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A PERFORMANCE EVALUATION OF WARM MIX ASPHALT MIXTURE BY INCORPORATING SASOBIT ADDITIVE

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Abstract - *Around 80% of road system in India comprises of flexible pavement in which Hot Mix Asphalt (HMA) is used in the bituminous layer. Warm Mix Asphalt (WMA) is useful in certain circumstances when the issues related with HMA might be lessened. Warm Mix Asphalt brings down the mixing temperatures at which asphalt materials are mixed and laid on road. The benefits of WMA are reduced emission, enhanced workability and lessened energy consumption. Furthermore, it gives simpler compaction in longer pull separations and outrageous climate conditions. In this study, experimental investigations have been carried including a warm mix chemical sasobit additive which is effectively accessible. To choose the ideal concentration of sasobit additive substance for DBM mix, warm mix has been prepared by utilizing sasobit additive substance with VG 30 at different mixing temperatures of 110°C, 120°C, 130°C and 140°C. According to specifications by MORTH, samples of Marshal test made by the use of Dense Bituminous Macadam (DBM) grade and a short time later Marshall properties were studied with ideal mixing temperature and ideal Binder sasobit additive composite. It was found that the DBM warm mix with sasobit additive has given high Indirect Tensile Strength (ITS) and high Marshall Soundness (stability) with other satisfactory Marshall parameters. The held stability and tensile strength are observed likely to be satisfactory in such warm mixes. The resulting warm mixes are additionally seen to be comparable to the control HMA.*

Key Words: **Warm Mix Asphalt, Sasobit, Indirect Tensile Strength, Marshal Properties, Retained stability**

1. INTRODUCTION

Warm mix asphalt is picking up acknowledgment now a day in light of around 80% of the paved roads in India are involves flexible pavement, which comprises of aggregate and asphalt binder which are heated and mixed together. Generally, the mixing temperatures of warm mix asphalt limits from 100 to 135°C (Hurley and Prowell, 2005) compared with the mixing temperatures of 150 to 180°C (300 to 350°F) for hot mix asphalt. WMA uses Sasobit, a chemical additive to yield asphalt mix at lower temperature by decreasing the binder viscosity, which increase the workability of mix without compromising performance of asphalt. Energy use, global warming, oxidative solidifying of asphalt, and overhead cost expenses of the asphalt industry are lessened in warm mix asphalt and it makes better working environment too. Warm mix asphalt is produced, placed and compacted at temperature10°C to 40°C lesser than the control Hot Mix Asphalt (D' Angelo et.al, 2008). In any case, the lower mixing temperatures have raised concerns on the performance of the mix. Along these lines, it is expected to completely assess and characterize the WMA mixtures to ensure sufficient performance.

2. POTENTIAL ADVANTAGES

Warm Mix Asphalt (WMA) deals with the technology which reduces production and compaction temperatures.

- **Environmental-** Fumes and emission (bringing lower discharges of CO2 and other greenhouse gasses) are lessened on account of the temperature level is nearly low, air-contamination is less.
- **Production -** Ageing of bitumen binder amid the production and paving process is controlled significantly, which enhances serviceability of pavement.
- **Paving -** Compaction and workability are enhanced because of reducing bitumen viscosity at paving temperature. Construction season develops and furthermore it increases haul distance. Pavement cooling time is reduced because of low initial temperature. It is convincing to public near work and production site as emissions, odour and fumes are decreased.

As compared with Hot Mix Asphalt, WMA offers a few advantages mentioned below.

Energy cost is lessened due to lower production and placement temperatures. During the production of WMA, aging of binder is controlled considerably which enhances of pavement service life. Due to decreased temperature, it causes less wear on Asphalt plant. Because of lower temperature, it makes decrease in pavement cooling time.

3. OBJECTIVE OF STUDY

The essential objective of the study is to develop WMA using Sasobit additive and to assess the effects of additive on the properties of binder and mixture.

- To investigate the physical properties and viscosity of the binder modified with different percentages of Sasobit additive at various temperatures.
- To choose suitable percentage of Sasobit for optimum mixing temperature for the mixtures.
- To assess the warm asphalt mix prepared with different percentages of additive in terms of Engineering Properties such as indirect tensile strength and Marshall Characteristics.
- To study performance of mix in terms of their held tensile strength ratio and retained stability value.

