UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION OF BUCKLING BEHAVIOUR OF AXIALLY COMPRESSED CONE WITH UNEVEN AXIAL LENGTH HAVING SINUSOIDAL WAVES

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

FAIRUZ MARDHIAH BINTI MAHIDAN

B071510486

960909-02-5954

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

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I hereby, declared this report entitled INVESTIGATION OF BUCKLING BEHAVIOUR OF AXIALLY COMPRESSED CONE WITH UNEVEN AXIAL LENGTH HAVING SINUSOIDAL WAVES is the results of my own research except as cited in references.

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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

Kajian ini menumpukan kepada penyiasatan kelakuan gelendong kon keluli lembut yang dipotong di bawah kesan beban paksi. Kajian ini dijalankan secara eksperimen menggunakan INSTRON 50kN Universal Testing Machine dan secara numerik menggunakan perisian ABAQUS. Terdapat sejumlah 18 sampel dengan pelbagai nombor gelombang. Kesan panjang paksi yang tidak rata yang mempunyai gelombang sinusoidal serta variasi bilangan gelombang pada kapasiti penyimpanan beban kon diselidiki. Akhirnya, perbandingan antara beban keruntuhan cangkerang konikal sempurna dan tidak sempurna dilakukan. Perbandingan antara perbezaan eksperimen dan numerikal menunjukkan antara 1% hingga 5%. Adalah diperhatikan bahawa panjang paksi yang tidak rata mempunyai kesan yang signifikan terhadap tingkah laku cangkerang konikal tetapi variasi bilangan gelombang menunjukkan kesan minimum.

ABSTRACT

The study focuses on investigating the buckling behaviour of mild steel truncated cones under the effect of axial loading. The study is conducted experimentally using INSTRON 50kN Universal Testing Machine and numerically using ABAQUS software. There are a total of 18 samples with various wave number. The effects of uneven axial length having sinusoidal waves as well as the variation of number of waves on the load carrying capacity of cones are investigated. Finally, a comparison between the collapse load of perfect and imperfect conical shells is conducted. Comparison between experimental and numerical shows difference ranging from 1% to 5%. It is observed that uneven axial length had a significant effect towards the buckling behaviour of conical shells but the variation of number of waves shows a minimal effect.

DEDICATION

This report is dedicated to my parents who have always been a constant source of support and encouragement during the challenges of my whole university life. Also to my friends whom I am truly grateful for having in my life.

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TABLE OF CONTENTS

LIST OF TABLES

TABLE **TITLE** **PAGE**

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

F_{crit}	-	Critical buckling load
F_{cyl}	-	Critical buckling load of cylinder
β	-	Cone semi-vertex angle
r_1	-	Top radius of cone
r_2	-	Bottom radius of cone
h	-	Height of cone
L	-	Slant length of cone

LIST OF ABBREVIATIONS

UTeM	Universiti Teknikal Malaysia Melaka
FEM	Finite Element Method
CAD	Computer Aided Drawing
DXF	Drawing Interchange Format
MIG	Metal Inert Gas
CNC	Computer Numerically Controlled
TIFF	Tagged Image File Format
IGES	Initial Graphic Exchange Specification

LIST OF PUBLICATIONS

1. Ifayefunmi, O., Wang, S. H., Mahidan, F.M. 2018. “Experimental investigation of buckling behaviour of axially compressed truncated cones with imperfect length”, in *Proceedings of Mechanical Engineering Research Day 2018*, pp. 212-213, May 2018.

2. Ifayefunmi, O., Mahidan, F.M. 2019. “Buckling of cones with imperfect length subjected to axial compression”, in *Proceedings of the 38^th^ International Conference on Ocean, Offshore and Arctic Engineering,* Glasgow, Scotland, United Kingdom, June 9 - 14, 2019, abstract accepted.

CHAPTER 1

INTRODUCTION

1.1 Background

Aeronautical, marine, offshore and mechanical are among the industries where conical shell structure are used as structural parts. The conical shell structure are regularly being utilized as pressure vessels, pipelines, offshore platforms and transition elements between two cylinders that have different diameters. For example, in aeronautical application, the load carrying capacity is usually constrained by elastic buckling. This is as a result of the high value of radius-to-thickness proportion of thin conical shells. Thin shell structures also broadly used in the field of civil engineering. A few cases that utilize thin shells as structural components are storehouses, rooftops, container, tanks, pipes, pressure vessels, submarines and aircraft wings (Deshpande, 2010).

Practically, thin conical shell structures are subjected to different loading conditions such as axial compression. The limit to which the structures can be loaded or deform is affected by many factors. One of them is instability. One must really understand the behaviour of shell structure in order to carry out buckling analysis of conical shells (Ifayefunmi, 2014). Buckling is a mechanical and numerical instability, prompting to a failure mode (Monfared, 2012). It is one of the popular phenomena in solid mechanics and a menace for thins shells that are subjected to axial loading. The impact of buckling is the loss of structure's stability which is very important for many fields such as mechanical, chemistry, aerospace engineering, marine industry etc. (Boorboor et al., 2012).

In thin-walled shell structures, small geometric imperfections can cause a significant reductions in buckling strength. Amazigo & Budiansky (1972), Narasimhan & Hoff (1971) and Stein (1968) are among the researches who did research on buckling imperfection stability of shell-of-revolution structures containing small geometric imperfections. However, practically the imperfections happen locally rather than axisymmetric or have the shape of buckling modes (Cooper & Dexter, 1974).

1.2 Statement of the Purpose

The purposes of this study are:

1) To design and fabricate truncated cones with and without sinusoidal waves as imperfection at the boundary of small diameter cone using mild steel.

2) To study the effect of different sinusoidal wave number on buckling behaviour of axially compressed truncated conical shell structure.

3) To compare the experimental and numerical results of axially compressed truncated conical shell.

1.3 Problem Statement

The behavior of steel plate has been studied over the years. One of the behavior of steel plate is buckling. It is a phenomenon which occurs in structures which are stiff in the loaded and slender in another direction (Bhoi & Kalurkar, 2014). This phenomenon on imperfect shells is one of the most difficult issues in industry. The buckling load of certain structures depends on the initial geometric imperfections. When a structure is imperfect, the buckling load of that structure will reduce (Sofiyev, 2010).

Buckling behavior of conical shells is affected by the material and geometric properties of the shells, type of load applied on it and any geometric imperfection on the shells (Maali et al., 2012). It is very crucial to study the failure phenomenon of conical shells as the slightest imperfection on it can result in significant decrease of buckling capacity of the structure. Small geometric imperfections in thin-walled shell structures can cause vast reduction in buckling strength (Cooper & Dexter, 1974).

From the literature study, it was discovered there have been only one study on the buckling load of conical shells having uneven length as imperfection. Researchers are more focused on the initial geometric imperfection, dimple discontinuity, loading conditions imperfection and uneven length. This study attempts to concentrate on the effect of uneven axial length towards the buckling behaviour of conical shell for further investigation due to lack of data on the said effect.