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UNIVERSITI TEKNOLOGI MALAYSIA

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JUDUL: **SECONDARY BENDING MOMENT OF TRAPEZOID WEB BEAM UNDER SHEAR LOADING**

SESI PENGAJIAN : 2006/2007

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SECONDARY BENDING MOMENT OF TRAPEZOID WEB BEAM UNDER SHEAR LOADING

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A project report submitted in partial fulfillment of the requirements for the award of the degree of Master of Engineering (Civil - Structure)

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NOVEMBER 2006

I declare that this project report entitled "Secondary Bending Moment of Trapezoid Web Beam Under Shear Loading" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved family

ACKNOWLEDGEMENTS

I wish to take this opportunity to extend my sincere gratitude and heartfelt appreciation to my supervisor, Associate Professor Ir. Dr. Mohd. Hanim Osman, for his invaluable guidance, encouragement, support, concern and advice throughout the preparation of this study.

I am indeed deeply indebted to Dr. Robiah Aznan, Faculty of Mathematical Sciences, University of Technology Malaysia, Skudai for her help in clearing my confusions and doubts in the process of doing this study.

To my loving parents and siblings, thank you for your patience and encouragement in times of difficulty. Special thanks to my friends who had encouraged and assisted me during this study; especially to Mr. Gan Chun Hou.

Thank you.

ABSTRACT

In structural and fabrication technology, new techniques of optimized steel structures design have been developed. One of the developments in steel structure design is the introduction of trapezoidal web beam. One of the phenomena being studied for the trapezoid web beam is the secondary bending moment which is induced in the flanges of section subjected to shear loading in the web, due to the corrugation of the web. A parametric study was carried out to develop a formula for the secondary bending moment. The parametric study involved in this study are depth of web, D, width of flange, B, thickness of flange, T and thickness of web, t. This study was carried out by using finite element method. The formula of secondary bending moment has been successfully derived and can be used for any other sections of trapezoid web beam with same corrugation thickness and corrugation angle.

Keywords: trapezoid web beam, secondary bending moment, finite element

ABSTRAK

Dalam stuktur dan teknologi pembuatan, teknik baru rekabentuk optimum struktur keluli telah dimajukan. Salah satu perkembangan dalam struktur keluli ialah pengenalan rasuk dengan *web* trapezoid. Salah satu fenomena yang telah dikaji dalam rasuk *web* trapezoid adalah momen lengkukan kedua yang terhasil dalam bebibir apabila beban rich dikenakan dalam *web*, disebabkan kerutan *web* tersebut. Satu kajian parametrik telah dijalankan untuk menghasilkan satu formula bagi momen lengkukan kedua dalam rasuk *web* trapezoid apabila dikenakan beban ricih. Kajian parametrik ini termasuklah ketigggian *web*, D, kelebaran *web*, B, ketebalan bebibir, T dan ketebalan *web*, t. Kajian ini dijalankan dengan menggunakan kaedah usur terhingga. Formula bagi momen lengkukan kedua telah berjaya dihasilkan dan boleh digunakan untuk apa-apa saja saiz bagi rasuk *web* trapezoid dengan tebal kerutan dan sudut kerutan yang tetap.

Kata kekunci: rasuk *web* trapezoid, momen lengkukan kedua, usur terhingga

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	ix
	LIST OF FIGURES	xi
	LIST OF SYMBOLS	xiv
1	**INTRODUCTION**	1
	1.1 General	1
	1.2 Problem Statement	3
	1.3 Objective of Study	3
	1.4 Scope of Study	4
2	**LITERATURE REVIEWS**	5
	2.1 Introduction of Trapezoid Web Section	5
	2.2 Secondary Bending Moment of Trapezoid Web Beam	6
	2.2.1 The Bending Capacity of TWP Section	8
	2.3 Finite Element Analysis (FEA)	21
	2.4 LUSAS Finite Element Software	22

