THE SOLID WOOD FILLED TUBE UNDER AXIAL LOADING

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DECLARATION

I declare that this project report entitled “The Solid Wood Filled Tube Under Axial Loading” is the result of my own work except as cited in the references

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this project report 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 (Structure & Materials).

Signature : ....

Supervisor's Name : ....

Date : ....

DEDICATION

To my beloved mother and father

ABSTRACT

Efficient energy absorbers are widely made from thin-walled structures such as aluminium because of the good energy absorption capacity. In this paper, the behavior of hollow tubes and wood-filled tubes that subjected to axial loading in quasi-static test is studied. Agarwood which known as "Gaharu" would be the wood that been used in this study. To this aim, quasi-static axial loading test have been performed on square and circular aluminium tube. Experimental work showed the effect of solid wood for the energy absorption capacity of tubes. The mode of deformation for the circular tube and square tube is investigated. Results from the quasi-static test are presented on tubes of various length which consisted of 50mm, 100mm, 150mm and 200mm. Theoretical models of axial collapse modes for circular tube and square tube has been developed and established a comparison between theoretical results and experimental results. The results obtained for the mean load and plastic wavelength agreed reasonably with the experimental observations. Satisfactory agreement were generally achieved between theoretical value and experimental value of mean load and plastic wavelength. In this paper, it also highlighted the comparison of square tube and circular tube in terms of energy absorption and specific energy absorption. The energy absorption in wood-filled tube is shown to be higher than the hollow tube whereas the specific energy absorption in hollow tube is shown to be higher than wood-filled tube. Some observations are made on the influence of geometrical imperfection and the methods to reduce the deviation of theoretical value and experimental value.

ABSTRAK

Penyerap tenaga yang cekap diperbuatkan daripada struktur berdinding nipis secara meluas seperti aluminium kerana mempunyai kapasiti penyerapan tenaga yang baik. Dalam laporan ini, ciri-ciri tiub berongga dan tiub dipenuhi kayu yang dikenakan pembebanan paksi dalam ujian kuasi-statik akan dikaji. Kaya gaharu akan digunakan dalam kajian ini. Untuk mencapai matlamat ini, ujian statik beban paksi telah dilakukan ke atas tiub aluminium persegi dan bulat. Eksperimen menunjukkan impak daripada kayu yang kukuh kepada kapasiti penyerapan tenaga tiub. Cara ubah bentuk untuk tiub bulat dan tiub persegi telah dikaji. Keputusan ujian kuasi-statik yang ditunjukkan adalah pada tiub yang terdiri daripada pelbagai kepanjangan seperti 50mm, 100mm, 150mm dan 200mm. Model teori untuk mod kejatuhan paksi untuk tiub bulat dan tiub persegi telah dibangunkan dan mewujudkan suatu perbandingan antara keputusan teori dan keputusan eksperimen. Keputusan yang diperolehi untuk beban purata dan kepanjangan plastik gelombang adalah munasabah dengan pemerhatian daripada eksperimen. Persetujuan yang memuaskan pada umumnya dicapai antara nilai teori dan nilai eksperimen beban purata dan kepanjangan plastik gelombang. Dalam laporan ini, ia juga menekankan perbandingan tiub persegi dan tiub bulat dari segi penyerapan tenaga dan penyerapan tenaga tertentu. Penyerapan tenaga dalam tiub dipenuhi kayu ditunjukkan lebih tinggi daripada tiub berongga manakala penyerapan tenaga tentu dalam tiub berongga ditunjukkan lebih tinggi daripada tiub dipenuhi kayu. Beberapa pemerhatian yang dibuat ke atas pengaruh ketidaksempurnaan geometri dan kaedah untuk mengurangkan penyelewengan nilai teori dan nilai eksperimen.

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ASTM	American Society for Testing and Materials
AutoCAD	Auto Computer Aided Design
kPa	kiloPascal
MPa	MegaPascal
GPa	GigaPascal
UTM	Universal Testing Machine
LED	Light Emitting Diode
J	Joule
kJ	kiloJoule
kg	kilogram
N	Newton

LIST OF SYMBOLS

D	=	Diameter
t	=	thickness
Y	=	yield strength
H	=	tube length
E	=	modulus of elasticity
σ	=	sigma
A	=	cross sectional
P	=	magnitude of load
P_{max}	=	initial phase peak load
P_{ij}	=	maximum and minimum load
P_m	=	mean or average load
EA_i	=	energy absorptions quantity
H	=	plastic half fold length
h	=	thickness
M_o	=	fully plastic bending moment per unit length
n	=	number of lobes
c	=	side length

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, safe design of components and systems is an important issue in our community. This is due to the purpose of decreasing the human suffering as well as the financial burdens on society. One of the awareness that increased among public is what can be done in order to reduce the potential danger of impact dangers. One of the many types of tragedies like vehicle crash, the occupant safety is the main concern. So, the vehicle structures need to be designed well, acted as collision safety protection to absorb and dissipate the direct impact force (Alghamdi, 2001). Thin-walled structures are widely used in the crashworthiness application such as automotive and aeronautical to withstand the impact force (Liu et al., 2015). An energy absorber is a system that transform, fully or partially, kinetic energy into another form of energy. Thin-walled structures are good energy absorber due to the impressive folding deformation during axial compression (Alavi Nia and Parsapour, 2014). Techniques of applied load, transmission rates, deformation patterns and material properties are the dependent variables for the conversion of kinetic energy into plastic deformation (Johnson and Reid, 1978). In addition, thin-walled structures are light weight, economic, high ductility and ease of manufacture. Since long time ago, there are many researchers had done the studies on how to enhance the energy absorbance and dissipation during crash via changing material characteristic, geometry and type of filler.

