

ABSTRACT

In this study, it was applied the American Specifications for Structural Steel Buildings standard by taking the effect of the wind loads on designing of steel tall building frames depending on the location and topography of construction place. In order to study the structural behavior of the frames, different types of tall building forms were selected with typical plans and heights. These systems were rigid, shear-wall and tube frames. Each selected type of tall building frame was studied using three different types of bracing system, as well as, unbracing frame system. The bracing types were cross, diagonal and V-shape. The unbraced frames were assumed to be the basic reference for comparative purposes. The frames were defined, simulated, analyzed, and designed by analytical computer software (ETABS 2013). The analysis results were tabulated and presented according to maximum values of beam and column stresses and lateral story displacements. These analysis results were compared using graphical presentation. In order to get the frame with the minimum weight, the self-weight of braced frames were taken as percentage of unbraced frame weight. Then, the maximum story displacement of unbrace frames were obtained and compared by the same way. It was concluded that the weights of tube frame with diagonal bracing and V-shape bracing were reduced by 12.6% comparing with the unbraced tube frame. Also, the story displacement of rigid frame with cross bracing was reduced by 61% comparing with unbraced rigid frame.

المستخلص

في هذه الدراسة تم تطبيق ما تنص عليه الموصفات القياسية الأمريكية لمباني الحديد الإنشائية وذلك بأخذ تأثير أحمال الرياح على المبني الفولاذية العالية بناء على موقع وطبوغرافية ومكان الإنشاء للمبني، ولأجل دراسة السلوك الإنسائي لهيماكل مبني عالي تم اختيار ثلاثة أنواع مختلفة من هيماكل المبني العالية بحيث تكون متساوية في الأبعاد والإرتفاع ، والهيماكل التي تم اختيارها بغرض الدراسة هي: هيماكل مثبتة، وهيماكل حوائط القص، وهيماكل الأنبوية وكل نوع من أنواع هيماكل المختارة تمت دراسته باستخدام ثلاثة أنظمة تقييد مختلفة وهي نظام التقييد المتقاطع، ونظام التقييد المائل ونظام التقييد على شكل حرف V أضف لذلك هيكل آخر من كل نوع لا يحتوي على نظام تقييد ويعتبر بمثابة المرجع للمقارنة في هذه الدراسة، بعد ذلك تم تعريف وادخال ومحاكاة وتحليل وتصميم النماذج جميعها وذلك باستخدام برنامج تحليل إنشائي في الحاسوب ETABS وتمت جدولة ورسم البيانات المخرجة من البرنامج لكل من القوى على 2013 عدد من الأيام والأعمدة وأيضا تم حساب الإزاحة الجانبية لكل طابق، إن جميع المخرجات تمت المقارنة بينها ودراستها في شكل رسوم بيانية، ومن أجل الحصول على أخف النماذج المدروسة وزناً تم قياس الوزن الذاتي لجميع هيماكل والمقارنة بينها ، ومن ثم وجد أن وزن المبنيان الأنبوبيان ذوي التقييد مائل ووالتقييد على شكل حرف V ينقصان بمقدار 12.6% مقارنة بالمبني الأنبوبي الغير مقيد، أيضا المبني المثبت ذو التقييد المتقاطع يقل بمقدار 61% في إزاحة الطوابق مقارنة بالمبني المثبت الغير مقيد.

DEDICATION

To the one who always supports me

(My Father)....

To the one who raises me since I born

(My mother)....

To the one who never stops advising me

(My Supervisor)....

ACKNOWLEDGMENT

My deep thankful and grateful to mighty god Allah to give me the patience and success to complete this work, and inspiring me with thoughts that I would never think of it without him. I attribute the level of my Master's degree to his encouragement and effort and without him this thesis, too, would not have been completed or written.

I would like to express my deep gratitude to my master thesis advisor Dr. Abusamra Awad. One simply could not wish for a better or friendlier supervisor. He spent very much time instructing me how to write a paper, how to search literature, how to collect data and how to analyze the data. Foremost, I would like to express my sincerely thankful to my parents for the continuous support of my study and research, for their patience, motivation, enthusiasm, and immense knowledge. Their guidance helped me in all the time of research and writing of this thesis.

I am also grateful to the following former or current staff at Sudan University of Science and Technology, for their various forms of support during my graduate study.