4. EXPERIMENTAL TESTS TO BE PERFORMED

Based on the literature review, the following experimental tests were carried out.

I. Aggregate tests
   - Shape Test (Elongation Index)
   - Shape Test (Flakiness Index)
   - Aggregate Crushing Strength Test
   - Aggregate Impact Test
   - Los Angeles Abrasion
   - Water Absorption Test Of Aggregates

II. Bituminous tests
   - Specific gravity
   - Softening Point
   - Penetration
   - Ductility
   - Elastic Recovery
   - Marshall test

5. TEST RESULTS

Table -1: Physical Properties of Coarse Aggregates

Property	Test Method	Test Result
Elongation Index (%)	IS: 2386 (P I)	21.5
Water Absorption (%)	IS: 2386 (P III)	0.1
Los Angeles Abrasion Value (%)	IS: 2386 (P IV)	18
Flakiness Index (%)	IS: 2386 (P I)	18.8
Aggregate Impact value	IS: 2386 (P IV)	14.3
Aggregate crushing value	IS: 2386 (P IV)	13

Table -2: Physical Properties of VG 30 bitumen

Property	Test Method	Value
Specific gravity	IS: 1203:1978	1.03
Softening Point, ºC	IS: 1203:1978	48.5
Penetration at 25ºC(0.1mm) I	IS: 1203:1978	52
Ductility, mm	IS: 1208:1978	80.2
Elastic Recovery, mm	IS 15462	76

6. METHODOLOGY

According to the methodology and experimental work, test results are presented, analyzed and discussed as following in four sections.

- First section refers to Marshall parameters used for volumetric analysis of mix.
- Second section deals with choosing optimum mixing temperature used for warm mix preparation. This section also gives physical properties of bitumen with different percentages of additive.
- Third section deals the Marshall properties of additive modified DBM warm mix with mixing temperature of 110°C, 120°C, 130°C or 140°C and choosing the suitable mixing temperature.
- Fourth section refers the other engineering properties of additive modified DBM.

7. EXPERIMENTAL TEST RESULTS

7.1 Binder Test results

In this study, it is suggested to prepare warm mix asphalt with mixing temperature obtained from Brookfield viscometer by using VG 30 with various percentages of Sasobit additive. As the mixing temperature plays an important role for improve the DBM warm mix Marshall properties. Mixtures prepared with changing mixing temperatures have been studied. Mixing temperatures of 110°C, 120°C, 130°C and140°C were considered for preparation of sample and compared without Sasobit additive at various temperature.

7.1.1 Determination of Mixing Temperature for warm DBM mix

In this study, the mixing temperature is find out by conducting viscosity experimental test of binder in Brookfield viscometer at various temperature for different percentages of Sasobit. Viscosity of VG-30 with 1%, 2% & 3% percentage of Sasobit is measured at 110°C, 120°C and 130°C to produce WMA. It is Compared without Sasobit additive at various temperatures.

Table -3: Rotational viscometer temperature test results

Temperature (°C)	Torque (%)	Shear Rate (Sec-1)	Viscosity (cp)	Viscosity (Pa.s)	Average Viscosity (Pa.s)
110	0.73	6.80	730	0.73	0.73
110	0.73	6.80	730	0.73	
110	0.73	6.80	730	0.73	
120	0.64	6.80	640	0.64	0.61
120	0.64	6.80	640	0.64	
120	055	6.80	550	0.55	
130	0.43	6.80	430	0.43	0.38
130	0.37	6.80	370	0.37	
130	0.34	6.80	340	0.34	
140	0.25	6.80	250	0.25	0.29
140	0.33	6.80	330	0.33	
140	0.29	6.80	290	0.29	
160	0.13	6.80	130	0.13	0.17
160	0.22	6.80	220	0.22	
160	0.16	6.80	160	0.16	

