شبكة المعلومات الجامعية

بسم اللّه الرحمن الرحيم

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم باللّه العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

يجب أن

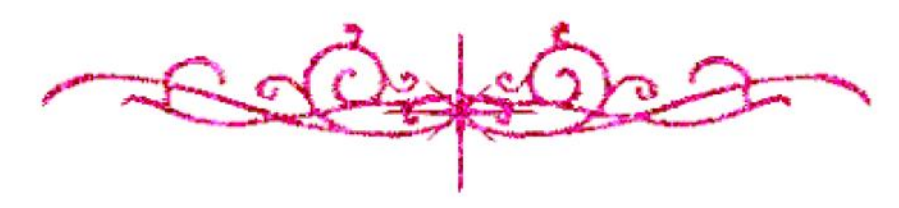
تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

شبكة المعلومات الجامعية

بعض الوثائق الأصلية تالفة

بالرسالة صفحات

لم ترد بالأصل



Ain Shams University
Faculty of Engineering
Department of Structural Engineering

Comparative Study between Force Based Design Method and Performance Based Seismic Design of Reinforced Concrete Shear Walls

A THESIS
Submitted in Partial Fulfillment of the Requirements of the Degree of
MASTER OF SCIENCE IN CIVIL ENGINEERING

Submitted by

Mahmoud Mohamed Mohamed Zidan
B.Sc. in Civil Engineering – Structural Engineering (2016)
Faculty of Engineering – Ain Shams University

Supervised by

Prof. Ahmed Hassan Ghallab

Professor of Structure Engineering
Structural Engineering Department
Faculty of Engineering
Ain Shams University

Dr. Yasser Saeed El Zeni

Assistant Professor of Structure Engineering,
Structural Engineering Department
Faculty of Engineering
Alexandria University

Cairo – 2020

Curriculum Vitae

Name:	Mahmoud Mohamed Mohamed Zidan
Date of Birth:	27 September 1993
Place of Birth:	Egypt
Nationality:	Egyptian
University Degree:	B.Sc. in Civil Engineering, Faculty of Engineering, Ain Shams University, 2016
Current Job:	Structural Engineer

Declaration

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Civil Engineering (Structural Engineering). The work included in this thesis was carried out by the author in the Department of Structural Engineering, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

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

Name: Mahmoud Mohamed Mohamed Zidan

Acknowledgment

I wish to express my gratitude to Dr. Ahmed Hassan Ghallab , Professor in the Structural Engineering Department, Ain Shams University and Dr.Yasser Saeed ElZeni Assistance Professor in the Structural Engineering Department, Alexandria University for their kind supervision, sincere assistance and valuable guidance during the preparation of this thesis.

This thesis could not have been completed without the greatest supports and love from my family and my friends throughout the study.

Abstract

This research studies the performance of reinforced concrete (RC) structures under the effect of seismic load. Mostly, design codes demonstrates the effect of seismic load on the structures as a lateral force and assign a force reduction factor (R) for structures in order to take into consideration the ductility provided by the system, without taking into consideration level of damage of structures. The performance seismic method gives better prediction of the structure behavior under seismic load. performance based design methods are the capacity spectrum and displacement coefficient method which is carried out by applying nonlinear pushover analysis leading to formation of plastic hinges that give an indication about the behavior level of the structure. In this research a verification study will be carried out to verify the results of the non-linear pushover analysis through comparing the pushover analysis results applied on shear walls with experimental wall results. Also the performance based design method and force based method will be applied on RC shear wall buildings with different heights and different reinforcement ratios of the structural elements using different seismic zones and the results will be compared with each other in terms of base shear, drift. This comparison is applied also between the performance based design methods to show the difference between these methods.