Most importantly, none of this would have been possible without the love and patience of my family. My immediate family to whom this dissertation is dedicated to, has been a constant source of love, concern, support and strength all these years. I would like to express my heart-felt gratitude to my family.

Special thank goes to my grandfather Eng. Qurashi Ismael to giving me the first spark of this research, nevertheless, gave unconditional support with his precious advices.

Finally, I would like to thank all those who contributed to this work with a paper, poster or even piece of advice or information. Thanks are also due to all my friends, without their support it would not have been possible to complete this research.

Table of Contents

Abstract	I
المستخلص	II
Dedication	III
Acknowledgement.....	IV
Table of Contents	V
List of Tables.....	VII
List of Figures	IX

Chapter 1

INTRODUCTION

1.1 Introduction	1
1.2 Objectives.....	3
1.3 Methodology	3
1.4 Thesis Outline	3

Chapter 2

LITERATURE REVIEW OF STEEL TALL BUILDINGS

2.1 Introduction	5
2.2 Structural Forms of Tall Buildings	5
2.3 Braced Frames.....	19
2.4 Types of Loading on Tall Buildings	20
2.5 Loads Combinations.....	29
2.6 Storey Drift.....	29
2.7 Structural Steel Specifications	31
2.8 The Structural Analysis Computer Software (ETABS).....	32

Chapter 3

METHODOLOGY AND MODELLING AND ANALYSIS

3.1 Introduction	35
3.2 Modelling Steps.....	37
3.3 Building's Assigned Properties.....	37
3.4 Structural Analysis of Rigid Frames of Tall Building	40
3.5 Structural Analysis of Shear-wall and Tube Frames of Tall Building	61
3.6 Graphical Presentation for Analysis Results of Tall Building Frames.....	61

Chapter 4

DISCUSSION OF ANALYSIS AND DESIGN RESULTS OF TALL BUILDINGS

4.1 Introduction	72
4.2 Design Results of Steel Tall Building Models.....	72
4.3 Discussion of The Weight of The Tall Building Frames	89
4.4 Discussion of The Story displacement of The Tall Building Frames.....	92

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions	95
5.2 Recommendations	96

REFERENCES	97
------------------	----

APPENDIX A	98
------------------	----

APPENDIX B	123
------------------	-----

APPENDIX C	157
------------------	-----

List of Tables

Table (2.1): Minimum uniformly distributed live loads L_0 and concentrated load	25
Table (2.2): Live load element factor K_{LL}	26
Table (2.3): Steel grades according to American standards	34
Table (3.1): Material properties	38
Table (3.2): Load patterns used for frames of tall building analysis	38
Table (3.3): The distribution of axial forces and bending moments on columns C1 and C24 for load combination 3 of unbraced rigid frame system.....	42
Table (3.4): Beams' maximum bending moments of unbraced rigid frame system.....	43
Table (3.5): Beams' maximum shear forces of unbraced rigid frame system	44
Table (3.6): The distribution of axial forces and bending moments on columns C1 and C24 for load combination 3 of cross bracing rigid frame system	47
Table (3.7): Beams' maximum bending moments of cross bracing rigid frame system	48
Table (3.8): Beams' maximum shear forces of cross bracing rigid frame system.....	49
Table (3.9): The distribution of axial forces and bending moments on columns C1 and C24 for load combination 3 of diagonal bracing rigid frame system.	52
Table (3.10): Beams' maximum bending moments of diagonal bracing rigid frame system.....	53
Table (3.11): Beams' maximum shear forces of diagonal bracing rigid frame system.....	54
Table (3.12): The distribution of axial forces and bending moments on columns C1 and C24 for load combination 3 of V-shape bracing rigid frame system.....	57
Table (3.13): Beams' maximum bending moments of V-shape bracing rigid frame system.....	58
Table (3.14): Beams' maximum shear forces of V-shape bracing rigid frame system.....	59

