UNIVERSITI PUTRA MALAYSIA

# SKID RESISTANCE AND TEXTURE DEPTH ANALYSIS OF STONE MASTIC ASPHALT

ABDULLAHI ALI MOHAMED

# SKID RESISTANCE AND TEXTURE DEPTH ANALYSIS OF STONE MASTIC ASPHALT

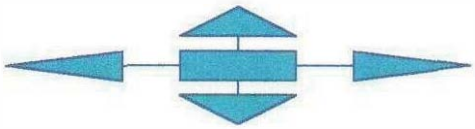
**By**

**ABDULLAHI ALI MOHAMED**

**Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Engineering Universiti Putra Malaysia**

**January 2001**

*Dedicated to My Beloved Family:*
*Dad (Ali Mohamed Hogsade), Mum (Haw Haji Hassan)*
*Brothers (Dr. Cabdirzaq, Abuker, Cabdikadir) and Sisters (Fatima, Canab and Luul)*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master Science

**SKID RESISTANCE AND TEXTURE DEPTH OF STONE MASTIC ASPHALT (SMA)**

**By**

**ABDULLAHI ALI MOHAMED**

**January 2001**

**Chairman:** **Mr. Ratnasamy Muniandy**

**Faculty:** **Engineering**

The skid resistance of highway pavements, particularly when wet, is a serious problem. As traffic speeds and densities continue to rise, the chances of skidding accidents as well as their consequences are both growing at an alarming rate with each passing year. Skid resistance between tire and road surface is a function of contact area. Maximum grip may be generated in dry conditions while in wet conditions the presence of surface water on the road surface may reduce the contact area and consequently reduce the available grip.

Since 1994, Universiti Putra Malaysia had been involved in Stone Mastic Asphalt (SMA) Technology research, to formulate for Malaysian roads, SMA, presents a very uniformly textured surface that can achieve grip or friction between rubber tire and road surface. In this study, pavement surface

interaction was given the highest priority, and slab specimens were prepared by varying gradation of SMA 14 to simulate the actual behavior of field skid resistance. Conventional hot mix asphalt was also prepared as a control.

The results of skid resistance and texture depth were tabulated with the variables (Angularity Number, Particle Index, and Percentage of Asphalt, Voids in Total Mix, Voids in Mineral Aggregate, Distribution of Coarse Aggregate and Polished Stone Value). Statistical analyses were performed to assess the relationship between physical and mechanical properties of the mix, and to study how the mixing materials contribute to the skid resistance and the texture depth of SMA. SPSS and EXCEL packages were employed to investigate these relationships.

The foregoing data indicate convincingly that Angularity Number as measured by the angularity test, had highly significant effects on the skid resistance of SMA. In this case, the British Portable Number is shown to increase with increasing value of angularity number. For coarse aggregate and percentage of asphalt has significant effect $P<0.05$ on texture depth.

It was also noted that the data of skid resistance and texture depth indicated a wide spread of values obtained ranging from SMA 14 ranging 93 up to 124 BPN units, regardless of composition of the mixture. It may therefore be concluded that SMA has the potential to optimize the contact area between tires and road surface under dry and wet surface conditions.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Máster Sains.

# RINTANGAN GELINCIRAN DAN KEDALAMAN PERMUKAAN CAMPURAN ASPHALT MAMAH

Oleh

**ABDULLAHI ALI MOHAMED**

**Januari 2001**

**Pengerusi: Encik Ratnasamy Muniandy**

**Fakulti: Kejuruteraan**

Rintangan gelinciran permukaan turapan, terutamanya ketika basah, merupakan satu masalah yang serius. Ketumpatan dan kelajuan traffik meningkatkan peluang berlakunya kemalangan akibat gelinciran dan kesannya meningkat pada kadar yang membimbangkan. Rintangan gelinciran antara tayar dan permukaan jalan adalah merupakan satu fungsi permukaan sentuh. Permukaan sentuh maksimum boleh dicapai pada keadaan kering. Bila terdapatnya kehadiran lapisan air di dalam keadaan basah, ia mengurangkan lagi permukaan sentuh ini sekaligus mengurangkan geseran permukaan.

Semenjak 1994, unit penyelidikan keselamatan Jalan Raya UPM telah terlibat dalam kajian menghasilkan teknologi Campuran Asphalt Mamah bagi kegunaan jalan raya di Malaysia; di mana ia dapat memberikan permukaan

yang kasar yang boleh mengurangkan kesan gelinciran antara tayar kenderaan dan jalan.

Dalam kajian ini, interaksi permukaan jalan diberikan keutamaan dan specimen slab disediakan dengan menggunakan variasi gradiasi SMA14 bagi mendapat keadaan sebenar di jalan terhadap rintangan gelinciran. Campuran asphalt panas yang lazim digunakan di jalan di sini juga disediakan sebagai sampel kawalan.