TABLE OF CONTENTS

CHAPTER (1) INTRODUCTION 22

1.1 General 22

1.2 Thesis objective 23

1.3 Thesis organization 24

CHAPTER (2) Literature Review 26

2.1 Introduction 26

2.1.1 Performance objectives 26

2.1.2 Performance levels 27

2.2 Pushover analysis 31

2.2.1 Load application in pushover analysis 32

2.2.2 Control of loading in pushover analysis 33

2.2.3 Steps of push over analysis 35

2.2.4 Failure mechanism 37

2.2.5 Idealization of pushover analysis 44

2.2.6 Connection between pushover analysis and performance based design 48

2.3 Performance based design methods 49

2.3.1 Capacity spectrum method 50

2.3.2 Displacement coefficient method FEMA-356: 58

2.3.3 Direct Displacement-Based Design 60

2.3.4 Performance based design codes 77

2.4 Differences between force based design and performance based design 77

2.5 Background studies 80

2.5.1 Direct displacement based design 80

2.5.2 Direct displacement based design and Push over analysis 84

2.5.3 Push over analysis 86

2.5.4 Push over, time history analysis and direct displacement based design 87

2.5.5 Time history analysis 89

2.5.6 Experimental studies 90

2.6 Studied factors 96

CHAPTER (3) Finite Element Modelling 97

3.1 General 97

3.2 Types of elements used in finite element 97

3.2.1 Shell element 97

3.2.2 Frame element 99

3.2.3 Plastic hinges 100

3.2.4 Materials 103

3.3 Boundary conditions 104

3.4 Diaphragm effect 105

3.5 Loading 106

CHAPTER (4) VERIFICATION OF THE FINITE ELEMENT MODELING 107

4.1 Introduction 107

4.2 Experimental wall verification from P.Lestuzzi et al, 2007 107

4.2.1 Experimental wall data 108

4.2.2 Finite element modelling of experimental walls 114

4.2.3 Comparison between experimental wall and pushover analysis results 117

4.3 Experimental wall verification from Englekirk, Robert E, 2003..... 118

4.3.1 Experimental wall data 119

4.3.2 Results..... 120

4.3.3 Comparison between experimental wall and pushover analysis results 121

4.4 Flexure behavior of shear walls 122

4.4.1 Moment curvature calculation 122

4.4.2 Moment curvature calculation verification 125

4.4.3 Plastic moment capacity of shear walls verification 126

CHAPTER (5) parametric study 137

5.1 Description 137

5.2 Design Procedures..... 142

5.2.1 Design codes 142

5.2.2 Materials 142

5.2.3 Loads..... 144

5.2.4 Design of sections..... 146

5.3 Analysis methods 146

5.3.1 Performance based design method 147

5.3.2 Force based design method 147
5.4 Results and discussion 149
5.5 Performance based design results 150
5.5.1 Capacity curve and story drift results 150
5.5.2 Capacity spectrum method results 169
5.5.3 Displacement coefficient method results 184
5.5.4 Comparison between performance based design methods 184
5.6 Force based design results 198
CHAPTER (6) Summary and CONCLUSION 204
6.1 Summary and conclusions 204
6.1.1 Summary 204
6.1.2 Conclusions 204
6.2 Recommendations for future studies 206
APPENDIX (A) 213
PUSHOVER ANALYSIS MODELLING IN FINITE ELEMENT 213
1.1 Materials 213
1.2 Loading 215
APPENDIX (B) FALIURE CRITERIA OF SHEAR WALLS 218

List of Figures

Figure (2-1): Performance Objectives for Buildings (Adopted from National Research Council, 2003)..... 27

Figure (2-2): Graphical Representation of the Performance Levels (FEMA-389) 30

Figure (2-3): Capacity curve of pushover analysis 31

Figure (2-4): Lateral load pattern distribution in pushover analysis 32

Figure (2-5): Values for Determining the Vertical Distribution of the Lateral Loads 33

Figure (2-6): Difference between load control and displacement control (CSI-Analysis reference manual) 34

Figure (2-7): Relation between base shear and roof displacement and plastic hinge formation (Elastic phase) 36

Figure (2-8): Relation between base shear and roof displacement and plastic hinge formation (yielding phase) 36

Figure (2-9): Relation between base shear and roof displacement and plastic hinge formation (Post yielding phase) 37

Figure (2-10): Plastic hinge location at structural elements 38

Figure (2-11): Force and displacement relationship, same type of curve is used for moment curvature relationship (CSI-Reference manual) 38

Figure (2-12): Different types of plastic hinges for structural elements..... 39

Figure (2-13): Generalized force-deformation relation for concrete elements 40

Figure (2-14): Concrete stress strain curve with performance levels strain limits 43