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Evaluating the Effect of SBR Polymer Modified Bitumen on the Moisture Susceptibility of HMA

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ABSTRACT: Using anti-striping additives is the most optimal method to improve the strength of asphalt mix against moisture. In this survey, it is tried to review the effect of using polymeric materials as bitumen modifiers on the reduction of moisture damage of hot asphalt mix. To investigate the effect of polymeric materials, repetitive loading test in dry and wet condition together with thermodynamic parameters have been used. The results showed that using Styrene-Butadiene Rubber (SBR) have led to improve the ratio of wet to dry module of asphalt mixes, showing their strength against moisture damage. Moreover, SBR have increased the conjunction free energy and have decreased the released energy of system in striping event and this indicates drop in system's tendency to striping. Moisture susceptibility index which is the surface percent of aggregates exposed to moisture have been obtained according to the measuring the components of surface free energy of bitumen and aggregate and asphalt mix module in loading cycles. The results of this index showed similar results to the ratio of dry module to wet module. Obtained results represents that SBR has led to considerable decrease in striping percentage in samples of controlled asphalt mixes.

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1- Introduction

Moisture damage is bitumen displacement from aggregate's surface or fracture in bitumen's cover. This damage happens when aggregates tend to absorb more water than to be covered by bitumen [1]. Not only moisture causes moisture damage, but also it may cause other damages like fatigue, rutting, bleeding, pothole, and shoving [2]. Most of existing tests to determine the potential of moisture damage in asphalt mixture use the comparison of mechanical function of mixes in dry and wet conditions in order to determine their susceptibility and effect of striping additives [3]. Despite the span of these test like modified Lottman test (AASHTO T283), it can be stated that these methods do not concentrate on the fundamental properties of materials which are effective in moisture damage occurrence, and these methods can not indicate the reason for weakness or strength of asphalt mix and they offer a proper modification method to improve the function of asphalt mix against moisture. Accordingly, some researches have been conducted in recent decades in order to use the methods to determine moisture susceptibility against asphalt mixes, and according to this, the primary properties of materials which hare effective on bitumen's cohesion and adhesion of bitumen-aggregate have been formed [4, 5].

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Regarding to the technical and execution problems in using the existing anti-striping materials, in this research it has been tried to review the use of polymeric modifiers. This research makes attempts to obtain at first the components of surface free energy of modified ad controlled bitumen and aggregates. Then, we review the role of using SBR polymer in function of asphalt mixtures by suing thermodynamic concepts. In order to validate the results obtained from thermodynamic concepts, repetitive loading in dry and wet conditions have been conducted on asphalt mix samples in dry and wet conditions, the proportion of module in dry and wet conditions has been considered as the index of moisture susceptibility of different asphalt mixtures. Bitumen striping percentage has been obtained by surface of aggregates and mechanism of moisture damage in loading cycles. The most important of this research are:

- Reviewing the effect of using SBR polymer on the components of surface free energy in controlled bitumen.
- Reviewing the effect of SBR polymer on the thermodynamic parameters including continuous free energy of bitumen, free energy of aggregate-bitumen adhesion, system's released energy during striping event.
- Reviewing the effect of using SBR polymer on the module proportion in wet condition to that of dry condition in controlled and modified samples.
- Comparison of the results obtained from thermodynamic parameters and module proportion in dry condition to wet condition.

- Combining the results of thermodynamic parameters and repetitive loading in order to determine the trend of striping event in controlled and modified samples.

2- Methodology

The laboratory different steps used in this survey include:

- Modifying the controlled bitumen with two percent of SBR polymer
- Mix design by AASHTO T245 method
- Determining the components of surface free energy of controlled and modified bitumen
- Computing the thermodynamic parameters according to the components of surface free energy of bitumen, aggregates and water for different compounds of asphalt mixes, and
- Computing the striping percentage of aggregates' surface of asphalt mixes in different loading cycles by combining the results of repetitive loading test and thermodynamic parameters.

3- Results and Discussion

Base component of limestone and granite aggregates (respectively 522.4 and 525.8 ergs/cm^2) is bigger than their acid component (respectively 31.7 and 20.5 ergs/cm^2) that this is true for all aggregates but the ratio of acid component to base component of granite aggregates to that of limestone is more. Non-polar component of limestone and granite aggregates (respectively 67.1 and 68.8 ergs/cm^2) are close to each other, but the polar component of limestone aggregates (257.50 ergs/cm^2 is more than that of granite (207.7 ergs/cm^2) and this has led that total surface free energy related to limestone aggregates is considerably more than that of granite aggregates.

