



LOCAL AND POST LOCAL BUCKLING OF HOLLOW AND CONCRETE FILLED BOX STEEL TUBES

By

Omar Saber Rizq Hassan

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
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Title of Thesis:

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Key Words:

Concrete Filled Steel Tube (CFT); Hollow Steel Section ; Local Buckling; Post Local Buckling; Finite element analysis.

Summary:

This research studies the local and post local buckling behavior of hollow and concrete filled box steel tubes. ANSYS program is used to model the specimens. The critical stresses and buckled shapes of ANSYS are compared to their corresponding results of experiments and mathematical solution. Eighty four models are implemented to conduct the parametric study which determined the effects of section slenderness ratio b/t , yield strength of steel tube, and concrete infill on initial buckling stress σ_L , post local buckling stress σ_{uL} , non dimensional critical stress σ_L/σ_y , and reserve strength σ_r which is gained due to the post local buckling.

Acknowledgements

I would like to express my deepest gratitude and appreciation to my supervisor Professor Dr. Ahmed Foad Sabry for his constant supervision, planning, guidance, valuable suggestions, precise advice and constant encouragement during all stages of this research work.

Also I would like to thank Dr. Kamal Ghamry for his precious contribution in using ANSYS software Package and for helpful suggestions, comments and encouragement throughout this thesis.

to Salwa Alawam

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Table of Contents

TABLE OF CONTENTS	I
LIST OF TABLES	III
LIST OF FIGURES	IIV
ABSTRACT	VII
CHAPTER 1: INTRODUCTION.....	ERROR! BOOKMARK NOT DEFINED.
1.1 GENERAL.....	ERROR! BOOKMARK NOT DEFINED.
1.2 RESEARCH OBJECTIVE.....	2
1.3 THESIS ORGANIZATION AND CONTENTS	ERROR! BOOKMARK NOT DEFINED.
CHAPTER 2: LITERATURE REVIEW AND BASIC VARIABLE.....	ERROR! BOOKMARK NOT D
2.1 GENERAL.....	ERROR! BOOKMARK NOT DEFINED.
2.2 COMPOSITE CONSTRUCTION.....	ERROR! BOOKMARK NOT DEFINED.
2.2.1 General	Error! Bookmark not defined.
2.2.2 Historical Background.....	6
2.3 COMPOSITE COLUMNS TYPES.....	6
2.4 MECHANICAL BEHAVIOR OF COMPOSITE COLUMNS	8
2.4.1 The Confinement in Concrete Filled Tube Columns.....	8
2.4.2 Using High Strength Concrete in Concrete Filled Tube Columns	9
2.4.3 Local Buckling Effects	10
2.4.4 Elastic Flexural Rigidity EI	11
2.4.5 Failure Modes of Composite Columns	13
2.5 PAST RESEARCH	14
2.6 THEORETICAL STUDY ON LOCAL AND POST LOCAL BUCKLING	23
2.6.1 General	23
2.6.2 Plate Buckling Behavior	23
2.6.3 Elastic Local Buckling Stress of Steel Plates	25
2.6.4 Buckling of Plates in the Inelastic Range	29
2.6.5 Von Karman Large Deflection Equations	30
2.6.6 Post buckling and Effective Width Concept.....	31
2.7 COMPOSITE COLUMNS IN CODES	33
2.7.1 Composite Columns Classification	33
2.7.2 AISC-LRFD	25
2.7.3 Euro-Code 4.....	36
2.7.4 Egyptian Code of Practice LRFD.....	39
CHAPTER 3: MODELING AND VERIFICATION	42
3.1 INTRODUCTION	42
3.2 FINITE ELEMENT MODELING	43

3.2.1 Introduction	43
3.2.2 Numerical Methods Technique and Convergence.....	44
3.2.3 Buckling Analysis Methods in ANSYS	46
3.2.4 Modeling.....	49
3.2.5 Thin Plates Elastic Buckling.....	62
3.2.6 Thin Walled Hollow Tube Elastic Buckling	65
3.3 VERIFICATION OF EXPERIMENTAL TESTS	69
3.3.1 Introduction	69
3.3.2 Tests Description	70
3.3.3 Results and Comparison	71
3.4 SUMMARY AND CONCLUSION	86
CHAPTER 4: PARAMETRIC STUDY.....	87
4.1 INTRODUCTION	87
4.2 INDEPENDENT VARIABLES.....	88
4.3 PARAMETRIC ANALYSIS	91
4.3.1 Introduction	91
4.3.2 Models results.....	91
4.3.3 Effects of steel tube slenderness b/t	101
4.3.4 Effect of steel yield strength F_y	116
4.3.5 Effects of concrete infill	122
CHAPTER 5: SUMMARY AND CONCLUSIONS	131
5.1 GENERAL.....	131
5.2 SUMMARY	131
5.3 CONCLUSION	132
5.4 RECOMMENDATIONS FOR FUTURE WORK.....	133
REFERENCES.....	134

List of Tables

Table 2.1 Values of buckling coefficient K

Error! Bookmark not defined.

