## SUPERVISOR DECLARATION

“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Material and Structure)

Signature : ……………………………………

First Supervisor : MR. HAIRUL BIN BAKRI

Date : ......................................................

Signature : ……………………………………

Second Supervisor : MR. HAMZAH BIN MOHD DOM

Date : ......................................................

# ANALYTICAL STUDY ON CONTROL OF BUCKLING LOBE ONSET FOR HOLLOW RECTANGULAR TUBE UNDER AXIAL IMPACT

**NIK MOHD AFIQ BIN NIK MOHD ARIF**

**A report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Mechanical Engineering (Structure and Materials)**

**Faculty of Mechanical Engineering**
**Universiti Teknikal Malaysia Melaka**

**MAY 2011**

**DECLARATION**

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : ……………………………………
Author : NIK MOHD AFIQ BIN NIK MOHD ARIF
Date : ......................................................

To my beloved father and mother

NIK MOHD ARIF BIN NIK ABDUL RAZAK

ZALEHASENI BINTI AHMAD

## ACKNOWLEDGEMENT

**In the name of ALLAH S.W.T, the most Gracious and most Merciful**

All praises to God for His blessings and guidance. Thanks for giving me strength to complete this PSM. I am really grateful as I have completed this Projek Sarjana Muda with the help and support, encouragement and inspirations by various parties. All the knowledge and information that they give are really helpful.

Here I would like to express my gratitude to Mr. Hairul Bin Bakri which is my PSM supervisor for all his supports and advices during the completion of this project. All the helps, knowledge and advices through a few consultations increase my confident level in completing this project report.

I also would like to thanks to my beloved family, person and all fellow friends, for all their concern, contribution, encouragement and understanding.Lastly, thank to all people around me, who has giving support directly or indirectly for the contribution in this PSM project.

## ABSTRACT

In the present paper, numerical analysis have been used to investigate the ability to control buckling process of hollow rectangular tube subjected to axial impact. The inertia force induced to solid mass that attached to the hollow rectangular tube during the axial impact is exploited to trigger the first buckling lobe. There are two cases is conducted using dynamic explicit finite element method in order to prove that first buckling lobe will occur at portion where solid mass attached. The first case is hollow rectangular tube with attach solid mass on tube and second case is without attach solid mass. The tube fixed to the drop-hammer was impacted against the stationary rigid plate at 5 or 10 m/s. For the case of tube attached solid mass, the site of the first buckling lobe occur at the portion where the solid mass attached. In second case without attach solid mass, the site first buckling lobe occurred varied and the slight wavy plastic deformation remained further that the buckling lobes.

# ABSTRAK

Dalam thesis ini, penyelidikan berangka telah dilakukan untuk mengawal lekukan yang berlaku pada tiub empat segi tepat berongga apabila dikenakan kesan paksi. Daya inersia yang dihasilkan oleh jisim padat yang dilampirkan pada tiub empat segi tepat berongga semasa kesan paksi dieksploitasikan untuk menghasilkan lekukan pertama. Dua kes telah diuji menggunakan kaedah unsur terhingga eksplisit dinamik dalam membuktikan lekukan pertama berlaku pada tempat jisim padat dilampirkan. Kes pertama diuji dengan kesan paksi pada tiub empat segi tepat berongga dengan dilampirkan jisim padat dan kes kedua tanpa dilampirkan jisim padat. Tiub telah dikenakan tekanan oleh plat pada kadar kelajuan 5 atau 10 m/s. Untuk kes yang dilampirkan jisim padat, lekukan pertama berlaku pada tempat dimana jisim padat dilampirkan. Dalam kes kedua tanpa dilampirkan jisim padat, lekukan pertama akan berlaku lekukan rawak.

# CONTENT

# LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATION AND SYMBOLS

| | | |
|---|---|---|
| P | = | force push the wall |
| Q | = | force acts along the wall |
| E | = | Young Modulus |
| V | = | Poisson ratio |
| σ | = | yield stress |
| n | = | exponent |
| C | = | multiplier |
| w | = | width of square tube |
| ρ | = | density |
| $l$ | = | length of square tube |
| a | = | acceleration at solid mass |
| x | = | distance |
| d0 | = | outer diameter |
| di | = | internal diameter |
| t | = | thickness |
| kg | = | unit of mass |

| | | |
|---|---|---|
| Pa | = | Pascal (unit of stress) |
| kN | = | kilo Newton (unit of force) |
| mm | = | millimeter (unit of length) |
| m/s | = | meter per second (unit of velocity) |
| kg/$m^3$ | = | kilogram per meter cubic (unit of density) |

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

This chapter will cover on objective, problem statement, scope and outline of the whole project. Furthermore, in this chapter, the information on the project will be stated clearly to enhance the understanding to achieve the project goal.

