hossam maghraby

شبكة المعلومات الجامعية

بسم اللّه الرحمن الرحيم

hossam maghraby

شبكة المعلومات الجامعية

شبكة المعلومات الجامعية
التوثيق الالكتروني والميكروفيلم

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شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

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Menoufia University
Faculty of Engineering

SHEAR BEHAVIOUR OF REINFORCED CONCRETE FLAT SLAB-COLUMN EDGE CONNECTIONS WITH OPENINGS

By

Ehab Fathy El-Salakawy

A *Thesis* Submitted for the Degree of *Doctor of Philosophy* in Engineering

STRUCTURAL ENGINEERING

in the field of

REINFORCED CONCRETE

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1998

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STATEMENT

This thesis is submitted to Civil Engineering Department, Faculty of Engineering, Menoufia University for the award of the degree of Philosophy Doctor in Engineering (Structural Engineering - Reinforced Concrete).

Thesis title: " Shear Behaviour of Reinforced Concrete Flat Slab-Column Edge Connections with Openings "

The work presented in this thesis has been conducted by the author in the Civil Engineering Department, Faculty of Engineering, Menoufia University in cooperation with the Civil Engineering Department, University of Waterloo, Ontario, Canada through the Scientific Channel System Program.

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

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ABSTRACT

In design and construction of two-way reinforced concrete slab systems it is often necessary to construct openings in the vicinity of columns. Such openings, which are often located at the edges, are required for services installation (sanitary, heating, air-conditioning etc.). At the edge columns, even under gravity loads only, the transverse shear stresses are caused not only by concentrated loads but also by moments that must be transferred between a slab and a column. The existence of openings in the vicinity of a column reduces the area of concrete that can resist transverse shear, which makes the slab-column connection weaker and the failure can be brittle. The use of shear reinforcement increases the shear strength and the ductility of the connection. Stirrups, bent bars and shear heads can be used as shear reinforcement.

In this study, punching shear due to concentrated load and moment transfer in reinforced concrete flat slabs with openings was investigated through an extensive experimental program and finite element modeling. The experimental program included tests on fourteen full-scale slab-column edge connections. The dimensions of the slab portion were 1540 × 1020 ×120 mm and the cross section of the column was 250 × 250 mm. The test specimens consisted of Series I, II and III. Series I, consisted of six specimens without shear reinforcement and Series II consisted of four specimens with shear studs as shear reinforcement. Series III consisted of four specimens subjected to higher moment to shear ratio. The test parameters were: the location of openings, the size of openings, the amount of shear reinforcement and the moment to shear ratio. The Finite Element Analysis (FEA) using quadrilateral isoparametric degenerated shell elements were conducted to analyze the reinforced concrete slabs. The layered formulation of an element was employed to account for different material properties. The test results were compared to those of the FEA. Good agreement between test results and FEA predictions was found. Using the FEA (computer program "NASH") parametric studies were carried out to investigate the effects of openings of different sizes and locations on the behaviour of slab-column edge connections. Based on the conducted tests and the performed analyses, some conclusions are offered.

Key Words: edge connections; concrete slabs; punching shear; shear strength; openings; failure; shear studs; shear reinforcement; reinforced concrete.

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TO MY WIFE,

SON AND DAUGHTER

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