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FACULTY OF ENGINEERING
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Early Punching Resistance of Concrete Slabs

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BY
Moataz Mohamed El-Taher El-Sayed
Teaching Assistant, Structural Engineering Department,
Faculty of Engineering - October 6 University

Supervised by

Prof. Dr. AYMAN HUSSIN HOSNI
Professor of R.C. Structure, Structural Engineering Department,
Faculty of Engineering - Ain Shams University

Dr. Wael M. Montaser
Assistant Professor, Structural Engineering Department,
Faculty of Engineering - October 6 University

Faculty of Engineering
Ain Shams University
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STATEMENT

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Date : / / 2019

Name : Moataz Mohamed El-Taher El-Sayed Abbas

Signature : ……..

Ain Shams University
Faculty of Engineering

Approval Sheet

Thesis **:** Master of Science in Civil Engineering (Structural)

Student Name **:** Moataz Mohamed El-Taher El-Sayed

Thesis Title **:** Early Punching Resistance of Concrete Slabs

Examiners Committee: **Signature**

PROF. DR. MOHAMED ELSAEED EISSA ……..
Professor of Concrete Structures
Structural Engineering Department, Faculty of Engineering, Cairo University

PROF. DR. AMR HUSSEIN ABD EL AZIM ZAHER ……..
Professor of Concrete Structures
Structural Engineering Department, Faculty of Engineering, Ain Shams University

PROF. DR. AYMAN HUSSEIN KHALIL ……..
Professor of Concrete Structures
Structural Engineering Department, Faculty of Engineering, Ain Shams University
(Supervisor)

Date: / / 2019

INFORMATION ABOUT THE RESEARCHER

Name: Moataz Mohamed El-Taher El-Sayed

Date of Birth: July, 8th, 1990

Place of Birth: Cairo, Egypt

Last Academic Degree: 2014, B.Sc. in Structural Engineerig, Faculty of Engineering, October 6 University

Present Job: Teaching Assistant, Structural Engineerig Department, Faculty of Engineering, October 6 University

Email: *Eng.moatazeltaher@gmail.com*

Signature:

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DEPARTMENT OF STRUCTURAL ENGINEERING

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EARLY PUNCHING RESISTANCE OF CONCRETE SLABS

ABSTRACT

The reinforced concrete flat slab system is a widely used structural system. Its formwork is very simple as no beams or drop panels are used. However, the catastrophic nature of the failure exhibited at the connection between the slab and the column has concerned engineers. This area becomes the most critical area as far as the strength of flat slabs is concerned due to the concentration of high bending moments and shear forces.

During construction of multi-story building with reinforced concrete floor slabs, shoring and reshoring operations are carried out. The construction is started by setting up the shoring on the previously cast floors and then pouring fresh concrete on next floor, during shoring and reshoring process the weight of freshly poured concrete is transferred by shoring into the previously cast floors. This construction load may exceed the design loads and led to early failure of slabs.

One of the common cause of failures of flat-slab structures during construction is insufficient early-age punching shear capacity under relatively high construction loads. Punching shear failure is a local phenomenon which generally occurs in a brittle manner, at concentrated load or column support region. This type of failure is catastrophic because no external, visible signs are shown prior to occurrence of the failure.

Most of the current concrete researches focuses on punching resistance of concrete slabs after reaching its strength (after 28 days). Punching failure may happen during construction due to insufficient concrete compressive strength of premature concrete. So, the main objective of this thesis is to study and investigate the early punching resistance of concrete slabs.

Keywords: Slabs, Early punching capacity, Premature concrete, Early-age, Punching shear behavior, Early strength admixture.

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NOTATION

f_{cu}	Concrete characteristic Strength.
q_{cup}	The ultimate punching shear strength for concrete.
γ_c	Material Reduction Factor for Concrete.
α	Factor depends on the column location.
d	Effective slab depth.
a, b	Column short and long direction respectively.
v	Nominal shear stress.
f_c'	Cylinderical concrete compressive strength.
$ß_c$	The column aspect ratio.
u	The critical punching perimeter.
ρ	The reinforcement ratio.
F'_c	Specified Compressive Strength of Concrete
T_s	Thickness of Slab
LVDT	Linear Variable Displacement Transducer
E_c	Young's Modulus of Concrete
E_s	Young's Modulus of Steel Section
EXP.	Experimental

Chapter One

INTRODUCTION

1.1 Background

One of the features in design of modem day reinforced concrete buildings is the use of a flat slab cast monolithically with supporting columns. A flat plate is, by definition, a two-way slab structure with a uniform thickness, without beams, drop panels or column capitals. Flat plate structures have properties that are demanded for many types of construction such as underground parking, commercial towers and industrial buildings. The main advantages of this type of construction are low formwork and workmanship cost, less construction duration, high modularity in floor space partitioning and architectural convenience.

One of the practical problems for flat slab construction system is how to avoid punching shear failure at the columns. Punching shear is generally associated with high concentrations of shear forces and bending moments are the column peripheries. In the case of symmetric punching, the ultimate limit, state is characterized by the formation of a frustum of a cone having generatrices inclined with respect to the plane of the slab by an angle usually between 22 and 30 degrees.The incorporation of lightweight concrete opens various possibilities concerning the overall weight reduction of multi-story buildings, projects with severe problems in foundation situation or in the case of adding extra floors to existing buildings.

Modern construction techniques enable reinforced concrete structures to be constructed in a very short time. The loads occurring due to the construction process on the partially completed structure can be larger than the design service load. The available strength of the immature partially completed structure is dependent upon the available concrete strength which may be less than the specified strength. Failure would occur if the available strength is less than that required to support the construction loads.

Slabs are usually designed by using the theory of bending and shear. A slab may be loaded prematurely when it has not been allowed to develop its full characteristic strength at the normal 28 days period after casting and with adequate curing procedure following proper mixing and placing of the concrete. When loading is made on a slab prematurely, it will result in misbehavior in service hence, it is necessary to investigate the effect of premature loading

on reinforced concrete slabs in order to avoid such failures as wide cracks, de-bonding, other defects and consequently failure. Premature loading of reinforced concrete members may not be deliberate as we find in the construction industry and site procedures. It occurs most of the time in order to meet project time targets as individual structural elements is not allowed to fully develop their characteristic strength before being loaded. For example, a slab may be used to support the formwork for another floor or other structural elements, or it may be loaded with masonry blocks for walls before being laid.

Since very limited researches has been performed to study early punching behavior, and therefore empirical data is scarce, this research presented herein was aimed at investigating the early punching behavior of concrete slabs.

1.2 Research Scope and Objectives

This research consists of an experimental program conducted to study the effects of different parameters on the punching behavior of concrete slabs . A Total of eight slabs were fabricated and tested to investigate the early punching shear behavior of concrete slabs, in addition to a comparison between different code provisions regarding punching shear capacity . All slabs in the experimental program were tested under one concentrated load to study the effects of early loading on slabs, and different concrete compressive strength, and using an early strength concrete admixture. In addition, the experimental analysis has been refined and modified based on the literature review and previous analysis. Also it was carried out to achieve the main objectives of the research that can be summarized as follows:

- Study and investigate the early punching resistance of concrete slabs under concentric punching load.
- Investigate the punching behavior of concrete slabs with different concrete compressive strength.
- Evaluate the current provisions of the Egyptian code of practice and other international codes related to punching capacity of slab-column connections subjected to concentric punching load.