STRUCTURAL PERFORMANCE OF ASPHALT BLOCKS PAVEMENT AS RELATED TO THICKNESS, BINDER TYPES, AND JOINT WIDTH

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Dedicated to Allah S.W.T,

my beloved Mother and Father

Thanks for your support and love.

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ABSTRACT

Asphalt block pavement is an innovative alternative to asphalt pavements. This study investigated the performance of asphalt paving blocks with a number of variables: block thickness, bitumen types and joint width between blocks. The effect of dynamic and static loads and their transfer from one block to another on the behaviour of asphalt block pavements were studied. Asphalt blocks were laid on sand bedding, but direct laying on a base course was also investigated. The experiments conducted in the laboratory were push-in test, pull-out test, and accelerated trafficking test. Two types of bitumen were used as binder to produce asphalt blocks: normal bitumen (60/70) and modified bitumen (PG 76) and different block thicknesses: 70 mm, 80 mm, and 90 mm. Asphalt blocks were laid in stretcher bond with various joint widths: no joint spacing, 2 mm, and 3 mm. The instruments of the push-in test and pull-out test were constructed within a steel box of 1.0 metre square; the push-in vertical load was increased from 0 to 30 kN on the samples of asphalt blocks. The accelerated trafficking loading test was conducted in a steel platform of 1.0 m × 5.0 m, the loaded wheel was moved over the pavement model and the deflection was taken at specific intervals. The results indicate that asphalt blocks have a great performance after being exposed to static load and dynamic load. The study shows that placing asphalt blocks directly on the base course resulted in uneven surface; therefore the bedding sand layer is a necessary component in the structure of asphalt block pavements. From the statistical results, the thickness of the block has insignificant impact on the structural performance. However, there is a trend that a change in block thickness from 70 to 90 mm decreases the deflection and displacement of asphalt block pavement which could be due to a greater frictional area and load transfer, thus increase the response of the pavement. The results also show the type of bitumen used in this study has insignificant impact on the structural performance. However, it has an impact on the compressive strength and density of the block. The finding reveals that placing blocks with no joint spacing is found to yield the best performance.

ABSTRAK

Turapan blok asfalt adalah inovatif yang alternatif kepada turapan asfalt. Kajian ini dijalankan untuk mengkaji prestasi struktur turapan blok asfalt dengan beberapa perubahan seperti ketebalan blok, jenis-jenisbitumen dan jarak antara blok yang digunakan. Kesan dinamik dan beban statik dan pemindahan dari satu blok ke blok lain pada prestasi blok turapan asfalt turut dikaji. Blok asfalt disusun atas lapisan pasir pengalas, tetapi turapan terus ke atas fondasi jalan juga dikaji. Eksperimen yang dijalankan adalah ujian bebanan tekan masuk, ujian bebanan tarik keluar, dan ujian lalu lintas dipercepatkan. Dua jenis bitumen digunakan untuk menghasilkan blokasfalt: bitumen biasa (60/70) dan bitumen diubahsuai (PG 76) dan ketebalan blok yang berbeza iaitu 70 mm, 80 mm dan 90 mm. Blok asfalt diletakkan bersama dalam corak ikatan usungan dengan tiada jarak di antara blok, 2 mm, dan 3 mm. Ujian bebanan tekan masuk dan ujian bebanan tarik keluar dilakukan dalam kotak keluli 1.0 meter persegi, dengan tekanan beban tegak ditingkat kandaripada sifar kepada 30 kN atas sampel blok asfalt. Ujian lalu lintas dipercepat kan dilakukan dalam platform keluli 1.0 m × 5.0 m di mana defleksi diambil secara khusus bila tayar-tayar melalui model turapan tersebut. Selepas didedah kepada beban statik dan dinamik, kajian telah menunjukkan bahawa blok asphalt mempunyai prestasi yang baik. Kajian tersebut menunjukkan bahawa blok asfalt yang diletakkan di atas lapisan fondasi menyebabkan permukaan yang tidak sekata. Oleh itu, lapisan pasir pengalas adalah satu komponen yang penting dalam struktur turapan blok asfalt. Dari keputusan statistik, ketebalan blok tidak memberikan kesan pada struktur prestasi. Walau bagaimanapun, keputusan ada menunjukkan kecenderungan di mana perubahan ketebalan blok dari 70 mm ke 90 mm menurunkan defleksi dan anjakan turapan blok asfalt. Blok tebal mengakibatkan geseran yang lebih luas dan perpindahan beban yang lebih besar, seterusnya meningkatkan tindak balas turapan. Pengujian tersebut menunjukkan bahawa jenis bitumen yang digunakan dalam kajian ini tidak banyak menghasilkan kesan dalam struktur prestasi.Walau bagaimanapun, ia mempunyai kesan ke atas kekuatan mampatan dan ketumpatan blok. Keputusan ujikaji menunjukkan tanpa menjarakkan blok asfalt antara satu sama lain dapat menghasilkan kesan yang paling baik.

