

FINITE ELEMENT ANALYSIS OF COLD-
FORMED STEEL WEB STIFFENED
CHANNELS UNDER COMPRESSION LOAD

NURUL AMIRA BINTI AMILRUDDIN

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering

(Supervisor's Signature)

Full Name : MR. KHALIMI JOHAN BIN ABD HAMID

Position : Lecture

Date : 19 June 2017



STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : NURUL AMIRA BINTI AMILRUDDIN

ID Number : AA13154

Date : 19 June 2017

FINITE ELEMENT ANALYSIS OF COLD-FORMED STEEL WEB STIFFENED
CHANNELS UNDER COMPRESSION LOAD

NURUL AMIRA BINTI AMILRUDDIN

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2017

Special dedicated to
my beloved parents:
Amilruddin Bin Ismail
Notera Binti Embong

my siblings:
Muhammad Farezwani Bin Amilruddin
Nurul Assyeila Binti Amilruddin

my friends:
Muhammad Lutikhwan Bin Abdullah
Nurul Atikah Binti Zulkipli
Siti Robiah Binti Arshad
Nur Idayu Binti Ibrahim
Nur Fathin Nadhirah Binti Mohamad Noor
Nur Asyikin Binti Ruhannudin
Nurhasbazilah Binti Rusli

and
all my fellow friends,
thank you for your pray, endless love and support

ACKNOWLEDGEMENTS

First and foremost, thanks to God for giving strength to accomplished this final year project as a requirement to graduate in a Bachelor (Hons.) of Civil Engineering from Universiti Malaysia Pahang.

My sincere gratitude to my final year project supervisor Mr. Khalimi Johan Bin Abd Hamid for the continuous support of my degree of bachelor civil engineering study and research, for his patience and knowledge. His guidance helped me in all the time of study and writing of this thesis.

Thanks to my fellow team members, Nurul Atikah Binti Zulkipli, Nur Idayu Binti Ibrahim and Nur Zayani Binti Zaharudin, for the stimulating discussion and for help to learning LUSAS software. Also thank all my friends in Civil Engineering course of UMP.

In addition, thanks to everyone that involve in this research direct and indirectly, you and your kindness is appreciated.

Lastly, sincere thanks to my parents, Amilruddin Bin Ismail and Notera Binti Embong, for supporting me spiritually throughout my life, my siblings, Muhammad Farezwan Bin Amilruddin and Nurul Assyeila Binti Amilruddin, for constantly stay on my side when facing difficulty in the life.

TABLE OF CONTENT

DECLARATION	
TITLE PAGE	
DEDICATION	ii
ACKNOWLEDGEMENTS	iii
ABSTRAK	iv
ABSTRACT	v
TABLE OF CONTENT	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xvii
LIST OF ABBREVIATIONS	xviii
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Problem Statement	4
1.3 Objective	4
1.4 Scope of Study	5
1.5 Significant of Study	6
CHAPTER 2 LITERATURE REVIEW	7
2.1 Introduction	7
2.2 Steel Structure	7
2.2.1 The Different Between Reinforced Concrete and Structural Steel	8

2.2.2	Hot-Rolled Steel	10
2.2.3	Cold-Formed Steel	11
2.2.4	The Different Between Hot-Formed Steel and Cold-Formed Steel	12
2.3	Characteristic of Cold-Formed	12
2.3.1	Advantage of Cold-Formed	12
2.3.2	Application of Cold-formed in Industry	13
2.4	Buckling Behaviours	14
CHAPTER 3 METHODOLOGY		16
3.1	Introduction	16
3.2	Finite Element Model	16
3.3	Finite Element Analysis	19
3.4	LUSAS Modeller 14.0	19
3.5	Specimen Attributes in LUSAS Analysis	21
3.5.1	Modelling	21
3.5.2	Meshing	23
3.5.3	Geometric	24
3.5.4	Material Properties	25
3.5.5	Support	26
3.5.6	Loading	28
3.5.7	Complete Modelling in LUSAS	29
CHAPTER 4 RESULTS AND DISCUSSION		30
4.1	Introduction	30
4.2	Finite Element Analysis	30
4.2.1	Deformed Mesh of Cold-Formed Steel	31

4.2.2	Maximum Stress	43
4.2.3	Maximum Strain	61
4.3	Eigenvalue Analysis	79
4.3.1	Fixed – Fixed Support	79
4.3.2	Pinned – Pinned Support	98
CHAPTER 5 CONCLUSION		116
5.1	Introduction	116
5.2	Conclusion	117
5.3	Recommendation	117
REFERENCES		118

LIST OF TABLES

Table 1.1	Type of specimen	5
Table 2.1	Different between reinforcement concrete and structural steel	9
Table 2.2	Different between hot-rolled steel and cold-formed steel	12
Table 3.1	Stage of modelling specimen	20
Table 4.1	Buckling analysis for short column	80
Table 4.2	Buckling analysis for medium column	87
Table 4.3	Buckling analysis for slender column	93
Table 4.4	Buckling analysis for short column	99
Table 4.5	Buckling analysis for medium column	105
Table 4.6	Buckling analysis for slender column	111

