Evaluation of Indirect Tensile Strength of an Experimental Highway Section Containing Additives

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Abstract. Many researchers tried to improve asphalt mixtures by substituting small amounts of binder with additives to decrease distress. Since highway pavements are usually subjected to various types of distress due to exposed to high traffic volume and environmental factors. One of the most popular additions in several states is SBS. In recent years, an experimental section within the Basra-Baghdad expressway within Al-Diwaniyah province has been paved using SBS with a length of 1.2 km with different SBS percentages. This paper examines the indirect tensile strength (ITS) of the layers of pavements for sample cores taken from these sections within Al-Diwaniyah. This represents the first local experimental work for the evaluation of using additives for asphalt pavements out of laboratory conditions. So far, the results indicated a substantial increase. The ITS results have been increased by about 25% with an SBS of 6% compared with the case of no additives. Further research work will be followed to examine the rutting resistance for samples taken from the same sites and the tensile strength ratio (TSR).

Keywords: SBS; additives; ITS; asphalt mixture; bituminous mixture; indirect tensile strength.

1. INTRODUCTION

Many researchers tried to improve asphalt mixtures by substituting small amounts of binder with additives to decrease the distresses. Since highway pavements are usually subjected to various types of distress because they are exposed to traffic volume and environmental factors [1-4]. According to the literature, styrene-Butane-Styrene (SBS) has been used as an additive for asphalt pavements worldwide [1,2-8]. This led to a successful application to enhance the mechanical characteristics of mixtures, such as resistance to cracking and rutting. According to Dziadosz [9], adding SBS can reverse the aging process by reducing how quickly asphalt relaxes. During warm mix asphalt laboratory testing, Zhang [1] used a compound additive of SBS and Surfactant additive (SA) and discovered that the compound effect produced greater resistance to rutting and cracking. `

Numerous studies in Iraq looked into additives to improve asphalt mixtures. Such studies offer "laboratory" proof that some modifiers may aid in strengthening such mixes. Al-Shaybani [10] employed recycled mixtures with reused rubber in varying ratios. Through laboratory testing, Khudair and Kadhim [11] hypothesized that adding Polypropylene granules to the asphalt binder could improve Marshal Stability and ITS. According to Naser [12], introducing SBS polymer might enhance the ITS of HMA. Ceramic fiber and hydrated lime were employed by Ali and Ismaeel [13] as additives to improve the HMA. Their findings indicated a rise in tensile strength and a maintained strength index. According to Aboud [14], PVC polymer with natural rubber would improve the mechanical properties of HMA. Acrylic emulsion (ACR) was utilized by Alnaieli and Al-Busaltan [15] to enhance semi-flexible mixes. According to their research, ACR increased the compressive strength of such mixes.

So far, most researchers have claimed that using their additives in lab settings would result in appreciable improvements. No research hasn't been done in Iraq to look at how these chemicals perform in actual settings. It may be argued that mixing asphalt pavement components in a lab setting is not the same as mixing and heating production in actual facilities. Therefore, this experimental highway section containing additives is therefore necessary. Additionally, it is necessary to investigate the age effect of the polymer because Karakaş [16] suggested that the mechanical properties of HMA with SBS change significantly after only one year of exposure to the traffic load. This paper examines the indirect tensile strength of the layers of pavement. Further work will be followed to examine the pavement condition index (PCI) for the pavement with and without additives after about six years of being paved and exposed to traffic, as well as other laboratory tests such as rutting resistance.

2. METHODOLOGY

In this study, the mechanical parameters of an experimentally paved section with a total length of 1.2 km long roadway containing SBS polymer additives were evaluated. Table 1 illustrates the sections that extract ITS samples with and without additives. Two percentages of 6% and 8% were subtracted from the weight of the asphalt binder used to lay down 400 m of asphalt for each percentage. Additionally, there is an additional 400 m segment where SBS was employed in two layers (the surface layer, which contained 8% SBS, and the binder layer, which contained (6% SBS) that were placed beneath the surface layer. The section with additives was opened to traffic six years ago as a section of the Al-Basra-Baghdad freeway. Figure 1 shows the location of Al-Diwaniyah segment. The procedure for estimating ITS is described in ASTM D6931-12 [17].

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Table 1: SBS additive percentage.

No. of layers with additives	Layer type	SBS (%)	Section length (m)
1	Surface layer	6%	400
2	Surface layer	8%	400
	Binder layer	6%	500
1	Surface layer	8%	400
1	Surface layer	0%	1200

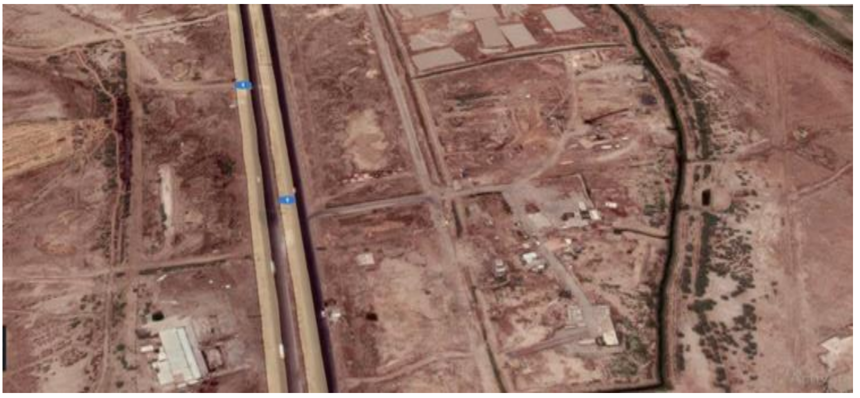

Figure 1: Site location in Al-Diwaniyah.

