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Effect of SBS Modified Bituminous Binder on Pavement Performances

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Abstract
SBS modified bituminous binder consisting of 4, 4.5, 5, 5.5 and 6 weight % of bitumen was prepared in high speed sheer mixer. Their performance in relation to temperature susceptibility, low temperature cracking, fatigue, rutting in hot condition and workability was tested by penetration, softening point, viscosity and ductility test as per their standard specifications. It is found that with increasing amount of SBS in bituminous binder, the penetration value decreases and softening point increases, which shows improved high temperature performance of modified bituminous binder. The increased value of ductility confirms an improvement in low temperature performance of SBS modified bituminous binder. However, a linearly decreased in penetration index was observed after the blending of SBS with bitumen more than 4% by weight showing the temperature sensitivity. Therefore, the 4% dosages of SBS is the optimized amount to achieve improved performances of SBS modified bituminous binder.

Keywords: Bitumen , SBS, viscosity, softening point, viscosity.

Introduction
In the developing countries highway infrastructure plays a vital role in the growth of their economy. In recent decades the pavement has experienced more pavement destruction like fatigue, rutt and crack,due to heavy axle load and extreme weather conditions[1]. Due to viscoelastic in nature, the mechanical performance of bituminous binder mainly depends on working temperature and shear pressure[2]. At elevated temperature bitumen as bitumen tends to flow causing rutting in pavement, while at low temperature it becomes solid i.e. brittleness in pavement.The mixture to be used in pavement (known as asphalt mix) must have a set of mechanical and physicochemical properties such as types and source of bitumen, content of bitumen, gradation, shape, texture and composition of aggregate. Some of the properties, which an asphalt mix have to achieve for better quality of pavement includes, rresistance to permanent deformation, durability, fatigue resistance, skid resistance, workability i.e. sufficient viscosity, moisture resistance, low noise and resistance to low temperature cracking[8].
To improve the pavement performances, many researchers worked on polymer modification of bitumen binders, which enhances the durability and better service conditions of roads[4]. Gate-together to encourage high-temperature blocks of asphalt, as expected, to ensure other road performance of the asphalt mix (for example, LTCR, water injury barrier, property loss, etc.) changed to its central location. For example, there is the famous road execution in styrene-butadiene-styrene (SBS)-modified asphalt to be fully utilized in a short time frame. Regardless, as s progresses, many appraisals are trying to find other equally heavy plans[5].
Modified asphalt adds value to the many advantages in road performance, albeit with a number of other issues as well. For example, in the asphalt pavement's improvement blueprint, SBS-modified asphalt tackles three focal uneven deserts: heat generation,

isolation, and hot disconnecting during management and storage. It achieves various quality plans that routinely precede progress and, unimaginably, affect the quality of progress more radically[6].Initiating bitumen transformation using polymers is to achieve essential conducting properties such as increasing shear modulus and decreasing ductility at high temperatures and reducing hot break cravings at low temperatures.Huge effects include the non-presence of low heat of flourish and detailed certification from remarkably surprising separation under weight and low braking temperatures. The safe assembly should provide new covers with better rheological and mechanical properties.

Bitumen is a very viscoelastic mixture of high molecular weight hydrocarbons, characterized by two fractions; asphaltene and maltene. The maltene phase can be fractionated[9, 10] again into complex compounds called as saturates (S), aromatics and resins (R) and aromatics fractions (A) containing conjugated ring compounds[11]. It is thought that the due to somehow similarity of the structure of SBS and bitumen, the blend of them, deliver the enhanced physicochemical and mechanical properties of asphalt mix[12].

SBS is swollen with aromatics and saturates creating an interaction of SBS copolymer with fractions of bitumen[13]. It is observed that π-electron clouds of polybutadiene (PB) chain of SBS copolymer may interact with bitumen constituents, which enhances the compatibility between SBS and bitumen[14]. The styrene-butadiene-styrene (SBS) polymer transformation promotes the versatility of the folios at high temperatures and is related to the adaptability at low temperatures.Those inclined in the direction of the properties should summarize the significantly more extended confirmation of the frequent cracking of asphalt at varying high and low temperatures[7, 15].Hiller et al described that the SBS transformation is related to the rheological properties of bitumen. The amazing properties can be visualized by the various endpoints obtained using DMA and BBR. The degree of development is influenced by the bitumen source and type and by the SBS content[16]. Ressel et al. highlighted that significant improvement in rheological properties is observed when SBS content is added from 3% to 6% by weight. Expanded SBS containing modified SAFE show higher ductility and lower temperature requirements than folios modified with SBS at high temperatures in any case, the two polymer types do not dissociate from the frontal cortex at low temperatures[6].