Table (4.1): Sections of B1 for rigid frames	73
Table (4.2): Sections of B348 for rigid frames	74
Table (4.3): Sections of B350 for rigid frames	75
Table (4.4): Sections of B190 for rigid frames	76
Table (4.5): Sections of C1 for rigid frames	77
Table (4.6): Sections of C24 for rigid frames	78
Table (4.7): Sections of B5 for shear-wall frames	79
Table (4.8): Sections of C1 for shear-wall frames	80
Table (4.9): Sections of C24 for shear-wall frames	81
Table (4.10): Sections of B50 for tube frames	82
Table (4.11): Sections of B53 for tube frames	83
Table (4.12): Sections of B206 for tube frames	84
Table (4.13): Sections of C11 for tube frames	85
Table (4.14): Sections of C16 for tube frames	86
Table (4.15): Sections of C20 for tube frames	87
Table (4.16): Sections of C27 for tube frames	88
Table (4.17): The weights of all structural tall building frames	90

List of Figures

Figure (2.1): Typical example of different types of bracing in braced building	7
Figure (2.2): Typical example of rigid frame building	8
Figure (2.3): Typical example of infilled-frame structure	8
Figure (2.4): Typical example of flat slab with drop panel	9
Figure (2.5): Typical example of shear-wall frame structure	10
Figure (2.6): Typical example of coupled shear-wall frame structure	11
Figure (2.7): Typical example of wall-frame structure.....	11
Figure (2.8): Typical example of tube-frame structure.....	12
Figure (2.9): Typical example of tube-in-tube frame structure	14
Figure (2.10): Typical example of bundled-tube frame structure.....	14
Figure (2.11): Typical example of steel braced tube frame structure	15
Figure (2.12): Typical example of outrigger frame structure	16
Figure (2.13): Typical example of core frame structure	17
Figure (2.14): Typical example of suspended frame structure	18
Figure (2.15): Typical example of spaced frame structure	19
Figure (2.16): Typical examples of bracing systems	22
Figure (3.1): The plan of tall building models	35
Figure (3.2): Plan of rigid frame system	36
Figure (3.3): Plan of shear-wall frame system.....	36
Figure (3.4): Plan of tube frame system.....	36
Figure (3.5): The distribution of maximum storey displacement in x-direction for all load combinations of unbraced rigid frame system	45
Figure (3.6): The distribution of maximum storey displacement in y-direction for all load combinations of unbraced rigid frame system	45
Figure (3.7): The distribution of maximum storey displacement in x-direction for all load combinations of cross bracing rigid frame system.....	50

Figure (3.8): The distribution of maximum storey displacement in y-direction for all load combinations of cross bracing rigid frame system.....	50
Figure (3.9): The distribution of maximum storey displacement in x-direction for all load combinations of diagonal bracing rigid frame system	55
Figure (3.10): The distribution of maximum storey displacement in y-direction for all load combinations of diagonal bracing rigid frame system..	55
Figure (3.11): The distribution of maximum storey displacement in x-direction for all load combinations of V-shape bracing rigid frame system ..	60
Figure (3.12): The distribution of maximum storey displacement in y-direction for all load combinations of V-shape bracing rigid frame system ..	60
Figure (3.13): Distribution of bending moments of B190 of rigid frames	63
Figure (3.14): Distribution of shear forces of B190 of rigid frames	63
Figure (3.15): Distribution of bending moment of B1 of rigid frames	64
Figure (3.16): Distribution of shear forces of B1 of rigid frames.....	64
Figure (3.17): Distribution of bending moment of B348 of rigid frames	65
Figure (3.18): Distribution of shear forces of B348 of rigid frames.....	65
Figure (3.19): Distribution of bending moment of B350 of rigid frames	66
Figure (3.20): Distribution of shear forces of B350 of rigid frames	66
Figure (3.21): Distribution of bending moments of C1 of rigid frames	67
Figure (3.22): Distribution of axial forces of C1 of rigid frames	67
Figure (3.23): Distribution of bending moments of C24 of rigid frames	68
Figure (3.24): Distribution of axial forces of column 24 of rigid frames	68
Figure (3.25): The distribution of maximum storey displacements in x-direction for all rigid frames models.....	69
Figure (3.26): The distribution of maximum storey displacements in y-direction for all rigid frames models.....	70
Figure (4.1): Percentage of rigid frames base reactions	91
Figure (4.2): Percentage of shear-wall frames base reactions	91
Figure (4.3): Percentage of tube frames base reactions	92
Figure (4.4): Percentage of maximum story displacement of rigid frames about y- direction	93

Figure (4.5): Percentage of maximum story displacement of shear-wall frames about y- direction 93

Figure (4.6): Percentage of maximum story displacement of tube frames about y- direction 94