BEHAVIOUR OF REHABILITATED REINFORCED CONCRETE ELEMENTS UNDER CYCLIC LOADING USING VARIOUS COMPOSITE MATERIALS

By

MOHAMED SAYED GOMAA MAHMOUD

A Thesis Submitted to the
Faculty of Engineering, Cairo University,
Fayoum Branch in Fulfilment of
the Requirements for the Degree of

MASTER OF SCIENCE

in

Civil Engineering (Structural Engineering)

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
FAYOUM BRANCH, EGYPT
May 2005

BEHAVIOUR OF REHABILITATED REINFORCED CONCRETE ELEMENTS UNDER CYCLIC LOADING USING VARIOUS COMPOSITE MATERIALS

By

MOHAMED SAYED GOMAA MAHMOUD

A Thesis Submitted to the
Faculty of Engineering, Cairo University,
Fayoum Branch, in Fulfilment of
the Requirements for the Degree of

MASTER OF SCIENCE

In

Civil Engineering (Structural Engineering)

Under the Supervision of

Prof. Dr. Hany A. El-Ghazaly

Prof. of Structural Analysis and Mechanics,
Vice Dean of Post Graduate Studies and Research,
Faculty of Engineering
Cairo University, Fayoum Branch

Dr. Mohamed M. Elassaly

Assist. Prof. of Structural Engineering,
Cairo University, Fayoum Branch

Dr. Ahmed F. El-Ragi

Assist. Prof. of Structural Engineering,
Cairo University, Fayoum Branch

FACULTY OF ENGINEERING, CAIRO UNIVERSITY,
FAYOUM BRANCH, EGYPT
May 2005

BEHAVIOUR OF REHABILITATED REINFORCED CONCRETE ELEMENTS UNDER CYCLIC LOADING USING VARIOUS COMPOSITE MATERIALS

By

MOHAMED SAYED GOMAA MAHMOUD

A Thesis Submitted to the
Faculty of Engineering, Cairo University,
Fayoum Branch in Fulfilment of
the Requirements for the Degree of

MASTER OF SCINECE

in

Civil Engineering (Structural Engineering)

Approved by the

Examining Committee:

Name and Affiliation	Signature
Prof. Dr. Ibrahim Mahfouz Mohamed Ibrahim Professor of Structural Engineering (Emeratis) Zgazig University, Banha Branch	**Member**
Prof. Dr. Hany A. El-Ghazaly, Professor of Structural Analysis and Mechanics Vice Dean for Post Graduate Studies and Research, Cairo University, Fayoum Branch	**Thesis Main Advisor**
Prof. Dr. Adel Yehia Akl Professor of Structural Analysis and Mechanics Cairo University	**Member**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
FAYOUM BRANCH, EGYPT
2005

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude and most sincere appreciation to **Prof. Dr. Hany Ahmed EL-Ghazaly,** Professor of Structural Analysis and Mechanics, for his caring guidance, untiring advice, encouragement, valuable suggestions and support throughout all stages of the research program.

I also wish to express my sincere gratitude to **Dr. Mohamed M. El-Assaly,** Assist. Prof. of structural engineering, Civil Engineering Department, Cairo University, Fayoum Branch, for his generous donation of time, constructive criticism and valuable discussions.

Deep appreciation is extended to **Dr. Ahmed F. El-Ragi**, Assist. Prof. of structural engineering, Civil Engineering Department, Cairo University, Fayoum Branch, for his great concern, valuable assistance and critical ideas through which the scope of the work could be enhanced.

Finally, I would like to offer this work to my wife, whose continuous love and support guided me through difficult times and who gave me the ambition to continue my studies as far as possible.

Mohamed Sayed Gomaa

April, 2005

ABSTRACT
An investigation of the behavior of the strengthened RC elements under cyclic loading is presented. To get better understanding of the behavior of strengthened elements under cyclic loading, their behavior under static loading is investigated first. Two models are developed to simulate the performance of the strengthened elements under static and cyclic loading.

An analytical model is produced to help understanding the behavior of strengthened RC beams under flexure due to static loading. The model takes into account the materials properties of concrete, reinforcing steel, FRP. Results of the analytical model are compared to results of static experimental tests available in the literature in order to verify the analytical model. Results show a good agreement between experimental and analytical model results.

A finite element model is produced to simulate the behavior of the strengthened RC beams under either static or cyclic loading. The produced model takes into consideration properties of the used materials. To verify this model, results obtained by the model are compared to experimental static and cyclic tests results available in the literature. Results show good agreement with the experimental results for both static and cyclic loadings.

Based on the verified analytical model, design charts are developed to simplify the design process of any strengthened RC beam with rectangular cross section subjected to flexure. The charts are developed for some commonly used FRP products in Egypt, and for various grades of reinforcing steel.

Using the finite element model, the relation between the FRP laminate thickness and the deflection of the strengthened beam under cyclic loading is investigated. It is noted that increasing the used FRP laminate thickness decreases the mid-span deflection but the relation between them is not linear. Another investigation is carried out forpp the relation between the used FRP thickness and the natural frequency of the strengthened element. It is noted that, strengthening of RC elements increases the natural frequency of the

element. The relation between FRP thickness and the natural frequency is found to be almost linear.