Table 3.1 Mesh configurations parameters values	60
Table 3.2 Steel plates properties and results	62
Table 3.3 Steel plates and tubes critical stresses	65
Table 3.4 Sources data of verified specimens	69
Table 3.5 Verification specimens geometric and material properties	70
Table 3.6 Results of experiments and models for steel loaded only specimens	71
Table 3.7 Results of experiments and models for steel and concrete loaded specimens	72
Table 4.1 Geometric and material properties of study models	89
Table 4.2 List of Independent Variables	91
Table 4.3 Hollow steel tubes models results	93
Table 4.4 Filled steel tube models results	94

List of Figures

Fig. 2.1: Composite beam system	5
Fig. 2.2: Types of composite columns	Error! Bookmark not defined.
Fig. 2.3: Typical stress strain curve for concrete	Error! Bookmark not defined.
Fig. 2.4: Local buckling effects on concrete filled steel box columns performance	Error! Bookmark not defined.
Fig. 2.5: Slenderness ratio effects on the load-axial strain behavior of concrete filled steel box columns.....	Error! Bookmark not defined.
Fig. 2.6: Steel and concrete constitutive relations	Error! Bookmark not defined.
Fig. 2.7: Elastic determination	Error! Bookmark not defined.
Fig. 2.8: Local buckling modes of stiffened and unstiffened hollow and infilled columns	Error! Bookmark not defined.
Fig. 2.9: Behavior of perfect and imperfect systems during buckling mode interaction	21
Fig. 2.10: Locally buckled thin walled steel tube	24
Fig. 2.11: Post buckling path of steel tube	25
Fig. 2.12: Rectangular plate subjected to compression stress	Error! Bookmark not defined.
Fig. 2.13: Buckling of steel plate in contact with concrete	29
Fig. 2.14: The consecutive stages of stress distribution in stiffened compression elements	31
Fig. 2.15: Typical cross sections of concrete filled tubular sections	Error! Bookmark not defined.
Fig. 3.1: Newton-Raphson Method.....	44
Fig. 3.2: Bifurcation Buckling	Error! Bookmark not defined.
Fig. 3.3: Post Buckling Behavior	Error! Bookmark not defined.
Fig. 3.4: Solid 65 Geometry.....	Error! Bookmark not defined.
Fig. 3.5: Solid 45 Geometry.....	50
Fig. 3.6: Target and Contact Geometry	51
Fig. 3.7: Typical uniaxial compressive and tensile stress-strain curve for concrete.....	52
Fig. 3.8: Simplified stress-strain curve for concrete	54
Fig. 3.9: Concrete stress-strain curve for specimen 10&11	54
Fig. 3.10: Concrete failure surfaces	55
Fig. 3.11: Steel stress strain relationship	Error! Bookmark not defined.
Fig. 3.12: Mesh configurations	58
Fig. 3.13: Structural error energy of mesh 1 configuration	59
Fig. 3.14: Structural error energy of mesh 6 configuration	59
Fig. 3.15: Mesh configurations stress relationship	60
Fig. 3.16: Boundary conditions.....	61
Fig. 3.17: Closed form solution versus ANSYS solution	63
Fig. 3.18: Buckled shape of plate 1.....	63
Fig. 3.19: Buckled shape of plate 3.....	64
Fig. 3.20: Buckled shape of plate 6.....	64
Fig. 3.21: Plate results versus box results results.....	65
Fig. 3.22: Typical hollow box tube buckled shape	66
Fig. 3.23: Buckled shape of hollow box 7	67
Fig. 3.24: Buckled shape of hollow box 8	67
Fig. 3.25: Buckled shape of hollow box 9	68
Fig. 3.26: Buckled shape of hollow box 10	68

