



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EXAMINATION OF BUCKLING BEHAVIOUR OF CONE-CYLINDER TRANSITION UNDER AXIAL COMPRESSION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive) with Honours.

by

AMIRUL HUSAINI BIN MAZLI

B071510385

960409-05-5129

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING
TECHNOLOGY

2018

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: EXAMINATION OF BUCKLING BEHAVIOUR OF CONE-CYLINDER
TRANSITION UNDER AXIAL COMPRESSION

Sesi Pengajian: 2019

Saya **AMIRUL HUSAINI BIN MAZLI** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. ****Sila tandakan (X)**

SULIT* Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.

TERHAD* Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.

TIDAK TERHAD

Yang benar,

Disahkan oleh penyelia:

.....

AMIRUL HUSAINI BIN MAZLI

.....

DR.OLAWALE IFAYEFUNMI

Alamat Tetap:

Cop Rasmi Penyelia

No.59, Jalan Ria 3, Taman Ria 2,

43950 Sungai Pelek,

Selangor Darul Ehsan

Tarikh:

Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini

DECLARATION

I hereby, declared this report entitled EXAMINATION OF BUCKLING BEHAVIOUR OF CONE-CYLINDER TRANSITION UNDER AXIAL COMPRESSION is the results of my own research except as cited in references.

Signature:

Author : AMIRUL HUSAINI BIN MAZLI

Date:

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

Signature:

Supervisor : DR.OLAWALE IFAYEFUNMI

ABSTRAK

Penyelidikan ini bertujuan untuk mengkaji pengaruh sudut kon dan ketinggian kerucut pada tingkah laku tenggelam peralihan silinder yang tertimbun kepada mampatan paksi. Kerja penyelidikan ini melibatkan 12 spesimen silinder kon yang mempunyai 6 kes. Setiap kes mengandungi 2 sampel. 12 spesimen tersebut difabrikasikan menggunakan lembaran keluli yang berketebalan 1mm. Perisian SolidWorks digunakan untuk melukis model kon dan silinder dalam lukisan 2D. Lukisan itu diimport ke perisian FlowPath manakala mesin jet air digunakan untuk memotong lembaran keluli kepada 12 sampel kon dan silinder. 12 sampel tersebut telah menjalani proses penggulungan dan kimpalan untuk membentuk bentuk silinder kon. Ujian mampatan aksial pada 12 spesimen silinder kon telah dilakukan dengan menggunakan mesin ujian sejagat. Kajian yang dilakukan adalah untuk membandingkan hasil eksperimen dan berangka. Data hasil semua spesimen ditunjukkan dalam laporan ini. Keputusan eksperimen menunjukkan bahawa apabila sudut kon berubah, beban juga akan berubah, sama ada ia meningkat atau menurun.

ABSTRACT

This research aims to investigate the influence of cone angle and cone height on the buckling behaviour of cone-cylinder transition subjected to axial compression. This research work involves 12 specimens of cone-cylinder which have 6 cases. Each case contains 2 sample. Those 12 specimens were fabricated using 1mm mild steel sheet. SolidWorks software was used to draw the model of cone and cylinder in 2D drawing. The drawing was imported to the FlowPath software while water-jet machine was used to cut the mild steel sheet into 12 sample of cones and cylinders. Those 12 samples were undergone rolling and welding processes to form cone-cylinder shape. Axial compression test on 12 specimens of cone-cylinder were done using universal testing machine. The research conducted was to compare experimental and numerical results. The results data of all specimens were presented in this report. The experiment results indicated that as the cone angle changes, the load will also changes, either increase or decrease

DEDICATION

This report is dedicated to my beloved parents, my siblings and my friends, who always support me during this final year project work. Last but not least, my final year report group mates who were always with me to complete my final year project research.

ACKNOWLEDGEMENTS

First of all, I would like to take this opportunity to express my sincere gratitude to my supervisor Dr Olawale Ifayefunmi from Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM) for his guidance, supervision and support towards the process of this final year project report.

In addition, I like to acknowledge the help received from Mr. Shafiq and Mr. Azizul, the technician from Faculty of Mechanical and Manufacturing Engineering Technology for guiding us during our project work. Special thanks to the Faculty of Mechanical and Manufacturing Engineering Technology, UTeM, for the short funding for this project.

Last but not least, I will like to say a big thank you to my parents, siblings and friends for the encouragement and support that were given to me.