Acid component of unmodified bitumen (2.69 ergs/cm^2) is much bigger than its base component (0.45 ergs/cm^2). This has brought about that bitumen has more acidic properties. Acidic properties of bitumen will form stronger bonds with base materials like limestone aggregates. Using SBR polymer has led to increase in acidic and base components of modified bitumen. The increase percentage of base component is more in comparison to that of acidic component and this will form more base properties in bitumen modified by this material. Increase in percentage of this material from 2 to 4 percent may cause the mentioned changes. The additives used in this research have made the polar component of bitumen to rise from 2.20 ergs/cm^2 in samples of modified bitumen with 2 and 4 percent of SBR to 3.07 ergs/cm^2 and 3.67 ergs/cm^2, respectively. Using SBR polymer has caused that the non-polar component of modified bitumen be increased in comparison to unmodified bitumen from 11.36 in modified samples with 2 and 4 percent of SBR to 12.28 and 13.84 ergs/cm^2, respectively. This brings about to formation of stronger non-polar bonds. Using SBR polymer has led to increase in this parameter from 13.56 ergs/cm^2 respectively in modified bitumen samples with 2 and 4 percent of SBR to 15.35 and 17.51 ergs/cm^2. The total surface free energy has direct and linear relation to conjunction/cohesion free energy.

Using SBR polymer in samples made by both types of aggregates used in this research have made reduction in de-bonding energy. Percentage increase of these materials will decline this parameter. This has led to reduction of striping tendency through rising the percentage of polymeric material. The samples made by controlled bitumen have shown the minimum proportion of module in wet condition to dry condition. Using SBR polymer has caused increase in module proportion of these samples. The more increase in polymeric additive, the more obvious function of asphalt mixes against moisture in comparison to controlled samples. Comparison in proportion of wet module to dry module in low-loading cycles has declined among the controlled and modified samples. The higher the number of loading cycles, the more the difference. Stiffness ration (module) in wet to dry condition can be considered as equal to the adhesion proportion between aggregate-bitumen in dry and wet conditions. Using polymeric additives has brought about reduction of bitumen's striping percentage from aggregates' surface in different loading cycles. Moreover, it can be observed that the graph gradient of striping percentage against loading cycles is upward. In fact, in preliminary loading cycles, nearly all aggregates have adhered to the bitumen. Whatever the samples are exposed to wet conditions and repetition of loading, a higher percentage of aggregates will be striped by bitumen. This will led to reduction of adhesion together with decrease in percentage of aggregates attached to each other and these two intensify one another and the striping trend of bitumen will proceed in more slope (Figures 1 and 2).

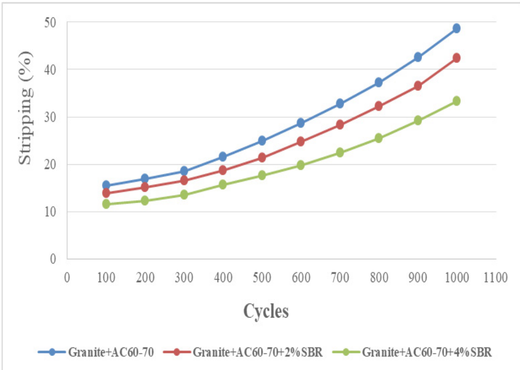

Figure 2. Striping percentage of aggregates' surface in samples made by granite aggregates

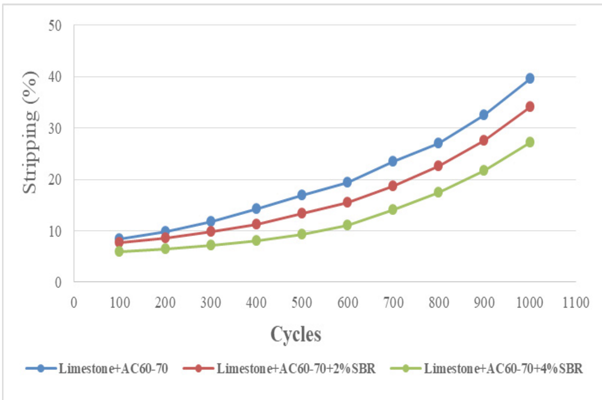

Figure 1. Striping percentage of aggregates' surface in samples made by limestone aggregates

4- Conclusions

The most important results obtained from this research are:

- Using SBR polymer has caused that the strength of asphalt mixes against moisture damage will improve especially in samples made by granite aggregates.
- Adding SBR polymer will led to increase in conjunction/ bonding free energy and adhesion free energy and decrease in system released energy in striping event in samples containing both aggregates and this indicates decline of system's tendency to striping.
- Striping percentage index which was obtained from combining the results of repetitive loading system in dry and wet conditions with the results of thermodynamic parameters shows that the samples made by controlled bitumen in loading cycles and in wet conditions will be striped more and decline rate of loading module is more quickly in them rather than modified samples.
- Using SBR polymer has increased both base and acid component of controlled bitumen.

References

[1] Stuart, K.D., Moisture damage in asphalt mixtures-a state-of-the-art report. 1990.

[2] McGennis, R.B., T.W. Kennedy, and R.B. Machemehl, Stripping and moisture damage in asphalt mixtures. 1984.

[3] Hamedi, G.H., Evaluating the Effect of Asphalt Binder Modification Using Nanomaterials on the Moisture Damage of HMA. Road Materials and Pavement Design, 2016: p. In press.

[4] Al-Qadi, I.L., et al., Effects of Various Asphalt Binder Additives/Modifiers on Moisture-Susceptible Asphaltic Mixtures. 2014, Illinois Center for Transportation.

[5] Al-Qadi, I.L., et al., Effects of Various Asphalt Binder Additives/Modifiers on Moisture-Susceptible Asphaltic Mixtures. 2014, Illinois Center for Transportation.

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