		2.4.1 Introduction	22
		2.4.2 LUSAS Finite Element System	23
	2.5	Shear Stress Flow	24
	2.6	Secondary Bending Moment Capacity of Flange, M_{cyf}	29
	2.7	Research Programme	30
3	**ANALYSIS OF SECONDARY BENDING MOMENT USING FEM**		31
	3.1	LUSAS Finite Element Analysis	31
	3.2	Preliminary Data Analysis	46
	3.3	Comparison Data of FEA and German Table Properties	57
	3.4	Parametric Study Analysis	57
	3.5	Graph Simulation	66
4	**DERIVATION OF FORMULA C_o**		76
	4.1	Manually	76
		4.1.1 $C_o/M_{sec,o}$ Comparison	88
5	**CONCLUSIONS AND SUGGESTIONS**		98
	5.1	Conclusions	98
	5.2	Suggestions	99
REFERENCES			100

LIST OF TABLES

TABLE NO.	TITILE	PAGE
2.1	German Table Properties reffered to [1].	9
2.2	Result of C_o from FEA and comparison to C_o from existing table of capacities and ratio of $C_o/M_{sec,o}$ obtained reffered to [2].	15
2.3	$C_o/M_{sec,o}$ calculated from German table properties with various web depth, fixed flange width and flange thickness.	17
2.4	$C_o/M_{sec,o}$ calculated from German table properties with fixed web depth, various flange width and flange thickness.	19
2.5	The reactions in X and Y direction.	25
2.6	Surface stress of the node and element.	25
3.1	Lateral reactions, Fz of each node at top and bottom flange for model with web depth 300mm.	49
3.2	Summary of lateral reaction in each oblique part at top and bottom flange.	50
3.3	Summary of lateral reaction, Q in z direction in each oblique part for each section size	51
3.4	Values of C_o from finite element analysis and comparison to existing table capacities.	54
3.5	Values of C_o/ M_{cyf} and $C_o/ M_{sec,o}$ from finite element analysis and comparison to existing table.	55
3.6	Summary of lateral reaction, Q in z direction in each oblique part for each section size.	59
3.7	Values of C_o and C_o/M_{cyf} for various web depth, flange width and flange thickness.	62
3.8	Values of C_o and C_o/M_{cyf} for various flange width.	65

3.9	Values of C_o and C_o/M_{cyf} for various flange thickness.	65
3.10	Values of C_o and C_o/M_{cyf} for various web thickness.	66
4.1	Coefficient, P, Y and power, Z of C_o and C_o/M_{cyf} from graph equation shown in Figure 3.5 - 3.18	77
4.2	Value of C_o calculated based on formula derived and divided by M_{cyf} and compare with FEA.	82
4.3	Value of C_o/M_{cyf} calculated based on formula and compare with FEA	85
4.4	Comparison values of C_o/M_{cyf} and $C_o/M_{sec,o}$ within formula derived, FEA and German table properties.	89

LIST OF FIGURES

FIGURE NO.	TITILE	PAGE
2.1	The shear stress flow at the trapezoidal web.	6
2.2	Plan view of lateral force, Q at trapezoidal web subjected to the shear stress flow.	6
2.3	Plan view of secondary bending moment, M_{sec} at trapezoidal web.	7
2.4	The shear stress flow at the flat web.	7
2.5	Plot of C_o versus depth of web, d in comparison between finite element analysis to the existing value referred to [2].	16
2.6	Plot of $C_o/M_{sec,o}$ versus depth of web, d in comparison between finite element analysis to the existing value referred to [2].	16
2.7	Graph $C_o/M_{sec,o}$ versus web depth, D from German table properties.	18
2.8	Graph $C_o/M_{sec,o}$ versus flange width, B from German table properties.	20
2.9	Graph $C_o/M_{sec,o}$ versus flange thickness, T from German table properties.	20
2.10	The FEM model of the web plate subjected to pure shear force	24
2.11	The direction of surface stress SX and reaction FX.	28
3.1	Trapezoidal web beam model with depth web 300mm.	32
3.2	Support condition assigned to the model with depth web 300mm.	33
3.3	Vertical loading with total 20kN assigned to the points to the model with web depth 300mm.	33
3.4	Steps of build up a LUSAS model with web depth 300mm.	34
3.5	Node labels along the connection of the web to the flange which war restrained in z direction for web depth 300mm.	47

