



DESIGN REQUIREMENTS OF LATERAL BRACING OF I BEAMS

By

MOHAMED HUSSEIN ABD EL-GHANY ABD EL-AZIZ

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
2015

DESIGN REQUIREMENTS OF LATERAL BRACING OF I BEAMS

By

MOHAMED HUSSEIN ABD EL-GHANY ABD EL-AZIZ

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. Sherif Ahmed Mourad

Prof. Dr. Sherif Saleh Safar

.....
Dean of Faculty of Engineering

.....
Professor of Steel Structures

Professor of Steel Structures

and Bridges

and Bridges

(Cairo University)

(Cairo University)

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

2015

DESIGN REQUIREMENTS OF LATERAL BRACING OF I BEAMS

By

MOHAMED HUSSEIN ABD EL-GHANY ABD EL-AZIZ

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
Examining Committee

Prof. Dr. Sherif Ahmed Mourad, Thesis Main Advisor
Dean of Faculty, Professor of Steel Structures and Bridges
Faculty of Engineering, Cairo University

Prof. Dr. Sherif Saleh Safar, Member
Professor of Steel Structures and Bridges
Faculty of Engineering, Cairo University

Prof. Dr. Hisham Sobhy Sayed Khedr, Internal Examiner
Professor of Steel Structures and Bridges
Faculty of Engineering, Cairo University

Prof. Dr. Ahmed Abdelsalam El-Serwi, External Examiner
Professor of Steel Structures and Bridges
Faculty of Engineering, Ain Shams University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

2015

Engineer's Name: Mohamed Hussein Abd El-Ghany Abd El-Aziz

Date of Birth: 24/08/1981

Nationality: Egyptian

E-mail: Mohamed.Abdelghani@dargroup.com

Phone: 002 01002337510

Address: 252 Saad Ibn Obadah St. 7th district. 6 Oct. City, Egypt

Registration Date: 01/10/2011

Awarding Date: 2015

Degree: Master of Science

Department: Structural Engineering



Supervisors: Prof. Dr. Sherif Ahmed Mourad

Prof. Dr. Sherif Saleh Safar

Examiners: Prof. Dr. Sherif Ahmed Mourad (Thesis main advisor)

Prof. Dr. Sherif Saleh Safar (Member)

Prof. Dr. Hisham Sobhy Sayed Khedr (Internal examiner)

Prof. Dr. Ahmed Abdelsalam El-Serwi (External examiner)

(Faculty of Engineering, Ain Shams University)

Title of Thesis:

Design Requirements of Lateral Bracing of I Beams

Key Words:

Nodal Lateral Bracing, Ideal Stiffness, Inelastic Lateral Torsional Buckling, Local Buckling, AISC 2010 (Appendix 6).

Summary:

A bracing system that causes straight beams to buckle between brace points and to achieve full critical moment capacity is often designated as ideal bracing system. However, the design requirements of beam bracing system stipulated by current codes do not account for the effect of local buckling, yielding, and the ratio of warping to torsion moment resistance of beams. In this work, the effect of the geometric parameters of the beam was investigated by the finite element method using ANSYS. Parametric analysis was conducted on a set of simple beams. It was concluded that: Ideal stiffness of lateral braces decreased when thin flanges were used and/or material yielding was incorporated. Current AISC specifications provided a conservative estimate of lateral braces stiffness. A mathematical model was proposed for ideal stiffness of nodal lateral bracing of beams.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor, Dr. Sherif Safar, whose expertise, understanding, and tolerance, added a lot to my graduate experience. I appreciate his large knowledge and his assistance in writing the thesis as he provided me with continuous support during this study.

Very special thanks for my supervisor Dr. Sherif Mourad whom I learned from him so much since my undergraduate degree study, graduate study, and all through the way of our academic and professional career, but all over my life.

I would like to thank Dr. Hesham Sobhy -who learned my a lot during my undergraduate studies- he was my first professor in studying steel construction, and Dr. Ahmed Abdelsalam for taking time out from their busy schedule to serve as my external readers and examiners.

Finally, many thanks and appreciation goes to all my colleagues in Steel Department in Dar Al-Handasah for all the instances in which their assistance helped me along the way.

