Investigating the Effect of PVC on Moisture Damage of Hot Mix Asphalt

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1. Introduction and Objectives

The occurrence and severity of moisture damage in asphalt mixtures is closely related to thermodynamic concepts. Surface free energy analysis can help in the precise design process that has been used less in the field of pavement industry. Based on this, it seems that conducting research by determining the important parameters of the properties of the material and its adaptation to the results of the performance tests can be predict moisture damage. The study was designed to apply the concepts of thermodynamic theory to the occurrence and prediction of the performance of asphaltic mixtures against stripping. The purpose of this research was not to develop the concepts mentioned in other sciences, but rather to use effective concepts and parameters to investigate the effect of various additives in preventing the deterioration of asphalt mixtures against moisture. The main goals of this research are:

• Introducing and calculating the parameters related to moisture damage from the theory of thermodynamics;
• Comparing and analyzing the results of methods for determination of moisture sensitivity based on mechanical methods using the concepts of thermodynamic theory.

2. Laboratory Program

In this research, two types of aggregates of limestone and granite with different sensitivities against moisture damage have been used.

Pure bitumen with a degree of penetration of 60-70 was used. PVC is available in both soft and hardened softeners. In this study, hard type powder was used as an anti-stripping additive at 1% and 2% bitumen.

In this study, the effect of the performance of asphaltic mixtures on moisture damage using mechanical method based on AASHTO T283 standard has been used as the most comprehensive method. In order to clarify the differences in the performance of different asphalt mixtures, tests of indirect tensile strength (1, 3 and 5 freeze-thaw cycles) have been used. The surface free energy of aggregates and bitumen used in this study was measured using the universal sorption device and Wilhelm plate, respectively.

3. Results and Discussion

The use of polymer additives has improved the resistance of improved modified asphalt mixtures to control samples. The use of the PVC additive has reduced the acidity of the surface free energy and increased its cover ability, which can provide better adhesion between bitumen and acidic aggregates that are prone to moisture damage. Also, the use of PVC has led to a significant increase in the non-polar component of bituminous surface free energy. It is worth noting that there is little difference between the surface free energy components of modified bitumen with 1 and 2% of PVC. The use of an additive in both different percentages has increased the overall free energy of bitumen. This will increase the amount of energy needed to rupture in the membrane of the bitumen and reduce the probability of a failure of cohesion in mastic.

The results related to the free energy of cohesion, free energy of adhesion and separation energy are presented in Table 1. As can be seen in the table, bitumen correction has led to a significant increase in the surface free energyof cohesion. This makes the bitumen resist to the cohesion failure. Also, the use of PVC additives has led to an increase in the amount of free adhesion in samples containing both types of aggregate. This makes it possible to increase the amount of energy needed to separate bitumen from the aggregate surface area. The increase in the PVC content does not significantly alter the free energy of adhesion. It can be said that this parameter is close to the other in samples containing 1 and 2% of the additive. The results of the separation energy column indicate that the use of PVC reduces the separation energy. This means that less energy is released in the event of a nibble. The reduction in adhesion energy causes the system to tend to be less prone to decay and thermodynamics to be more stable.

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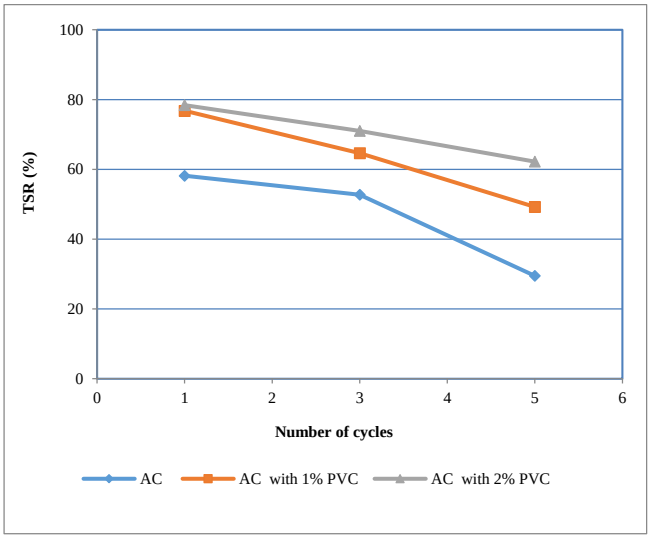

Figure 2. TSR results of samples made with granite aggregates

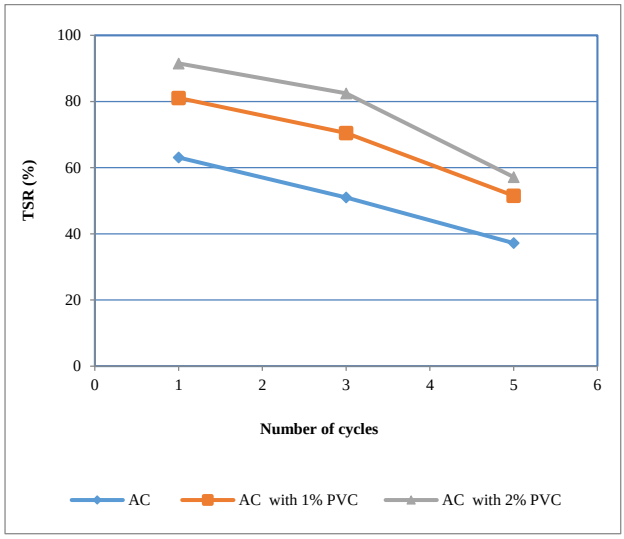

Figure 1. TSR results of samples made with limestone aggregates

Table 1. Frequency of surface free energy of bitumen used (ergs /cm^2)

Asphalt binder types	SFE Components (ergs/cm^2)				
	Basic	Acidic	Polar	Non-Polar	Total
AC 60-70	0.61	1.58	1.96	12.48	14.44
AC 60-70 with 1% PVC	1.19	1.44	2.62	19.43	22.05
AC 60-70 with 2% PVC	1.26	1.39	2.65	20.48	23.49

4. Conclusion

The most important results in this research are:

1. The use of anti-stripping additives has led to a decrease in the acid component and base pitch play, respectively. This phenomenon causes the amount of adhesion of bitumen to increase with limestone and granite aggregates. Also, this material has significantly increased the nonpolar component of surface free energy. This leads to the formation of better non-soluble bonds. The total amount of free energy released from the bitumen is higher than that of the base bitumen.
2. The free energy of adhesion in the modified specimens increases compared to the base specimens. In fact, to separate the bitumen from the aggregate unit surface, more energy is needed, which reduces the possibility of the occurrence of pruning. Using PVC reduces the amount of detergent in the modified specimens. This causes the bitumen-aggregate system to be thermodynamic in a more stable state and the severity of the occurrence of denting to decrease.
3. Using PVC will increase the indirect ratio of indirect tensile strength in samples with both types of aggregate used in this research.
4. Due to the fact that the granite-forming structure has more minerals with higher hydrophilicity, samples made with this type of aggregate show less resistance to moisture breakdown.
5. The results of both of the energy parameters used in this study indicate that the use of PVC causes the asphalt mix resistance to deteriorate moisture.