Table -4: Rotational viscometer temperature test results

Temperature (°C)	Torque (%)	Shear Rate (Sec-1)	Viscosity (cp)	Viscosity (Pa.s)	Average Viscosity (Pa.s)
110	0.15	6.80	150	0.15	0.70
110	0.30	6.80	300	0.30	
110	1.65	6.80	165	1.65	
120	0.59	6.80	590	0.59	0.58
120	0.53	6.80	530	0.53	
120	0.62	6.80	620	0.62	
130	0.39	6.80	390	0.39	0.34
130	0.39	6.80	390	0.39	
130	0.62	6.80	620	0.62	
140	0.31	6.80	310	0.31	0.26
140	0.23	6.80	230	0.23	
140	0.24	6.80	240	0.24	

Table -5: Rotational viscometer temperature test results

Temperature (°C)	Torque (%)	Shear Rate (Sec-1)	Viscosity (cp)	Viscosity (Pa.s)	Average Viscosity (Pa.s)
110	0.78	6.80	780	0.78	0.65
110	0.59	6.80	590	0.59	
110	0.58	6.80	580	0.58	
120	0.63	6.80	630	0.63	0.54
120	0.54	6.80	540	0.54	
120	0.45	6.80	450	0.45	
130	0.35	6.80	350	0.35	0.32
130	0.28	6.80	280	0.28	
130	0.35	6.80	350	0.35	
140	0.15	6.80	150	0.15	0.20
140	0.23	6.80	230	0.23	
140	0.23	6.80	230	0.23	

Table -6: Rotational viscometer temperature test results

Temperature (°C)	**Torque (%)**	**Shear Rate (Sec-1)**	**Viscosity (cp)**	**Viscosity (Pa.s)**	**Average Viscosity (Pa.s)**
110	0.54	6.80	540	0.54	0.58
110	0.51	6.80	510	0.51	
110	0.69	6.80	690	0.69	
120	0.51	6.80	510	0.51	0.48
120	0.46	6.80	460	0.46	
120	0.47	6.80	470	0.47	
130	0.31	6.80	310	0.31	0.3
130	0.21	6.80	210	0.21	
130	0.38	6.80	380	0.38	
140	0.15	6.80	150	0.15	0.13
140	0.09	6.80	90	0.09	
140	0.15	6.80	150	0.15	

7.1.2 Determination of physical properties of VG 30 with varying percentages of additive

Before using this additive in road construction, it is important to the test the physical properties of binder. In this way, subsequent after adding the additive in VG 30, the physical properties are studied here in terms of penetration value, softening point, ductility and elastic recovery.

Table -7: Penetration test results of VG30 bitumen without Sasobit at 25 °C

Test No.	**1**	**2**	**3**
Penetration	51	55	50
Average Penetration (dmm)		52	

Table -8: Penetration test results of VG30 bitumen with 1% Sasobit at 25 °C

Test No.	**1**	**2**	**3**
Penetration	42.5	38	39
Average Penetration (dmm)		40	

Table -9: Penetration test results of VG30 bitumen with 1% Sasobit at 25 °C

Test No.	**1**	**2**	**3**
Penetration	39	36.5	38.5
Average Penetration (dmm)		38	

Table -10: Penetration test results of VG30 bitumen with 1% Sasobit at 25 °C

Test No.	**1**	**2**	**3**
Penetration	34.5	33.5	37
Average Penetration (dmm)		35	

Table – 11: Softening point test results of VG30 bitumen without Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	49	49
2	49	

Table – 12: Softening point test results of VG30 bitumen without Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	46	46.5
2	47	

Table – 13: Softening point test results of VG30 bitumen without Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	49.5	50
2	50.5	

Table – 14: Softening point test results of VG30 bitumen 1% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	56	56
2	56	

Table – 15: Softening point test results of VG30 bitumen 1% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	59.5	60
2	60.5	

Table – 16: Softening point test results of VG30 bitumen 1% Sasobi

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	58	58
2	58	

Table – 17: Softening point test results of VG30 bitumen 2% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	60.5	61
2	61.5	

Table – 18: Softening point test results of VG30 bitumen 2% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	61.00	61.15
2	61.30	

Table – 19: Softening point test results of VG30 bitumen 2% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	62	62.5
2	63	

Table – 20: Softening point test results of VG30 bitumen 3% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	65.60	64.8
2	64	