## 1.2 PROBLEM STATEMENT

Buckling has become of a problem in recent years since the use of high strength material require less material for load to support structures. If buckling deflections become too large then the structure fails, this is a geometric consideration, completely divorced from any material strength consideration.

If a component or part there of is prone to buckling then its design must satisfy both strength and buckling safety constraints. The phonomenon of buckling is the single most important factor limiting the load-bearing strenght of structure.

Hollow rectangular are in general highly efficient structures of building and they have wide of application. For example, in the automotive, construction industries and others have caused these categories to be considered as the modern structures. Buckling is one of the main failure considerations when designing these structures.When hollow rectangular structures are loaded in axial impact and with high speed, buckling will be occur. The reliable prediction of the buckling strength of material is a strong aspiration for engineers.

Control of buckling process is important because fail to control buckling at certain point maybe will result in more severe damage to the structure. The method that can use to control buckling is with attaching solid mass at structure. Buckling can be control to occur at certain position

## 1.3 OBJECTIVE

To investigate whether buckling process can be controlled or not by attaching solidmass at hollow rectangular tube in order to control the deformation when axial impact is applied.

## 1.4 SCOPE

i. Literature review on buckling mechanism and method to control buckling
ii. Find suitable method to control buckling lobe onset of hollow rectangular tube when axial impact applied
iii. Investigate and conclude the mechanism of deformation of hollow rectangular tube

## 1.5 PROJECT OUTLINE

Based on this project, chapter 1 will be discussed on problem statement, objective and scope of the project. Furthermore, for chapter 2, we will discussed on literature review that related control of buckling lobe onset for hollow rectagular tube under axial impact. Then, for chapter 3, we will be discussed on methodology of controling buckling by numerical simulation using FEM software ( ABAQUS ) that will be used in this project. Then, for chapter 4, we will discuss on evaluation and analysis of result produce numerical simulation. Lastly, in chapter 5, we will discussed on recommendation and conclusion of entire project in order to improvement previous control of buckling method that have been developed.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

This chapter will cover on the overview of the project, also the study of theories and methods to get the idea on research that was conducted by researchers around the world. Literature review has been done to explore the previous research related to control of buckling lobe onset for hollow rectangular tube under axial impact. Furthermore, this chapter will define about buckling, axial impact, and other related topics in order to strengthen the knowledge on method to control of buckling using journals, seminars papers, books and etc. On the other hand, the literature review has been continued to discover the previous research which related to the analysis that was done and the results obtained by the researchers examined will be compared as guidelines for carrying out this project.

## 2.2 BUCKLING

According to the Wierzbicki's theory, crushed shape of square tube can be modeled by basic element, as show in figure 2.1 ( Abramowicz, W. and Jones, N. 1984 ) pointed out that dynamic progressive buckling of square tube could have four type of mode – symmetric mode, asymmetric mode A, asymmetric mode B and extensional mode. Each layer of symmetric mode consist of 4 type I element. Each two layer of asymmetric mode A consist of 6 type I element and 2 type II element. Each two layer of asymmetric mode B consist of 4 type II element. Extensional mode of square tube is similar to axisymmetric mode or concertina mode of cylindrical tubes. As extensional energy is include in type II element, the extensional mode absorbs more energy than other modes.

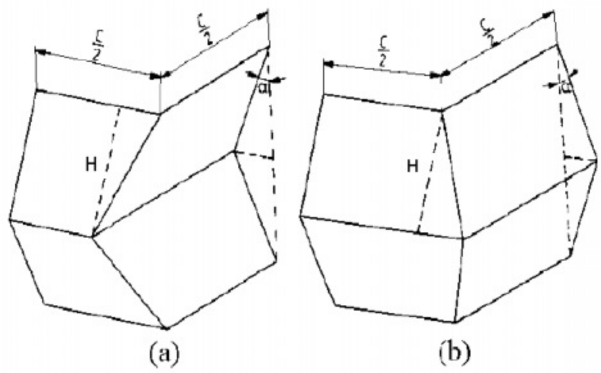


**Figure 2.1 :** *Basic Collapse Element of Dynamic Progressive Buckling Of Square Tube (a) type I, (b) type II. ( source : Abramowicz, W. and Jones, N. ( 1984 ) )*

