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A REVIEW ON MODIFIED BITUMINOUS MIX USING HDPE AND GLASS POWDER

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Abstract
The mechanical properties of most asphalt binders may not be sufficient to withstand the increased load requirements experienced by flexible pavement in practice, especially in regions notorious for severe climatic conditions. This necessitated the need to often enhance the properties of asphalt binder so that it can counteract most pavement distresses, such as rutting and moisture susceptibility. In this study, economical industrial waste plastic dust IWPD was used to modify base bitumen with a penetration grade of 60/70, and its effect on the moisture susceptibility and rutting potential of hot-mix asphalt HMA was investigated thereafter. The IWPD was added at varying percentages (3%, 6%, and 9%) to the base bitumen by weight of the optimum bitumen content. Afterward, Marshall stability and indirect tensile strength ratio were performed on HMA samples produced with the IWPD-modified bitumen blends to evaluate, respectively, its rutting and moisture susceptibility. Based on the results obtained from the analysis, it was found that the modified blends of bitumen enhance the properties of the conventional bitumen. More importantly, the modified blend of bitumen with 6% IWPD content gave optimal results in terms of the increment of rutting resistance and improvement of moisture susceptibility of HMA.
Keywords: Flexible pavement, industrial waste plastic dust, hot-mix asphalt

I.Introduction

The recycling of road pavements is a structural rehabilitation technique for damaged pavements that emerged as an alternative solution to traditional paving methods. This technique enables reducing the use of raw materials, the construction costs and the environmental impacts. However, the addition of reclaimed asphalt pavement (RAP) in the new asphalt mixtures production could induce some problems due to the bitumen characteristics. The bitumen present in RAP material has lost its fundamental characteristics as a consequence of the ageing process, which requires additional concern in the design and production of new asphalt mixtures

Road paving recycling has been acquiring more relevance in society, especially within the paradigm of a circular economy. The addition of waste materials in asphalt mixtures is an excellent solution to face the gradual emergence of a great diversity of waste materials and reduce the production costs. This study aims to evaluate the addition of commercial and laboratory-produced polymer modified binders as rejuvenators in recycled asphalt mixtures with high contents of reclaimed asphalt pavement material (RAP). A commercial polymer modified binder (PMB) and a conventional bitumen modified with 5% of styrene-butadiene-styrene (SBS) or 4% of Regefalt were added to RAP aged bitumen and compared with a rejuvenated binder. Fatigue, permanent deformation and water sensitivity tests carried out on recycled mixtures produced with those binders showed that polymer modified binders could be used as rejuvenators to improve their performance significantly. The recycled asphalt mixture produced with the commercial PMB presented the best mechanical performance. The polymer-modified binders revealed an ageing resistance equivalent to that of the control rejuvenated binder, or slightly better in the case of the final binder with SBS polymer.

II.Literature review

i. Obaid, H.A (2021) investigated Characteristics of warm mixed asphalt modified by waste polymer and nano-silica. warm mixture asphalt (WMA) contains Polypropylene polymer (PP) and Nano- silicaparticles (NS). Two kinds of WMA were used: unmodified WMA and modified WMA contain 3% PP and NS (2–5) % by total weight of asphalt.

ii. Ikeagwuani, C.C.; Nwonu, D.C. (2021) investigated Significant improvement in the expansive soil was found when a combination of 20% SDA, 10% QD and 8% OPC (A6 B2 C3) were blended with it. The CBR of the expansive soil that was combined with the optimum combination of additives increased significantly apparently due to the improved mechanical strength of the soil. The improvedmechanical strength aroused from the micro-filler effect experienced between the reaction of the QD and the soil. Furthermore, cation exchange effect caused by the reaction between ionized potash in the SDA and the montmorillonite clay mineral also contributed to the significant improvement in theCBR.

iii. AASHTO-T283; American Association of State Highway and Transportation Officials (2022) standard method of test for resistance of compacted asphalt mixtures to moistureinduced damage.

iv. Hasan, E.A.; Abed, Y.H.; Al-Haddad (2021) investigated that - Adhesion work of asphalt binders modified with different modifiers is higher than the pure asphalt binder. Maximum improvement inadhesion work due to the addition of 7% of SBS modifier with an increment rate of 9.577% in the Durah asphalt binder and 7.363% in Basrah asphalt binder with Dukan aggregate case.

v. Y. ISSA (2016) investigated the effect of adding crushed glass to asphalt mix and found that crushedglass can be used in asphalt pavement with optimum replacement ratio of 10% by weight of total aggregates. The value of stability and MQ for 10% glass modified mixture was higher than the control mixture. Therefore, a significant improvement occurred in the Marshall properties of asphaltconcrete mixtures using a crushed glass modifier.

vi. Sandip Karmakar and Tapas Kumar Roy (2016) used modifying agents like plastic carry bag (PB), plastic milk pouch (PMP), plastic disposal tea cup (PC), mixed plastic (MP), tire rubber ash (TRA) and TRA+MP, mixed with 60/70 penetration grade bitumen and investigated the modified properties of the mix. The results of experiment indicate that addition of 1% by weight of mixed plastic (MP) to the hot 60/70 pen grade bitumen provides the enhancement in the temperature susceptibility
resistant characteristics, viscous properties, and elastic recovery properties with good compatibility and cohesiveness at the micro level by satisfying the essential criterion of PMB 40.