TABLE OF CONTENTS

	PAGE
TABLE OF CONTENTS	x
LIST OF TABLES	xiv
LIST OF FIGURES	xv
LIST OF APPENDICES	xix
LIST OF SYMBOLS	xx
LIST OF ABBREVIATIONS	xxi
CHAPTER 1 INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Scope of Study	3
CHAPTER 2 LITERATURE REVIEW	4
2.1 Introduction	4
2.2 Different angle of cones	4
2.3 Buckling behaviour	5
2.4 Radial ring load	6
2.5 Buckling of steel silo	8

2.6	Stresses and stability transition	9
2.7	Post buckling of cone-cylinder	12
CHAPTER 3	METHODOLOGY	14
3.1	Working process	14
3.2	Conceptual design	15
3.2.1	Sketching and CAD drawing	16
3.3	Material selection	17
3.4	Fabrication process	18
3.4.1	Cutting process	18
3.4.2	Rust proof	20
3.4.3	Tags removal	21
3.4.4	Thickness measurement	21
3.4.5	Tensile test	23
3.4.6	Rolling process	24
3.4.7	Welding	25
3.4.8	Cone-cylinder measurement	26
3.4.9	Axial compression test	27
3.5	Numerical Analysis Procedure	28
3.5.1	ABAQUS software	28
3.5.2	The modelling of each specimens	28

3.5.3	Settings of material behaviors	30
3.5.4	Creating of model section	31
3.5.5	Creating reference point	33
3.5.6	Creating instance	33
3.5.7	Creating sets	34
3.5.8	Creating steps	34
3.5.9	Creating of field and history output	35
3.5.10	Creating constraint	37
3.5.11	Creating Load	38
3.5.12	Creating boundary condition	39
3.5.13	Meshing of model	40
3.5.14	Job submission	41
CHAPTER 4	RESULT & DISCUSSION	42
4.1	Introduction	42
4.2	Tensile data	42
4.3	Pre-test measurement	43
4.3.1	Thickness measurement for specimen cut-out	43
4.3.2	Diameter measurement of mild steel cone-cylinder	44
4.3.3	Height measurement of cone-cylinder	45
4.3.4	Angle of cones	46

4.4	Testing Procedure	47
4.5	Experimental and numerical results	48
CHAPTER 5	CONCLUSION & FUTURE WORK	56
5.1	Conclusion	56
5.2	Future work	57
REFERENCES		58
APPENDIX		62

LIST OF TABLES

TABLE	TITLE	PAGE
Table 3.1:	Dimension of each cone cylinder	15
Table 4.1:	Overall tensile data	42
Table 4.2:	Thickness of specimens	43
Table 4.3:	The average top and bottom diameter of cone-cylinder	44
Table 4.4:	The nominal and average height of cone-cylinder	45
Table 4.5:	The nominal and average angle of cones	46
Table 4.6:	Collapse load for experimental results	48
Table 4.7:	The collapse load between experimental and numerical result	50
Table 4.8:	The selected data of experimental and numerical result	51

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Buckling of cone angles by BOSOR5.	5
Figure 2.2:	Schematic of cone-cylinder intersection (Teng & Zhou, 2000)	6
Figure 2.3:	Cone-cylinder intersection under a radial ring load (Greiner & Ofner, 1991)	7
Figure 2.4:	Typical elevated steel silo (Jumikis, 1987)	8
Figure 2.5:	Plastic collapse of the junction (Jumikis, 1987)	8
Figure 2.6:	Plastic out-of-plane buckling of the ring (Jumikis, 1987)	9
Figure 2.7:	Cone-cylinder shell transition (Anwen, 1993a)	10
Figure 2.8:	Cone-cylinder shell with transition of variational curvature (Anwen, 1993a)	10
Figure 3.1:	Working process flowchart	14
Figure 3.2:	2D drawing	16
Figure 3.3:	Mild steel with 1mm thickness	17
Figure 3.4:	The measurement of mild steel	18
Figure 3.5:	Shearing machine	18
Figure 3.6:	Abrasive sand mesh 80	19
Figure 3.7:	Waterjet cutting process	19

Figure 3.8:	Waterjet pathway	20
Figure 3.9:	WD40	20
Figure 3.10:	Tags removal process	21
Figure 3.11:	Gridlines of specimen	22
Figure 3.12:	Micrometer screwgauge	22
Figure 3.13:	Thickness measurement	23
Figure 3.14:	Tensile coupon drawing	23
Figure 3.15:	Tensile coupon product	24
Figure 3.16:	Conventional slip roll machine	25
Figure 3.17:	Metal inert gas (MIG) welding	25
Figure 3.18:	Digital weight scale	26
Figure 3.19:	Digital vernier caliper	26
Figure 3.20:	INSTRON universal testing machine	27
Figure 3.21:	Cone-cylinder coordinate	28
Figure 3.22:	Angle of revolution	29
Figure 3.23:	3D model	29
Figure 3.24:	The elastic property	30
Figure 3.25:	The plastic property	31
Figure 3.26:	The category of type section	31
Figure 3.27:	Shell thickness	32
Figure 3.28:	The assigned model	32

