RUTTING POTENTIAL OF HOT MIX ASPHALT
IN VARIABLE CONDITIONS

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"TO HUMAN KIND"

"RACE TO PERFECTION HAS NO FINISH LINE…"

"CARPE DIEM"

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ABSTRACT

Flexible pavements are designed to withstand structural and functional failures. Rutting is a structural defect associated with functional implications. Rutting is mainly caused by wheel loads and accelerated by environmental factors. Although rutting is contributed by all the five layers in flexible pavement *(subgrade, subbase , road base bindercoarse and wearing coarse)* the behaviour of wearing coarse is least understood and contributes significant effect to the overall pavement. The objective of this study is the identify the rutting behaviour of wearing coarse subjected to repetitive vehicle load and exposed to different environments. This study is carried on scaled down pavement stretch of 22.6m consisting of two mixes ACW14 and ACW20 which is then subjected to repetitive load with exposure to different environmental effects such as wet stretch, heat condition, spillage of petrol, diesel and cooking oil. For each selected pavement, section rut is measured after 50 cycles of the wheel track which has a weight of 280kg. A multivariate regression analysis is carried out to determine the relationship of rut depth and number of wheel track passes. The results show exposure to petrol and diesel has a very detrimental effect to the pavement.

ABSTRAK

Turapan anjal direkabentuk untuk menampung kegagalan berbentuk struktur mahupun kegagalan yang ada kaitan dengan fungsi turapan itu sendiri. Fenomena *rutting* merupakan kegagalan struktur turapan yang ada kaitan dengan fungsi turapan. Fenomena ini diakibatkan terutamanya oleh beban roda kenderaan dan diburukkan lagi oleh faktor-faktor persekitaran. Walaupun fenomena *rutting* ini disumbangkan oleh kelima-lima lapisan yang membentuk turapan anjal (*subgrade*, *subbase*, *road base*, *binder course* and *wearing course*), kelakunan lapisan *wearing course* adalah yang paling kurang difahami oleh para pengkaji walhal lapisan inilah yang menyumbangkan kesan yang paling signifikan kepada keseluruhan struktur turapan anjal. Objektif kajian ini adalah untuk mengenalpasti fenomena *rutting* pada lapisan *wearing course* yang telah dikenakan beban roda kenderaan yang berulang-ulang pada keadaan persekitaran yang berbeza-beza. Kajian ini dijalankan pada model turapan sepanjang 22.6 meter yang terdiri daripada dua jenis bancuhan konkrit asfalt iaitu bancuhan ACW 14 dan ACW 20. Model turapan ini dikenakan beban roda kenderaan seberat 280kg yang berulang-ulang pada keadaan persekitaran yang berlainan seperti kelembapan, haba dan limpahan minyak seperti limpahan minyak petrol, limpahan minyak diesel dan limpahan minyak masak.

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LIST OF ABBREVIATIONS

ACW14	Asphaltic Concrete Wearing Course with Nominal Maximum Aggregate Size of 14mm
ACW20	Asphaltic Concrete Wearing Course with Nominal Maximum Aggregate Size of 20mm
HMA	Hot Mix Asphalt

CHAPTER I

INTRODUCTION

1.1 Introduction

Permanent deformation or rutting is the primary failure mode of hot mix asphalt pavements. Failure due to rutting compromises serviceability of pavement and can pose danger to road user. A variety of laboratory test methods have been developed in order to gain a better understanding of rutting of hot mix asphalt pavements. Wheel tracking is the latest addition to laboratory equipment. Wheel tracking devices subject asphalt pavement to cyclic loads by a moving wheel so that the permanent deformation or rutting experienced by the pavement can be determined.

This test enables engineers and researches to mimic the actual condition experienced by the pavements, thus enabling them to design pavement mixes which are more durable and less costly to maintain.

1.2 Problem Statement

After a new pavement is constructed, both environmental and traffic stresses cause it to deteriorate. The rate of deterioration depends on the severity of the traffic loads and the variability of the road materials. In the evaluation process, the identification and classification of the type of failure is necessary if correct remedial treatments are to be undertaken. Pavement engineers are faced with the difficult task of evaluating pavements that have been subjected to varying traffic loads under variable environmental conditions and material properties. Field measurements are valuable practical tools in the evaluation of road performance and in the identification of the causes of failure. The task becomes more difficult if the pavement has gone through a series of previous unrecorded maintenance treatments.

To ensure a good return on the investment in road construction, a cost benefit analysis is needed to ensure that the most cost effective method of maintenance is employed. If the future performance of the road is not correctly predicted, then large sums of money may be wasted in maintenance alone. Thus, there is a need to carry out research on the rutting potential of hot mix asphalt in variable conditions so that pavement engineers can estimate the right time frame within which the pavement is mostly likely to undergo repair or rehabilitation works.

1.3 Objectives of the Study

The objectives of this study are as follows: -

1. To develop regression equations to predict rut depths for different environment exposure conditions and number of wheel track passes.

1.4 Scope of the Study

The scope of this study involves calibrating the wheel track gauges and developing regression equations to predict rutting potential of hot mix asphalt in variable conditions. The entire test is conducted at Makmal Pengangkutan, UTM Skudai.

1.5 Significance of the Study

From the result of the study, the relationship between rutting potential of hot mix asphalt in variable conditions will be established. Number of wheel passes and rut depth is correlated to derive a mathematical equation based on respective exposure conditions. By establishing this mathematical equation, future rut depth respective to number of wheel passes on variable exposure conditions can be determined. Therefore, this study would not only give pavement engineers a better understanding of hot mix asphalt behaviour under different variable conditions, but enable them to carry out rehabilitation and repair works in a more scheduled and systematic manner.

