EVALUATION OF CRACK RELIEF LAYER FOR AIPPORT RUNWAYS

ASHRAF BIN AHMAD ZAINI

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“Dedicated to my family especially my mother Zalina Binti Mahzan and Amanah Binti Benu, my father Ahmad Zaini Bin Abdullah and also my brother and sister for their love, encourage and support.”

“Special thanks to all lecturers, friends for their motivation, concern and help.”

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ABSTRACT

This paper investigates some observations that have been made in a number of countries around the world on the behavior and function of crack relief layer (CRL). Throughout the years, crack in pavement is a major problem that causes an obstruction to transportation system which has cost multi-millions of dollars. This is especially in airport runway business industry where the air traffic flow of aircraft cannot be easily diverted or disturbed as it involve many parties and would jeopardize a lot of money at stake. This paper describes and investigates the significant and effectiveness of applying CRL into the pavement which will be evaluated to relieve crack. The characteristic of the CRL will be thoroughly investigated to achieve it desirable functional capability to act as the crack relieving layer. The objectives of the experimental study are to identify the optimum bitumen content (OBC) and evaluate the engineering properties of the CRL by using 60-70 PEN bitumen with variation in percentages of bitumen content which are 2.0, 2.5, 3.0, 3.0, and 4.0%. The specimens are mixed and compacted for 50 blows each side and tested. The result shows that the OBC for CRL is 3.0% and the properties of CRL to mitigate crack is distinctly influent by resilient modulus and bulk density values.

ABSTRAK

Kajian ini mengkaji beberapa pemerhatian yang telah dibuat di beberapa negara di serata dunia iaitu tingkah laku dan fungsi “Crack Relief Layer” (CRL). Sepanjang tahun, retak di permukaan jalan adalah masalah utama yang menyebabkan halangan kepada sistem pengangkutan yang telah menelan belanja berjuta ringgit. Ini terutamanya dalam industri perniagaan landasan lapangan terbang di mana aliran trafik udara pesawat tidak boleh dengan mudah dialihkan atau diganggu kerana ia melibatkan banyak pihak dan akan menjejaskan banyak wang yang terlibat. Kertas ini menerangkan dan menyiasat kepentingan dan keberkesanan CRL dalam jalan yang akan dinilai untuk melegakan keretakan. Ciri-ciri daripada CRL telah disiasat dengan teliti untuk mencapainya keupayaan berfungsi wajar untuk bertindak sebagai lapisan melegakan retak. Objektif kajian eksperimen adalah untuk mengenal pasti kandungan “Optimum Bitumen Content” (OBC) dan menilai ciri-ciri kejuruteraan CRL dengan menggunakan 60-70 PEN bitumen dan perubahan dalam peratusan kandungan bitumen iaitu 2.0, 2.5, 3.0, 3.5, dan 4.0%. Spesimen telah dicampurkan dan dipadatkan dengan 50 pukulan setiap sisi dan diuji. Hasil kajian menunjukkan bahawa OBC untuk CRL ialah 3.33% dan sifat-sifat CRL untuk mengurangkan retak adalah jelas faktor oleh modulus berdaya tahan dan nilai-nilai ketumpatan pukal.

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CHAPTER 1

INTRODUCTION

1.1 Background

Airport is one of the major capital investments in the infrastructure of a country. It is also representing one of the most important sectors in economy, transportation of people and goods. Therefore, the sustainability of these investments in good condition is an essential requirement for government and strategic policy to be adopted. In this millennium era, air space means of transportation has becoming more crucial which then contributes to the aircraft traffic congestion. The increasing in aircraft traffic directly caused the declining of airport runway quality. This fact has been taken into consideration in the airport development by shifting the conventional focus from maintaining the pavement to preventing the deterioration in the pavement itself. Thus, it is necessary to study the factors in minimizing the declining of runway quality and to take essential measurements to counteract the problem. Previous studies in additional layer of pavement strata have introduced CRL as the crack relieving alternative to the pavement design (Nataraj and Van der Meer 2000). The weight of aircraft greatly differs from (or heavier than) the weight of land transportation that operates on paved platform, thus consideration of its load capacity is needed. The characteristics of CRL are essential to be determined in order to access the ability of the layer in

term of its crack relieving strata in pavement layer. CRL minimizes the crack development of the pavement not by tackle the outer disturbance that practically very hard to be tackled but by adding a new layer to a set of fundamental pavement layer.

1.2 Problem Statement

Crack development in pavement is a multi-million dollar problem occurs around the world. This causes by a lot of source that literally speaking impossible to be prevented such as traffic load, weather, ultraviolet radiation, etc. Traffic loading is increasing by day as human population growth in this millennium is exponentially rapid compare to decades ago due to technology development.

This problem is a crucial and major causes to a larger sequential of pavement deterioration as cracking occurrence in pavement lead to seepage of water into the pavement layers, clogging of the pavement which will disturb the asphalt chemical bonding, decrease the bearing capacity of pavement layers and the porthole formation would occur and disrupt the driving comfort of the pavement depleted.

1.3 Objective of the Study

The aim of this study is to identify crack relief layer design properties for flexible pavement which product of aggregate and bitumen. The objectives are as follows:

1. To identify the Optimum Bitumen Content (OBC) for CRL with 60-70 PEN bitumen.
2. To evaluate the engineering properties of CRL.

