EVALUATION OF BOND STRENGTH BETWEEN HOT MIX ASPHALT AND STONE MASTIC ASPHALT SURFACING LAYERS

VRIDA INGRID VELIAN

A project report submitted in partial fulfillment of the
requirement for the award of the degree of
Master of Engineering (Civil-Highway and Transportation)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

AUGUST 2013

To my beloved father and mother

ACKNOWLEDGEMENT

Firstly, I would like to praise the almighty God for giving me the strength and energy to complete this report.

At the same time, I would like to express my sincere appreciation to my supervisor, Dr Haryati Yaacob for the patience, encouragement, advices and guidance to me. I would also like to thanks to all my friends for their support and help.

Last but not least, I am grateful to my family members for their love, care, support and daily encouragement during carrying the study.

ABSTRACT

Poor bonding between asphalt layers cause many distresses, and the most typical problem is the slippage failure. This failure usually occurs when there are exists insufficient bond between the interfaces of the two layers in contact. Therefore, sufficient tack coat is needed to provide greater bonding strength between pavement layers to be able to withstand traffic and environmental stresses. Thus, this study is conducted to evaluate the influence of tack coat, application rates, and layer thickness on the interface bond strength between hot mix asphalt and stone mastic asphalt. A total of three tack coat materials have been used, which are RS-1K and RS-2K and RS-2KL. These tack coat materials were applied at three different application rates, 0.25 l/m^2, 0.40 l/m^2 and 0.55 l/m^2 which represent low, medium and high application rates respectively in accordance with the JKR specification. Direct shear test has been conducted at shearing rate 1 mm/min and shearing platens 5 mm gap. Analysis obtained shows interface shear strength increased as layer thickness and application rate increase. High viscosity of tack coat produced high interface shear strength than low viscosity tack coat.

ABSTRAK

Ikatan yang lemah antara lapisan asfal menyebabkan banyak kerosakan pada jalan, dan masalah yang paling biasa berlaku ialah kegagalan gelinciran. Kegagalan in biasanya berlaku apabila terdapat wujudnya ikatan yang tidak mencukupi antara permukaan kedua-dua lapisan asfal. Oleh itu, salut jelujur yang mencukupi diperlukan untuk memberi ikatan yang lebih kuat antara lapisan turapan agar dapat menahan tekanan dari trafik and alam sekitar. Maka, kajian ini dijalankan untuk menilai pengaruh salut jelujur, kadar aplikasi, dan ketebalan lapisan pada kekuatan ikatan antara permukaan *HMA* dan *SMA*. Sebanyak tiga bahan salut jelujur digunakan, iaitu RS-1K, RS-2K dan RS-2KL. Ketiga-tiga bahan ini digunakan pada tiga kadar aplikasi yang berbeza, 0.25 *l*/m², 0.40 *l*/m² and 0.55 *l*/m dan tiga kadar aplikasi tersebut mewakili kadar aplikasi rendah, sederhana dan tinggi mengikut spesifikasi JKR. Ujian ricih dijalankan pada ricih 1 mm/min dan jurang ricih pada 5 mm. Analisis yang diperolehi menunjukkan kekuatan ricih antara permukaan lapisan meningkat apabila ketebalan lapisan and kadar aplikasi meningkat. Salut jelujur yang mempunyai kelikatan yang tinggi menghasilkan kekuatan ricih yang tinggi antara permukaan lapisan daripada salur jelujur yang mempunyai kelikatan yang rendah.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Asphalt pavement plays an important role in order to ensure that the pavement distribute the traffic loadings to the base course. Asphalt pavement consists of several layers and it is depends greatly on the mechanical properties of each layers as well as the bonding between the pavement interlayers to perform better during its service life.

Besides that, pavement surface course consists of wearing course and binder course, which is the crucial part during construction to provide good bonding between the pavement layers in order to maintain the structural integrity of pavement. Therefore, the most important variable which influences the bond between the pavement layers is a tack coat.

The use of tack coat is to provide the sufficient adhesive bond between the pavement layers. Tack coat is a very light application of asphalt, usually it is applied to a new or an existing pavement prior to paving works. Apart from that, the bonding between the pavement layers work together as a monolithic structure in order to withstand the traffic and environmental loading.

Asphalt emulsion is the most common used of tack coat followed by the paving grade and cutback asphalt. However, the use of cutback asphalt as tack coat has significantly decline due to the environmental concern related to the volatile components. Thus, asphalt emulsion is the most favored use as tack coat due to the simplicity of being capable to be applied at lower temperature and relatively pollution free.

1.2 Problem Statement

The influence of surface characteristics on the bonding properties at the interlayer is important to understand better how multilayered pavements behave under traffic conditions**.** Nowadays, problem related to the pavement surface due to the poor bonding no longer new issues. Poor bonding between asphalt layers cause many distresses, and the most typical problem is the slippage failure. This failure usually occurs when there are exists insufficient bond between the interfaces of the two layers in contact as shown on Figure 1.1. Normally, slippage cracking occurs at location where there is a sharp curves and busy junction where the vehicle accelerates and decelerates continuously. However, this problem was also results from where vehicle is likely to exert high horizontal force.