REFERENCES

A Guide To The Visual Assessment of Flexible Pavement Surface Conditions, Institut Kerja Raya Malaysia (IKRAM)

Alabama Power (1985). *Construction Department Training, Bituminous Surfacing*. USA: Multi-Amp Corporation.

American Association of State, Highway, and Transportation Officials. *AASHTO (1986) Guide for design of pavement structures*. Washington, D. C.

American Association of State Highway and Transportation Officials, AASHTO (2000). *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*. Washington, DC, Ed. 20.

American Society for Testing and Materials, ASTM (1994). *Annual Books of ASTM, Standards American Society for Testing and Materials.* Philadelphia.

Asphalt Institute (1988). *Principles of Construction of Hot-Mix Asphalt Pavement.* United States of America: Asphalt Institute.

Barksdale R., (1978), *Practical application of fatigue and rutting tests on bituminous based mixes*, APT VOL.47

Barksdale, R., Han, J., Miller, S., and Thompson, S. (1995). *Optimum Design of stone Matrix Asphalt*, Geogia Tech, FHWA Report No. FHWA-GA-95-9217.

Bonquist R. R. (1989), *Effects of tire pressure on flexible pavement response and performance,* Draft Report, Federal Highway Administration, Washington, D. C.

Brown, E.R. (1990). *Density of Asphalt Concrete-How Much Is Needed.* Transportation Research Record 1282.

Brown, E.R., and Brandau, L.S. (2000). *Hot Mix Asphalt Paving Handbook 2000,* US Army Corps of Engineers.

Brown E.R. and Charles E. Bassett (1990), *Effects of maximum aggregate size on rutting potential and other properties of asphalt aggregate mixtures*, M . 1259

Button J.W., Dario Perdomo and Robert L. Lytton (1990), *Influence of aggregate on rutting in asphalt concrete pavements*, TRR 1259

Carpenter H. Samuel (1993), *Permanent deformation: Field Evaluation*, Paper # 930768, Transportation Research Board ,72nd meeting

Compaction America (2000). *Hot Mix Asphalt Fundamental,* Compaction America, Inc.

Cooley, L.A. Jr., Prowell, B.D., and Brown, E.R. (2002). *Issues Pertaining to the Permeability Characteristics of Coarse Graded Superpave Mixes.* Jounal of the Association of Asphalt Paving Technologists, Volume 71.

Garber, N.J., and Lester, A.H. (2002). *Traffic and Highway Engineering.* The Wadworth Group. Brooks/Cole..

Henrin M. and W.H. Goetz (1954), *Effect of aggregate shape on stability of bituminous mixes,* Joint Highways Research Projects, Purdue University. HRB. Proceedings 33rd Annual Meeting

Hughes C. S. and G. W. Maupin, Jr. (1987), *Experimental bituminous mixes to minimize pavement rutting,* APT Vol. 56

Jabatan Kerja Raya (1988). *Standard Specification For Road Works.* Kuala Lumpur: JKR/SPJ/1988.

Jack Morris, *The prediction of permanent deformation and structural design method for flexible pavements*". Department of civil Engineering, University of Waterloo, Waterloo Ontario Canada.

Kamran M. and Measorvic S (1992), *A constituative model for asphalt concrete, application to rutting*, Paper # 929386, 71th meeting TRB

Kandhal, P.S, and Koehler, W.S. (1985). Marshall Mix Design Method: Current Practices. *Proceedings, Association of Asphalt Paving Technologists.* Volume 54..

Kumar, A., and Goetz, W. H. (1977). Asphalt Hardening as Affected by Film Thickness, Voids and Permeability in Asphaltic Mixture, *Proceeding of the Association of Asphalt Paving Technologists,* Volume 46, pp.: 571-605.

Lee K. W. and Dhalaan M. (1989), *Rutting, Asphalt Mix-Design, and Proposed Test Road in Saudi Arabia*, Implications of Aggregate in the Design, Construction, and Performance of Flexible Pavements, ASTM STP 1016, H. G. Schreuders and C. R. Marek, Eds., American Society for Testing Materials, Philadelphia

Parker F. and Brown E. R., *Effects of aggregate properties on flexible pavements rutting in ALABAMA*, Paper # 910760, 70^{th} meeting TRB 1991.

Quintus H. V. and Kennedy T. W. (1989), *AAMAS Mixture properties related to pavement performance,* APT. Vol 58.

Report 5, Highway Research Board Special Report 61E (1962), *The ASSHO Road Test*

Roberts, F.L., Kandhal, P.S., Brown, E. R., Lee, D.Y, and Kennedy, T.W. (1996). *Hot Mix Asphalt Materials, Mixture Design and Construction. 2nd ed.* Lanham, Maryland, NAPA Education Foundation.

Smith H. A., (1991), *Truck fire characteristics and asphalt concrete rutting*, Paper No. 910035, Transportation Research Board (TRB) 70TH Annual Meeting

Smith Partitioning Ltd. (2004). *HMA Catalog*. United States of America: Permeability Brochure.

The American Association of State Highway and Transportation Officials (1986). *Standard Method Test for Resistance of Compacted Bituminous Mixture to Moisture Induced Damage.* Washington D. C. T 283-85.

The Asphalt Institute (1984). *Mix Design Methods for Asphalt Concrete and Other Hot Mix Types. MS-2*. Philadelphia..

Wright, P.H., and Dixon, K.K. (2004). *Highway Engineering.* 7th ed, United State of America, John Wiley & Son, Inc.

W.S. Mendenhall, Jr., Chairman (1987), *Ad hoc task force on asphalt pavement rutting and stripping*, August 14, 1987

Yoder EJ. and M. W. Witfzak (1975), *Principles of pavement desig*n A Wiley-Interscience Publication, John Wiley and Sons, Inc.