AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

PERFORMANCE-BASED ASSESSMENT OF MEDIUM-RISE MASONRY BUILDINGS

By

Ahmed Mohamed Abd-El Latif Yassin

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

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Supervised By/

Prof. Dr. Amr Ali Abd El Rahman
Professor of RC Structures, Ain-Shams University

Dr. Hussein Okail
Assistant Professor of RC Structures, Ain-Shams University

Dr. Marwan Shedid
Assistant Professor of RC Structures, Ain-Shams University

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APPROVAL SHEET

Thesis : Master of Science in Civil Engineering
Student Name : Ahmed Mohamed Abd El Latif Yassin
Thesis Title : Performance-Based Assessment of Medium Rise Masonry Buildings

Examiners Committee: **Signature**

Prof. Dr. Mashhour Ahmed Ghoneim ……..........……..
Professor of Concrete Structures,
Faculty of Engineering-Cairo University

Prof. Dr. Ahmed Sherif Essawy ……..........……..
Professor of Concrete Structures,
Faculty of Engineering-Ain Shams University

Prof. Dr. Amr Ali Abdelrahman ……..........……..
Professor of Concrete Structures,
Faculty of Engineering-Ain Shams University

Date: / / 2015

Statement

This thesis is submitted as a partial fulfillment 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 Mohamed Abd El Latif

Signature

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I believe that I have given my all effort in developing this research as accurately and truthfully as possible. Moreover, I am surely personally responsible for the conclusions and opinions expressed in this research.

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<u>Information about the Researcher</u>

Name: Ahmed Mohamed Abd El Latif Yassin

Date of Birth: 5 July 1989

Place of Birth: Cairo, Egypt

Qualifications: B. Sc. Degree in civil engineering (structural department)
Faculty of Engineering, Ain-Shams University (2011).

Present Job: Teaching Assistant

Abstract

The behavior of masonry walls depends on the behavior of several materials that have different characteristics such as blocks, mortar, reinforcement and grout. Such combination makes nonlinear analysis of such walls challenging. Consequently, there is a need to develop numerical models of such complex combination that are both accurate and simple. These macro models are used to simulate the in-plane response of structural walls under cyclic loading simulating earthquake effects which is difficult to be implemented in the laboratory. The validity of the developed models was investigated against previous experimental results and comparison showed that developed models could be used in simulating reinforced fully-grouted masonry shear walls.

The principal objective of this study was to predict the seismic performance of medium rise reinforced masonry shear walls having rectangular, flanged and end-confined cross sections while varying wall aspect ratio, level of applied axial stress and vertical reinforcement ratio. The second main objective was to predict the probability of a specific damage state by using fragility curves as a sort of performance based assessment criteria. The third objective was to study the ductility response of a structure composed of different wall types and having different ductility capacities and consequently the response modification factor for the whole building can be specified and implemented through this study.

Results showed that displacement ductility capacity was very sensitive to the level of axial compression much more than the effect of vertical reinforcement, where displacement ductility decreases significantly with the increase of axial load compared to increase in vertical reinforcement ratio. Also, it was concluded that higher aspect ratio (height to length ratio) walls poses lower ductility capacity.

Fragility diagrams were used to predict the probability of exceeding a specific state of damage (initial cracking, steel yielding, wall toe crushing and steel buckling or fracture) when walls are subjected to a seismic demand input parameter which is considered as drift ratio. It was found that end-confined wall

section is the least vulnerable wall system for the third and fourth damage states followed by flanged then rectangular wall sections. The third and fourth damage states are directly related to ductility and hence the best indicator for the seismic performance of structural wall systems.

Regarding to structure integrity for a building composed of ten walls having different ductility capacities, it was concluded that the outcome global ductility response of a building was totally different from individual walls and it is highly sensitive to the ratio of participation of ductile wall system such as end-confined and flanged wall sections. And by considering equal displacement approach which is implemented in many codes, it could be considered that response modification factor equal to system displacement ductility.

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H_W = wall height

L_W = wall length

C = distance between neutral axis and maximum compression fiber

L_S = distance between maximum and minimum moment of wall height

A_R = wall aspect ratio

L_P = equivalent plastic hinge length

D_b = bar diameter

μ_Δ = displacement ductility

$\mu_{\Delta 0.8u}$ = displacement ductility measured up to 20% strength degradation

$\mu_\varnothing$ = curvature ductility

$\varnothing$ = section curvature

$\varnothing_y$ = yield curvature

$\varnothing_p$ = inelastic curvature

Θ_p = inelastic rotations

Δ_y = yield displacement

Δ_p = inelastic displacement

Δ_u = displacement at ultimate strength

$\Delta_{0.8u}$ = displacement at 20% strength degradation

ε_{mu} = ultimate masonry compressive strain

ε_m = masonry strain

ε_s = steel strain

ε_y = steel yield strain

P = axial compressive load

Q_u = ultimate shear strength

Q_y = lateral load corresponding to yielding

Q_d = design lateral load

σ = axial compressive stress

A_g = section gross area

E_m = masonry modulus of elasticity

E_s = steel modulus of elasticity