Keputusan rintangan gelinciran dan kedalaman permukaan ditabulusikan dengan pembolehubah ( AN, PI, PA, VMA, DOC dan PSV). Analisa statistik juga dijalankan bagi membantu mendapatkan hubungan antara sifat mekanikal dan fizikal campuran berkenaan dan juga bagi mengkaji bagaimana campuran ini menyumbang kepada rintangan terhadap gelinciran dan kedalaman permukaan asphalt mamah. Analisa ini dilakukan dengan menggunakan SPSS, SAS dan EXCEL.

Daripada data yang dianalisis, didapati Nombor Angularasi yang diperolehi melalui ujian Nombor Angularasi menghasilkan kesan paling ketara terhadap rintangan gelinciran campuran asphalt mamah. Dalam kes ini didapati BPN meningkat apabila meningkatnya nombor angularasi. Sementara itu, batuan kasar dan peratusan asphalt mempunyai kesan yang ketara terhadap kedalaman permukaan.

Dalam kajian ini juga mendapati data rintangan gelinciran dan kedalaman permukaan bagi SMA 14 adalah dalam lingkungan 93 ke 124 unit BPN tanpa mengira komposisi campuran berkenaan. Dengan ini dapat disimpulkan bahawa SMA, mempunyai potensi bagi memaksimakan kawasan sentuh antara jalan dan tayar dalam keadaan kering dan basah.

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Last but not least, I would like to express my deep gratitude and great indebtedness to my younger brother Abuker Ali for his emotional support and continual encouragement during my study. I pray that Almighty God may bless

all that have contributed in whatever way to the success of my studies at Universiti Putra Malaysia but have not mentioned here.

I certify that an Examination Committee met on 22th January 2001 to conduct the final examination of Abdullahi Ali Mohamed on his Master of Science thesis entitled "Skid Resistance and Texture Depth Analysis of Stone Mastic Asphalt " in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Date: 20 MAR 2001

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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**Date:** 12 APR 2001

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

Name: Abdullahi Ali Mohamed

Date: 20/3/2001

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| | |
|---|---|
| A.C.V | Aggregate Crushing Value Test. |
| A.I.V | Aggregate Impact Value Test. |
| AASHTO | American Association of State Highway and Transportation Official |
| AAV | Aggregate Abrasion Value |
| AN | Aggregate Angularity Number |
| ANOVA | Analysis of Variance |
| ASTM | American Society for Testing and Materials |
| DOC | Distribution of Coarse Aggregate |
| DOF. | Distribution of Fine Aggregate |
| HFWC | High Friction Wearing Coarse |
| HMA | Hot Mix Asphalt |
| BPN | British Portable Number |
| PA | Percentage of Asphalt |
| JKR | Jabatan Kerja Raya |
| L.A | Los Angels Abrasion Test |
| LVDT | Linear Variable Differential Transformer |
| TTI | Texas Transportation Institute |
| MATTA | The Material Testing Apparatus |
| N. R. | Negri Roadstone Quarry |

| | |
|---|---|
| NAA | National Aggregate Association |
| OECD | Organisation for Economic Co-Operation and Development |
| OBC | Optimum Binder Content |
| PDRM | Royal Malaysian Police |
| PI | Particle Shape Index of stones |
| PSV | Polished Stone Value |
| PWD | Public Works Department |
| RSRC | Road Safety Research Centre |
| S. G. | Aggregate Specific Gravity Test |
| SAS | Statistical Analysis Software |
| SGC | Superpave Gyratory Compactor |
| SMA | Stone Mastic Asphalt |
| SPSS | Statistical Package for Social Science |
| SST | Super Shear Tester |
| TD | Texture Depth |
| TRRL | Transport and Road Research Laboratory |
| TSR | Tensile Strength Ratio |
| U.S.A | United States of America |
| UPM | Universiti Putra Malaysia |
| SMA-UPM | UPM – In House Procedure |
| VFA | Voids Filled with Asphalt |
| VMA | Voids in Mineral Aggregate |
| VTM | Voids in Total Mix |

# CHAPTER I

# INTRODUCTION

## Background of the Study

Road surface requirement has been changing significantly over the last thirty years. In the fifties, surface evenness maintenance work was confined to remedying potholes. Assessment of wet weather skid resistance was at an early stage. Since then, in response to rapid growth, most countries have been concerned with road traffic safety (OECD, 1984).

Malaysia is one of the countries that experienced a rapid economic development for the last ten years. This economic growth accompanied by increased building of highways has resulted in a substantial increase of traffic-related problems, such as loss of human lives and properties.