In this study bitumen is blended with varying amount of SBS (wt %) and the performances of these blends were evaluated in terms of terms of stiffness, resistance to deformation, viscosity and ageing over a long period.

Material and Methods:

Penetration grade bitumen and SBS copolymer (Table 1) were blended, with amount of SBSvarying 4, 4.4, 5, 5.5and 6 weight%, in double jacketed steel vessel fitted with high speed shear mixer for 2 hours 90- 135^{0}C and then mixed with sped of 1300 rpm at 160^{0}C for 40 minutes.

Table 1. Physical properties of SBS copolymer

olatile content (%)	elt flow rate (g/10 min)	I longation at break (%)	P ermanent deformation rate at break (%)	300% tensile strength (MPa)
.70	.80	7 20	2 8	2. 0

Results and discussion

Penetration test of base bitumen (0% SBS) and SBS modified bitumens was carried out at 15, 25 and 30^{0}C temperatures. It is evident from the table 2 that with increase of content of SBS in SBS modified binder, the penetration values of bituminous binder decrease, indicating that sensitivity of bitumen towards temperature is decreases. Similar results are observed from the figure 1. The reduced penetration index of SBS modified bitumen binder also confirms its reduced sensitivity toward temperature. At more than 4 % dosage of SBS, the temperature sensitivity of binder increases, showing that the optimum dosage SBS content in modified bituminous binder is up to 4% by weight to meet the technical requirement of technical specification for pavements and lower dosages also reduces the cost of construction.

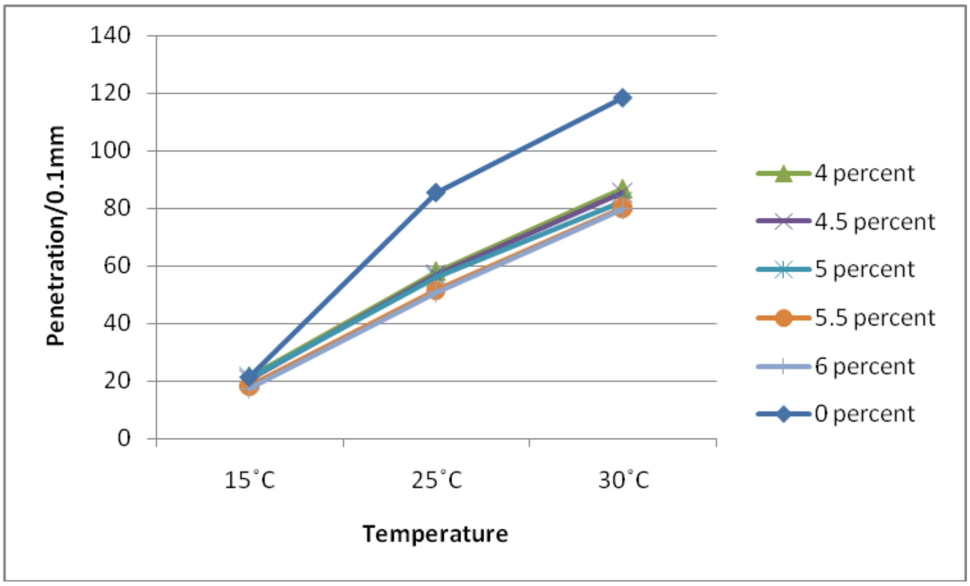

Figure 1. Penetration value of SBS modified bitumen binder at different temperatures

The softening point is measurement of stiffness and temperature susceptibility of bitumen binder, the physical state of binder is shifted from visco-plastic to viscous flow, at this critical temperature. Higher value of softening point of binder shows that binder will possess high temperature resistance[17]. The disadvantages of less temperature performance of asphalt binder can be seen in the summer season, the roads become rutt as the temperature rises, and it is converted to permanent deformation, increases the chances of road accidents and discomfort to drivers[18].

