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Performance Evaluation of WMA Made with Reclaimed Asphalt Pavement and Para-Fiber

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ABSTRACT: Asphalt recycling not only is one of the effective approaches to increase the efficiency of the existing budget and capital which is used to protect and improve the road network but also leads to conserve natural resources and save expenses. However, the process of producing Hot Mix Asphalt (HMA) using Reclaimed Asphalt Pavement (RAP) leads to hardening of bitumen and quite a bit of environmental pollution which is derived by emission of toxic gases. Besides, reducing environmental pollution as well as saving energy, reducing the temperature in Warm Mix Asphalt (WMA) technology decreases aging and stiffness of bitumen caused by oxidation. Furthermore, by utilizing WMA technology, better working conditions regarding lower heat rate and emission of poisonous materials are provided. To reduce the costs and the environmental pollution caused by asphalt production as well as improve the performance of asphalt, this research evaluated two approaches, including WMA with Kaowax additive and RAP techniques. The additive of Para-fiber with different values was also used to improve the functional properties of the asphalt. Resilient modulus, dynamic creep, and fatigue tests were performed to compare and evaluate the performance of asphalt mixtures. Given the results, in addition to improvement of the resistance against permanent deformation, utilizing RAP causes an increase in resilient modulus of the mixture, the reason lies in increasing the stiffness of asphalt mixture because of adding RAP. According to the results of fatigue tests, by adding RAP, the fatigue life of the mixture is significantly decreased. On the contrary, by adding Para-fiber, the fatigue life is considerably improved. It seems that tensile resistance and high flexibility of Para-fiber can be considered as the reason for improving the fatigue function of asphalt mixture. Thus, the costs and environmental pollutions can be reduced; meanwhile, an asphalt with good function can be produced.

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1. Introduction

In order to produce conventional Hot Mix Asphalt (HMA), an extremely high temperature obtained by the combustion of fossil fuels is required, thereby releasing significant contamination. Hence, in the field of asphalt mixtures, researchers have implemented quite a few researches to solve the mentioned problem. Warm Mix Asphalt (WMA) technology was one of the solutions suggested by this research [1].

WMA technology was introduced in Europe in the late 1990s, and then it is widely employed around the world due to the importance of a sustainable pavement system and its distinguishing environmental and economic benefits. The temperature required to produce WMA is about 35 °C less than HMA, and therefore WMA consumes less energy. By doing so, much fewer fossil fuels are consumed and as a result, the energy will be effectively conserved [2–4].

Asphalt recycling is another way to decrease the amount of environmental pollution caused by the construction of asphalt pavement. A decrease in the consumption of raw materials such as bitumen and stone materials is another advantage of asphalt recycling. Asphalt recycling has been investigated by different researchers in many studies [5].

1.1. Literature review

Fakhri (2017) investigated rutting resistance and the resistance against moisture of WMA containing RAP (0, 20, 40, and 50%), glass fibers (0.3%), and Sasobit (1.5%). Considering the results, due to an increase in adding RAP to the mixture, rutting resistance significantly increased and moisture sensitivity decreased [6].

Yang (2017) performed a comprehensive assessment of the environmental and mechanical performance of WMA containing Evotherm and crumb rubber (CR). the results demonstrated that tensile and rutting resistance as well as the resistance against moisture increase for WMA (with CR and Evotherm), and HMA (with CR) mixtures in comparison with HMA [7].

Studies about the performance of WMA and HMA mixtures (with 50% RAP) and asphalt mixtures (with 50% RAP and rejuvenator) have been conducted by Song (2018). Given the results, by adding a rejuvenator, the creep resistance

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Table 1. Resilient modulus test results.

Specimens	Resilient modulus (MPa)
R0P0	2419
R0P6	2628
R0P12	3031
R0P18	3632
R50P0	4809
R50P6	5048
R50P12	5201
R50P18	5325
R100P0	5108
R100P6	5257
R100P12	5439
R100P18	5506

decreased and the resistance against moisture increased, and by adding 50% RAP, the costs reduced over 30%. The production of WMA also led to a reduction of about 20% in energy consumption [8].

1.2. Research objectives

Due to the considerable advantages of WMA production, including a reduction in energy consumption and pollution emissions, this study seeks to investigate the performance of WMA (with RAP) and introduce a strategy to improve the weaknesses of this type of mixture.