LIST OF FIGURES

Figure 1.1	Type of cold-formed section	2
Figure 1.2	Type of light weight structure. a) industry building b) housing c) temporary structure	3
Figure 2.1	Type of hot-rolled sections	10
Figure 2.2	Type of cold-formed sections	11
Figure 2.3	Guard rail at road highway	13
Figure 2.4	Installation of cold-formed sheet pile	14
Figure 2.5	Cold-formed steel framing for residence house	14
Figure 2.6	Type of buckling behaviours. a) local buckling b) distortional buckling c) flexural – torsional buckling	14
Figure 3.1	The experiment setup of cold-formed	17
Figure 3.2	Project flow	18
Figure 3.3	Modelling in LUSAS	20
Figure 3.4	LUSAS modeller start-up	21
Figure 3.5	Created new file	21
Figure 3.6	Entering the coordinated	22
Figure 3.7	Modelling the structure	22
Figure 3.8	Sweeping the structure	23
Figure 3.9	Attributes mesh	23
Figure 3.10	Surface mesh database	24
Figure 3.11	Attributes geometric	24
Figure 3.12	Geometric properties database	25
Figure 3.13	Attributes material	25
Figure 3.14	Material properties dataset	26
Figure 3.15	Top surface support	26
Figure 3.16	Bottom surface support	27
Figure 3.17	Complete modelled support	27
Figure 3.18	Structural support database	28
Figure 3.19	Complete model loading	29
Figure 3.20	Complete modelling in LUSAS	29
Figure 4.1	Deformed mesh for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	31
Figure 4.2	Deformed mesh for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	32

Figure 4.3	Deformed mesh for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	32
Figure 4.4	Deformed mesh for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	33
Figure 4.5	Deformed mesh for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	34
Figure 4.6	Deformed mesh for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	34
Figure 4.7	Deformed mesh for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2S and c) SS1.2S	35
Figure 4.8	Deformed mesh for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	36
Figure 4.9	Deformed mesh for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	36
Figure 4.10	Deformed mesh for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	37
Figure 4.11	Deformed mesh for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	38
Figure 4.12	Deformed mesh for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	38
Figure 4.13	Deformed mesh for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	39
Figure 4.14	Deformed mesh for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	40
Figure 4.15	Deformed mesh for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	40
Figure 4.16	Deformed mesh for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2S and c) SS1.2S	41
Figure 4.17	Deformed mesh for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	42
Figure 4.18	Deformed mesh for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	42
Figure 4.19	Contour of linear analysis maximum stress for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	44
Figure 4.20	Contour of linear analysis maximum stress for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	44
Figure 4.21	Contour of linear analysis maximum stress for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	45
Figure 4.22	Contour of linear analysis maximum stress for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	47

Figure 4.23	Contour of linear analysis maximum stress for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	47
Figure 4.24	Contour of linear analysis maximum stress for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	48
Figure 4.25	Contour of linear analysis maximum stress for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	50
Figure 4.26	Contour of linear analysis maximum stress for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	50
Figure 4.27	Contour of linear analysis maximum stress for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	51
Figure 4.28	Contour of linear analysis maximum stress for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	53
Figure 4.29	Contour of linear analysis maximum stress for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	53
Figure 4.30	contour of linear analysis maximum stress for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	54
Figure 4.31	Contour of linear analysis maximum stress for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	56
Figure 4.32	Contour of linear analysis maximum stress for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	56
Figure 4.33	Contour of linear analysis maximum stress for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	57
Figure 4.34	Contour of linear analysis maximum stress for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	59
Figure 4.35	Contour of linear analysis maximum stress for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	59
Figure 4.36	Contour of linear analysis maximum stress for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	60
Figure 4.37	Contour of linear analysis maximum strain for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	62
Figure 4.38	Contour of linear analysis maximum strain for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	62
Figure 4.39	contour of linear analysis maximum strain for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	63
Figure 4.40	Contour of linear analysis maximum strain for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	65
Figure 4.41	Contour of linear analysis maximum strain for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	65
Figure 4.42	Contour of linear analysis maximum strain for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	66

Figure 4.43	Contour of linear analysis maximum strain for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	68
Figure 4.44	Contour of linear analysis maximum strain for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	68
Figure 4.45	Contour of linear analysis maximum strain for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	69
Figure 4.46	Contour of linear analysis maximum strain for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	71
Figure 4.47	Contour of linear analysis maximum strain for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	71
Figure 4.48	Contour of linear analysis maximum strain for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	72
Figure 4.49	Contour of linear analysis maximum strain for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	74
Figure 4.50	Contour of linear analysis maximum strain for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	74
Figure 4.51	Contour of linear analysis maximum strain for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	75
Figure 4.52	Contour of linear analysis maximum strain for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	77
Figure 4.53	Contour of linear analysis maximum strain for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	77
Figure 4.54	Contour of linear analysis maximum strain for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	78
Figure 4.55	Case 1 buckling analysis for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	81
Figure 4.56	Case 2 buckling analysis for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	81
Figure 4.57	Case 3 buckling analysis for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	82
Figure 4.58	Case 1 buckling analysis for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	82
Figure 4.59	Case 2 buckling analysis for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	83
Figure 4.60	Case 3 buckling analysis for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6	83
Figure 4.61	Case 1 buckling analysis for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	84
Figure 4.62	Case 2 buckling analysis for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	84

