
# ANALYTICAL STUDY ON REINFORCED CONCRETE BARBELL SHEAR WALLS

By

**Mahmoud Ahmed Sayed Saeed**

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
**MASTER OF SCIENCE**
In
**Structural Engineering**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

# ANALYTICAL STUDY ON REINFORCED CONCRETE BARBELL SHEAR WALLS

By
**Mahmoud Ahmed Sayed Saeed**

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
**MASTER OF SCIENCE**
In
**Structural Engineering**

Under the Supervision of

**Prof. Dr. Hany Ahmed Abdalla**
Professor of Concrete structures
Faculty of Engineering,
Cairo University

**Dr. Khaled Farouk El-Kashif**
Assistant Professor of Concrete structures
Faculty of Engineering,
Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

# ANALYTICAL STUDY ON REINFORCED CONCRETE BARBELL SHEAR WALLS

By
**Mahmoud Ahmed Sayed Saeed**

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
**MASTER OF SCIENCE**
In
**Structural Engineering**

Approved by the
Examining Committee

_____
**Prof. Dr. Hany Ahmed Abdalla** **Thesis Main Advisor**
Professor of Concrete Structures, Cairo University

_____
**Prof. Dr. Akram Mohamed Torkey** **Internal Examiner**
Professor of Concrete Structures, Cairo University

_____
**Prof. Dr. Tarek Ibrahim Ebeido** **External Examiner**
Professor of Concrete Structures, Alexandria University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

| | |
|---|---|
| **Engineer's Name:** | Mahmoud Ahmed Sayed Saeed |
| **Date of Birth:** | 29/12/1992 |
| **Nationality:** | Egyptian |
| **E-mail:** | Mahmoudsaeed4321@gmail.com |
| **Phone:** | 01148281258 – 01094569480 |
| **Address:** | 26 Zakry$^{st}$ Bani suef, Bani suef |
| **Registration Date:** | 01/10/2015 |
| **Awarding Date:** | …./…./2018 |
| **Degree:** | Master of Science |
| **Department** | Structure Engineering |
| **Supervisors:** | **Prof. Dr. Hany Ahmed Ali Abdalla**<br>**Dr. Khaled Farouk El-Kashif** |
| **Examiners:** | **Prof. Dr. Hany Ahmed Ali Abdalla (Thesis Advisor)**<br>**Prof.Dr. Akram Mohamed Torkey (Internal Examiner)**<br>**Prof. Dr. Tarek Ibrahim Ebeido (External Examiner)**<br>Professor of Concrete Structures, Alexandria University |


**Title of Thesis:** **Analytical Study on Reinforced Concrete Barbell Shear Walls**


**Key Words:**

Shear wall behaviour - Barbell shear wall - Confinement of shear wall - Boundary columns of shear wall



**Summary:**

Behavior of reinforced concrete barbell shear walls is investigated in this research. The output of the finite element program ANSYS are validated using experimental results**.** The shear wall specimens were analyzed for different parameters. The results from validation were used as inputs for studying the effect of enlargement ratio, confining end region of shear walls, ratio of vertical loads and the effect of increasing the thickness and width of enlargement on performance of shear wall for resisting lateral forces. It was concluded that for the optimum seismic performance, width of enlargement should not exceed the length of compression zone and vertical loads ratio should not exceed 10 % of gross area of shear walls. It was found that the thickness of enlargement has no effect if it exceeds (1/10) of the unsupported height and confining of enlargement has an important effect on strain of the compression zone.

# Acknowledgments

I would like to show my gratitude for my supervisors (Prof**. Dr. Hany Abdalla and Dr. Khaled El Kashif)** for their guidance, advices, support and valuable discussions review during my Master, and their great efforts to achieve my objectives.

I want also to thank **my parents, my brother, my sisters, my grand mather, my big family, eng_ Taha Husssien** and all my friends who always help me for the success. I would not have to achieve this goal without their help and support.

# *Dedication*

*To my Family, my brother, my sisters, my fiancée, eng_ Taha Hussien and all my friends*

# Table of contents

# List of Tables

# List of Figures

# Abstract

Shear walls are major members in tall concrete buildings for resisting lateral loads. Most failure patterns of shear walls are concrete crushing in compression zone although they are designed to collapse in tension zone. The behavior of most walls does not achieve the required ductility because of an additional stain due to lateral forces. Barbell shear wall has two enlargements and has better ductility than rectangular shear wall. This thesis evaluates the effect of monotonic lateral loads on shear walls.

A computation analytical finite element model FEM has been applied using ANSYS program version 16. Various codes provisions are used for comparison with FEM results. These include the Egyptian Code for Design and Construction of Concrete Structures, Building Code Requirements for Reinforced Concrete (ACI 318 – 14) and CSA Committee A23.3. Many parameters considered; enlargement ratio, confining of end region of shear walls, ratio of vertical loads, increase of the thickness of enlargement and increase of width of enlargement. It was concluded that for the optimum seismic performance, width of enlargement should not exceed the length of compression zone, vertical loads ratio should not exceed 10 % of gross area of shear walls, thickness of enlargement has no effect if it exceeds (1/10) of the unsupported height and confining of enlargement has an important effect on strain of compression zone. The results of the FEM and codes provisions are illustrated in Tables, figures and charts to explain the effect of each parameter on shear wall.

# CHAPTER 1: INTRODUCTION

## 1.1 GENERAL

In the 19th century, high rise concrete buildings appeared. These buildings were most likely to collapse due to lateral loads. Rectangular shear walls were the first solution used to resist lateral loads. Rectangular shear wall is the most important element in high - rise reinforced concrete structures. Recently, many RC shear walls were collapsed and cracked because of earthquakes, so researchers searched how to improve ductility of shear walls. Laboratory tests have been done to investigate their behavior. They concluded that the behavior of shear walls did not achieve the required ductility. Although the design was considered to be flexural failure not shear failure, most failures pattern of shear walls were concrete crushing in compression zone. Compression failure occurred due to buckling of compression zone as a result of an additional compression force. It was proved that many factors affect the behavior of shear wall such as reinforcement ratio, shape of shear wall, compressive strength, vertical loads ratio and confinement.

In this thesis, main requirements for improving ductility of shear walls can be summarized as follows:

1- Concentrating reinforcement in end region
2- Boundary column dimensions
3- Confinement of end region
4- Uniform vertical loads ratio

## 1.2 RESEARCH OBJECTIVES

The two main objectives of this research are:

1- Investigate the behavior of barbell shear walls subjected to lateral force using finite element method. The finite element results are compared to those of laboratory tests from the literature.
2- Study the effect of concentrating reinforcement in end region, boundary columns dimensions, confinement of boundary column and uniform vertical loads ratio.

## 1.3 SCOPE OF RESEARCH

Thirty specimens of shear walls subjected to both vertical and lateral loads are modeled by ANSYS. Six of them were used for verification of finite elements results against available laboratory results. The rest of specimens were used to study the effect of shear wall shape, reinforcement concentration in end region, confinement of end region, vertical loads ratio and boundary column dimension.