Figure 3.29:	The setup of reference point	33
Figure 3.30:	Creating of instance	33
Figure 3.31:	Creating of four different sets	34
Figure 3.32:	Creating steps	34
Figure 3.33:	Nlgeom settings	35
Figure 3.34:	Variables selected in displacement	36
Figure 3.35:	Variables selected in forces	36
Figure 3.36:	Constraint setting	37
Figure 3.37:	MPC type setting	37
Figure 3.38:	Final constraint setup	38
Figure 3.39:	The setup of load	38
Figure 3.40:	Top boundary condition	39
Figure 3.41:	Bottom boundary condition	39
Figure 3.42:	Final boundary condition	40
Figure 3.43:	Global size setting	40
Figure 3.44:	Meshing of the specimen	41
Figure 3.45:	General setting printout data	41
Figure 4.1:	Sample specimen of each cases	47
Figure 4.2:	The setup of the specimen before experiment	47
Figure 4.3:	The comparison between numerical and experimental graph for specimen 1b	51

Figure 4.4:	The comparison between numerical and experimental graph for specimen 2a	52
Figure 4.5:	The comparison between numerical and experimental graph for specimen 2b	52
Figure 4.6:	The comparison between numerical and experimental graph for specimen 4a	53
Figure 4.7:	The comparison between numerical and experimental graph for specimen 6a	53
Figure 4.8:	The comparison between experimental and numerical buckling condition	54
Figure 4.9:	The graph of load vs angle	55

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX 1:	2D drawing geometry of cone-cylinder	62
APPENDIX 2:	Design of specimens (cylinder)	63
APPENDIX 3:	Design of specimens (tensile coupon)	63
APPENDIX 4:	Design of specimens (cone)	64
APPENDIX 5:	Thickness of cone-cylinder	65
APPENDIX 6:	Overall measurement of each sample	77

LIST OF SYMBOLS

h1	-	Height of cylinder
h2	-	Height of cone
r	-	Radius of cylinder
r1	-	Top radius of cone
r2	-	Bottom radius of cone
β	-	Angle of cone

LIST OF ABBREVIATIONS

UTeM	Universiti Teknikal Malaysia Melaka
FEM	Finite Element Method
CAD	Computer Aided Drawing
VFD	Variational finite-difference
MIG	Metal Inert Gas

CHAPTER 1

INTRODUCTION

1.1 Background

Cone-cylinder shell has a wide range of application in structural engineering. Some of the application that are used is pipes, pressure vessels, tanks, silos and roof structures. Internal pressurization causes large circumferential compressive stresses in the crossing point of the substantial end of a cone and a cylinder. These stresses can lead to failure of the intersection either symmetric or non-symmetric buckling (Teng, 1994 & 1995).

Conical shells are frequently used as transition elements to join cylindrical shells. In term of different angle and height of cones, it is important to determine the best geometry of cone if the structure subjected with different loading condition such as axial compression.

In term of stability of cone-cylinder, it have been investigated by the Rayleigh-Ritz strategy. By using analytical and finite element methods, the stresses in the cone-cylinder with a toroidal segment as a transition, subjected to external hydrostatic pressure can be calculated (Anwen, 1998) . Then, it will be compared with the cone-cylinder shells without transition.

1.2 Problem Statement

Most of the literature review states that thin walled cone-cylinder usually buckle elastically under axial compression. The buckling strength for axially loaded cone-cylinder is usually lower than the theoretical elastic critical stress. The presence of imperfections and geometric nonlinearity is the cause of buckling strength decreases. However, the presence of accompanying internal pressure reduces the effect of imperfections by increasing the buckling strength of the shells.

The influences in buckling mode of cone-cylinder are the material properties and the load applied at cone-cylinder. Besides that, the way of rolling the cylinder and cone shape might effect the buckling mode. Cylindrical panels are easy to roll, as they can be produced by simply keeping the axis in parallel. However, it is quite difficult to obtain precise conical shapes using the manual rolling process and it must carefully controlled during the process.

To weld together the shell components is another difficult task since this project have different angle and height of the cones. Perfect welding is required to ensure that the weld is strong enough so that structural failure can be prevented and all of the geometry cone-cylinder is similar to those in real structure.

1.3 Objectives

Based on the problem statement, the objective of this project is:

- To study the effect of different angles and height of cones on buckling behaviour of cone-cylinder intersection
- To determine the numerical and experimental result on buckling behaviour of cone-cylinder intersection

1.4 Scope of Study

The project is related with the buckling behaviour of cone-cylinder intersection with different angles of cones. The cone angles that includes is 11.31° , 16.7° , 26.57° , 8.53° and 18.43° . It was determine by the calculation of the cones with different height, top radius and bottom radius. The material that was chosen for the project is mild steel with 1mm thickness. All sample was drawn by using Solid work in 2D design. Each sample have 2 identified samples in order to achieve the accurate data. The total specimen that have to be draw is 24 including 12 for cones and 12 for cylinder. The product of each specimens was then subjected to compression test by using INSTRON Universal Testing Machine. The result obtained from the test was then recorded and tabulated and it will then be compare with numerical outcomes.