3.6	The total lateral forces at each node, Q at each oblique sub panel of web depth 300mm.	53
3.7	Graph C_o versus depth web,d in comparison between finite element analysis to the existing value.	56
3.8	Graph $C_o/M_{sec,o}$ versus depth web, d in comparison between finite element analysis to the existing value.	56
3.9	The total lateral reactions, Q_1, Q_2 and Q_3 of each oblique sub panel in top flange and bottom flange.	58
3.10	Graph C_o and C_o/M_{cyf} versus web depth, D for fixed flange width, B= 160mm and flange thickness, T = 12mm.	67
3.11	Graph C_o and C_o/M_{cyf} versus web depth, D for fixed flange width, B = 200mm and flange thickness, T = 15mm.	68
3.12	Graph C_o and C_o/M_{cyf} versus web depth, D for fixed flange width, B = 240mm and flange thickness, T = 18mm.	69
3.13	Graph C_o and C_o/M_{cyf} versus web depth, D for fixed flange width, B = 280mm and flange thickness, T = 20mm.	70
3.14	Graph C_o and C_o /M_{cyf} Versus web depth, D for fixed flange width, B = 300mm and flange thickness, T = 22mm.	71
3.15	Graph C_o and C_o /M_{cyf} versus web depth, D for fixed flange width, B = 350mm and flange thickness, T = 25mm.	72
3.16	Graph C_o and C_o /M_{cyf} versus flange width, B for fixed web depth, D = 750mm and flange thickness, T = 10mm.	73
3.17	Graph C_o and C_o /M_{cyf} versus flange thickness, T for fixed web depth, D = 750mm and flange width, B = 120mm	74
3.18	Graph C_o and C_o /M_{cyf} versus web thickness, t for fixed web depth, D = 750mm and flange width, B = 120mm, flange thickness, T = 10mm.	75
4.1	Graph P versus Flange Width, B	77
4.2	Graph P versus Flange Thickness, T	78
4.3	Graph Z versus Flange Width, B	78
4.4	Graph Z versus Flange Thickness, T	79
4.5	Graph Y versus Flange Width, B	79
4.6	Graph Y versus Flange Thickness, T	80

4.7	Graph C_o/M_{cyf} versus Web Depth for various flange width and flange thickness.	92
4.8	Graph C_o/M_{cyf} versus Flange Width with web depth 750mm, web thickness 3mm.	95
4.9	Graph C_o/M_{cyf} versus Flange Thickness with web depth 750mm, web thickness 3mm.	96
4.10	C_o/M_{cyf} versus Web Depth from formula result for various flange width and flange thickness	96
4.11	C_o/M_{cyf} versus Web Depth from FEM analysis result for various flange width and flange thickness.	97

LIST OF SYMBOLS

a	-	Length of straight part of the web corrugation
B	-	Width of flange
C_o	-	Secondary bending moment coefficient
D	-	Depth of web
T	-	Thickness of flange
t	-	Thickness of web
M_{cx}	-	Section bending capacity, which is calculated by neglecting the contribution of web
M_{yf}	-	Secondary bending moment of this study
M_{cyf}	-	Secondary bending moment capacity of this study
M_{sec}	-	Secondary bending moment of German
$M_{sec,o}$	-	Secondary bending moment capacity of German
M_x	-	Applied bending moment
V	-	Shear loading
Q	-	Total lateral reactions at each oblique sub-panel
Q_{avr}	-	Average lateral reactions
p_y	-	Design strength
Z_{yf}	-	Elastic modulus of each flange in y axis

CHAPTER 1

INTRODUCTION

1.1 General

Demand for steel structures is increasing dramatically especially in construction industry. A number of new structural and fabrication technology has been developed to optimize the efficient use of steel in construction. One of the developments in steel structures is the introduction of trapezoidal web I-beam.

