# REINFORCEMENT BENEFITS OF NATURAL FIBER IN LIME-TREATED ASPHALT BASED DAMPING MATERIAL

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

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2018

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Sesi Pengajian: **2017/2018 Semester 2**

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I hereby, declared this report entitled "Reinforcement Benefits of Natural Fiber in Lime-Treated Asphalt Based Damping Material" is the results of my own research except as cited in references.

Signature : …….....

Author's Name : PUA RUI SI

Date : 26th JUNE 2018

# APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons.). The member of the supervisory committee is as follow:

…….

(Project Supervisor)

(PROF. DR. QUMRUL AHSAN)

# ABSTRAK

Kajian ini fokus pada kesan-kesan untuk memperkukuh jenis gentian daun teh terpakai dan jumlah beban gentian daun teh terpakai yang berbeza (0~20%) pada kapasiti redaman daripada komposit asphalt-daun teh terpakai. Komposit berguna untuk menghasilkan bahan viscoelastic. Objektif kajian ini adalah untuk menyiasat kesan-kesan daripada perbezaan jenis dan jumlah isi gentian daun teh terpakai dalam sifat fizikal dan akustik pada bahan redaman mendasarkan asphalt dengan menggunakan ujian fizikal dan mekanikal. Bahan redaman berdasarkan asphalt dihasilkan melalui proses pencampuran mekanikal dan tekanan isostatik panas. Sifat fizikal diuji oleh pengukuran ketumpatan, ujian rintangan haba dan interaksi interfacial antara dua fasa komposit asphalt-daun teh terpakai dan rasuk keluli ringan telah dicirikan oleh mikroskop optik. Walau bagaimanapun, sifat akustik diuji oleh ujian oberst beam. Berdasarkan keputusan analisis dan pencirian telah menunjukkam bahawa menambah sama ada gentian kasar atau halus dalam jumlah isi gentian daun teh terpakai mampu menghasilkan hasil sampel lembaran redaman yang lebih ringan daripada sampel untuk dikawal. Jumlah beban 15% gentian kasar atau halus daun teh terpakai menunjukkan ketumpatan terendah di antara semua gentian bahan komposit redaman (0~20%). Dalam ujian rintangan haba, bahan lembaran redaman yang diisi dengan gentian adalah stabil sebagai sampel untuk dikawal dan tidak terdapat sebarang tanda-tanda penyingkiran antara muka atau retak yang diperhatikan dalam mikrograf mikroskop optik. Penggunaan daun teh terpakai boleh meningkatkan redaman getaran yang menunjukkan pengurangan puncak frekuensi dan mengurangkan penghantaran getaran dengan peningkatan jumlah beban gentian daun teh terpakai.

# ABSTRACT

This research focuses on the effect of reinforced different types and fiber loading of spent tea leaf fiber (0~20%) on the damping capacity of asphalt-spent tea leaf composites. Composites were fabricated as a viscoelastic sheet material. The objectives of this research are to investigate the effect of different types and spent tea leaf fiber loading on physical properties and acoustic properties of asphalt damping composite material by using the physical and mechanical characterization. The asphalt damping composite materials are fabricated through mechanical stirring and hot compress moulding process. The physical properties were tested through density measurement, cyclic heat resistance test and the interface condition between the mild steel beam and asphalt-spent tea leaf composites were characterized through optical microscope technique. The acoustic properties were tested through Oberst Beam Method analysis. From the analysis and characterisation result, it has revealed that with the increase of either coarse or fine fiber loading are capable to resulting damping sheet samples yield lighter as compared to controlled sample. 15% coarse or fine spent tea leaf fiber loading shows the lowest density among all fiber filled damping material composites (0~20%). Fiber filled damping sheet materials are stable as controlled sample in cyclic heat resistance test and there is no sign of interface delamination or cracking were observed in micrographs of optical microscope. The use of spent tea leaf fiber can improve the vibration damping which shows reduction in frequency peak and reduce vibration transmission with the increase of fiber loading.

# DEDICATION

Dedicated to

my beloved father, Pua Gek Hui

my lovely mother, Chuah Mooi Yean

and my adored siblings, Pua Swee Ying and Pua Rui Ching

for giving me moral support, cooperation, encouragement and also understanding.