Dedication

I dedicate this work to

My Parents

who gave me each and every valuable thing in my life. They had the tolerance, wisdom, kindness, decency and enough guidance to put me on the right path all over my life.

I dedicated this work also to

My Lovely Wife Hagar

who supported me to stand up against obstacles with confidence and never despair. She was my inspiration along the way.

May God bless all of them.

Table of Contents

ACKNOWLEDGEMENTS.....	i
DEDICATION.....	ii
TABLE OF CONTENT.....	iii
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
ABSTRACT.....	xiii
CHAPTER ONE: INTRODUCTION.....	1
1.1 OBJECTIVE.....	1
1.2 METHODOLOGY.....	1
CHAPTER TWO: LITERATURE REVIEW.....	3
2.1 BRACING REQUIREMENTS FOR COLUMNS.....	3
2.1.1 Stiffness Requirements for Bracing of Columns.....	3
2.1.2 Strength Requirements for Bracing of Columns.....	8
2.1.3 AISC (2010) Requirements for Bracing of Clumns (AISC, 2010).....	9
2.2 BRACING REQUIREMENTS FOR BEAMS.....	12
2.2.1 Elastic Lateral Torsional Buckling of Beams.....	12
2.2.2 Different Types of Bracing of Beams.....	13
2.2.3 Lateral Bracing Requirements.....	15
2.2.3.1 Effect of vertical position of bracing on lateral brace requirements	17
2.2.3.2 Effect of vertical position of load on lateral brace requirements.....	19
2.2.3.3 Effect of double curvature on lateral brace requirements.....	21
2.2.3.4 Effect of multiple lateral supports on lateral brace requirements.....	22
2.2.4 Lateral Bracing Design.....	23
2.2.5 AISC (2010) Requirements for Bracing of Beams (AISC, 2010).....	25

CHAPTER THREE: MODELING AND VERIFICATION.....	27
3.1 GENERAL.....	27
3.2 FINITE ELEMENT MODELING.....	27
3.2.1. Description of Elements.....	27
3.2.2. Material Model.....	29
3.2.3. Loading Configuration.....	29
3.2.4. Analysis Procedures.....	31
3.3 VERIFICATION MODELS.....	31
3.4 SUMMARY AND CONCLUSION.....	40
 CHAPTER FOUR: PARAMETRIC STUDY.....	 41
4.1 GENERAL.....	41
4.2 SELECTION OF INDEPENDENT VARIABLE.....	41
4.3 METHODOLOGY.....	43
4.4 PARAMETRIC ANALYSIS OF GROUP (1).....	44
4.4.1 Results of Profile (1).....	45
4.4.2 Results of Profile (2).....	47
4.4.3 Results of Profile (3).....	49
4.4.4 Results of Profile (4).....	51
4.4.5 Results of Profile (5).....	53
4.4.6 Results of Profile (6).....	55
4.4.7 Results of Profile (7).....	57
4.4.8 Results of Profile (8).....	65
4.4.9 Results of Profile (9).....	61
4.4.10 Conclusion from Results of Group (1).....	63
4.5 BUCKLING SHAPE FOR CROSS SECTIONS OF GROUP (1).....	64
4.6 ASSESSMENT OF NUMERICAL RESULTS OF GROUP (1).....	66
4.6.1 Effect of (M_w/M_T).....	66
4.6.2 Effect of (Lb/r_t).....	70
4.7 PARAMETRIC ANALYSIS OF GROUP (2).....	72

4.7.1 Assessment of Numerical Results.....	73
CHAPTER FIVE: MATHEMATICAL FORMULATION.....	75
5.1 GENERAL.....	75
5.2 PROPOSED EQUATION TO DETERMINE IDEAL BRACE STIFFNESS..	75
5.3 VERIFICATION OF THE PROPOSED EQUATION.....	85
CHAPTER SIX: SUMMARY AND CONCLUSIONS.....	85
6.1. GENERAL SUMMARY OF RESEARCH WORK.....	85
6.2. CONCLUSIONS.....	86
6.3. RECOMMENDATIONS FOR FUTURE STUDIES.....	87
REFERENCES.....	88