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LIST OF ABBREVIATIONS

2D	-	Two-dimensional
3D	-	Three-dimensional
AASHTO	-	American Association of State Highway and Transportation Official
ASTM	-	American Society for Testing and Material
BS	-	British Standard
CBP	-	Concrete Block Pavement
CBR	-	California Bearing Ratio
ESA	-	Equivalent Standard Axle
JKR	-	Jabatan Kerja Raya
HALI	-	Highway Accelerated Loading Instrument
HMA	-	Hot Mix Asphalt
OBC	-	Optimum Bitumen Content
PG	-	Bitumen of Performance Grade
SSD	-	Saturated-surface-dry
TMD	-	Theoretical Maximum Density
VFB	-	Voids Filled with Bitumen
VMA	-	Voids in Mineral Aggregate
VTM	-	Voids in Total Mix

LIST OF SYMBOLS

A	-	Area
D, d	-	diameter
π	-	Pi = 3.14
Gmm	-	Maximum specific gravity
Gmb	-	Bulk specific gravity of a compacted mixture
S.G eff	-	Effective specific gravity of aggregates
σ	-	Stress

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CHAPTER 1

INTRODUCTION

1.1 Background

The use of small-segment paving to establish a solid surface for pavements has been a unique tradition which can be traced back to the royal roads of ancient Babylon, Greek and Roman eras. The block pavements have been widely used over the past years. The block pavements have been laid broadly along roads, especially where they are constructed on steep slopes or at junctions due to their ability to prevent vehicles from slippery and their resistance to load (Croney and Croney, 1998).

The general global tendency towards a beautification of some town pavements, the speedy rise in construction and maintenance cost have urged road engineers to find an alternative paving material. Furthermore, outstanding engineering properties of paving blocks such as ease of removal, reuse possibility and capability to be used in different weather circumstances have been the most important advantages of paving blocks to be used in a diversity of commercial, municipal and industrial applications.

There are several types of block pavements produced from different materials such as concrete blocks, clay bricks, and wood blocks (Thye, 1979). The asphalt blocks have been known and used along the roads in the USA and Canada for the past decade (Baillairgé, 1964). The bitumen is the main material in producing the asphalt blocks. Appropriate methods of manufacturing the blocks permit the production of a very dense and strong blocks with an ability to resist the worst conditions that may cause serious pavement distresses (Hanover Product Guide., 2012). Asphalt paving blocks are completely engineered consequences made in the factory to deliver consistency and accuracy. In addition, the machine used to produce the paving blocks tends to produce blocks of significantly higher quality than the conventional road pavements with respect to density, compressive strength and durability.

1.2 Problem Statement

Asphalt block pavements have been known and used in some places around the world such as in the United States, Canada, and Germany over the past decades (Baillairgé, 1964), but there have been very limited studies being carried out to evaluate the performance of such pavement.

Furthermore, the conventional (normal) asphalt pavements are constructed by using heavy machines such as paver machine, thereby, it would be beneficial to have an alternative method of laying and paving the roads. So that, asphalt can be formed into small segments (blocks) thus, blocks can be placed by hands.

By producing the asphalt paving blocks in factory, some merits might be achieved. The quality and strength of the paving blocks can be controlled. In other words, by compacting the normal asphalt pavement in open air area, many circumstances, such as rain, snow, and hot weather might affect the compaction, thereby, it would be useful to control the temperature of compaction of asphalt paving blocks in the factory.

1.3 Objectives

The main aim of this study is to develop asphalt blocks for road pavements and evaluate its structural performance. The main objectives of this study are as follows:

(i) To characterize the engineering properties of asphalt paving blocks.

(ii) To assess the structural performance of asphalt paving blocks which are affected by static and dynamic vertical loads with a number of variables: types of bitumen used as a binder of materials to produce asphalt blocks, joint widths (spacing) between the blocks, and thickness of the blocks.

(iii) To study the feasibility of placing the asphalt blocks directly on the base course instead of on the bedding sand layer.

1.4 Scopes of the Study

To attain the objectives, the scopes of the study are mostly through experimental works. The scopes of this study are:

(i) Development of asphalt paving blocks to characterize their engineering properties

a. Mechanical properties

- Block compressive strength
- Block density.
- Air voids.

b. Physical properties

- Block dimensions.

(ii) The effect of bedding sand layer and evaluate the placement of asphalt paving blocks directly on the base course.

(iii) Application of asphalt paving blocks as a structural system to evaluate the structural performance.

Assessment of structural performance of asphalt block pavements was based on:

a. Accelerated trafficking loading test:

- Longitudinal and transverse rutting profile.
- The effect of using a number of variables on pavement performance.
  Two and three-dimensional deformed surface
- Rut depth under wheel path.

b. Push-in loading test.

c. Pull-out loading test.

The experimental works and research program were carried out in this study with some limitation parameters as shown in Table 1.1.

Table 1.1 : Study scopes

Parameter	Selection
Laying pattern	Stretcher bond
Jointing sand	Passing 2 mm sieve size
Bedding sand	Passing 5 mm sieve size
Bedding sand layer thickness	30 mm (compacted sand)
Base course	Steel base plate with 3 mm neoprene sheet (simulate 6 % CBR)
Traffic accelerated load	12 kN on one wheel

1.5 Significance of the Study

The significant outcomes of this study can aid researchers as follows:

(i) This research presents the steps and procedures that can be followed to produce asphalt paving blocks with certain engineering properties.

(ii) Since the studies on asphalt paving blocks are very limited, therefore, this research presents the detailed results of the behaviour and performance of such block under different load conditions: dynamic load and static load.

(iii) As asphalt blocks are hand-paved (manual paving), therefore, this type of pavement can be a good alternative to the normal (conventional) asphalt pavement, especially to paving narrow roads where the heavy paver machines have difficulties to get in.

(iv) This study develops an innovative paving blocks which exhibit better engineering properties and comparable service performance.

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