Generally, there are various types of absorbers that been used such as tubular rings, circular tubes, square tubes, corrugated tubes, honeycomb cell and so forth. Under the quasi-static loadings, the square tube and circular tube will be collapsed in either concertina, diamond or mixed mode. Basically, there are divided into seven categories such as sequential concertina, sequential diamond, Euler, concertina and diamond, simultaneous concertina, simultaneous diamond and tilting of tube axis (Andrews et al., 1983).

For these thin wall tubes, the filler such as solid wood can be combined with the tubes to stabilize and minimize the probability of the tubes to undergo Euler type of buckling. For the square tubes and circular tubes that filled with solid wood, it has been proved that the solid wood is able to increase the stability of the tubes (Lampinen and Jeryan, 1982).

This is because the filling of solid wood enable the tubes to undergo higher plastic deformation and higher energy absorption (Duarte et al., 2015).The solid wood is able to decrease the half-wavelength of the elastic buckling mode to values nearer to plastic fold lengths. Therefore, the energy absorption capacity can be enhanced by eliminating the non-compact mode (Reddy and Wall, 1988).

The solid wood filled tube and the empty tube will be compared in terms of the peak load, mean plastic half wavelength, energy absorption and the buckling mode (Florence et al., 1991). The energy absorption of the empty square tube and circular tube is roughly half of the energy absorption of the solid wood filled tube (Reid and Reddy, 1986). It is known that the interaction between the solid wood and the tube can provide a maximum benefit when there is an optimum combination (Reid et al., 1986).

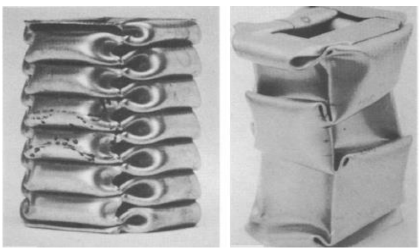

Figure 1.1 Axially crushed square tube in compact and non-compact mode (Reddy and Al-Hassani, 1993)

1.2 Problem Statement

The impact of transport vehicles is an unfortunate but common occurrence. It is becoming apparent that, in the future, transport structures will have to be designed to withstand impact and crashes. The current trend in producing lighter structures but puts greater demands on the designer since more aspects of design become critical as the weight is reduced, and working stresses become closer to the ultimate strength of the material. In the case of crash or impact, the requirement is achieved through properly designed high absorption system. Thin-walled structure is always a good energy absorber but there is still insufficient to sustain the huge impact that acted upon it sometimes. So, the combination of the filler such as solid wood with the tube is able to increase the energy absorption and prevent the happening of fatal accident.

1.3 Objectives

The objectives of this project are as follows:

1. To observe and study the deforming mode of empty and filled tube under axial loading
2. To determine the plastic wavelength and compare with theory
3. To study the load-displacement characteristics and lead to energy absorption

1.4 Scope of Project

The experimental project will focus on the empty and wood filled circular and square tube that will be compressed. The mode is compared between quasi-static with various length of tube with only one type of local wood. The deforming mode, plastic folding, mean load and densification and energy absorbed will be observed. INSTRON quasi-static is used to perform experimental. Previous analytical work will be compared. Particularly in Euler Global bucking is searched and observed. Compression of wood alone is also performed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature study is to find the relevant information that related on the solid wood filled tube under axial loading. The criteria that included in this chapter are energy absorber, deformation mode of empty tube, solid wood, uniaxial loading and mechanical properties.

2.2 Energy Absorber

Energy absorber is a device that able to absorb energy due to impact and dissipate it in other form of energy which is ideally in an irreversible manner. An energy absorber should be light in weight and able to keep the maximum allowable retarding force the same with the greatest displacement. Tubes that will buckle in the progressive manner when subjected to axial compression is providing a cheap and good energy absorbing capacity (Jones, 2012).

Circular and square shape tubes are frequently preferred as energy absorber due to their common occurrence and easy manufacturability. For example, circular tubes can dissipate elastic and inelastic energy through different modes of deformation which show the different response of energy absorption. Lateral compression, lateral indentation, tube splitting, tube inversion and axial crushing are the examples of the methods of deformation.

Nowadays, mostly all of the transportation are designed with thin-walled component. The structure components of vehicles must withstand the huge loading or impact during various kinds of accident to meet stringent integrity requirements. For instance, accidents are happened either motorcycles, car or aeroplane, the design of the passenger seat must able to withstand