ANALYTICAL EVALUATION STUDY OF THE BEHAVIOUR OF STRUCTURES SUBJECTED TO BLAST LOADS

By

AHMED ABDEL BARI MAHDI EMARAH

A Thesis Submitted to
The Faculty of Engineering, Cairo University
In Partial Fulfillment of the Requirement for the Degree of
DOCTORATE OF PHILOSOPHY
In
STRUCTURAL ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

ANALYTICAL EVALUATION STUDY OF THE BEHAVIOUR OF STRUCTURES SUBJECTED TO BLAST LOADS

By

AHMED ABDEL BARI MAHDI EMARAH

A Thesis Submitted to
The Faculty of Engineering, Cairo University
In Partial Fulfillment of the Requirement for the Degree of
DOCTORATE OF PHILOSOPHY
In
STRUCTURAL ENGINEERING

Under the Supervision of

Prof. Abdelhamid Ibrahim Zaghw
Professor of Concrete Structures
Structural Engineering Department
Faculty of Engineering
Cairo University

Ass. Prof. Kamal Ghamry Metwally
Ass. Professor of Structures
Civil Engineering Department
Faculty of Engineering
Beni-Suef University

ANALYTICAL EVALUATION STUDY OF THE BEHAVIOUR OF STRUCTURES SUBJECTED TO BLAST LOADS

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018
By
AHMED ABDEL BARI MAHDI EMARAH

A Thesis Submitted to
The Faculty of Engineering, Cairo University
In Partial Fulfillment of the Requirement for the Degree of
DOCTORATE OF PHILOSOPHY
In
STRUCTURAL ENGINEERING

Approved by the Examining Committee:

Abdelhamid Ibrahim Zaghw Professor of Concrete Structures, Faculty of Engineering, Cairo University	**Thesis Main Advisor**
Kamal Ghamry Metwally Associate Professor of Civil Engineering, Faculty of Engineering, Beni-Suef University	**Advisor**
Hamed Mohamed Hadhoud Professor of Concrete Structures, Faculty of Engineering, Cairo University	**Member**
Ehab Ahmed Badr-El-din Khalil Professor of Structures, Construction Research Institute, Ministry of Water Resources and Irrigation	**Member**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

Engineer: Ahmed Abdel bari Mahdi Emarah
Date of Birth: 4/7/1984
Nationality: Egyptian
Registration Date: 01/03/2013
Awarding Date: / /
Degree: Doctorate of Philosophy
Department: Structural Engineering

Supervisors: Prof. Dr. Abdelhamid Ibrahim Zaghw
Ass.Prof. Dr. Kamal Ghamry Metwally

Examiners: Prof. Dr. Abdelhamid Ibrahim Zaghw
Ass.Prof. Dr. Kamal Ghamry Metwally
Prof. Dr. Hamed Mohamed Hadhoud
Prof. Dr. Ehab Ahmed Badr-Eldin Khalil

Title of Thesis:

ANALYTICAL EVALUATION STUDY OF THE BEHAVIOUR OF STRUCTURES SUBJECTED TO BLAST LOADS

Key Words: Blast, LSDYNA, control displacement, UFC and Arching Walls.

Summary:

This study used the LSDYNA computer program to investigate the behavior of the structures against blast loads. It analyzed the displacements and the consequent stages of damage or failure under blast loads. Three different structures were studied. The study showed that the use of the arching masonry walls as a structural system is easy and cheap and can be applied to both existing and new structures to reduce the flying debris, which is the main source of property damage, human injuries and loss of lives. Results of this study can be used in the design and evaluation of safety of structures.

ACKNOWLEDGEMENTS

The author would like to express his sincere appreciation and gratitude to ***Abdelhamid I. Zaghw***, Professor of Concrete Structures, Cairo University, Kamal ***G. Metwally,*** Associate Professor of Structures, Civil Engineering Department, Beni-Suef University, ***Hamed M. Hadhoud***, Professor of Concrete Structures, Cairo University, and ***Ehab A. B. Khalil***, Professor of Structures, Constuction Research Institute, Ministry of Water Resources and Irrigation for their supervision, suggestions, valuable advice, continuous encouragement and guidance throughout this thesis.

Most importantly, none of this would have been possible without the love and patience of my family. I feel a deep sincere of gratitude to My Parents, who always show persisting love and support to my ideas and decisions.

ABSTRACT

Structures may experience catastrophic damages due to sudden large dynamic loads such as petro-chemical explosions, aircraft crashes, terrorist attacks by explosives. Since most of structures have not been designed to be subjected to this kind of extreme destructive loads, failure consequences can be expected. Attention brought to develop new methods to improve the structure response capacity against these dynamic loads. Since blast field tests are dangerous, expensive, and always have limitation on scale of explosions, the development of numerical models that could accurately describe the structure response behavior under such loads is of urgent need.

In this study, evaluation on three types of structures against blast load performed using LSDYNA software program. The selected structures previously designed to withstand blast loads using different software program: WAI-MAZ, for hardened aircraft shelter, UFC design manuals, for reinforced concrete wall, and experimental tests, for unreinforced masonry wall. Close agreement observed between the results that validate all the models. A sensitivity study then performed to adapt the out of plane dynamic resistance of the unreinforced masonry walls implementing arching action as a cost-effective technique. Unreinforced masonry walls have low out-of-plane flexural strength. Flying debris considered the most dangerous to building occupants from blast loads and considered the major source of individual injuries and loss of lives. The results of this study can be used for the design and safety evaluation of structures.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES