BEHAVIOR OF REINFORCED CONCRETE BEAMS STRENGTHENED WITH EXTERNALLY BONDED FIBER/STEEL REINFORCED POLYMERS AND GRANCRETE

By

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DOCTOR OF PHILOSOPHY

in Civil Engineering

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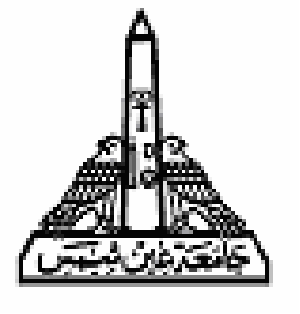

ABSTRACT

Title of the Thesis : **BEHAVIOR OF REINFORCED CONCRETE BEAMS STRENGTHENED WITH EXTERNALLY BONDED FIBER/STEEL REINFORCED POLYMERS AND GRANCRETE**

Submitted by : Judy Mohamed Ibrahim Soliman

Supervisors : Distinguished Prof. Dr. Sami Hanna Rizkalla
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Strengthening of reinforced concrete (RC) structures with externally bonded FRP composites has become very popular around the world over the past decade due to the well-known advantages of FRP composites over other materials. Advances in material science have led to the production of a novel patented material, commercially known as Grancrete. The material can be used as special cementitious materials for new constructions, repair of existing structural elements, sprayable coating for protection of structures from severe surrounding environmental conditions and for fire resistance applications. Using Grancrete as an adhesive material for the externally bonded fibres to concrete substrate allows increasing the strengthening limits in the current codes as

they are primarily based on the low fire resistance of Epoxy adhesives. Therefore, it is expected to lead to a more economical design and expand the service life of strengthened concrete structures.

The main objective of this research was to investigate and evaluate the effectiveness of the proposed fiber reinforced Grancrete (FRG) strengthening system, using Grancrete paste as an adhesive material for flexural strengthening of reinforced concrete beams with different types of externally bonded fibers (Basalt grid sheet, Steel reinforced polymers (SRP) and Carbon strands sheets). The thesis is extended to study the effect of different parameters believed to affect the bond characteristics among Grancrete, concrete and the different types of fibers. The main variables included the type and configuration of the strengthening scheme, Grancrete thickness, and presence of U-wraps. The experimental program undertaken in the current study consisted of three phases. The first phase was designed to obtain an optimum Water/Grancrete, W/G, ratio to be used in the mix design of Grancrete using compressions cubes. The second phase was designed to evaluate the bond strength of Grancrete with different strengthening systems including Basalt Grid, Steel Reinforced Polymers, etc. Different tests were conducted on concrete slabs measuring 600x600 mm to examine the bond characteristics of different strengthening schemes. The third phase focuses on real applications of Grancrete in flexural members. A total of thirty-two T-Section concrete beams were constructed and tested at the Structural Laboratory at Ain Shams University. The beams were strengthened using different FRP externally bonded

systems. The beams were tested using four point bending setup. Test results demonstrated that most of the specimens were likely to fail by debonding of the FRP from the concrete either at the ends or at intermediate flexural cracks. Due to the complexity of debonding failures, considerable uncertainty still exists with the failure mechanisms and the prediction of debonding failure loads. This research presents an in-depth study aimed at the development of a better understanding of debonding failures in RC beams strengthened with externally bonded FRP systems, using Basalt Grid sheets. No significant increase in load carrying capacity of the beam nor decrease in the maximum deflection were observed using Basalt Grid fibers. Using SRP sheets and Carbon strands sheets, the beams were most likely to fail due to sheet end debonding, the use of U-Wraps provides better results compared to the similar unconfined specimens and leads to a significant increase in the load carrying capacity of the strengthened beams which reached almost double the load carrying capacity of the control specimen.

Research findings indicate that published analytical approach of Malek et. al., 1998 for plate end debonding fibers can safely be used to predict the plate end debonding failure moments. The classical cracked section analysis method can be safely used to predict the ultimate flexural moments and deflections.

Rational model was developed to predict plate end debonding mechanism of Grancrete strengthened FRP systems. The model was validated with test results.

Keywords: beam, concrete, externally bonded FRP, Grancrete, SRP, Carbon Strands, Basalt Grid, strengthening, debonding.

Biography

Judy Soliman began her study of engineering in 2000 at the Faculty of Engineering, Ain Shams University, Egypt. In June 2005, she obtained her Bachelor of Science (B.Sc.) in Civil Engineering with honors. Upon graduation she was appointed as a teaching assistant at the Ain Shams University teaching Design of Reinforced Concrete Structures. She pursued her graduate studies at the Faculty of Engineering, Ain Shams University, Egypt. In January 2008 she earned her Master of Science (M.Sc.) degree in structural engineering. The title of her master thesis was "**Bond Behaviour of High Strength and Corrosive Resistant Steel Reinforcement**".

In October 2008, she pursued with her graduate studies leading to her Doctor of Philosophy degree in civil engineering.

STATEMENT

This thesis is submitted to the Engineering Faculty of Ain Shams University for the degree of Doctor of Philosophy in Civil Engineering (Structural Engineering).

The work included in this thesis has been carried out by the author in the department of Structural Engineering, Ain Shams University, from October 2008 to May 2012.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

Date : 06/05/2012

Signature :

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Finally, I would like to express my appreciation to my unique Father, Mother, husband, sister, brother and children for the support they showed to me, their encouragement and unconditional love.

Dedication

To my parents
Who are the reason why I am everything I am
To my husband
For whom I am trying to be the best I can
To my lovely angels, Haya and Judy
My love for them is unconditional
Thank you.

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