The optimum bitumen content of CRL is identifying the best bitumen content CRL for mitigation of crack without internal failure occurrence. As rigid property in CRL would cancel out the crack relevant factor of CRL, the CRL design should possess low in bitumen content which ranges between 2.0 to 4.0%. CRL allows some momentary movement within the layer to absorb impact and minimize crack development.

The engineering properties of CRL are the air voids content, resilient modulus, bulk density values. Air void in CRL provide buffer zone for vibration to less likely transfer through the layers. High resilient modulus endorse that the CRL to be good in elasticity to avoid permanent deformation. As for bulk density means that the denser CRL proves as the layer to be less risk in internal failure.

1.4 Scope of the Study

This study focused on the material and properties of crack relief layer developed in the study. The material is asphalt and aggregate, the properties of receiving the crack to prevent crack formation is the highlight of this study. The specimen used 60-70 PEN bitumen grade and test the OBC by difference of bitumen content which are 2.0, 2.5, 3.0, 3.5, and 4.0%. The sample of different bitumen content is mixed and compacted for three (3) set of samples. The three (3) set of samples are tested for marshal test, theoretical maximum density test, and resilient modulus test. All the batching, mixing, compacting, and testing were

carried out at highway laboratory in University Teknologi Malaysia (UTM), Malaysia in 2015.

1.5 Significant of the Study

Despite the significant advances in the understanding of reflective cracking phenomenon, there is still minimal practical technical guidance needed for an airport pavement designer or contractor on assessing when a given pavement can be effectively treated with reflective crack control measures, what constitutes an effective method for a given situation, how to apply the treatment, and how to evaluate the effectiveness of the treatment prior to and after installation/construction of the treatment. CRL is one of the treatments for reflective cracking on pavement strata. Furthermore, the understandings on mechanisms of CRL in relieving cracks are known but the engineering properties of CRL are sparsely accessible on any guidance or specification to justify the mechanism effectiveness.

REFERENCES

Adaska, W. S. and D. R. Luhr (2004). Control of reflective cracking in cement stabilised pavements 5th International RILEM Conference, Limoges, France, May.

Ali, A., et al. (2013). "Effect of temperature reduction, foaming water content, and aggregate moisture content on performance of foamed warm mix asphalt." Construction and Building Materials 48: 1058-1066.

Aman, M. Y., et al. (2015). "A comparative study on properties of Malaysian porous asphalt mixes with different bitumen contents." Research Journal of Applied Sciences, Engineering and Technology 9(10): 797-806.

Arulrajah, A., et al. (2013). "Reclaimed asphalt pavement and recycled concrete aggregate blends in pavement subbases: laboratory and field evaluation." Journal of Materials in Civil Engineering 26(2): 349-357.

Braham, A., et al. (2015). "Effect of binder type, aggregate, and mixture composition on fracture energy of hot-mix asphalt in cold climates." Transportation Research Record: Journal of the Transportation Research Board.

Chen, S. and Y. Jiang (2008). "Pavement Reflective Cracking Control with Coarse-Aggregate Asphalt Mix Interlayer." International Journal of Construction Education and Research 4(3): 200-209.

Chiranjeevi, T., et al. (2012). Laboratory Evaluation of Permanent Deformation Characteristics of Bituminous Mixes Using Different Binders. Proceedings of International Conference on Advances in Architecture and Civil Engineering (AARCV 2012).

Han, J., et al. (2013). Tolerable Strains for Hot Mix Asphalt Overlays over Concrete Pavements, Kansas Department of Transportation.

Kurokawa, K., et al. (1999). Kisho Kurokawa: Kuala Lumpur International Airport, Edition Axel Menges.

Mallick, R. (1999). "Use of Superpave gyratory compactor to characterize hot-mix asphalt." Transportation Research Record: Journal of the Transportation Research Board(1681): 86-96.

Mansour, T. N. and B. J. Putman (2012). "Influence of aggregate gradation on the performance properties of porous asphalt mixtures." Journal of Materials in Civil Engineering.

Moreno, F. and M. Rubio (2013). "Effect of aggregate nature on the fatigue-cracking behavior of asphalt mixes." Materials & Design 47: 61-67.

Nataraj, A. and A. Van der Meer (2000). Use of asphalt crack relief layer in airport pavements. Reflective cracking in pavements-research in practice. Proceedings of the 4th International Rilem Conference, 26-30 March 2000, Ottawa, Canada.

Redelius, P. and H. Soenen (2015). "Relation between bitumen chemistry and performance." Fuel 140: 34-43.

Tashman, L. S., et al. (2000). Internal structure analysis of asphalt mixes to improve the simulation of superpave gyratory compaction to field conditions, Washington State University.

Von Quintus, H., et al. (2010). Techniques for mitigation of reflective cracks. FAA Worldwide airport technology transfer conference. Atlantic city, New Jersey.

Wielinski, J., et al. (2009). "Laboratory and field evaluations of foamed warm-mix asphalt projects." Transportation Research Record: Journal of the Transportation Research Board(2126): 125-131.

Xiao, F., et al. (2009). "Laboratory investigation of moisture damage in warm-mix asphalt containing moist aggregate." Transportation Research Record: Journal of the Transportation Research Board(2126): 115-124.

Yin, H. and D. Barbagallo (2013). "Development of full-scale reflective cracking test at the FAA National Airport Pavement Test Facility." Transportation Research Record: Journal of the Transportation Research Board(2368): 81-91.