Evaluation of Mechanical Properties of Asphalt Mixtures Containing Anti-Stripping Additives of GRIPPER® L, TeraGrip and WETMUL-950

Afshar A. Yousefi[1] Wshyar Mohammed Hasan[2]

Alireza Saghaei[3] Pooyan Ayar[4] Mahmoud Ameri[5]

1. Introduction

Moisture susceptibility is one of the common pavement damages that may occur due to reduced adhesion between bitumen and aggregates and reduced cohesion in the bitumen structure. Separation, displacement, emulsification, and environmental effects are among the various factors that cause stripping. To evaluate the stripping and moisture susceptibility of asphalt mixtures, various methods and experiments such as modified Lottman (AASHTO T283), Wheel Track test, resilient modulus, energy methods based on the theory of surface free energy between bitumen and aggregate have been used by some researchers.

Moisture susceptibility of asphalt mixtures can be affected by factors such as type and chemical properties of bitumen, bitumen aging rate, type and grading of aggregate, mixing temperature, compaction temperature of asphalt mixtures, etc.

Infiltration of moisture into the asphalt mixture can reduce durability, increase stripping, and cause damages such as rutting and cracking. To increase the durability and resistance to the moisture of asphalt mixtures, anti-stripping additives, hydrated lime, and polymer have been the focus of many researchers in the asphalt industry. The addition of anti-stripping liquid increases the resistance to moisture susceptibility and stripping of asphalt mixtures by changing the surface properties of aggregates and improving the adhesion between bitumen and aggregates.

Although anti-stripping additives can increase the resistance of asphalt mixtures to stripping, they can have different effects on other parameters and mechanical properties. Therefore, understanding the behavior of anti-stripping additives in asphalt mixtures and their effect on mechanical properties is an essential prerequisite for making asphalt mixtures resistant to stripping and other failures such as rutting and cracking.

2. Experimental program

In this study, the effect of three different types of anti-stripping additives (i.e., GRIPPER, Tragrip, and WETMUL-950) on the mechanical properties and durability of asphalt mixtures were evaluated using various methods, including resilient modulus, dynamic creep, semi-circular bending fracture test, and indirect tensile strength tests. Furthermore, correlation analysis between the results of performance tests was conducted. Table 1 describes the physical properties and the dosage of anti-stripping used in this research.

Table 1. Physical properties of the used additives

Additive	ID	Content	Physical properties
GRIPPER ® L	G	0.4 %	Physical state: liquid Color: yellow Viscosity (20°C): 2.5 Pa.S Density (gr/cm^3 at 20°C): 1.02 Softening point: more than 150
TeraGrip	TG	0.4 %	Physical state: liquid Color: Honeyed Density (gr/cm^3 at 20°C): 0.94-0.96 Softening point: more than 150
WETMUL -950	W	0.5 %	Physical state: liquid Color: brown Density (gr/cm^3 at 20°C): 0.94-0.96 Solubility in water: Not soluble Solubility in hydrocarbons: soluble

3. Results and discussion

Table 1 shows the flow number (FN) value of asphalt mixtures containing various anti-stripping agents. Anti-stripping agents have increased the flow number of asphalt mixtures, which can create a strong bond between bitumen and aggregates and enhance adhesion work between them. Thus, the addition of anti-stripping agents has increased the rutting resistance of modifies asphalt mixtures.

Table 2. FN value of different asphalt mixtures

	Base	G	TG	W
FN	228	276	325	318

Additionally, using G, TG, and W agents as anti-stripping additives increased resistance to moisture susceptibility. The highest increase in the ITS ratio for asphalt mixes containing W is by about 25.2%. According to previous studies, to evaluate the moisture susceptibility of different asphalt mixtures, a TSR of 80% is the threshold (Figure 1).

[1] MSc Student in Highway and Transportation Engineering, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran

[2] MSc Student in Highway and Transportation Engineering, School of Civil Engineering, Islamic Azad University, Science and Research Branch, Tehran, Iran

[3] MSc Student in Highway and Transportation Engineering, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran.

