EVALUATION OF LABORATORY SHORT-TERM AGEING AND RUTTING CHARACTERISATION OF BITUMEN AND ASPHALT MASTICS

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by

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To Shamsul, Aufa and Arman.

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"Through patience, the sorrow will be replaced with joy, and the difficulty will be replaced with ease" ~ Imam Ali AS ~

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LIST OF SYMBOLS

$\nabla\eta_A$	Non-Dimensional Viscosity Index
G*	Complex Modulus
δ	Phase Angle
G'	Loss Modulus
G''	Storage Modulus
J_{nr}	Non-Recoverable Creep Compliance
R	Percent Recovery
I_{CO}	Carbonyl Index
I_{SO}	Sulfoxide Index
G_0	Static modulus when $\omega \rightarrow 0$
G_g	Glassy modulus when $\omega \rightarrow \infty$

LIST OF ABBREVIATIONS

2S2P1D	2 Springs 2 Parabolic Creep Elements and 1 Dashpot
AASHTO	American Association of State Highway and Transportation Officials
AE	Activation Energy
ANOVA	Analysis of Variance
ASTM	American Society for Testing and Materials
ATR	Attenuated Total Reflection
CCD	Central Composite Design
CRMB	Crumb Rubber-Modified Bitumen
DSR	Dynamic Shear Rheometer
ER	Elastic Recovery
ERTFOT	Extended Rolling Thin Film Oven Test
FHWA	Federal Highway Administration
FTIR	Fourier Transform Infrared
GLM	General Linear Model
IKRAM	Institut Kerja Raya Malaysia
JKR	Jabatan Kerja Raya
LTA	Long-Term Aged
LVE	Linear Viscoelastic
MNE	Mean Normalized Error
MSCR	Multiple Stress Creep and Recovery
MTFO	Modified Thin Film Oven
NCAT	National Center for Asphalt Technology
NCHRP	National Cooperative Highway Research Program
NRTFOT	Nitrogen Rolling Thin Film Oven Test

PAV	Pressure Ageing Vessel
PG	Performance Grade
PMB	Polymer-Modified Bitumen
PWD	Public Works Department
RCAT	Rotating Cylinder Ageing Test
RRT	Rapid Recovery Test
RSM	Response Surface Method
RTFO	Rolling Thin Film Oven
RTFOTM	Rolling Thin Film Oven Test Modified
RV	Rotational Viscometer
SBS	Styrene-Butadiene-Styrene
SHRP	Strategic Highway Research Program
SSE	Sum Square Errors
STA	Short-Term Aged
STOA	Short-Term Oven Ageing
TFO	Thin Film Oven
TTSP	Time-Temperature Superposition
USM	Universiti Sains Malaysia
WLF	William, Landel and Ferry
ZSV	Zero Shear Viscosity

PENILAIAN PENGUSIAAN JANGKA PENDEK MAKMAL DAN PENCIRIAN UBAH BENTUK KEKAL BITUMEN DAN MASTIK ASFALT

ABSTRAK

Di Malaysia, bentuk retakan permukaan yang paling lazim adalah retakan dari atas ke bawah sebagai akibat beban berulang dan dipercepatkan oleh penuaan bitumen. Penuaan juga menyebabkan kegagalan struktur dan fungsi sebuah turapan asfalt. Menurut piawai makmal antarabangsa (ASTM D2872), penuaan jangka pendek disimulasikan dengan mengenakan bitumen kepada ujian ketuhar putaran lapisan nipis (RTFO). Walau bagaimanapun, sebilangan penyelidik melaporkan beberapa percanggahan antara keputusan yang diperolehi dari RTFO dan penuaan di tapak. Tesis ini membentangkan prosedur penuaan jangka pendek yang dibangunkan dengan menggunakan kaedah respon balas permukaan (RSM), untuk menentukan tempoh penuaan dan suhu yang sesuai yang mewakili penuaan yang berlaku semasa pengeluaran asfalt di loji campuran asfalt Malaysia. Prosedur pengoptimuman mencadangkan protokol penuaan dengan mengenakan bitumen kepada suhu 170°C selama 132 minit yang bersamaan dengan sifat bitumen yang diukur dari tapak. Tempoh dan suhu penuaan adalah faktor penting yang mempengaruhi sifat fizikal dan reologi bitumen penuaan jangka pendek. Pencirian reologi menunjukkan bahawa kelikatan bitumen meningkat dengan peningkatan tahap penuaan dan seterusnya meningkatkan rintangan ubah bentuk kekal bitumen. Kesan pengukuhan didapati bergantung kepada jenis bitumen, suhu dan tempoh penuaan, dan suhu ujian. Lengkung utama reologi bitumen dan mastik asfalt digambarkan menggunakan Model dua pegas, dua parabola dan satu daspot (2S2P1D). Model ini didapati