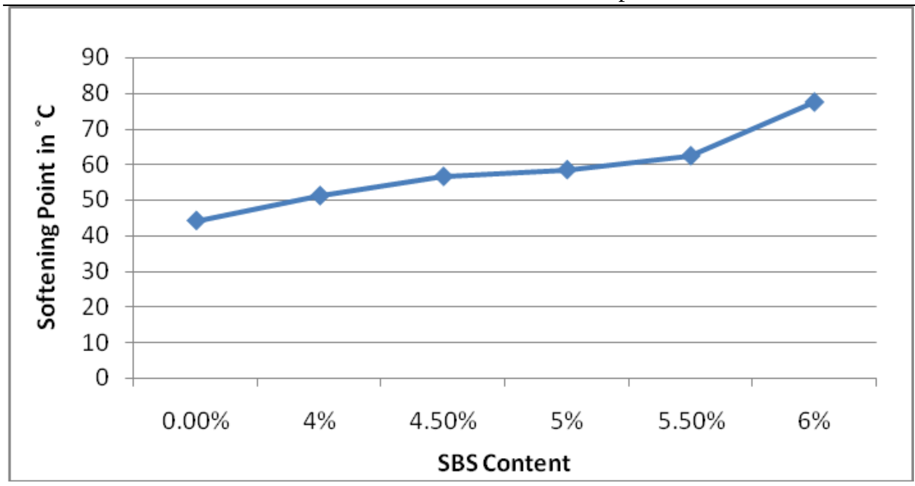

Figure 2. Softening point values of SBS modified bitumen binder Vs SBS content

The figure 2 shows that with addition of SBS in bitumen, the softening point of bitumen binder increased gradually. These results are also verified from table 2. This means that SBS had improved the temperature performance of SBS modified bitumen binder. It is evident from the figure 3 that viscosity of bitumen binder also increases with increased dosages of SBS.

Table 1. Performance index of SBS modified asphalt with different amount of SBS

Content	Temperatures			PI	Softening Point /°C	Kinematic viscosity(135°C) /Pa·s	Ductility(5°C, 5cm/min) /cm	Ductility after Ageing (5°C, 5cm/min) /cm
	15°C	25°C	30°C					
0.0%	21.4	85.5	118.4	-1.30	44.1	0.31	0	0
4.0%	21.6	58.0	86.6	0.13	51.1	0.81	24	14
4.5%	20.6	57.2	85.6	-0.03	56.5	0.82	34	14
5.0%	21.1	56	82.2	-0.20	58.4	1.04	40	24
5.5%	18.4	51.6	80.2	-0.20	62.3	1.2	45	25
6.5%	17.3	50.8	79.7	-0.41	77.4	1.5	46	27

The low temperature performance of asphalt binder is characterized by the ductility test; the higher ductility means that asphalt binder is more resistance to low temperature cracks. The table 2 to shows that SBS modified bitumen binder possessing increased value of ductility.

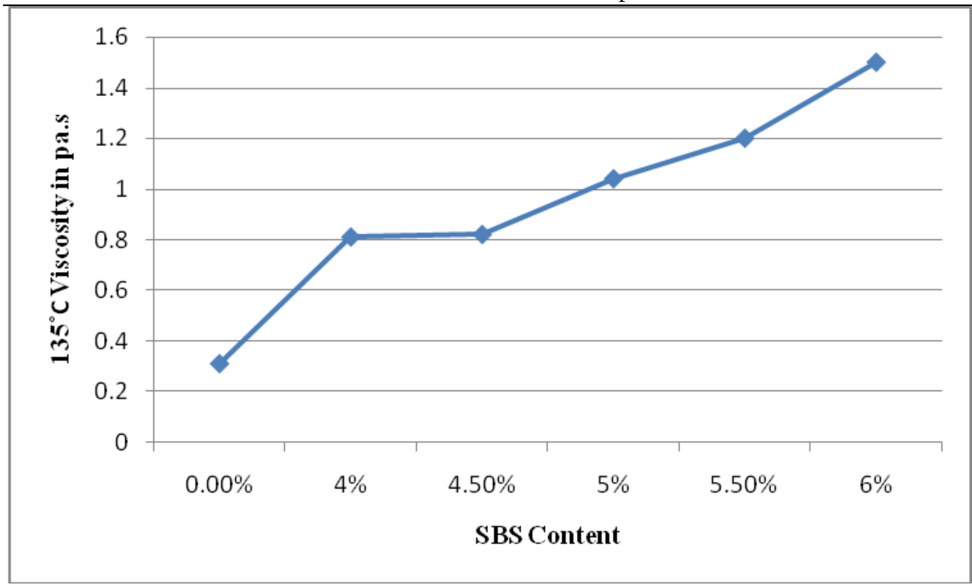

Figure 3. Viscosity of SBS modified bitumen binder Vs SBS content

Conclusion

The SBS modifier can significantly improve the high and low temperature performances of bitumen binder, when added in adequate amount into bitumen. The conventional properties of SBS modified bituminous binder showed improved resistance to low temperature cracking and resistance to rutting in hot seasonal conditions. The improved viscosity values give the better fluidity to SBS modified bitumen binder and also better workability at working site.

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