Besides that, other pavement distresses which were related to the insufficient bonding between asphalt layers such as surface layer delamination, premature fatigue and top down cracking and potholes. Despite the presence of any of these distresses can be seriously affects the pavement structural integrity as the loss of bond leads to increased subgrade deformation as well as reduce the riding quality. In Malaysia, delamination and potholes can be considered also one of the most common types of pavement distress which related to the poor bonding due to the less comprehensive guidelines on the proper tack coat application during construction.

Figure 1.1: Slippage failure due to poor bonding between HMA layers (West et al, 2005)

1.3 Objective of the Study

The specific objective of this research was to evaluate the influence of tack coat types, application rates, and layer thickness on the interface bond strength between hot mix asphalt and stone mastic asphalt.

1.4 Scope of Study

This study was focus on the performance of tack coat materials on the stone mastic asphalt (SMA) pavement wearing course. The mixtures with the nominal maximum aggregates size of 14 mm were studied. A total of three tack coat materials will were used, which are RS-1K and RS-2K and RS-2KL. These tack coat materials were applied at three different application rates, which are 0.25 *l*/m², 0.40 *l*/m² and 0.55 *l*/m² represent low, medium and high application rates respectively in accordance with the JKR specification (2008). Three specimens are prepared for each test. Direct shear test was conducted at shearing rate 1 mm/min and shearing platens 5 mm gap.

1.5 Significance of the Study

This study was carried out to enhance the pavement bonding between the layers. Besides that, the lack of tack coat between pavement layers can lead to premature failure. Thus, this study was investigating the factor that lead to this failure, therefore premature failure can be avoided.

REFERENCES

Abraham B, Louay, N.M, Elseifi M.A, Buttton, J. and Patel N. (2010). "Effects of Temperature on Interface Shear Strength of Emulsified Tack Coats and Its Relationship to Rheological Properties." Journal of Transportation Research board No. 2180, pp 102-109.

Ahmad b Ramly. (2002). "Prinsip Dan Praktis Pengurusan Penyenggaraan Bangunan." Kuala Lumpur: Pustaka Ilmi, Percetakan Putrajaya Sdn. Bhd. (in Malay Language)

ASTM D8-02 (2004). "Standard Terminology Relating to Materials for Roads and Pavements, Annual Book of ASTM Standard", Vol. 04.03.

Bernd Schneider. Stone Mastic Asphalt. Regional Export Manager, Road Construction Division, J.Rettenmaier & Sohne, Germany.

Buchanan, M.S., & Woods. M.E. (2004). Field Tack Coat Evaluator (ATACKerTM).

Caltrans (2003), "Paint Binder (Tack Coat) Guidelines", Construction Procedure Bulletin California, CPB 03-1, Sacramento, CA, State of California Department of Transportation

Chaignon, F. and J.C. Roffe. (2001). "Characterization Tests on Bond Coats: Worldwide Study, Impact, Tests, Recommendations." Canadian Technical Asphalt Association, Canada

Construction of Hot Mix Asphalt Pavements. Manual Series No. 22 (MS-22), Second Edition, The Asphalt Institute, Lexington, KY.

Cross, S.A. and Shrestha, P.P., (2005), "Guidelines for Using Prime and Tack Coats." Federal Highway Administration Report, FHWA-CFL/TD-05-002.

Chang, F.L., H. Yaacob, M.R. Hainin, and Putra R. (2013). "Curing Time of Malaysian Asphalt Emulsified Tack Coat." Unpublished raw data.

Chen J.S, and Huang, C.C. (2010). "Effect of Surface Characteristic on Bonding Properties of Bituminous Tack Coat." Journal of the Transportation Research Board No. 2180, pp 142-149.

Hachiya, Y. and Sato, K. (1997). "Effect of Tack Coat in Bonding Characteristic at Interface between Asphalt Concrete Layers." Proceeding of 8th International Conference on Asphalt Pavements, Vol. I, pp 349-362.

H. Yaacob, M.R. Hainin, A. Safuan and Fung-Lung Chang. (2013). Construction of hot mix asphalt surfacing layers: Information for the Malaysian Asphalt Industry towards Better Bonding. Manuscript submitted for publication.

H. Yaacob, M.R.Hainin and Fung-Lung Chang. (2013). Single face compaction on laboratory marshall specimen towards satisfactory degree of compaction and thickness. Manuscript submitted for publication

"Hot-Mix Asphalt Paving Handbook," (2000) AC 150/5370-14A, USACE.

Ibrahim M. Asi (2005). "Laboratory comparison study for the use of stone mastic asphalt in hot weather climates." Construction on Building Materials 20, 982-989.

JKR. (2008). Section 4: Flexible Pavement Standard Specification for Road Works: Jabatan Kerja Raya.

Lavin, Patrick G. (2003). "Asphalt Pavements". Spon Press, New York, NY.

