

THE EFFECT OF COCONUT SHELLS ON ENGINEERING  
PROPERTIES OF POROUS ASPHALT

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*To my beloved father and mother, my siblings and my special friend*

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## **ABSTRACT**

Properties of porous asphalt using coconut shells as substitute to aggregate is being studied. The control specimen of conventional porous asphalt and samples of porous asphalt incorporating 10%, 30% and 50% coconut shells were made. The physical properties of the coconut shells as well as the engineering properties of porous asphalt with coconut shells mixtures were investigated in the laboratory. Seven different tests were tested for each mixtures. The tests were including Marshall, Cantabro, binder drain-down, air voids, theoretical maximum density, permeability and impedance tube test. While to determine the materials properties, another four tests were conducted. They were including sieve analysis, aggregate impact value, specific gravity and water absorption test. From the investigation, it is found that the porous asphalt incorporating 10% coconut shells have pass all the parameters tested similar to conventional porous asphalt. It also shows better result for permeability and sound absorption. However, porous asphalt with 30% and 50% coconut shells shows a decrement of performance for engineering properties of porous asphalt.

## ABSTRAK

Ciri – ciri asphalt berliang yang menggunakan tempurung kelapa sebagai alternatif kepada agregat telah dikaji. Spesimen kawalan asphalt berliang konvensional dan sampel asphalt berliang yang mencampurkan 10%, 30% dan 50% tempurung kelapa sebagai ganti kepada batu baur telah dibuat. Sifat fizikal tempurung kelapa dan ciri-ciri kejuruteraan campuran asphalt berliang dengan tempurung kelapa telah dikaji di dalam makmal. Tujuh ujian telah dijalankan kepada setiap campuran. Ujian - ujian tersebut termasuklah *Marshall*, *Cantabro*, *Binder drain-down*, lompong udara, ketumpatan maksimum teori, kebolehtelapan dan tiub galangan. Manakala untuk menentukan sifat fizikal bahan, empat ujian lain telah dijalankan. Ianya termasuk analisis ayakan, penentuan nilai impak agregat, graviti tentu dan ujian serapan air. Daripada ujian-ujian tersebut, didapati bahawa kandungan asphalt berliang yang mengandungi 10% tempurung kelapa telah lulus semua parameter yang diuji sama seperti asphalt berliang konvensional untuk setiap ujian yang telah dijalankan. Ianya juga menunjukkan keputusan yang lebih baik bagi ujian kebolehtelapan dan serapan bunyi. Namun begitu, asphalt berliang dengan kandungan 30% dan 50% tempurung kelapa menunjukkan penurunan prestasi dari segi sifat kejuruteraan asphalt berliang.

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## LIST OF ABBREVIATIONS/SYMBOLS

AASHTO	-	American Association of State Highway and Transportation Officials
AIV	-	Aggregate Impact Value
ASTM	-	American Society for Testing and Materials
BS	-	British Standard
HMA	-	Hot Mix Asphalt
JKR	-	Jabatan Kerja Raya
LAAB	-	Los Angeles Abrasion Value
OBC	-	Optimum Bitumen Content
SG	-	Specific Gravity
TMD	-	Theoretical Maximum Density
$k$	-	Coefficient of Permeability
$a$	-	inside cross-sectional area of inlet standpipe, cm <sup>2</sup>
$l$	-	thickness of test specimen, cm
$A$	-	cross - sectional area of test specimen, cm <sup>2</sup>
$t$	-	average elapsed time of water flow between timing marks, s
$h_1$	-	hydraulic head on specimen at time $t_1$ , cm and
$h_2$	-	hydraulic head on specimen at time $t_2$ , cm

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

The development of infrastructure across the world especially building and road have created demand for aggregate application. Aggregates are the major ingredients in concrete as well as in asphaltic concrete. The pavement industry typically relies on the physical properties of the aggregate which is have a good strength and durable. However, because of the high demands of this natural material, many hillsides had been blown up and many mines had been dug which is significantly impact the environment. Creating the pits and the quarries not only effect to wildlife and biodiversity but also lead to affect the overall ecosystem by noise, dust, pollution and contaminated water.