2. Methodology

In this study, using WMA technology, twelve different asphalt mixtures were made. These specimens include combinations of three various amounts of RAP (0%, 50%, and 100% by weight of aggregates) and four different amounts of Para-fiber additives (0%, 0.06%, 0.12%, and 0.18% by weight of aggregates). Furthermore, 60-70 bitumen was used to prepare asphalt specimens, and also Kaowax was employed as a WMA additive. As a rejuvenator, Nano Poly (Polymer Oil) was added to the asphalt mixture with RAP.

Resilient modulus, dynamic creep, and fatigue resistance tests were conducted to evaluate and compare the performance of different types of mixtures.

3. Results and Discussion

3.1.Resilient modulus test result

According to the results of resilient modulus tests demonstrated in Table 1, adding RAP leads to a significant increase in the resilient modulus. Although adding Para-fiber to the mixture increases the resilient modulus, its effect is less than that of adding the RAP.

3.2. Dynamic creep test result

Results of the dynamic creep tests indicate that, by adding RAP and Para-fiber, the resistance against the permanent deformation and flow number increase, respectively (Table 2).

Table 2. Dynamic creep test results.

Specimens	Flow number
R0P0	1518
R0P6	1816
R0P12	2254
R0P18	2401
R50P0	2782
R50P6	3552
R50P12	5472
R50P18	6952
R100P0	15541
R100P6	18176
R100P12	26006
R100P18	33352

3.3. Resistance to fatigue test result

According to the results of fatigue tests, the fatigue life of the mixture greatly reduces by adding RAP. On the contrary, by adding Para-fiber, the fatigue life increases (Table 3). Therefore, by adding Para-fiber, the fatigue life of the mixture containing RAP can improve.

4. Conclusions

In the non-RAP mixtures, for each 0.06% adding of Para-fiber, on average, the resilient modulus value significantly increased by 14.6%. Meanwhile, in mixtures with 50% and 100% RAP, for each 0.06% adding of Para-fiber, the resilient modulus value increased by 3%.

In the non-RAP mixtures, for each 0.06% adding of Para-fiber, on average, flow number increased by 16.8%. Meanwhile, in mixtures with 50% and 100% RAP, for each 0.06% adding of Para-fiber, the flow number increased by 36.3% and 29.4%, respectively.

In the non-RAP mixtures, for each 0.06% adding of Para-fiber, on average, fatigue life increased by 11.7%. Meanwhile, in mixtures with 50% and 100% RAP, for each 0.06% adding of Para-fiber, the fatigue life increased by 5.6% and 4.4%, respectively.

Table 3. Resistance to fatigue test result.

Specimens	number of load application for fracture life
R0P0	15083
R0P6	17952
R0P12	18276
R0P18	20905
R50P0	12424
R50P6	13994
R50P12	14383
R50P18	14592
R100P0	6497
R100P6	6992
R100P12	7203
R100P18	7381

References

[1] Almeida-costa, A. Benta, Economic and environmental impact study of warm mix asphalt compared to hot mix asphalt, J. Clean. Prod., 112 (2016) 2308–2317.
[2] S. Zhao, B. Huang, X. Shu, M. Woods, Comparative evaluation of warm mix asphalt containing high percentages of reclaimed asphalt pavement, Constr. Build. Mater. 44 (2013) 92–100.
[3] M.C. Rubio, G. Martínez, L. Baena, F. Moreno, Warm mix asphalt: an overview, J. Clean. Prod., 24 (2012) 76–84.
[4] Y. Sun, W. Wang, J. Chen, Investigating impacts of warm-mix asphalt technologies and high reclaimed asphalt pavement binder content on rutting and fatigue performance of asphalt binder through MSCR and LAS tests, J. Clean. Prod., 219 (2019) 879–893.
[5] A. González, J. Norambuena-contreras, L. Storey, E. Schlangen, Effect of RAP and fibers addition on asphalt mixtures with self-healing properties gained by microwave radiation heating, Constr. Build. Mater. 159 (2018) 164–174.
[6] M. Fakhri, S.A. Hosseini, Laboratory evaluation of rutting and moisture damage resistance of glass fiber modified warm mix asphalt incorporating high RAP proportion, Constr. Build. Mater. 134 (2017) 626–640.
[7] X. Yang, Z. You, M.R.M. Hasan, A. Diab, H. Shao, S. Chen, D. Ge, Environmental and mechanical performance of crumb rubber modified warm mix asphalt using Evotherm, J. Clean. Prod., 159 (2017) 346–358.
[8] W. Song, B. Huang, X. Shu, Influence of warm-mix asphalt technology and rejuvenator on performance of asphalt mixtures containing 50% reclaimed asphalt pavement, J. Clean. Prod., 192 (2018) 191–198.

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