Ain Shams University
Faculty of Engineering
Structural Department

SEISMIC ANALYSIS OF ELEVATED REINFORCED CONCRETE TANKS

By

Mahmoud Mounir Abd El Azim Morsy
B.Sc. Civil Engineering
Ain Shams University, 2005

A Thesis

Submitted in Partial Fulfillment for Requirement of the Degree of the Master of Science in Structural Engineering

Supervisors

Prof. Ezzeldin Yazeed Sayed Ahmed
Professor of Structural Engineering
Faculty of Engineering
Ain Shams University

Dr. Hisham A. El Arabaty
Associate Professor of Structural Engineering
Faculty of Engineering
Ain Shams University

Dr. Sherif Saleh Safar
Associate Professor of Construction and Architectural Engineering Department
American University in Cairo

April 2013

Statement

This thesis is submitted to Ain Shams University, Cairo, Egypt, on April 2013 for the degree of Master of Science in Civil Engineering (Structural).

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

Date	:	29 / 4 / 2013
Name	:	Mahmoud MounirAbd El Azim
Signature	:	

Ain Shams University
Faculty of Engineering
Structural Department

Approval Sheet

Thesis	:	Master of Science in Civil Engineering (Structural)
Student Name	:	Mahmoud Mounir Abd El Azim
Thesis Title	:	Seismic analysis of elevated reinforced concrete tanks

Examiners Committee: **Signature**

Prof. Sherif Ahmed Mourad
Chancellor of Faculty of Engineering,
Cairo University.

Prof. Amr Ali Abd El Rahman
Professor of Structural Engineering,
Faculty of Engineering,
Ain Shams University.

Prof. Ezzeldin Yazeed Sayed Ahmed
Professor of Structural Engineering,
Faculty of Engineering,
Ain Shams University.

Date: 29 / 4 / 2013

Ain Shams University
Faculty of Engineering
Structural Department

Thesis	:	Master of Science in Civil Engineering (Structural)
Student Name	:	Mahmoud Mounir Abd El Azim
Thesis Title	:	Seismic analysis of elevated reinforced concrete tanks

Supervisors Committee: **Signature**

Prof. Ezzeldin Yazeed Sayed Ahmed
Professor of Structural Engineering,
Faculty of Engineering,
Ain Shams University.

Dr. Hisham A. El Arabaty
Associate Professor of Structural Engineering,
Faculty of Engineering,
Ain Shams University.

Dr. Sherif Saleh Safar
Associate Professor of Construction and
Architectural Engineering Department,
American University in Cairo.

Date: 29 / 4 / 2013

Information about the Researcher

Name	:	Mahmoud Mounir Abd El Azim
Date of Birth	:	August 14th, 1983
Place of Birth	:	Cairo, Egypt
Qualifications	:	B.Sc. Degree in Civil Engineering (Structural Eng.) Faculty of Engineering, Ain Shams University (2005)
Present Job	:	Structural Engineer, Dar Al-Handasah Consultant
Signature	:	

Acknowledgement

First of all, I would like to thank Allah for every gift bestowed on me…

Next, I would like to extend my warmest heartfelt gratitude to all my family especially my parents, who stood by me and supported me in every step of my life. I would like to deeply thank them and convey my sincere appreciation for their assistance, encouragement, support, understanding, and patience.

Moreover, I would like to express my sincerest appreciation to my advisors, Prof. Ezzeldin Yazeed Sayed Ahmed, Dr. Hisham A. El Arabaty and Dr. Sherif Saleh Safar, for their continuous valuable guidance, their constant encouragement, support, and friendship which was the motivating force that kept work on my thesis in force until completion, and the investments, giving me the opportunity to be involved in such interesting research. I would like to express my admiration and thanks for their loyalty and trustfulness.

I am greatly indebted to all my friends and colleagues who supported me physically and spiritually especially Dr. Hussien Okail, Mohamed Abdel Aziz, Mohamed El-Sawy and last but not least to Mohamed Fawzy whom his thesis was of great help for me.

I would like to send my thanks to Dar Al Handasah consultants for their support and providing helpful sources of scientific data and time.

Finally, there are no words can express my sincere gratitude to the love of my wife and great support of my dear brothers, to them this thesis is dedicated.

To my parents, whom, I owe too much. To my wife whom encouraged me so much.

Abstract

This study presents a proposed methodology for reliable determination and evaluation of the seismic performance factors of elevated reinforced concrete cylindrical tank with a frame supporting structure. The study focuses on developing an analytical methodology using numerical modeling of representative archetype structural system. The methodology adopted herein was based on the approach developed by the Applied Technical Council, ATC-63 (2008), "Quantification of Building Seismic Performance Factors", subsequently published as Federal Emergency Management Agency, FEMA P695 (2009), "Quantification of Building Seismic Performance Factors". The ATC-63 represents a broad knowledge base of standard building code concepts, structural systems, relevant research and technologies utilizing state-of-the-art nonlinear dynamic analysis and collapse simulation to reliably quantify system performance and response parameters for use in seismic design.

Seismic performance factors including system over strength factor, "Ω_o", deflection amplification factor, "C_d" and the response modification factor, "R" of elevated reinforced concrete tanks were determined and evaluated by performing nonlinear static pushover analysis and nonlinear dynamic time history analysis. The nonlinear dynamic time history analysis adopted using three earthquake records of El Centro (Imperial Valley, 1940), Newhall (Northridge, 1994) and Kobe (Japan, 1995) ground motion. Fluid-structure interaction is simulated using simplified analysis procedures "Housner's model". Damage Index obtained from the nonlinear time history analysis is compared with that obtained by the pushover analysis procedures. The analysis revealed that estimates of structures response from the nonlinear static analysis were