[4]. Corresponding Author. Assistant Professor, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran. **Email**: ayar@iust.ac.ir

[5]. Professor, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran

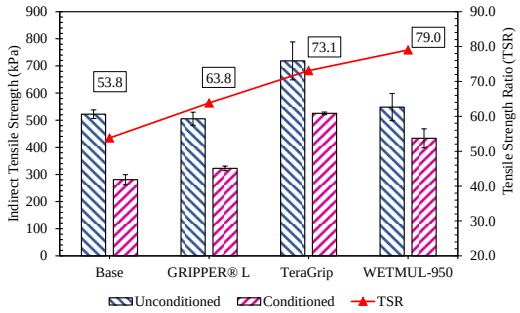

Figure 1. TSR of asphalt mixtures containing the anti-stripping additive

Figure 2 shows the resilient modulus of mixtures containing various additives under wet and dry conditions. According to this figure, the use of anti-stripping additives, creating a strong chemical bond between bitumen and aggregates, and creating a hydrophobic surface by increasing the amount of work of adhesion and cohesion increased the resilient modulus under wet and dry conditions. This increase in the resilience modulus value for the mixture containing G in the dry condition and the mixture containing W in the wet condition are about 59.7% and 156%, respectively. Changes in the resilient modulus ratio for different asphalt mixtures showed that the resilient modulus ratio (RMR) and indirect tensile stress ratio (TSR) had a similar trend and anti-stripping additives had a positive effect on the moisture resistance of asphalt mixtures.

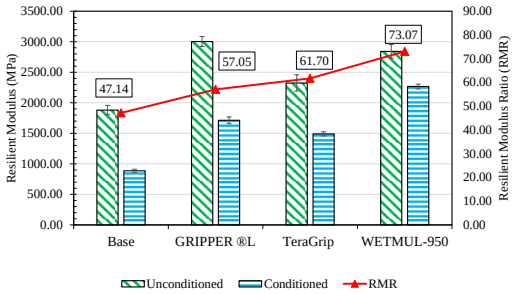

Figure 2. Resilient modulus of asphalt mixtures containing anti-stripping additives

Figure 3 shows the fracture energy and flexibility index value for asphalt mixtures containing anti-stripping additives. According to this figure, by adding anti-stripping additives, because of increasing the amount of adhesion and cohesion energy between bitumen and aggregates due to their chemical properties, the amount of energy required for breaking the samples made with these additives is increased (increment values: 18.7%, 49.6% and 24.6% for G, TG, and W, respectively). Moreover, modified asphalt mixture with anti-stripping agents increased the flexibility index and improved the cracking resistance of the modified asphalt mixtures.

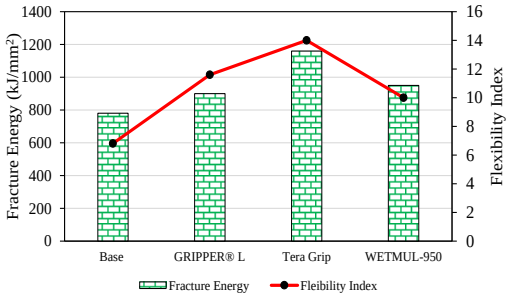

Figure 3. Fracture energy and flexibility index values for asphalt mixtures containing anti-stripping additives

4. Correlation analysis between the results of mechanical performance tests

The correlation analysis between the results of mechanical performance tests of asphalt mixtures showed that there was more correlation between the performed tests, so that the correlation coefficient between the parameter of indirect tensile strength ratio and resilient modulus under wet and dry conditions (TSR and RMR) with 0.974 has the highest correlation between different parameters of mechanical tests.

Table 3. The results of bivariate correlation analysis on various mechanical performance tests

	FN	TSR	RMR	FE	FI
FN	1				
TSR	0.9578	1			
RMR	0.8726	0.9740	1		
FE	0.9051	0.7482	0.5826	1	
FI	0.7582	0.5496	0.3841	0.9194	1

5. Conclusion

The mechanical tests showed that all additives used in this study increased the moisture resistance, rutting resistance, and crack resistance of asphalt mixtures. Asphalt mixture containing TeraGrip compared to other additives used in this study showed the higher resistance to rutting and cracking, resulting in a 43% increase in rutting resistance and 49.6% in crack resistance. Moreover, asphalt mixture containing WETMUL-950 showed a 25% increase in resistance to moisture damage (i.e., the highest resistance to moisture susceptibility among the various additives used in this study).