Table – 21: Softening point test results of VG30 bitumen 3% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	67.40	66.70
2	66.00	

Table – 22: Softening point test results of VG30 bitumen 3% Sasobit

Ring No.	Instant Temperature, °C	Softening Point, Average °C
1	65	65
2	65	

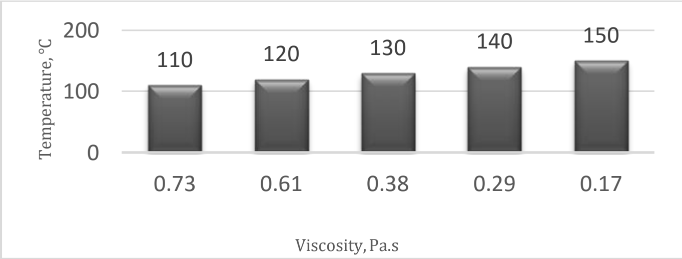

Fig. 1: Temperature, °C v/s Viscosity, Pa.s at 0% Sasobit

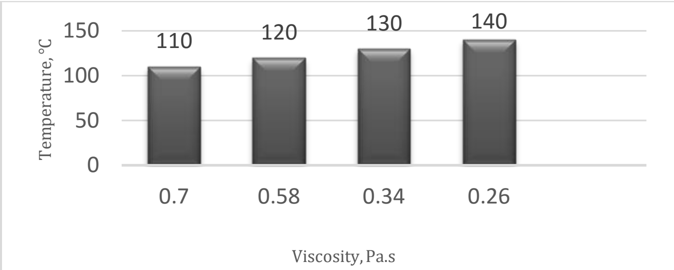

Fig. 2: Temperature, °C v/s Viscosity, Pa.s at 1% Sasobit

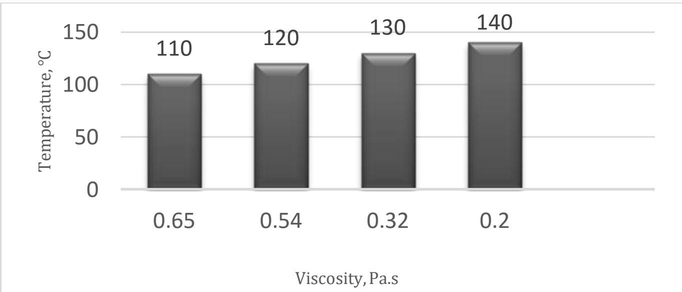

Fig. 3: Temperature, °C v/s Viscosity, Pa.s at 2% Sasobit

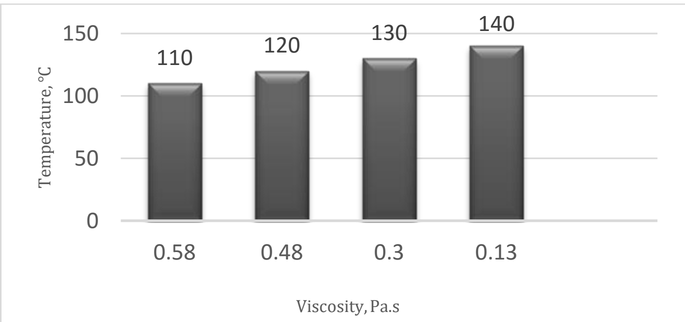

Fig. 4: Temperature, °C v/s Viscosity, Pa.s at 3% Sasobit

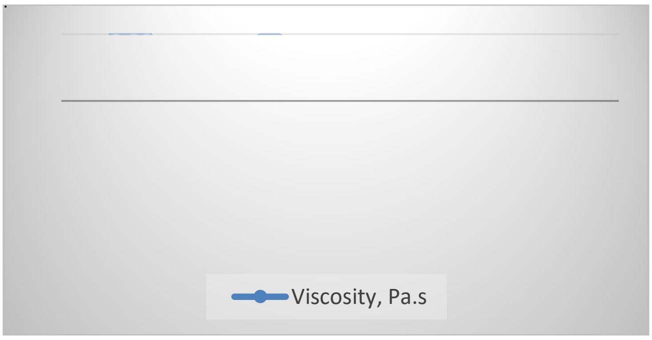

Fig. 5: Viscosity, Pa.s v/s % Sasobit at 130 °C

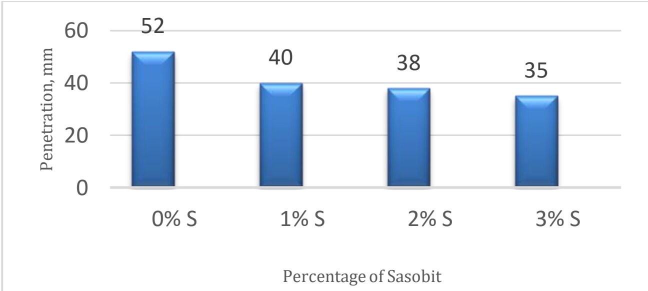

Fig. 6: Penetration, mm v/s % Sasobit at 25 °C

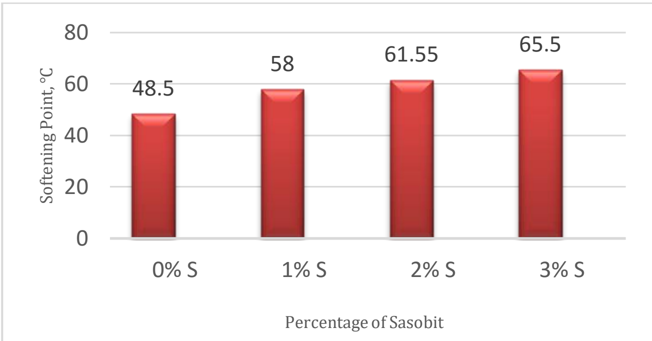