3. INDIRECT TENSILE STRENGTH (ITS)

The moisture in HMA contributes to the final separation of mixed components and the lack of adhesion between asphalt and aggregate. By applying line load on specimens, the ITS test is intended to forecast the tensile strength of HMA and the onset of cracks. The ASTM D6931-12 specification was followed throughout this test to determine the specimen's resistance to cracking. Three samples were set up for testing in a dry environment at 25°C for each case referred to above. The ITS testing requirements are shown in Table 2. The ITS is obtained using Equation 1.

$$\mathrm{ITS} = \frac{200\,\mathrm{P}}{\mathrm{D\,T}\,\pi} \qquad (1)$$

Where:
P=maximum load, N.
T=specimen height immediately before test, mm.
D=specimen diameter, mm.

Table 2: ITS testing conditions.

Parameters	The value used
Specimens' numbers	3
The load application rate, mm/min	50
Measuring device accuracy	0.01 N.
Specimen Conditioning Before the test	Air bath at 25°C for 2hr
Test temperature, °C	25 ± 2
Specimen thickness, mm	40
Specimen diameters, mm	100

Table 3 shows the number of ITS cores that were extracted. The specifications for height and diameter for specimens have an exception that specimens with a nominal diameter of 101.6 mm may have a minimum height of 38 mm. Cores should also have smooth, parallel surfaces. For testing, a minimum of three replicates from a currently used pavement must be prepared. For mixtures having a nominal maximum particle size of 19 mm or smaller, specimens with a nominal diameter of 101.6 mm are acceptable. Figure 2 shows the core machine that is used to extract samples from the pavement. Figure 3 shows the extraction process. Figure 4 shows the process of cutting samples to the required measurements and leveling the face of the sample, and Figure 5 Shows the ITS machine test.

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Figure 2: Core machine.

Figure 3: The extraction process.

Figure 4: The process of cutting samples to the required measurements

Figure 5: ITS machine test.

Table 3: ITS cores sampling.

Pavement	Length (m)	No. of samples
Surface pavement layer with additives SBS 6%	400	3
Surface pavement layer with additives SBS 8%	800	3
Binder pavement layer with additives SBS 6%	500	3
Surface pavement layer without Additives	1200	3
Surface pavement layer with additives SBS 6%	400	3

4. RESULTS

The ITS test assesses the tensile characteristics of asphalt mixtures that may be connected to pavement crack features. The ITS test results for asphalt concrete mixtures treated with SBS are shown in Figure 6. The figure shows that using the SBS additive has significantly increased the ITS with about 25% enhancement. The results indicate that 6% percent of SBS from the binder content is better than 8% for both surface and binder asphalt layers. In addition, the shape of the sample failure showing in Figure 7 suggested that the failure crack width without additives is much greater than the crack width with SBS additive.

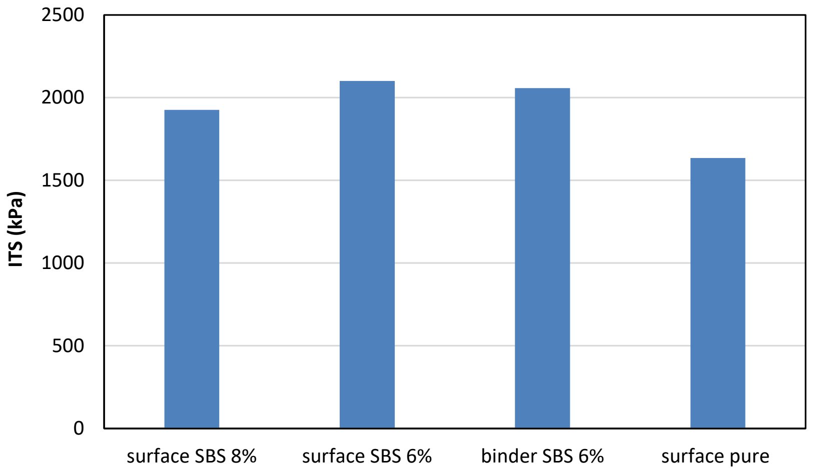

Figure 6: Result of ITS test.

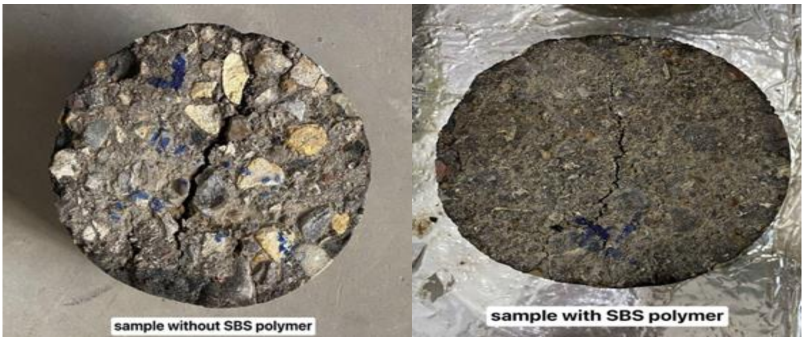

Figure 7: Samples after the ITS test showing the failure shape.

5. CONCLUSIONS

This paper examined the indirect tensile strength of the layer's pavements for a section of the freeway close to the city of Al-Diwaniyah that was paved with SBS additive. This highway was open to traffic for about six years. This represents the first local experimental work for the evaluation of using additives for asphalt pavements out of laboratory conditions. The research showed that using SBS additive has significantly increased the ITS. The ITS results have been increased by about 25% with an SBS of 6% compared with the case of no additives. Further research work will be followed to examine the rutting resistance for samples taken from the same sites and the tensile strength ratio (TSR).

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