Liu Si Hong. (2009)."Application of in situ direct shear device to shear strength measurement of rockfill materials." Water Science and Engineering, 2(3): 48-57

Louay N.M, Elseifi M.A, Bae A. and Patel N, (2012), "Optimization of Tack Coat for HMA Placement", Transportation Research Board.

Low, S. P. (1993). The rationalization of quality in the construction industry: Some empirical findings. Construction Management and Economics, 11(4): p. 247-259

Miro, R.R., Perez-Jimenez., Martinez A. (2003). "Assessing heat-adhesive emulsions for tack coats" 6th RILEM Symposium PTEBM'03, Zurich, pp 550-556.

Mohammad, L.N., Raqib, M.A., and Huang, B. (2002). "Influence of Asphalt Tack Materials on Interface Shear Strength." Transportation Research Record: Journal of the Transportation Research Record, No1789, pp 56-65.

Mohammad, L.N., Wu Zhong, Raqib M.A. (2005). "Investigation of the Behaviour of Asphalt Tack Interface Layer". Louisiana Transportation Research Center, L.A.

OHIO. (2001). "Proper tack coat application," Technical Bulletin by Flexible Pavements of OHIO.

OHIO. (2012). "Proper Tack Coat Application": Flexible Pavements of OHIO.

Partl M.N., Canestrari F., FerrottI G., and Santagata E. (2005). "Advanced Testing and Characterization Interlayer Shear Resistance". Journal of the Transportation Research Board No.1929, pp 69-78.

Partl, M. N., & Raab, C. (1999). Shear adhesion between top layers of fresh asphalt pavements in Switzerland Paper presented at the 7th Conference on Asphalt Pavements for Southern Africa.

Patel, N. 2010. Factors affecting the interface shear strength of pavement layers. Master's Thesis in Civil & Environmental Engineering, Louisiana State University.

Raab, C. and Partl,M. (2004). "Interlayer Shear Performance: Experience with Different Pavement Structure." 3rd Eurasphalt & Eurobitumen Congress, Vienna.

Raab Christiane. (2010)."Development of a Framework for Standardisation of Interlayer Bond of Asphalt Pavements." Department of Civil and Environmental Engineering, Carleton University.

Roberts F.L, Kandhal P.S, and Brown E.R, (1996), "Hot Mix Asphalt Materials, Mixture Design and Construction", NAPA Research and Education Foundation, Maryland

Sanders, P.J.,Brown, S.F., Thom N.H. (1999). "Reinforced Asphalt for Crack and Rut Control." 7th Conference on Asphalt Pavements for Southern Africa, pp 847-855.

Sangiorgi C.,Collop, A.C., and Thon, N.H. (2002). "Laboratory Assessment of Bond Condition using the Leutner Shear Test." Proceeding of 3rd International Conference on Bituminous Mixtures and Pavement, pp 315-324, Greece.

Santagata E. and Canestrari, F. (2005). "Temperature Effects on the Shear Behaviour of Tack Coat Emulsions Used in Flexible Pavement," International Journal of Pavement Engineering, Vol. 6, No.1, pp. 39-46.

Satterfield, Z. 2005. Quality Control in Construction Projects. Tech Brief, National Environmental Services Center.

Sholar, G. A., Page, G. C., Musselman, J. A., Upshaw, P. B., & Moseley, H. L. (2003). "Preliminary Investigation of a Test Method to Evaluate Bond Strength of Bituminous Tack Coats". Journal of the Association of Asphalt Paving Technologists, 73, 23-52.

Sholar, G., Page, G., Musselman, J., Upshaw, P., and Moseley H. (2004). "Preliminary investigation of a test method to evaluate bond strength of bituminous tack coats." Electron. Journal of the Association of Asphalt Paving Technologists, 73, 771-801.

Stephen R. Thomas, Richard L. Tucker, William R. Kelly.1998. Critical communications variables, Journal of Construction Engineering and Management. 124(1): p. 58-66.

Sutradhar Bidyut Bikash (2012). "Evaluation of Bond between Bituminous Pavement Layers." Department of Civil Engineering, Rourkela.

Tashman Laith, Nam Kitae, and Papagiannakis Tom. (2006). "Evaluation of the Influence of Tack Coat Construction Factors on the Bond Strength between Pavement Layers." Washington State Department of Transportation.

Tashman, L., Nam, K., Papagiannakis, T., Willoughby, K., Pierce, L., & Baker, T. (2008). "Evaluation of Construction Practices That Influence the Bond Strength at the Interface between Pavement Layers". Journal of Performance of Constructed Facilities, 22(3), 154-161

Unified Facilities Guide Specification (UFGS). (2008). "Unified Facilities Guide Specifications". U.S. Army Corps on Engineering.

U.S. Army Corps on Engineering (2001). "Unified Facilities Criteria (UFC)."

Uzan, J., Livneh, M., Eshed, Y. (1978). “Investigation of Adhesion Properties between Asphaltic Concrete Layers.” Journal of the Association of Asphalt Paving Techinologists, Vol. 47, pp 495-521.

West, R. C., Zhang, J., & Moore, J. (2005). Evaluation of bond strength between pavement layers. (Report 05-08). NCAT.