Road Development Index (RDI) as shown in Figure 1.1, prepared by the Public Works Department Malaysia, reported that the RDI which measures the level of road development, taking into account both area and population size of the country, also improved significantly from 0.54 in 1985 to 0.80 in 1985 or an increase of 48% (PWD, 1999).

The road service level comprises three indicators, which measure total road length to population, total vehicles and per RM 100 million Gross Domestic Product (GDP), respectively. The road service level in terms of road length to population increased by 31% from 2.46 kilometres in 1985 to 3.22 kilometres of roads per 1000 persons in 1995.

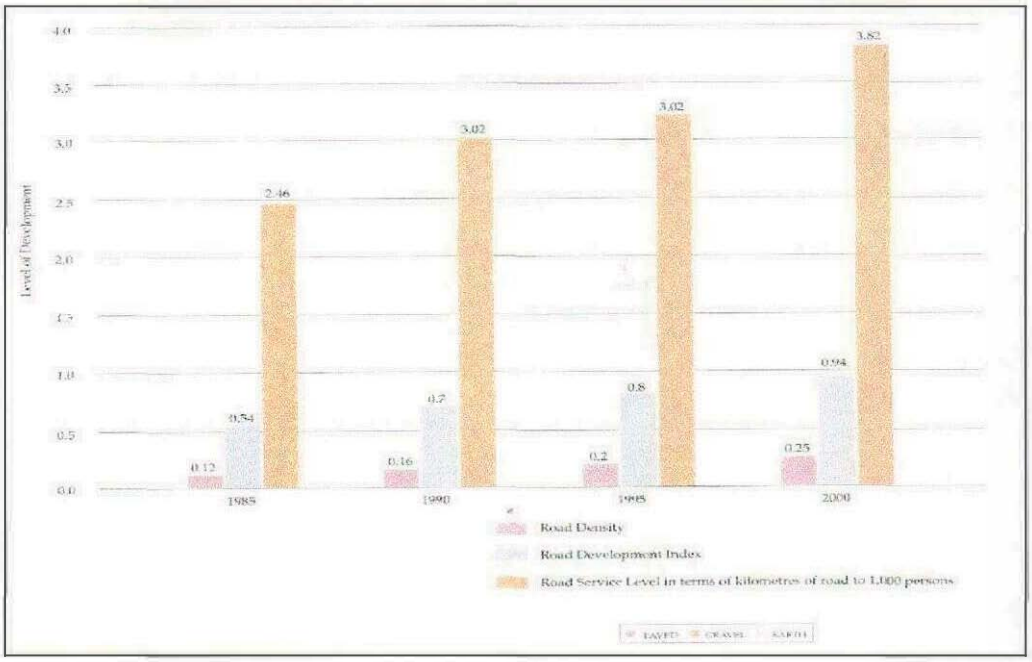


Figure 1.1 Road Development Indicators 1985-2000.
(Source: Public Works Department, 1999)

As a result of this tremendous economic increase, Malaysia entered a different phase of motorization transition. It was observed that there was a resultant growth in the number of registered vehicles during the last two decades, for the period of 1977 to 1997. A total number of registered vehicles increased from 1.78 million vehicles in 1977 to 8.5 million vehicles in 1997 respectively, with the average rate of 7.9 %per annum (PWD, 1999).

This explosive growth of automobile use has brought in, the need to recognize road safety as a complex problem that must be addressed properly, in order to save lives and properties. In 1997 alone, a total of 56, 574 casualties were reported of which 6302 were death, 14,105 were hospitalized, 36,167 were slightly injured (PDRM, 1998). Accidents related to skidding constitute 15% of the total accidents registered.

The Statistical Report on Road Accidents in 1998 by Polis Diraja Malaysia shows that there is a total of 1328 road accidents by surface conditions such as flood, wet, oily and sandy, which accounted to 561 cases of fatal accidents and 767 cases of serious accidents.

Table 1.1: Road Crash by Road Surface Condition

| | Types of Road Crashes | | |
|---|---|---|---|
| Surface Condition | Fatal | Serious | Total |
| Dry | 4,415 | 9,087 | 13,502 |
| Flood | 11 | 31 | 42 |
| Wet | 492 | 673 | 1,165 |
| Oily | 6 | 10 | 16 |
| Sandy | 52 | 53 | 105 |
| Under Repair | 16 | 41 | 60 |
| **Total** | **4,995** | **9,895** | **16,654** |

(Source: Polis Diraja Royal Malaysia, 1998)

Accidents related to skidding constituted 15% of the total accidents registered but deaths due to skidding comprises 25%. Studies by (Radin, 1993) have shown that the odd ratio of skidding is 4.7 times higher compared with dry surfaces. This is illustrated in Table 1.2 below: -