

DYNAMIC TEST OF A 1/8 SCALE TWO STORY LIGHTLY REINFORCED CONCRETE BUILDING

By

Khaled Sherif Abd-Elrahman Mohamed

B.Sc. Structural Engineering,
Helwan University, 2007.

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
2014

DYNAMIC TEST OF A 1/8 SCALE TWO STORY LIGHTLY REINFORCED CONCRETE BUILDING

By

Khaled Sherif Abd-Elrahman Mohamed

B.Sc. Structural Engineering, Helwan University, 2007.

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. Adel Galal El-Attar

Professor of Reinforced Concrete Structures
Structural Engineering Department
Faculty of Engineering
Cairo University

**Prof. Dr. Abd El-hamid Ibrahim
Zaghw**

Professor of Reinforced Concrete Structures
Structural Engineering Department
Faculty of Engineering
Cairo University

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2014**

DYNAMIC TEST OF A 1/8 SCALE TWO STORY LIGHTLY REINFORCED CONCRETE BUILDING

By

Khaled Sherif Abd-Elrahman Mohamed

B.Sc. Structural Engineering, Helwan University, 2007.

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 Examination Committee

Prof. Dr. Adel Galal El-Attar

(Thesis Advisor)

Professor of Reinforced Concrete Structures – Cairo University

Prof. Dr. Abd El-hamid Ibrahim Zaghw

(Thesis Advisor)

Professor of Reinforced Concrete Structures – Cairo University

Prof. Dr Sherif Ahmed Mourad.....

(Examiner)

Professor of Steel Structures and Bridges (Dean of Faculty) – Cairo University

Prof. Dr Alaa Gamal Sherif.....

(Examiner)

Professor of Reinforced Concrete Structures – Helwan University

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT**

2014

Engineer: Khaled Sherif Abd-Elrahman Mohamed
Date of Birth: 11 / 8 / 1985
Nationality: Egyptian
E-mail: Khaledsheref@gmail.com
Phone: 01114764744
Address: 100, street No. 10, Maadi, Cairo
Registration Date: 1 / 10 / 2008
Awarding Date: / /
Degree: Master of Science
Department: Structural Engineer



Supervisors: Prof. Dr. Adel Galal El-Attar
Prof. Dr. Abd El-hamid Ibrahim Zaghw

Examiners: Prof. Dr. Adel Galal El-Attar
Prof. Dr. Abd El-hamid Ibrahim Zaghw
Prof. Dr. Sherif Ahmed Mourad
Prof. Dr. Alaa Gamal Sherif

Title of Thesis: DYNAMIC TEST OF A 1/8 SCALE TWO STORY LIGHTLY
REINFORCED CONCRETE BUILDING

Key Words: Shaking Table - Microconcrete – Heat treatment – Dynamic model

Summary:

A 1/8 scale reinforced concrete building model was tested on a shaking table. The reinforcement details were based on typical elements subjected to vertical loads only according to (ECP 203). The model was tested using the time compressed Aqaba 1995 earthquake at different amplitudes. Free vibration test were performed before and after each seismic test to study the changes in the model building properties. Test results indicated that the non seismic reinforcement details may form a potential source of damage, and it was found experimentally that they did not lead to collapse or a complete failure mechanism.

Acknowledgement

Praise and glory are due to Allah whom I attribute all my knowledge and success in my life.

I would like to express my sincere appreciation and deep gratitude to Prof. Dr. Adel Galal El-Attar and, Dr. Abd El-hamid Zaghw, for their caring guidance, constant supervision, advice and encouragement during the progress of this research.

I would like to thank my friends and colleagues for their help and their support during my study period.

The grateful to all the members of the Reinforced Concrete Laboratory Staff, Faculty of Engineering, Cairo University, for their kind help during the experimental phase of this research.

Last, but certainly not least, I am grateful to my dear parents, brothers, and sister, for unlimited love, support during my whole life and without them I certainly would not have achieved what I did in my life.