Fig. 3.27: Buckled shape and lateral displacement for SP5.....	73
Fig. 3.28: Buckled shape for SP6.....	73
Fig. 3.29: Deformed shape for SP10 (weak axis bending)	74
Fig. 3.30: Deformed shape for SP11 (strong axis bending).....	74
Fig. 3.31: Deformed shape of steel tube for SP9	75
Fig. 3.32: Section in SP12.....	75
Fig. 3.33: Axial shortening for SP12	76
Fig. 3.34: Local buckling stress of ANSYS and experiments	77
Fig. 3.35: Post local buckling stress of ANSYS and experiments.....	77
Fig. 3.36: Failure load of ANSYS and experiments	78
Fig. 3.37: Stress axial shortening curve for SP2	79
Fig. 3.38: Stress lateral displacement curve for SP2	79
Fig. 3.39: Stress axial shortening curve for SP4.....	80
Fig. 3.40: Stress lateral displacement curve for SP4	80
Fig. 3.41: Stress axial shortening curve for SP6.....	81
Fig. 3.42: Stress lateral displacement curve for SP6	81
Fig. 3.43: Stress axial shortening curve for SP8.....	82
Fig. 3.44: Stress lateral displacement curve for SP8	82
Fig. 3.45: Load axial shortening curve for SP9	83
Fig. 3.46: Load lateral displacement curve for SP9.....	83
Fig. 3.47: Load axial shortening curve for SP10	84
Fig. 3.48: Load lateral displacement curve for SP10.....	84
Fig. 3.49: Load axial shortening curve for SP12	85
Fig. 3.50: Load lateral displacement curve for SP12.....	85

Fig. 4.1: Stress lateral deflection curve of model 22 (hollow,b/t=100,Fy=240MPa)	95
Fig. 4.2: Stress axial shortening curve of model 22 (hollow,b/t=100,Fy=240MPa)	95
Fig. 4.3: Stress lateral deflection curve of model 64 (Filled,b/t=100,Fy=240MPa).....	95
Fig. 4.4: Stress axial shortening curve of model 64 (Filled,b/t=100,Fy=240MPa).....	95
Fig. 4.5: Stress lateral deflection curve of model 34 (hollow,b/t=140,Fy=240MPa).....	97
Fig. 4.6: Stress axial shortening curve of model34 (hollow,b/t=140,Fy=240MPa)	97
Fig. 4.7: Stress lateral deflection curve of model 37 (hollow,b/t=150,Fy=240MPa)	98
Fig. 4.8: Stress axial shortening curve of model 37 (hollow,b/t=150,Fy=240MPa)	98
Fig. 4.9: Stress lateral deflection curve of model 76 (Filled,b/t=140,Fy=240MPa).....	99
Fig. 4.10: Stress axial shortening curve of model76 (Filled,b/t=140,Fy=240MPa)	99
Fig. 4.11: Stress lateral deflection curve of model77 (Filled,b/t=150,Fy=240MPa)...	100
Fig. 4.12: Stress axial shortening curve of model77 (Filled,b/t=150,Fy=240MPa)	100
Fig. 4.13: Effect of (b/t) on σ_L for hollow tubes (Fy =240 MPa).....	104
Fig. 4.14: Effect of (b/t) on σ_u for hollow tubes (Fy =240 MPa)	104
Fig. 4.15: Effect of (b/t) on non dimensional critical stress σ_L/σ_y for hollow tubes(Fy =240 MPa)	105
Fig. 4.16: Effect of (b/t) on σ_r/σ_u for hollow tubes (Fy =240 MPa)	105
Fig. 4.17: Effect of (b/t) on σ_L for hollow tubes (Fy =360 MPa).....	106
Fig. 4.18: Effect of (b/t) on σ_u for hollow tubes (Fy =360 MPa)	106
Fig. 4.19: Effect of (b/t) on non dimensional critical stress σ_L/σ_y for hollow tubes(Fy =360 MPa)	107
Fig. 4.20: Effect of (b/t) on σ_r/σ_u for hollow tubes (Fy =360 MPa)	107
Fig. 4.21: Effect of (b/t) on σ_L for hollow tubes (Fy =420 MPa).....	108