Realizing this, in the modern civil engineering construction, the use of alternative materials substitute to the use of natural aggregate is being actively pursued. Different alternative of materials to replace the use of natural aggregates are used such as coal ash, blast furnace slag, fibre glass, waste plastics and others (Brito and Saikia, 2013). Other than industrial by products, the agricultural by product also can be used as replacement

of aggregate such as coconut shells. A few studies had been conducted to find the effects of coconut shells as aggregate in concrete. But until now, there is no study available in determining the effect of this agricultural product as aggregate in asphaltic concrete. Thus, the aim of this study is to find the effect of coconut shell on engineering properties of porous asphalt and to give an alternative replacement of the aggregate in road industry.

## **1.2 Problem Statement**

Widely exploration of nature to extract aggregate can cause a huge impact for an ecosystem, animal wildlife and biodiversity. Besides, it will effect a natural water recharge and this will lead into a reduce quantity of drinking water. Furthermore, environment concern also causes the shortage of aggregates such as in Taiwan due to the government policy to protect the nature (Shen at al, 2007).

To overcome this problem, waste material can be used as a replacement of aggregate. By using a waste material, it is like killing a two birds with one stone. There are now many study are being conducted on the use of waste materials as substitute of aggregate such as coal ash, blast furnace slag and waste plastics. The waste materials can be obtained from industrial by products such as various slag from metal industries and agricultural by product such as oil palm kernel and coconut shells.

There are a lot of studies on the effect of aggregate substitute using oil palm kernel and coconut shells in concrete properties, but only a few studies using oil palm kernel in asphaltic concrete. However, until now, there is no study using coconut shells

as aggregate substitute in asphaltic concrete and porous asphalt. The latest study found that coconut exhibit more resistance against impact, crushing and abrasion compared to crushed granite aggregate (Kukarni & Gaikwad, 2013). This shows that it is worth to study this agricultural product as aggregate substitute to asphaltic concrete and porous asphalt.

Besides, the using of coconut shells also can give benefit to environmental and people health. Usually, coconut farmer dispose all the spate, husk, leaves and petiole by burning or leave it in an open space. By using an open burning technique, it can caused a serious air pollution, soil erosion and a decrease in soil biological activity. This will lead to decreasing of a soil fertility (Jr, 2013).

By leaving a coconut shell in an open space, it will cause a serious health issue. During a rainy seasons, a hollow center of the coconut shell are suitable to hold a water, thus it will become a perfect condition for a malaria or dengue carrying mosquito to breed. This disease cause a high number of death compared to the other disease in the coastal region. By eliminating a place for a mosquito to breed, this option should be seriously examined.

Thus, this study is to use the coconut shells as replacement of the aggregate in porous asphalt. The utilization of waste materials as replacement materials in construction industry can reduce the pollution and can contribute to sustainable environment.

### **1.3 Objectives**

This study is conducted for the purpose of :

- i) To study the effect of coconut shells on engineering properties of porous asphalt mixture.
- ii) To evaluate the performance of porous asphalt mixture with coconut shells onto reducing noise by traffic.

### **1.4 Scope of the study**

This study is limited for the scope below:

- i) The bitumen used is polymer modified bitumen PG 76
- ii) The bitumen content used for this study is fixed to 5.0%
- iii) The materials testings' for the coconut shells are limited to sieve analysis, aggregate impact value, specific gravity and water absorption
- iv) The tests were conducted for the mixtures in this study are binder drain-down, marshall stability, theoretical maximum density, air voids, permeability, cantabro and impedance tube only.



## **1.5 Importance and Benefits of Study**

Due to high economic growth, a lot of large construction project are being constructed such as major construction of infrastructure, building and highway, increased the demand of aggregate. Highly demand of aggregate can lead the construction world have faces shortage of aggregates. This circumstance also can depletion of natural resources. Hillsides had been blown up and many mines had been dug which is significantly impact the environment. Alternatives such as the consumption of recycle aggregates or industrial by products as aggregates replacement could be really helpful in minimizing the damage and at the same time can supply the demands of the aggregate.

Furthermore, people would benefit if agricultural by products such as coconut shells can be used for road and other application. It can reduce the health issues cause by mosquitos that breed inside the hollow center of the coconut shells as well as the environmental issues cause by coconut farmer who dispose the coconut shells by burning it or leave it in an open space. Most importantly, our environment also can be protected and preserved and next generation can still enjoy and live in our precious mother nature.

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