



Faculty of Engineering
Structural Engineering Department

STRENGTHENING OF FLAT SLABS IN PUNCHING SHEAR USING STEEL SHEAR BOLTS

A Thesis
Submitted in Partial Fulfillment of the
Requirements for the Degree of Doctor of philosophy
in
structural engineering

Prepared by
MOHAMED HAMDY ALY ESMAIL

B.Sc. in Civil Engineering, June 2009
M.Sc. in Civil Engineering, March 2015

Supervisors

PROF. DR. AMR ALI ABDELRAHMAN

Professor of Reinforced Concrete Structures
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

PROF. DR. SHERIF MOHAMED ELZEINY MOSTAFA

Professor of Reinforced Concrete structures
Housing and Building National Research Center, Cairo, EGYPT

ASSOC.PROF.DR. SHERIF KAMAL ELWAN

Associate Professor of Structural Engineering
The Higher institute of Engineering Elshrouk, Cairo, EGYPT

Dr. MOHAMED SAAFAN ABD-EL GAWAD

Lecturer of Structural Analysis
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

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THESIS APPROVAL

EXAMINERS COMMITTEE

Prof. Dr. Raafat El-Hacha

Professor of Structural Engineering
Faculty of Engineering, Calgary University.

Prof. Dr. Alaa Gamal El-Sherif

Professor of Reinforced Concrete Structures
Faculty of Engineering, Helwan University.

Prof. Dr. AMR ALI ABDELRAHMAN

Professor of Reinforced Concrete Structures
Faculty of Engineering, Ain Shams University.

Prof. Dr. SHERIF MOHAMED ELZEINY MOSTAFA

Professor of Reinforced Concrete structures
Housing and Building National Research Center, Cairo, EGYPT

SIGNATURE

R. El-Hacha

Date: 23/1/2019

STATEMENT

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of Ph.D. in Structural Engineering.

The work included in this thesis was carried out by the author in the department of Structure Engineering, Faculty of Engineering, Ain Shams University, from August 2015 to August 2018.

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

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others

Date: 23/1 /2019

Signature: -----

Name: *MOHAMED HAMDY ALY ESMAIL*



AUTHOR

Name : Mohamed Hamdy Aly Esmail

Date of birth : 13 August 1987

Place of birth : Cairo, Egypt

Academic Degree: B.Sc.in Structural Engineering, 2009.

University : Higher Institute of Engineering-El Shorouk Academy

Date : June 2009

Grade : Excellent with Honor

Academic Degree: M.Sc. in Structural Engineering, 2015.

University : Ain Shams University

Date : March 2015

Current job : Teaching Assistant

DEDICATION

I wish to dedicate this work to who suffered to educate, support and encourage me during the thesis work

To my Parents,

My Brothers, my Wife &my Lovely kids

For the encouragement and support to complete this work.

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ABSTRACT

The objective of this study is to enhance the punching shear strength of flat slabs at interior column. For this purpose, an economical and easy to install strengthening method was applied to $\frac{1}{2}$ scale flat slabs specimens. The proposed strengthening scheme employs the use of fabricated steel shear bolts placed around the column in different spacing and arrangements as vertical punching shear reinforcement. In addition, the effect of column aspect ratio on strengthening method was also investigated in the scope of this study. Strength increase of at least 30% was obtained for the strengthened specimens compared to the companion reference specimen. Three dimensional nonlinear finite element model was generated using ANSYS program to investigate the punching shear failure mechanism of test specimens. 3-D finite element models are successful in providing reasonable estimates of ultimate punching load capacity, load-deformation behavior and strains. Extended parametric study with new parameters was generated including new parameters. The effect of compressive strength, spacing between shear bolts, and column aspect ratio were investigated. A proposed guidelines and a design equation were generated from the parametric study results using regression analysis. The experimental punching load capacities of the specimens were compared with the estimations punching shear load given by ACI 318-14, Eurocode-2, and ECP203-2017.

Keywords: Punching Shear, Flat Slabs, Punching Shear RFT., Shear Bolts, Slab-Column Connections, Strengthening and Ductility, ANSYS, Finite Element Method.

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