Figure 4.63	Case 3 buckling analysis for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	85
Figure 4.64	Case 1 buckling analysis for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	87
Figure 4.65	Case 2 buckling analysis for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	88
Figure 4.66	Case 3 buckling analysis for medium column with 1.2 mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	88
Figure 4.67	Case 1 buckling analysis for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	89
Figure 4.68	Case 2 buckling analysis for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	89
Figure 4.69	Case 3 buckling analysis for medium column with 1.6 mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	90
Figure 4.70	Case 1 buckling analysis for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	90
Figure 4.71	Case 2 buckling analysis for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	91
Figure 4.72	Case 3 buckling analysis for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	91
Figure 4.73	Case 1 buckling analysis for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	93
Figure 4.74	Case 2 buckling analysis for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	94
Figure 4.75	Case 3 buckling analysis for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	94
Figure 4.76	Case 1 buckling analysis for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	95
Figure 4.77	Case 2 buckling analysis for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	95
Figure 4.78	Case 3 buckling analysis for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	96
Figure 4-79	Case 1 buckling analysis for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	96
Figure 4.80	Case 2 buckling analysis for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	97
Figure 4.81	Case 3 buckling analysis for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	97
Figure 4.82	Case 1 buckling analysis for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	99

Figure 4.83	Case 2 Buckling analysis for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	100
Figure 4.84	Case 3 buckling analysis for short column with 1.2 mm thickness for a) CS1.2S, b) VS1.2S and c) SS1.2S	100
Figure 4.85	Case 1 buckling analysis for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	101
Figure 4.86	Case 2 Buckling Analysis for Short Column with 1.6 mm Thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	101
Figure 4.87	Case 3 buckling analysis for short column with 1.6 mm thickness for a) CS1.6S, b) VS1.6S and c) SS1.6S	102
Figure 4.88	Case 1 buckling analysis for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	102
Figure 4.89	Case 2 Buckling Analysis for Short Column with 2.0 mm Thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	103
Figure 4.90	Case 3 buckling analysis for short column with 2.0 mm thickness for a) CS2.0S, b) VS2.0S and c) SS2.0S	103
Figure 4.91	Case 1 buckling analysis for medium column with 1.2mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	105
Figure 4.92	Case 2 buckling analysis for medium column with 1.2mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	106
Figure 4.93	Case 3 buckling analysis for medium column with 1.2mm thickness for a) CS1.2M, b) VS1.2M and c) SS1.2M	106
Figure 4.94	Case 1 Buckling Analysis for Medium Column with 1.6mm Thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	107
Figure 4.95	Case 2 buckling analysis for medium column with 1.6mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	107
Figure 4.96	Case 3 buckling analysis for medium column with 1.6mm thickness for a) CS1.6M, b) VS1.6M and c) SS1.6M	108
Figure 4.97	Case 1 buckling analysis for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	108
Figure 4.98	Case 2 buckling analysis for medium column with 2.0 mm thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	109
Figure 4.99	Case 3 Buckling Analysis for Medium Column with 2.0 mm Thickness for a) CS2.0M, b) VS2.0M and c) SS2.0M	109
Figure 4.100	Case 1 buckling analysis for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	111
Figure 4.101	Case 2 buckling analysis for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	112
Figure 4.102	Case 3 buckling analysis for slender column with 1.2 mm thickness for a) CS1.2L, b) VS1.2L and c) SS1.2L	112

Figure 4.103	Case 1 buckling analysis for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	113
Figure 4.104	Case 2 buckling analysis for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	113
Figure 4.105	Case 3 buckling analysis for slender column with 1.6 mm thickness for a) CS1.6L, b) VS1.6L and c) SS1.6L	114
Figure 4.106	Case 1 buckling analysis for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	114
Figure 4.107	Case 2 buckling analysis for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	115
Figure 4.108	Case 3 buckling analysis for slender column with 2.0 mm thickness for a) CS2.0L, b) VS2.0L and c) SS2.0L	115

LIST OF SYMBOLS

et. al.	And Other
m	Meter (Length Unit)
mm	Millimetre (Length Unit)
N	Newton (Load Unit)
kN	Kilo Newton (Load Unit)
E	Young's Modulus
ν	Poisson Ratio
Σ	Sigma

LIST OF ABBREVIATIONS

FEA	Finite Element Analysis
FEM	Finite Element Modelled
LUSAS	London University Structural Analysis Software
ABAQUS	Other Program Of Finite Element Analysis Software
ANSYS	Other Program Of Finite Element Analysis Software
QSL8	Quadrilateral Thin Shell Element with 8 Nodes Clockwise