Ain Shams University

Faculty of Engineering

Structural Department

Analytical Investigation of Reinforced Masonry Shear Wall Structures Exposed to Dynamic Load

A Thesis submitted in partial fulfillment of the requirements of the degree of Master of Science in Civil Engineering
(Structural Engineering)

By

Ahmed Alaa Elden Radwan Abd ElAziz

Bachelor of Science in Civil Engineering

(Structural Engineering)

Faculty of Engineering, Ain Shams University, 2019

Supervised by

Dr. Marwan Tarek Shedid
Associate Professor
Structural Engineering Department
Ain Shams University

Dr. Ezz-El Den Mostafa Arafa
Assistant Professor
Structural Engineering Department
Ain Shams University

Ain Shams University-Faculty of Engineering

Structural Department

Analytical Investigation of Reinforced Masonry shear wall structures Exposed to Dynamic Load

By

Eng. Ahmed Alaa Elden Rawdan Abd ElAziz

B.Sc. in Civil Engineering (Structural)

Faculty of Engineering – Ain Shams University

EXAMINERS COMMITTEE

Prof. Mashhour Ghoneim.

Structural Engineering Dept. ……………….
Faculty of Engineering – Cairo University

Prof. Mohamed Nour Elden Fayed.
Structural Engineering Dept. ……………….
Faculty of Engineering – Ain Shams University

Dr. Marwan Mohamed Tarek Shedid.

Structural Engineering Dept. ……………….
Faculty of Engineering – Ain Shams University
(Supervisor)

Date: 26/10/2019

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Civil Engineering (Structural Engineering), 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.

Student Name

Ahmed Alaa Elden Radwan Abd El Aziz

Signature

……………………………………………..

Researcher Data

Name	: Ahmed Alaa ElDen Radwan Abd ElAziz
Date of birth	: 27-09-1992
Place of birth	: Cairo, Egypt
Last academic degree	: B.Sc.
Field of specialization	: Civil Engineering
University issued the degree	: Ain Shams University
Date of issued degree	: June 2014
Current job	: Teaching Assistant

Acknowledgement

I like to say that no words can express my gratitude, love and appreciation to my mother, my father and my wife, whose help and encouragement were the main motive for me to complete this work. Thank you for supporting me throughout my entire life, words fail to explain how grateful I am for having you as my family.

I would like to express my gratefulness to my supervisors, Dr. Marwan Shedid and Dr. Ezz El Deen Mostafa. 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 honor working under your supervision.

My greatest appreciation goes to all my instructors and colleagues at the Faculty of Engineering, Ain Shams University. Each and every one of you participated in the achievement I made, by teaching, supporting and encouraging me throughout different stages. Thank you.

List of Publications

Ahmed Alaa, Shedid and Ezz Elden Mostafa. "Analytical Investigation of Reinforced Masonry Shear Walls Exposed to Dynamic Load", the 15th International Conference on Structural and Geotechnical Engineering (ICSGE15), Cairo, Egypt, 2018.

Abstract

Reinforced concrete masonry (RCM) shear walls are considered as an effective lateral load resisting system (LLRS), many analytical and experimental studies were conducted to survey the behavior of RCM shear walls against lateral loading to help designers to predict their response under the effect of severe ground motions. Analysis of structures using time history method is considered one of the methods used for simulating the response of structures subjected to seismic loading in order to predict the behavior of these structures. In international codes, the value of reduction factor was obtained by testing many types of walls under cyclic and dynamic loading. Actually, codes don't provide the configuration of tested walls, so in this research will make an investigation on different wall configurations and buildings exposed to dynamic loading.

This study was performed to have further insight on the behavior of RCM individual shear walls and midrise buildings composed of these walls as their main gravity and lateral load resisting system. A review of previous literature was undertaken to have clear ideas of the previous findings related to the point of study. After a review of literature this research was divided into two phases:

The first phase of the study was to generate analytical models for RCM individual shear walls with different configuration (rectangular, flanged and end-confined) tested by Shedid et al (2010) and verify these results against experimental results mentioned in literature. The softwares used in this study are OpenSees, Response-2000 and Seismo Signal software. The second phase was to generate a parametric study, where 27 specimen models for individual walls were generated in order to study the value of response modification factor (R) and deflection amplification factor (Cd). These walls have different configurations (rectangular, flanged and end-confined), reinforcement ratio and aspect ratio. Also, nine building models (symmetric and asymmetric) were generated to evaluate the seismic performance of

structures composed of different RCM walls with respect to ultimate lateral strength (Qu) and drift for each constitutive wall. All models were subjected to actual earthquake records (ten records). During this study, all walls within the building models were supported to be totally uncoupled.

Finally, the conclusions related to the RCM individual shear walls and buildings are presented.

Conclusion related to RCM individual shear walls,

- Response modification factor (R) and deflection amplification factor (Cd) are affected by aspect ratio, wall configuration and reinforcement ratio.
- R and Cd factors are sensitive to the variation in vertical reinforcement and wall configuration more than aspect ratio (equal or greater than 2).
- Walls with the same reinforcement ratio and same configuration but different aspect ratio, for aspect ratio equal or greater than 2, there is no significant change in value of R factor.
- According to the aspect ratio, the walls with lower aspect ratio (same walls configuration) have R and Cd values lower than those walls with higher aspect ratio.
- According to reinforcement ratio, the walls with higher reinforcement (same wall configuration) have R and Cd values lower than those walls with lower reinforcement ratio.
- According to wall configuration, rectangular walls have R and Cd values less than flanged and end confined walls.

Conclusion related to symmetric and asymmetric buildings,

- The building strength decreases as the distance between center of mass CM and center of rigidity CR increases.
- The building displacement increases as the distance between CM and CR increases.

- The location of the CR is not constant over the loading history due to the fact that not all walls lose their stiffness with the same rate.
- The location of the CR cannot be calculated based on the gross stiffness or even uniformly modified stiffness of elements of the LLRS.
- The use of constant value for stiffness modifiers for different elements of the structure to model its behavior under seismic loading, as used by current design codes, is not a realistic method since, as presented in this study, walls lost stiffness with different proportions.

Keywords: Time History Analysis, Response Modification Factor, Analytical Models, Ground Motion, Dynamic Analysis.

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LIST OF ABBREVIATIONS AND SYMBOLS

- CMU: Concrete Masonry Units
- RCM: Reinforced concrete masonry
- RC: Reinforced Concrete
- R: Seismic Design Response Modification Factor
- C_d: Deflection Amplification Factor
- LLRS: Lateral load resisting system
- CM: Center of Mass
- CR: Center of Rigidity
- DBE: Displacement Based Element
- FBE: Force Based Element
- LLRS: Lateral Load Resisting System
- f'_m: Masonry Prism Compressive Strength
- f_y: Steel Yield Stress
- H_w: Wall Height
- L_{ip}: Weight of Integration Point
- L_p: Plastic Hinge Length
- L_w: Wall Length
- G_f^c: Fracture Energy
- μ: Displacement Ductility
- SFRS: Shear Force Resistance System
- ρ: Reinforcement Ratio
- G: Modulus of Rigidity
- E_c: Concrete Modulus of Elasticity
- PGA: Peak Ground Acceleration
- PGV: Peak Ground Velocity
- PEER: Pacific Earthquake Engineering Research
- Δt: Time Interval
- dt: Time Step
- K: Wall Stiffness