SEISMIC RESPONSE MODIFICATION FACTOR FOR REINFORCED CONCRETE FRAMES BASED ON NON-LINEAR PUSHOVER ANALYSIS AND ITS EFFECT ON SEISMIC GAPS

By

WALAA MOHAMMED ABD EL SALAM EL-HEREBY

A Thesis Submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfilment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

Structural Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

2020

SEISMIC RESPONSE MODIFICATION FACTOR FOR REINFORCED CONCRETE FRAMES BASED ON NON-LINEAR PUSHOVER ANALYSIS AND ITS EFFECT ON SEISMIC GAPS

By

WALAA MOHAMMED ABD EL SALAM EL-HEREBY

A Thesis Submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfilment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

Structural Engineering

Under Supervision of

Prof. Dr. Walid Abd El-Latif Attia

……

Professor of Structural Analysis and Mechanics

Structural Engineering Department

Faculty of Engineering, Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

2020

SEISMIC RESPONSE MODIFICATION FACTOR FOR REINFORCED CONCRETE FRAMES BASED ON NON-LINEAR PUSHOVER ANALYSIS AND ITS EFFECT ON SEISMIC GAPS

By

WALAA MOHAMMED ABD EL SALAM EL-HEREBY

A Thesis Submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfilment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

Structural Engineering

Approved by the
Examining committee

_____

Prof. Dr. Walid Abd El-Latif Attia **(Thesis Main Advisor)**
Professor of Structural Analysis and Mechanics
Faculty of Engineering, Cairo University.

_____

Prof. Dr. Ahmed Hassan Amer **(Internal Examiner)**
Professor of Structural Analysis and Mechanics
Faculty of Engineering, Cairo University.

_____

Prof. Dr. Hatem Hamdi Geith **(External Examiner)**
Professor of Reinforced Concrete Structures,
Housing and Building National Research Center.

FACULTY OF ENGINEERING, CAIRO UNIVERSITY,

GIZA, EGYPT

2020

Engineer's name: Walaa Mohammed Abd el-Salam el-Hereby
Date of birth: 07/01/1992
Nationality: Egyptian
E-mail: walaa.elhereby@yahoo.com
Phone: 01118372657
Address: 8th district, Nasr city, Cairo
Registration date: 01/10/2015
Awarding date: ---/----/2020
Degree: Master of Science
Department: Structural Engineering

Supervisors: Prof. Dr. Walid Abd El-Latif Attia.

Examiners: Prof. Dr. Walid Abd El-Latif Attia. (Thesis Main Advisor.)
Professor of Structural Analysis and Mechanics, Cairo University
Prof. Dr. Ahmed Hassan Amer. (Internal Examiner.)
Professor of Structural Analysis and Mechanics, Cairo University
Prof. Dr. Hatem Hamdy Geith. (External Examiner.)
Professor of Reinforced Concrete Structures, Housing and Building National Research Center.

Title of Thesis:
Seismic response modification factor for reinforced concrete frames based on non-linear pushover analysis and its effect on seismic gaps.

Key words:
Response modification factor, Ductility, Reinforced Concrete Frames, Seismic Gaps, Pushover Analysis.

Summary:
This research is studying the response modification factor of RC frames by studying the effect of number of stories and the relative inertia of beam to column on the ductility of the reinforced concrete frames which have a significant effect on the response reduction factor by performing non-linear static analysis, then comparing these values with the mentioned values of same RC frames in ECP. In addition, a verification analysis was conducted to guarantee the calculation method of the R-factor. The change of the R-value affects the top plastic displacement and the seismic gap as well. The study shows the difference between seismic gap values using the R-factor resulted from the study and the mentioned values in the ECP using the SRSS method for seismic gap calculation. Based on the study results, the conclusions illustrate the base shear, displacement, ductility and seismic gap change due to using different R-values for same system.

DISCLAIMER

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Date: ../../…

Signature:

ACKNOWLEDGEMENT

I would like to express my honour and gratefulness for working on the degree to all who encouraged me and believed in me specially my family members who worked too hard for this day and all days and I wish they are proud of me. I also want to share my happiness with my true friends too who were like sisters and brothers all time and wishing my luck and success in my study, work and life.

I would like to express my gratefulness to my supervisor, Prof Dr Walid abdel latif attia. Thank you for your guidance, support and assistance throughout this research, I am indebted to all of you with the knowledge and experience I gained. It was an honour working under your supervision.

My appreciation goes to my thesis examiners Prof Dr. Ahmed Hassan amer and Prof Dr. Hatem hamdy Geith for their support and guidance. Every one of you participated in the achievement I made, by teaching, supporting and encouraging me throughout different stages. Thank you.

TABLE OF CONTENTS

DISCLAIMER ..... **i**

ACKNOWLEDGEMENT ..... **ii**

TABLE OF CONTENTS ..... **iii**

LIST OF TABLES ..... **vi**

LIST OF FIGURES ..... **vii**

NOMENCLATURE ..... **xviii**

ABSTRACT ..... **xx**

Chapter 1: Introduction **1**

1.1. Introduction 1

1.2. Research Objectives 2

1.3. Thesis Organization 2

Chapter 2: Literature Review **3**

2.1 Introduction 3

2.2 Response Reduction /Modification Factor 3

2.3 Ductility 7

2.4 Pushover Analysis 10

2.5 Critical Gap Between Adjacent Buildings 12

Chapter 3: Effects Of Number of Stories and Relative Inertia on Response Modification Factor for Ductile RC frames **21**

3.1. Introduction 21

3.2. Objectives 21

3.3. Response Reduction Factor 21

3.3.1. Ductility Reduction Factor (Rμ) 23

3.3.2. Structural Over Strength (Rs) 24

3.3.3. Damping Factor (R_ξ) 24

3.3.4. Redundancy Factor (R_R) 24

3.3.5. Response Reduction/ Modification Factor (R) in ECP 24

3.4. Pushover Analysis 25

3.5. Response Parameters 25

3.5.1. Yield Deformations 26

3.5.2. Ultimate Deformation 28

3.6. Elasto-Plastic Idealization Curve Used In The Study 29

3.7. Verification of Analytical Models 29

3.8. Case Study Reinforced Concrete (RC) Frames Configuration 34

3.9. Applied Loads on RC Frames of Parametric Study 40

3.10. Material Properties And model of Parametric Study 40

3.1. Concrete Material 40

3.2. Reinforcing Steel Material 42

3.11. SeismoStruct Models 43

3.12. Results of The Parametric Study 48

Chapter 4: Separation Distance of Adjacent Buildings Due to Seismic Effect 64

4.1. ECP Code Requirements: 64

4.1.1. Section Modifiers 64

4.1.2. Mass Sources 65

4.1.3. Damping 65

4.1.4. Static Method For Seismic Base Shear 65

4.1.5. Response Spectrum Analysis 66

4.2. Configuration of Frames Systems 67

4.3. Results 68

4.4. Seismic Gap Calculations 111

Chapter 5: Conclusion 114

5.1. Conclusion 114

5.2. Recommendations for Future Works 116

REFERENCES 117

APPENDICES 125

APPENDIX (A): Design of case study frames due to gravity and seismic loads 125

APPENDIX (B): Definition of static and dynamic seismic load using ETABS software 129

APPENDIX (C): Calculation of ultimate base shear force according to ECP 145