
شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم


# شبكة المعلومـــات الجامعية

# التوثيق الالكتروني والميكروفيلم


شبكة المعلومات الجامعية

# جامعة عين شمس

## التوثيق الالكتروني والميكروفيلم

## ﴿ قَسَـــم ﴾

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأفلام قد اعدت دون آية تغيرات


## يجب أن

تحفظ هذه الأفلام بعيداً عن الغبار

في درجة حرارة من 15 – 20 مئوية ورطوبة نسبية من 20-40 %

To be kept away from dust in dry cool place of
15 – 25c and relative humidity 20-40 %


# بعض الوثائق الأصلية تالفة


# بالرسالة صفحات

# لم ترد بالأصـــل

TANTA UNIVERSITY
FACULTY OF ENGINEERING
STRUCTURAL ENGINEERING DEPARTMENT

# BEHAVIOR OF REINFORCED CONCRETE COLUMNS CONFINED BY FRP UNDER ECCENTRIC LOADS

**A THESIS**
Submitted to the Faculty of Engineering at Tanta University
in Partial Fulfillment of the Requirements for the Degree of
**Doctor of Philosophy**
In
**Civil Engineering "Structural Engineering"**

**By**

**Eng. MOHAMED HUSSEIN MAHMOUD**

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B.Sc., M.Sc. Civil Engineering , Ain Shams University

Under the Supervision of

**Prof. Dr. Sami Rizkalla** — Distinguished Prof. North Carolina S.U, USA

**Prof. Dr. Kamal Nassif Ghali** — Prof. of Concrete Structures Ain Shams University, Egypt

**Prof. Dr. Mohamed Kassem** — Prof. of Structural Eng. Tanta University , Egypt

**Dr. Tarek Mohamed Fawzy**

Associate Prof. Structural Engineering
Tanta University, Egypt

**June, 2002**

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**June, 2002**

**To My Father and Mother**

**To Whom I Own My Whole Life**

**To My Wife Rania and My Child Ahamed**

**To Whom I Live**

**To My Dear Prof. Dr. Kamal Nassif Ghali**

APPROVAL SHEET

# BEHAVIOR OF REINFORCED CONCRETE COLUMNS CONFINED BY FRP UNDER ECCENTRIC LOADS

A thesis by

**Eng. Mohamed Hussein Mahmoud**

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# STATEMENT

This dissertation is submitted to TANTA UNIVERSITY for the degree of DOCTOR OF PHILOSOPHY in Civil Engineering "Structural Engineering" .

The work included in this thesis was carried out by the author in the Department of Civil Engineering from June 1998 to June 2002 .

No part of this thesis has been submitted for a degree of a qualification at any University or Institution.

Signature:

## ACKNOWLEDGMENT

The work presented in this thesis was suggested by Prof. Dr. Kamal Nassif Ghali, Professor of Concrete Structures Ain Shams University. It is pleasure for the author to express his sincere gratitude to him for his continuous supervision which has greatly contributed in achieving this work.

The author wishes to express his deep thanks to Prof. Dr. Sami Rizkalla, North Carolina State University for his guidance and sincere help.

The author wishes to express his deep thanks to Prof. Dr. Mohamed Kassem , Professor of Structural Engineering, Tanta University for his guidance and sincere help.

The author wishes to express his deep thanks to. Dr. Tarek Mohamed Fawzy , Associate Professor of Structural Engineering, Tanta University for his guidance and sincere help. It is pleasure for the author to express his sincere gratitude to him for his continuous supervision which has greatly contributed in achieving this work.

Thanks from heart to Dr. Mohamed Dabaon for his sincere help and valuable discussions during the experimental phase of the thesis.

Thanks also for Mr. Abdel Raouf Kamal, my father in low for his continuous encouragement, valuable discussion and the facilities given to carry out this work.

Thanks are also antipode to the engineers of the R.C department specially Eng. Mohamed Adbel Raouf, Eng. Ahmed Taha Baraghet and the staff of the laboratory in Faculty of Engineering, Tanat University.

Thanks also for all members of Structural Engineering Department specially R.C section for their helpful suggestions and continuous encouragement

# ABSTRACT

FRP-confined concrete columns benefit from a confining effect due to restraint of the lateral expansion. This effect increases the strength and the ductility of the concrete confined by FRP shell for case of centric load, as given by many researchers. However, more research work is necessary in order to investigate experimentally the behavior of R.C. columns confined by FRP under eccentric loads, as it seems that axially loaded columns do not exist in practice and that is why eccentrically loaded columns may be more representative.

This thesis deals with the effect of load eccentricity on the ultimate load and ductility of confined columns with different height to depth ratio. Thirty R.C columns were tested and their results were analyzed. An analytical model is proposed for analysis of columns subjected to eccentric loads, also empirical equation based on experimental results is proposed, which can be used to determine the ultimate load of FRP-confined concrete columns under eccentric loads tacking into account load eccentricity as well as height to depth ratio. Note that, we can not use any of the models given by many researchers which have been proved for case of centric loaded columns, as all these models based on a constant vertical strain of concrete along the column depth, while, in case of eccentric loading the vertical stress of concrete is no longer constant.

The proposed method of analysis is verified by comparing the prediction to experimental data published by different researches, as well as the present experimental work . Based on the finding, design guidelines are suggested.

Based on the proposed model, a computer program was designed specially to suite the unique response of FRP-confined concrete circular sections. In the same program we combine the design recommendations with the proposed design expressions to introduce a design program can be used to design FRP-confined short columns and piles, also an example for the proposed design procedure is given. A list of computer program is given in appendix "A".

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