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| | | |
|---|---|---|
| ASTM | - | American Society for Testing and Materials |
| BIW | - | Body-In-White |
| $CaCO_3$ | - | Calcium Carbonate |
| CLT | - | Cross-Laminated Timber Plates |
| CO | - | Controlled |
| $CO_2$ | - | Carbon Dioxide |
| DMA | - | Dynamic Mechanical Analysis |
| E’ | - | Elastic Modulus |
| E’’ | - | Loss Modulus |
| FE | - | Flax/Epoxy |
| FLD | - | Free-Layer Damping |
| FRF | - | Frequency Response Function |
| GE | - | Glass/Epoxy |
| GFE | - | Glass/Flax/Epoxy |
| IPCS | - | International Programme on Chemical Safety |
| NVH | - | Noise, Vibration and Harshness |
| OBM | - | Oberst Beam Method |
| OM | - | Optical Microscopy |
| SLP | - | Stress-Laminated Plates |
| STL | - | Spent Tea Leaf |
| STL-C | - | Coarse Spent Tea Leaf |

| | | |
|---|---|---|
| STL-F | - | Fine Spent Tea Leaf |
| TLF | - | Tea Leaf Fiber |
| VEM | - | Viscoelastic Material |
| WF | - | With Filler |

# LIST OF SYMBOLS

| | | |
|---|---|---|
| % | - | Percentage |
| °C | - | Degree Celsius |
| $g/cm^3$ | - | Gram per cubic centimetre |
| g/l | - | Gram per litre |
| GPa | - | Gega Pascal |
| Hz | - | Hertz |
| $kg/m^3$ | - | Kilogram per cubic metre |
| $kgf/cm^2$ | - | Kilogram-force per square centimetre |
| mins | - | Minutes |
| mm | - | Millimeter |
| GPa | - | Gega Pascal |
| MPa | - | Mega Pascal |
| Pa | - | Pascal |
| wt% | - | Weight Percentage |

# CHAPTER 1

# INTRODUCTION

This chapter describes the background of the study, the problem statements, the objectives and the scope of the study.

## 1.1 Background Study

In today's nature life, a greater challenges has been given to the environment and community health which motivates the researchers to carry forward new techniques and take advantages of the yearly produce agriculture residues. Thus, there are many kind of materials have been recycled from those waste residues which can called as green materials. The agriculture residues are useful to manufacture a new sound absorber and insulator which will benefits to the environment because it solves the noise and environmental pollution. At present, the natural fibrous materials are used to replace with commercially available glass or mineral fibrous materials due to its lightweight, low cost, and biodegradable properties. There are several fibrous materials such as foam, mineral fibers and glass wool are utilized in many industrial applications in order to minimize noise in vehicles, manufacturing area and building. The objective of this project is to discuss the measured physical and acoustical properties of spent tea leaf wastes' based damping material. Tea is a non-alcoholic drinks prepared from infusion of the leaves and buds of Camellia sinensis. Batiancela *et al*. (2014) found that the international consumption of tea is approximately 4.5 million tons yearly and

it becomes the second highest most popular beverage in the world. The extracted Camellia sinensis will turn into a large volume of waste tea leaf residues and it will cause increasing in solid waste and disposal issues in many nation. Besides that, spent tea leaf is a valuable natural fiber with good mechanical properties. The main purpose to use synthetic fiber replaced with natural fiber (spent tea leaf) to reduce the environmental impact, reduce the weight of vehicle, decrease the fuel consumption, provide low cost market and good noise, vibration and harshness (NVH) management in order to fulfil the market needs.

Damping sheet material is used to reduce the amplitude of vibration, resonance frequency and vibration transmission. A good sound absorption properties materials can revealed that they have good acoustic performance and it ensures the car passengers feel safe and acoustic comfort. Automotive manufacturers are apply many free layer of viscoelastic damping sheet materials to Body-In-White (BIW) vehicles in order to receive effective acoustic performance, better vibration isolation, good perform on harsh environment and provide a low density of vehicle. Most of the damping sheets are called as asphalt sheets and it is applied onto floor pan or body panel inside the vehicle. The amount of these sheets can reach application weights of 10kg/vehicle and it is fully depending on the size of vehicle (Fonseca *et al*. 2010).