vii. Ahmadinia et al. (2011) carried out experimental research on the application of waste plastic bottles (Polyethylene Terephthalate (PET)) as an additive in bituminous mixture. Wheel tracking, moisturesusceptibility, resilient modulus and drain down tests were carried out in their study on the mixturesthat included various percentages of waste PET as 0%, 2%, 4%, 6%, 8% and 10% by weight of bitumen content. Their results show that the addition of waste PET into the mixture has a significant positive effect on the properties of SMA which could improve the mixture’s resistance against permanent deformation (rutting), increase the stiffness of the mix, provide lower binder drain down and promotion of re-use and recycling of waste materials in a more environmentally and economicalway.

viii. Ahmed Abbas Jasim (2014) investigated waste glass as secondary aggregate in asphalt mixture. Thestudy covers firstly using glass as aggregates including two percentages of glass content (50 and 100
%) by weight of each sieve, and six sizes of glass (1/2, 3/8, No.4, No.8, No.50 and No.200). Secondly, using glass as additives including three percentages of glass content (1, 2 and 4 %) by weight of total mix, and two sizes of glass (No.50 and No.200) and concluded that Marshall Stability for glasphalt is higher than of the control mixture by (127 and 174) % when using glass size (No.8 and No.200) respectively as secondary aggregate in asphalt mixture.

ix. Awwad and Shbeeb (2007) indicated that the modified mixture has a higher stability and VMA percentage compared to the non-modified mixtures and thus positively influence the rutting resistance of these mixtures. According to them modifying asphalt mixture with HDPE polyethylene enhances its properties far more than the improvements realized by utilizing LDPE polyethylene.

x. G.H. Shafabakhsh, Y. Sajed (2014) studied dynamic properties of glasphalt, including fatigue life, stiffness modulus and creep compliance. The data showed that the dynamic properties of glass– asphalt concrete are improved in comparison with ordinary asphalt concrete.

xi. M. Panda and M. Mazumdar (2002) utilized reclaimed polyethylene (PE) obtained from LDPE carry bags to modify bitumen properties. They studied the basic properties such as Marshall Stability, resilient modulus, fatigue life, and moisture susceptibility of mixes with 2.5% of PE and compared with those of asphalt cement. They concluded that at a particular temperature and stress level, polymer modification increases the resistance to moisture susceptibility, resilient modulus and fatigue life of mixes.

xii. Bindu and Beena (2010) studied how Waste plastic acts as a stabilizing additive in Stone Mastic Asphalt when the mixtures were subjected to performance tests including Marshall Stability, tensile strength, compressive strength tests and Tri-axial tests. There results indicated that flexible pavementwith high performance and durability can be obtained with 10% shredded plastic.

III. Conclusions

The conclusions of above literature review are below ;

i. The addition of polymers could be seen as an alternative to commercial rejuvenators in recycled asphalt mixtures with high rates of RAP material. The high resilience of the modified binders improves the behaviour of the corresponding final blends with aged bitumen at service temperatures.

ii. The study of the final blends of the modified binder with aged bitumen is a crucial tool to predict the expected behaviour of the recycled asphalt mixtures during production, compaction and in service.

iii. Concerning the ageing resistance, the recovered binder modified with SBS shows the lowest variation in the rheological properties after the production process, which demonstrates its high resistance to short-time ageing. In opposition, the recovered binder modified with Regefalt has the lowest short-time ageing resistance, since this bitumen presents a high variation in its rheological properties after the production process. The dry process of modification does not seem to be as efficient as the wet process to reduce the binder ageing in recycled mixtures.

iv. Although the bitumen (with commercial rejuvenator) of the control mixture has an excellent ageing resistance, its low complex modulus (even after production process) justifies the insufficient permanent deformation resistance of that recycled asphalt mixture.

v. Significant improvement in the expansive soil was found when a combination of 20% SDA, 10% QD and 8% OPC (A6 B2 C3) were blended with it.

vi. The DFS of the expansive soil, which reduced considerably when the optimum combination of additives was added to it, was adduced to the interplay between the micro-filler effect experienced in the mixture which was driven by the presence of the QD and the cementitious compound formation in the soil-additive matrix.

vii. The CBR of the expansive soil that was combined with the optimum combination of additives increased significantly apparently due to the improved mechanical strength of the soil. The improved mechanical strength aroused from the micro-filler effect experienced between the reaction of the QD and the soil. Furthermore, cation exchange effect caused by the reaction between ionized potash in the SDA and the montmorillonite clay mineral also contributed to the significant improvement in the CBR.

viii. Based on tensile strength ratio analysis, the modification of bitumen with IWPD improved moisture susceptibility. However, beyond 6% IWPD, there might be no significant improvement in moisture susceptibility. Therefore, 6% modification content may be deemed desirable.

ix. The modification of bitumen with IWPD led to an improvement in the rutting potential of the asphalt mixture. Although at content beyond 6%, resistance to rutting might be reduced. Hence, like in the case of moisture susceptibility, the optimal performance of IWPD for rutting improvement might be effective at 6% by weight of bitumen.

x. Using waste glass size (1/2in, 3/8in, No.4, and No.50) as secondary aggregate in asphalt mixture decrease Marshall stability.

xi. Using waste glass (No.8) as secondary aggregate in asphalt mixture increase Marshall stability by more than 127%.

xii. Using waste glass (No.200) as secondary aggregate in asphalt mixture increase Marshall stability by more than 174%.

xiii. The Marshall stability of asphalt mixture increased by 166% after adding 2% of waste glass (No.200) as additive.

IV. Evaluate the long term performance of projects using waste glass as a construction Material. Evaluation of glassphalt to resist the permanent deformation and cracking. Evaluation of glassphalt to water stability.

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