Fig. 4.22: Effect of (b/t) on σ_u for hollow tubes ($F_y = 420$ MPa)	108
Fig. 4.23: Effect of (b/t) on non dimensional critical stress σ_L/σ_y for hollow tubes($F_y = 420$ MPa)	109
Fig. 4.24: Effect of (b/t) on σ_r/σ_u for hollow tubes ($F_y = 420$ MPa)	109
Fig. 4.25: Effect of (b/t) on σ_L for filled tubes ($F_y = 240$ MPa)	110
Fig. 4.26: Effect of (b/t) on σ_u for filled tubes ($F_y = 240$ MPa).....	110
Fig. 4.27: Effect of (b/t) on non dimensional critical stress σ_L/σ_y for filled tubes($F_y = 240$ MPa)	111
Fig. 4.28: Effect of (b/t) on σ_r/σ_u for filled tubes ($F_y = 240$ MPa)	111
Fig. 4.29: Effect of (b/t) on σ_L for filled tubes ($F_y = 360$ MPa)	112
Fig. 4.30: Effect of (b/t) on σ_u for filled tubes ($F_y = 360$ MPa).....	112
Fig. 4.31: Effect of (b/t) on non dimensional critical stress σ_L/σ_y for filled tubes($F_y = 360$ MPa)	113
Fig. 4.32: Effect of (b/t) on σ_r/σ_u for filled tubes ($F_y = 360$ MPa).	113
Fig. 4.33: Effect of (b/t) on σ_L for filled tubes ($F_y = 420$ MPa)	114
Fig. 4.34: Effect of (b/t) on σ_u for filled tubes ($F_y = 420$ MPa).....	114
Fig. 4.35: Effect of (b/t) on non dimensional critical stress σ_L/σ_y for filled tubes($F_y = 420$ MPa)	115
Fig. 4.36: Effect of (b/t) on σ_r/σ_u for filled tubes ($F_y = 420$ MPa)	115
Fig. 4.37: Effect of steel yield strength on σ_L for hollow tubes	118
Fig. 4.38: Effect of steel yield strength on σ_u for hollow tubes	118
Fig. 4.39: Effect of steel yield strength on non dimensional critical stress σ_L/σ_y for hollow tubes	119
Fig. 4.40: Effect of steel yield strength on σ_r/σ_u for hollow tubes	119
Fig. 4.41: Effect of steel yield strength on σ_L for filled tubes.....	120
Fig. 4.42: Effect of steel yield strength on σ_u for filled tubes	120
Fig. 4.43: Effect of steel yield strength on non dimensional critical stress σ_L/σ_y for filled tubes.....	121
Fig. 4.44: Effect of steel yield strength on σ_r/σ_u for filled tubes.....	121
Fig. 4.45: Effect of concrete infill on σ_L ($F_y = 240$ MPa)	125
Fig. 4.46: Effect of concrete infill on σ_u ($F_y = 240$ MPa).....	125
Fig. 4.47: Effect of concrete infill on non dimensional critical stress σ_L/σ_y ($F_y = 240$ MPa).....	126
Fig. 4.48: Effect of concrete infill on σ_r/σ_u ($F_y = 240$ MPa)	126
Fig. 4.49: Effect of concrete infill on σ_L ($F_y = 360$ MPa)	127
Fig. 4.50: Effect of concrete infill on σ_u ($F_y = 360$ MPa).....	127
Fig. 4.51: Effect of concrete infill on non dimensional critical stress σ_L/σ_y ($F_y = 360$ MPa).....	128
Fig. 4.52: Effect of concrete infill on σ_r/σ_u ($F_y = 360$ MPa)	128
Fig. 4.53: Effect of concrete infill on σ_L ($F_y = 420$ MPa)	129
Fig. 4.54: Effect of concrete infill on σ_u ($F_y = 420$ MPa).....	129
Fig. 4.55: Effect of concrete infill on non dimensional critical stress σ_L/σ_y ($F_y = 420$ MPa).....	130
Fig. 4.56: Effect of concrete infill on σ_r/σ_u ($F_y = 420$ MPa)	130

Abstract

In this thesis, the local and post local buckling of hollow and concrete filled square steel tubes was investigated. An outline of composite columns behavior, past experimental work, and theoretical study on local and post local buckling were presented. The adopted design equations of concrete filled steel tube columns in AISC-LRFD specifications, Eurocode4, and Egyptian code of practice LRFD were also presented.

