PERFORMANCE OF HOT MIX ASPHALT CONTAINING GLASS POWDER AS BITUMEN MODIFIER

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MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

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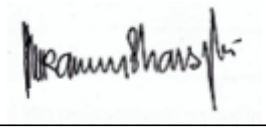

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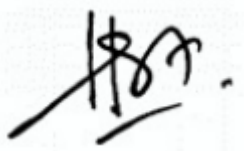

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ABSTRAK

Pengurusan sisa pepejal adalah isu kritikal bagi masyarakat di seluruh dunia. Kaca digunakan secara meluas dalam kehidupan seharian kita, dan kira-kira 10 juta tan sisa dan kaca hancur akan dihasilkan di bandar-bandar besar di seluruh dunia, yang membentuk kira-kira 3–5% daripada semua sisa isi rumah. Penggunaan kaca sisa sebagai komponen dalam campuran asfalt boleh membantu meringankan beban yang dihadapi oleh pihak berkuasa alam sekitar. Justeru, kajian ini dikemukakan untuk mengkaji prestasi asfalt campuran panas mengandungi serbuk kaca sebagai pengubah suai bitumen. Kaca dikisar hingga melepasi jaringan 30μm telah digunakan dalam kajian ini. Gred penembusan bitumen 60/70 disediakan untuk dicampur dengan pelbagai peratusan serbuk kaca pada 2, 4, 6, 8 dan 10%. Sifat kimia dan fizikal serbuk kaca sebagai pengubah bitumen telah dinilai dengan pelbagai ujian seperti spektroskopi inframerah fourier transformasi (FTIR), X-ray difraksi (XRD), X-ray fluorescent (XRF), pancaran medan mikroskopi elektron pengimbasan (FESEM), pengimbasan mikrokopel elektron (SEM), titik lembut, ujian penembusan dan indeks penembusan. Sifat mekanikal kemudiannya dinilai untuk menentukan kekuatan *Marshall*, uji kuat tarik tak langsung, kerentanan kelembapan, *Cantabro*, modulus resilien dan dinamik creep modulus. Reka bentuk eksperimen digunakan untuk menganalisis semua data yang dikumpul dan menentukan peratusan optimum bahan tambahan. Metode permukaan respon telah digunakan untuk menghasilkan model matematik tentang kekuatan dan kerentanan kelembapan asfalt campuran panas yang menggabungkan serbuk kaca. Penemuan daripada sifat kimia dan fizikal mendedahkan bahawa komposisi kimia utama serbuk kaca adalah silikon oksida (SiO_2). Serbuk kaca sebagai pengubah bitumen didapati berkesan dalam meningkatkan sifat mekanikal asfalt campuran panas. Serbuk kaca sebagai pengubah suai bitumen meningkatkan kestabilan *Marshall* dan aliran campuran asfalt, menunjukkan bahawa serbuk kaca mampu menahan ubah bentuk di bawah beban yang dikenakan. Seterusnya, serbuk kaca 8% menunjukkan kekuatan tegangan tidak langsung yang lebih tinggi yang membawa kepada meningkatkan rintangan keretakan. Selain itu, nisbah kekuatan tegangan serbuk kaca menunjukkan corak yang sama seperti kekuatan tegangan tidak langsung. Ini disebabkan serbuk kaca mempunyai ketahanan yang lebih baik terhadap pelucutan dan kurang terdedah kepada kerosakan lembapan. Tambahan pula, kekakuan dipertingkatkan dengan penambahan serbuk kaca 10%, yang juga meningkatkan modulus resilien dan dinamik creep modulus, seterusnya meningkatkan ketahanan terhadap kelelahan dan lekukan. Untuk analisis statistik, kekuatan dan kerentanan lembapan campuran asfalt mempunyai hubungan lengkung dengan serbuk kaca. Kedua-dua faktor telah berkorelasi menggunakan korelasi polinomial tertib kedua, dan menghasilkan korelasi campuran mempunyai korelasi yang kuat dengan nilai R^2 melebihi 0.90. Penemuan menunjukkan bahawa pengubahsuai bitumen dengan 4-10% serbuk kaca telah meningkatkan prestasi turapan jalan dalam prestasi mekanikal. Akhirnya, kajian menunjukkan bahawa asfalt campuran panas yang mengandungi serbuk kaca berpotensi untuk digunakan dalam industri jalan raya.

ABSTRACT

Solid waste management is a critical issue for society worldwide. Glass is widely used in our daily life, and around 10 million tonnes of waste and crushed glass will be produced in large cities worldwide, which compose about 3–5% of all household wastes. The use of waste glass as a component in asphalt mixture may help alleviate the burden faced by environmental authorities. Thus, this research was presented to investigate the performance of hot mix asphalt containing glass powder as bitumen modifier. The glass was ground to size passing 30μm sieve was used in this study. Bitumen 60/70 penetration grade was prepared to mix with variance percentage of glass powder at 2, 4, 6, 8 and 10%. The chemical and physical properties of glass powder as bitumen modifier was evaluated with various tests such as fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), X-ray fluorescence (XRF), field emission scanning electron microscopy (FESEM), scanning electron microscopy (SEM), softening point, penetration test and penetration index. Mechanical properties are then evaluated to determine the Marshall strength, indirect tensile strength, moisture susceptibility, Cantabro, resilient modulus and dynamic creep modulus. Design of experiment was used to analyse all collected data and determine the optimum percentage of additives. Response Surface Methodology was employed to produce mathematical models on the strength and moisture susceptibility of hot mix asphalt incorporating glass powder. The findings from chemical and physical properties reveals that the main chemical compositions of the glass powder are silicon oxide (SiO_2). The glass powder as bitumen modifier was found to be effective in improve the mechanical properties of hot mix asphalt. Glass powder as bitumen modifier improves the Marshall stability and flow of asphalt mixture, indicates that the glass powder was able to resist deformation under imposed loads. Next, 8% glass powder shows higher indirect tensile strength which leads to improve the cracking resistance. Moreover, the tensile strength ratio of glass powder demonstrates the same pattern as indirect tensile strength. This is due to glass powder had better resistance to stripping and less susceptible to moisture damage. Furthermore, the stiffness is enhanced by the addition of 10% glass powder, which also increases the resilient modulus and the dynamic creep modulus, hence enhancing the resistance to fatigue and rutting. For statistical analysis, the strength and moisture susceptibility of asphalt mixtures have a curvilinear relationship with glass powder. Both factors had correlated using a second-order polynomials correlation, and resulting the mixed correlation has strong correlation with R^2 value above 0.90. The findings show that the bitumen modifier with 4-10% of glass powder had improved the road pavements in mechanical performance. Finally, the study showed that hot mix asphalt containing glass powder has the potential to be used in the road industry.

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