Trapezoid web beam is a type of steel section to form an I-section which use corrugated web made in trapezoidal form. The beam with corrugated thin web is continuously welded to the flanges at the top and bottom. Trapezoid web beam is a built up section that able to support vertical loads over long spans. The higher bending capacity is achieved by increasing the depth of the section.

Corrugation web in trapezoidal form increases the stability against buckling and can result in very economical designs. Ordinarily, the economic design of steel web I-beam requires thin web. To eliminate the risk of using thicker web of the beam, web stiffeners or by making the web in trapezoidal form is needed for the purpose of strengthening the web. When beams with corrugated webs are compared with those with stiffened flat webs, it can be found that trapezoidal corrugation in the web enables the use of thinner webs and trapezoidal web beams eliminate costly web stiffeners.

The trapezoid web beam provides a higher resistance against bending moment about the weak axis, high strength-to-weight ratio, less cost and higher load carrying capacity. Furthermore, it also offers its naturally architectural design element with its own aesthetic quality in the various construction projects.

The flange of trapezoid web beam carries the bending moment and the trapezoidal web carries the shear force. Due to the shear force subjected at the trapezoidal web, a lateral bending moment is induced in the flange, which is known as secondary bending moment, M_{yf}. It may cause a minor reduction in the bending moment capacity of the web.

This study consists of finite element analysis by using a computer software which is known as LUSAS, to determine the lateral reactions at the flange of the trapezoidal web beam. The lateral reaction depends on the section properties and increase linearly with the applied shear force. Thus, secondary bending moment coefficient, C_o is induced.

A series of analysis on finite element has been done on various sizes and properties of the beams to determine the value of secondary bending moment coefficient, C_o by compared the value between finite element analysis and German existing table properties.

In the past, German table properties was developed on the specific size section of trapezoid web beam. From the derivation of formula C_o, it is to be used to determine M_{sec} for any size sections. Apart from that, local engineers have widen choice on size section while doing design work.

1.2 Problem Statement

There is not much work has been done for the secondary bending behavior of trapezoid web beam. From the German table properties of the trapezoid web beam, there is no explanation and formula on how the value of secondary bending moment coefficient, C_o and secondary bending moment, M_{sec} is obtained and the information is limited.

The behavior of C_o can be determined by lateral reaction by using finite element analysis with applied lateral support at the section. The value of secondary bending moment coefficient is acceptable if it is comparable with existing German table properties. Therefore, the study is necessary to determine the clear explanation on the value of C_o and derive the formula of C_o and extend the knowledge.

1.3 Objective of Study

This study has been conducted to address the problem statement mentioned above. This study will give a better understanding on C_o and M_{yf} due to various geometric properties by using LUSAS finite element software. The main objectives of this study are:

a) To determine the secondary bending moment, M_{yf} in the flange.
b) To derive the formula of secondary bending moment coefficient, C_o

1.4 Scope of Study

The scopes in this study consist of:

a) Determine the lateral reaction in the flanges of the trapezoidal web beams when subjected to shear loading by using LUSAS finite element software.
b) Determine the secondary bending moment, M_{yf} induced at the flanges and the value of C_o due to the lateral forces adopted by finite element analysis.
c) Carrying out parametric study by varying:
   i) Flange width
   ii) Flange thickness
   iii) Web depth
   iv) Web thickness
   v) Aspect ratio of sub-panel
   vi) Corrugation thickness
   vii) Corrugation angle and etc.
d) Derive the formula of C_o from the parametric study using manual calculation.
e) Verify the values of M_{yf} and C_o by comparing with the German table properties.