A finite element model used in the analysis of hollow and concrete filled steel tube columns was conducted using the general purpose finite element program ANSYS. The concrete infill is modeled using three dimensional structural solid elements (solid 65) which capable of cracking and crushing whereas the steel tube is modeled using solid 45. One of the difficulties of modeling the concrete filled steel tube columns in ANSYS is modeling the interface element between concrete and steel surfaces, the element type used and the input coefficient values are discussed. Local buckling takes place when the ability of steel tube to separate from concrete core is achieved. The material model used for concrete accounts for cracking, crushing, and nonlinear behavior. The material model used for steel accounts for yielding. The parameters values used to define concrete and steel material in ANSYS are explained. Solution accuracy and convergence are affected significantly by mesh density so mesh sensitivity analysis using the structural error energy method is performed. The boundary conditions of all models are applied according to the experimental specimens conditions to obtain accurate results. The results obtained from the finite element models are compared with that of experimental tests for verification.

A parametric study conducted to determine the effects of section slenderness ratio b/t , yield strength of steel tubes, and concrete infill on initial buckling stress σ_L , post local buckling stress σ_u , non dimensional critical stress σ_L/σ_y , and reserve strength σ_r gained due to the post local buckling occurrence in hollow and filled sections. Eighty four models were implemented to study the effects of each independent variable.

The influence of each parameter was studied by varying its value independently within practical limits whereas the other parameters were unchanged. The values of initial buckling stress σ_L , post local buckling stress σ_u , non dimensional critical stress σ_L/σ_y , and reserve strength σ_r are monitored while varying the independent variables. Stress-lateral deflection and Stress-axial shortening curves are plotted.

Chapter (1)

Introduction

1.1 General

The most popular materials in construction industry are steel and concrete due to their advantageous mechanical properties and behavior. Composite columns utilize the advantages of each material characteristic. A combination of steel and concrete in structural members and components of load bearing structures appears very efficient due to the advantageous properties of both materials that complement each other. It results in the design of highly reliable and cost saving structures. The important characteristics of steel are: high modulus of elasticity, high tensile strength, high ductility, ease in fabrication, high speed of erection, and low weight per square area which result in small size members and long clear spans. Concrete has many advantages such as: high compressive strength, massive stiffness, low cost, and high inherent mass. The main disadvantage of concrete is the low tensile strength.

The composite column is a compression member which commonly used in building construction due to their efficiency in resisting different straining actions with relatively small size and less cost. Composite columns are either composed of concrete encased steel section or concrete filled steel tube section. Composite columns must be designed to resist the most unfavorable load conditions. When the concrete core effect in restraining the local buckling of steel tube is incorporated in the design, steel cost can be minimized. Thin walled composite columns use the concrete restraint effect in delaying the steel tube initial local buckling. Local buckling reduces the strength and stiffness of the concrete filled steel tube columns.

Failure modes of composite columns are divided into two types: 1) material failure, 2) stability failure. Material failure includes concrete crushing and cracking and steel yielding. This mode of failure occurs in short concrete filled steel tube columns composed of compact steel section. Stability failure includes global buckling and local buckling. This mode of failure occurs in long columns and the concrete filled steel tube columns composed of slender steel sections.

1.2 Research Objective

The purpose of this study is to investigate the effect of many parameters on initial buckling stress σ_L , post local buckling stress σ_u , non dimensional critical stress σ_L/σ_y , and reserve strength σ_r gained due to the post local buckling occurrence in hollow and filled sections.

The independent variables considered in the parametric analysis are listed as follows:

- Section type: hollow or filled.
- Steel tube slenderness ratio, b/t ranges from 30 to 160.
- Yield stress of steel tube, F_y (MPa) which has values of 240,360, and 420 MPa.

The analysis procedure adopted in this work may be summarized as follows:

1. The coverage of composite columns behavior, past experimental work, and theoretical study on local and post local buckling. The adopted design equations of concrete filled steel tube columns in international codes and specifications were also presented.
2. Finite element models building, which can adequately represent the hollow and concrete filled steel tubes different modes of local instability failure.
3. Finite element model verification, by comparing its results to mathematical closed form solution and experimental test results.
4. Conducting a comprehensive parametric study using the verified finite element model technique used in chapter 3 to illustrate the effects of section slenderness ratio b/t , yield strength of steel tubes, and concrete infill on local and post local buckling of square hollow and filled steel tubes.

1.3 Thesis Organization and Contents

The thesis includes five chapters, detailed as follows:

- In Chapter one, a brief introduction with the main objectives of the research work and thesis contents are presented.
- In Chapter two, an outline of composite columns behavior, past experimental work, and theoretical study on local and post local buckling are presented. The adopted design equations of concrete filled steel tube columns in AISC-LRFD specifications, Eurocode4, and Egyptian code of practice LRFD are also presented.