ABSTRACT

A 1/8 scale two story one bay by one bay lightly reinforced concrete building was tested on the Cairo University shaking table. The structure model was designed solely for gravity loads without regard to any kind of lateral loads (wind or earthquakes), and had no walls or partitions. The reinforcement details were based on typical reinforced concrete elements subjected to vertical loads only according to (ECP 203), and characterized by (a) low reinforcing ratios in columns, (b) discontinues positive moment beam reinforcement at the columns, (c) low joint confinement, and (d) lap splices located immediately above the floor level. The model was tested using the time compressed Aqaba 1995 earthquake at different amplitudes. Free vibration test were performed before and after each seismic test to study the changes in the model building properties.

Test results indicated that this type of reinforced concrete frame will experience very large deformations associated with considerable stiffness degradation during a moderate earthquake. Although the non seismic reinforcement details may form a potential source of damage for lightly reinforced concrete building, it was found experimentally that they did not lead to collapse or a complete failure mechanism. The model failures occurred outside the joint region, indicating that the lack of joint confinement was not a potential source of damage. Also, the location and details of the column lap splices did not cause a serious problem to the model.

Both experimental and analytical results indicated that the inclusion of the slab contribution to the beam flexural strength is a vital step in the assessment of the performance of lightly reinforced concrete structures during earthquakes since it has the potential of altering the relatively ductile strong column weak beam mechanism to the more brittle soft story mechanism.

TABLE OF CONTENTS

	Page
Acknowledgement	i
Abstract	iii
Table of Contents	v
List of Figures	ix
List of Tables	xi
Chapter 1 – Introduction	
1.1 General	1
1.2 Background information	2
1.3 Objectives and scope	3
1.4 Thesis organization	4
Chapter 2 – Shaking Table	
2.1 Shaking Table Configuration	5
2.2 Shaking Table Limitation	6
2.3 Data acquisition system	7
2.4 Displacement Measurements and Reference Stiff Column	8
2.5 Pretest Seismic Qualification	10
Chapter 3 – Literature Review	
3.1. General	11
3.2. Dynamic Modeling Studies	12
3.3. Dynamic modeling theory	14
3.4. Dimensional Analysis	19
3.5. Models Classification	25
3.6. Structural Models	26

3.6.1. Models with Complete Similarity	27
3.6.2. Models with First-Order Similarity	29
3.6.3. Distorted Models	30
3.7. Similitude requirements	33
3.7.1. Reinforced Concrete Models	34
3.7.2. Structures Subjected to Dynamic loadings	40
3.7.2.1. Introduction	40
3.7.2.2. Earthquake Modeling of Structures	41
 Chapter 4 – Experimental Program	
4.1. General	43
4.2. Test Structure	43
4.2.1. Two Story building model	43
4.3. Test procedure	56
4.3.1. Introduction	56
4.3.2. Free vibration test	56
4.3.3. Simulated earthquake tests	60
 Chapter 5 – Experimental Results	
5.1. Introduction	63
5.2. Test Program	63
5.3. Run Aqaba 0.06 g	65
5.4. Run Aqaba 0.12 g	65
5.5. Run Aqaba 0.26 g	70
5.6. Run Aqaba 0.42 g	71
5.7. Run Aqaba 0.52 g-1	76
5.8. Run Aqaba 0.52 g-2	76
5.9. Run Aqaba 0.52 g-3	77
5.10. Summary	77

Chapter 6 – Analytical Results

6.1. Introduction	85
6.2. Program IDARC	85
6.2.1. General	85
6.2.2. Structural modeling	86
6.3. Two story model analysis	86
6.3.1. Input data	86
6.4. Two story model analysis	91
6.4.1. Run Aqaba 0.06g	91
6.4.2. Run Aqaba 0.12g	91
6.4.3. Run Aqaba 0.26g	94
6.5. Run Prototype Using IDARC	
6.5.1. Input Data	
6.5.2. IDARC output results for prototype	

Chapter 7 – Summary and Conclusions

7.1. Summary	97
7.1.1. Experimental Work	97
7.1.2. Analytical results	98
7.2. Conclusion	98

References	101
-------------------	-----

Appendix	109
-----------------	-----