Drop test on square tube has been performed excessively. In ( Abramowicz, W. and Jones, N. 1984 ) and ( Wierzbicki's, T. and Abramowicz, W. 1983 ) among many others work, extensional mode wasn't observed in experiment. To the author's knowledge, extensional mode of hollow square metal tube is only reported once by ( Langseth, M. and Hopperstad, O.S. 1996 )

The dynamic buckling of elastic–plastic tubes is characterised by two well-distinguished phases of deformation: an axial compression and expansion followed by a bending phase . ( Karagiozova, D and Jones, N. 2000 ). Buckling pattern can be analysis by using experimental method and numerical simulation. The experimental method buckling pattern as show in figure 2.2 and the buckling pattern obtained numerically in figure 2.3 show good agreement with the experimental shapes obtained for the same loading and others conditions

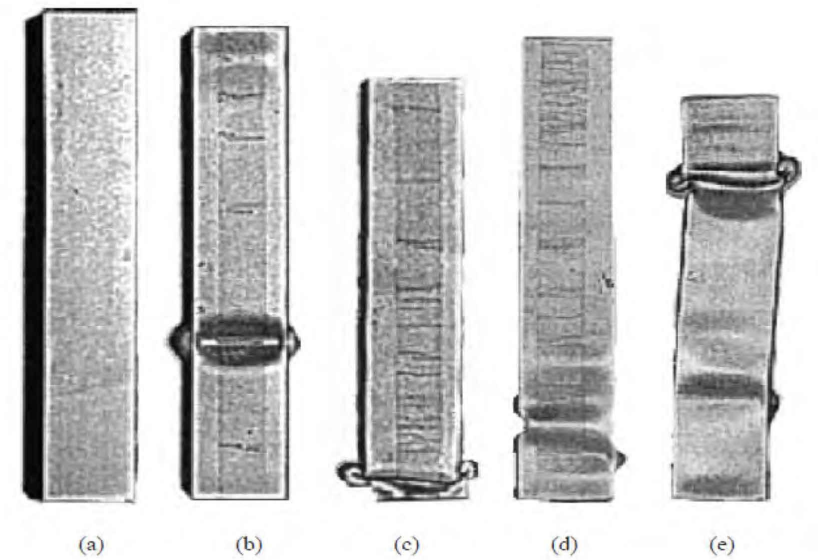


**Figure 2.2 :** *Buckling pattern of experimental method ( Source : Karagiozova, D and Jones, N. ( 2004 ))*

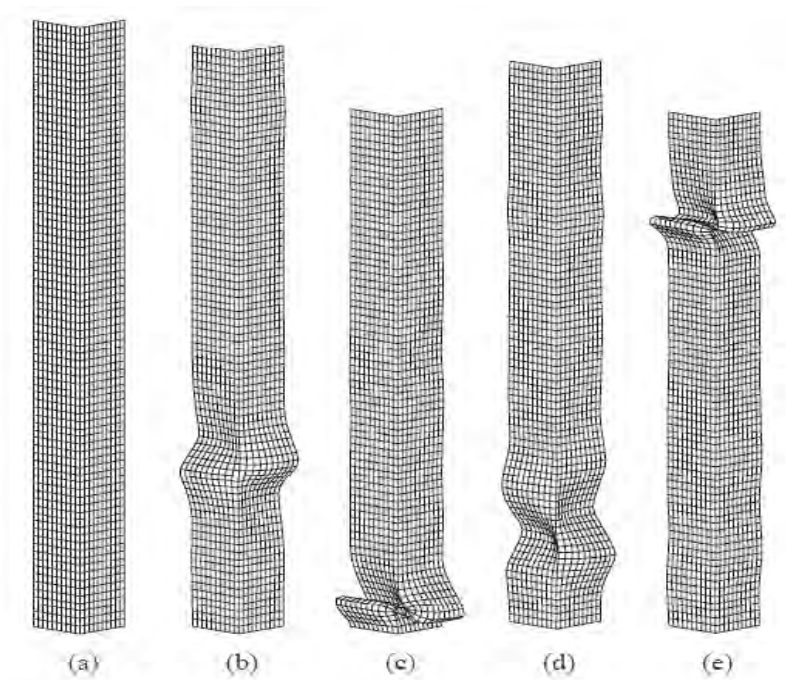


**Figure 2.3 :** *Buckling pattern of numerical simulation ( Source : Karagiozova, D and Jones, N. ( 2004 ))*