observations. The results include load–deflection curves, crack patterns, ultimate capacities, and modes of failure.

- Chapter (5) discusses the methodology adopted in the analytical study and includes verification from experimental work to check the validity of the analytical technique adopted.

- Chapter (6) includes formulation of results into clear design considerations for the use of the high strength and corrosive resistant steel as main flexural reinforcement to be incorporated in the Egyptian Code of Practice.

- Chapter (7) highlights the general conclusions of the study alongside with recommendations for future research and developments in the subject.

Flexural Behavior of Concrete Beams Reinforced with High Strength and Corrosive Resistant Steel

Submitted By

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Thesis Summary

Use of Micro-composite Multi-structural Formable Steel, commercially known as “MMFX”, as a replacement for convention steel is gaining popularity in many concrete structures. The high-corrosive resistance nature and high-strength characteristics of the MMFX rebars could provide additional service life to concrete structures in areas that are prone to severe environmental conditions.

The research program presented in this thesis was designed to study the flexural behavior of T-section concrete beams reinforced by MMFX rebars. The research presents the experimental program carried out at the Reinforced Concrete Structures laboratory at Ain Shams University, Cairo, Egypt. A total of eight full-scale concrete beams were constructed and tested. All beams were T-section of 500 mm flange width by 80 mm thick. The web was 250 mm wide by 400 mm deep. The nominal length of all beams was 4000mm. Six beams were reinforced by MMFX rebars in the tension side while the remaining two beams were reinforced by conventional steel rebars Grade (40/60) in the tension side. The beams were equally reinforced by conventional steel rebars Grade (40/60) on the compression side. All beams were tested under static

loading conditions to failure in order to investigate the behavior during the pre-cracking, cracking, post-cracking, ultimate capacities, and modes of failure.

Deformations, strains in longitudinal reinforcement, and crack pattern were recorded during the test at different loading stages. In the second phase of the research program, a comprehensive analysis of the tested specimens was conducted using cracked section analysis. The predicted behavior was compared to that observed during testing.

All MMFX reinforced concrete beams experienced higher ultimate strength and a comparable amount of ductility in comparison to beams reinforced by conventional steel rebars Grade (40/60). The failure mode of most beams was classified as ductile flexural failure due to significant straining of the tension reinforcement preceding the crushing of the concrete. Only two beams failed due to rupture of the MMFX rebars. No bond failure was observed during testing. The design recommendations and guidelines are proposed based on the results from this investigation and additional parametric study. Based on the research findings, the minimum and maximum reinforcement ratio has been identified as well as the optimal use of MMFX as reinforcement for concrete structures.

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