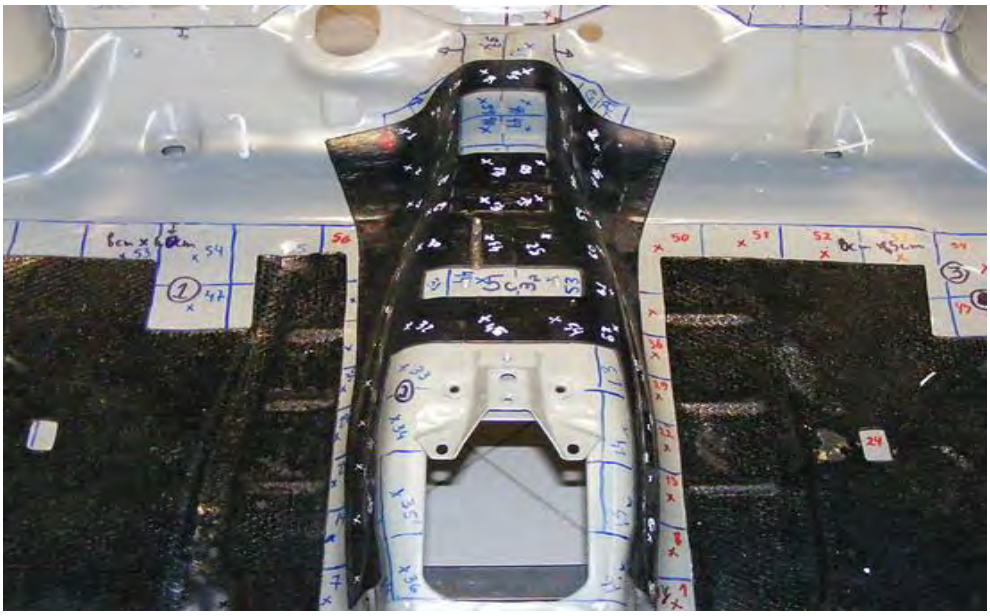

Figure 1.1: Damping material applied on body panels

There are three primary mechanisms of damping are important in the study of mechanical systems which are structural damping (at joints and interfaces), internal damping (material) and fluid damping (through fluid-structure interactions). In this study, structural damping mechanism is focused by automotive industry. Mechanical energy dissipation resulting from relative motions between components in a mechanical system that comprise common points of support, contact or joints that is the cause of structural damping.

Last but not least, reduce the weight of a vehicle can improve the rate of energy consumption. Thus, maximized the treatment of damping material on the body panel and floor pan of vehicles in order to receive the material loss factors. The storage modulus and loss factor of viscoelastic material are the main properties that highly dependent on frequency and temperature (Treatment, 2015).

## 1.2 Problem Statement

Nowadays, automotive production rate has increased continuously and it is estimate to reach 76 million cars annually by 2020 by Hassan *et al*. (2017). Due to these reasons, utilization of biodegradable materials like bio-composite is an efficient ways to decrease in weight of vehicles and carbon dioxide emission. Conventional damping sheets are focus on increase the thickness of the damping sheet or incorporating various fillers to improve the damping effect but it is not suitable to manufacture customer demanded lightweight vehicle. Thus, there has possibility of using low density filler in order to improve the damping effect.

Furthermore, natural fibers have increase renewed attention, especially as a glass fiber substitute in automotive manufacturing by Hassan *et al*. (2017). Nevertheless, there are some shortcomings of using natural fibers in the composites such as poor moisture resistance, poor fire resistance, and lack of fiber-matrix adhesion. Spent tea leaves (STL) as a new resources for sound absorption composite materials because spent tea leaves are rich in polyphenols and thus it help to possess high durability, high resistance to fire and fungal.

Moreover, the layout of free layer damping treatment is not optimized and induced unnecessary increase in vehicle average weight. Spent tea leaf fiber is used to replace artificial materials with the goal to achieve low density, low fuel consumption, and provides better stiffness per weight than synthetic fiber (glass). Furthermore, most of the automotive manufacturers are focus to use several free-layer damping sheet materials to apply on Body-In-White (BIW) of the vehicle in order to achieve the desired noise, vibration and harshness (NVH) management and lighter weight of vehicle.

In conclusion, most of the damping materials contain synthetic fillers, which give a negative impact to the environment and human health. Due to this issues, spent tea leaf fiber filler is used to introduce alternative fillers in order to improve human health, enhance environmental protection, decrease $CO_2$ emissions, and improve acoustic performance.

## 1.3 Objectives

The objectives of this research are:

(a) To investigate the effect of different types of spent tea leaf (STL) fiber and fiber loading on physical properties of asphalt damping composite material.

(b) To investigate the effect of different types of spent tea leaf (STL) fiber and fiber loading on acoustic properties of asphalt damping composite material.

## 1.4 Scopes of Research

The scope of the study is to focus on the preparation and characterisation of different types of spent tea leaf fiber and fiber loading in lime-treated asphalt based damping material. In this research, there are two different types of spent tea leaves are used such as coarse fiber and fine fiber. There are two fillers used to improve the stiffness of asphalt and acoustic performance which are calcium carbonate powder and mica powder. Asphalt-steel interface condition is studied under cyclic heat resistance test and characterized by optical microscopy (OM) technique. The material loss factor of asphalt based damping material are determined through oberst beam method (OBM) technique.