شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

MONA MAGHRABY

بسم الله الرحمن الرحيم

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شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

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Structural Engineering Department

Punching Behaviour of Flat Slab Interior Column Connection with Openings

A Thesis submitted in partial fulfilment of the requirements of the degree of
Master of Science in Civil Engineering
Structural Engineering Department

By

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Bachelor of Science in Civil Engineering
(Structural Engineering)
Faculty of Engineering, Ain Shams University, 2017

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Cairo - (2021)

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THESIS APPROVAL

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Date: February 2021

Statement

This thesis is submitted as partial fulfilment of the requirements for the degree of Master of Science in Civil Engineering (Structural Department), Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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ABSTRACT

Flat slabs system is being used in construction nowadays, as it provides larger clear ceiling height, as well as being aesthetically appealing. Sometimes mechanical, electrical ducts and other utilities needs require opening to be positioned near slab-column connection. These openings discontinue the natural load path of the structure and increase the risk of punching shear failure, This type of failure is the major disadvantage of flat slab system as it is a sudden failure and occurs when the shear stresses due to the transferred load and unbalanced moments exceed the slab's capacity with no warnings.

The main objective of this study is to investigate the punching behavior of flat slab interior column connection with openings. To fulfill this objective, numerical finite element models were constructed focusing on five main parameters, namely, the opening size and location, the flexural reinforcement ratio, column aspect ratio, the eccentricity of the applied load, and the existence of shear reinforcement. Twenty-six full scale specimens were conducted using the finite element analysis program **ANSYS 19**. The slabs were divided into two main groups, as the first group was with slab dimensions of (3000x3000x200) mm, and with various flexural reinforcement ratio ranging from 0.8% to 1.5%, and the second group was with slab dimensions of (4000x4000x250) mm, and with constant flexural reinforcement ratio of 1%, both groups have openings with different sizes and locations except two control specimens with no openings one for each group. Also, columns with different aspect ratios were investigated, the first group was with control column of size (400x400) mm investigated with column aspect ratio of (1:1, 3:2, and 2:1), and the second group was with control column of size (500x500) mm investigated with column aspect ratio of (1:1, and 3:2). All specimens were investigated under the effect of concentric load except one sub-set of the second group was under the effect of eccentric load. Also, five specimens of the second group were investigated with additional vertical shear reinforcement.

The existence of openings reduced the punching shear capacity, and the size and location of the placed opening had a major effect on the punching shear resistance as the increasing of opening size caused a reduction in punching shear strength approximately 10%. On the other hand when the opening was located at distance "d" from the column's face and compared to the opening adjacent to the column's face, the punching shear strength increased ranging by 3.7-21%.

Other parameters such as different column aspect ratio of (1:1, 3:2, and 2:1) has a minor effect on the punching shear strength as the increase of column aspect ratio slightly decreased the punching. As the flexural reinforcement ratio increased from 0.8% to 1%, and from 0.8% to 1.5%, the punching shear strength increased by 9.6%, and 20%, respectively.

Adding stirrups as a vertical shear reinforcement had a minor effect on the punching shear strength of flat slabs with openings near to column's face as the punching shear resistance slightly increased ranging from 1 to 9.5%. on the other hand, applying eccentric load caused a reduction in punching shear strength ranging by 8.2-16%.

Keywords: flat slab, punching shear failure, punching shear strength, opening size, opening location, column aspect ratio, shear reinforcement, load eccentricity, flexural reinforcement, finite element analyses, ANSYS.

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