Fig. 7: Softening Point, °C v/s % Sasobit

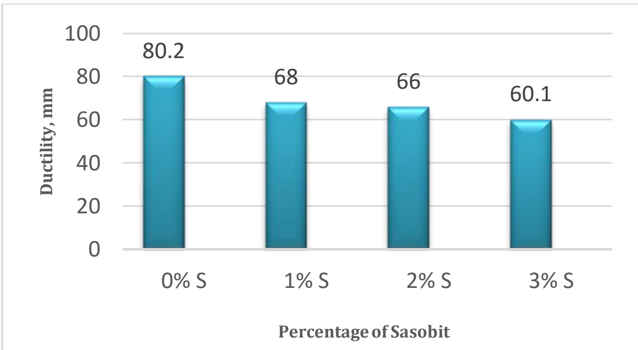

Fig. 8: Ductility, mm v/s % Sasobit at 27 °C

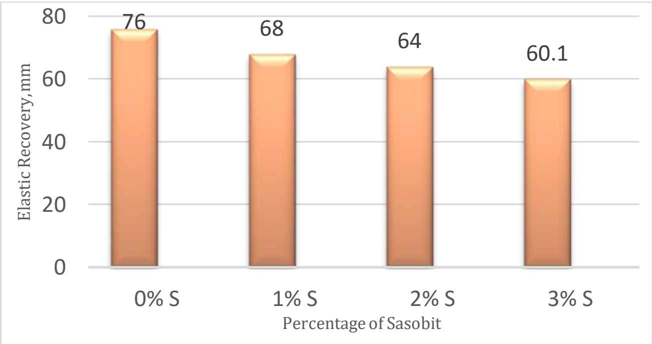

Fig. 9: Elastic Recovery, mm v/s % Sasobit at 15 °C

7.2Effect of additive content on Marshall Properties for DBM warm mix

To evaluate the best combination additive percentages in mixing temperature and bitumen, warm DBM mixtures are prepared with VG-30 with various percentages of additive content at 110°C, 120°C, 130°C and 140°C temperature.

7.2.1 Effect of additive content on Marshall Properties for DBM warm mix samples prepared at 110°C, 120°C, 130°C and 140°C.

For DBM warm mix having in different dosages of additives, the Marshall properties, such as air voids, flow value, unit weight, air voids, voids filled with mineral aggregates (VMA), stability, and voids filled with bitumen (VFB). It has been seen that pattern of variation in Marshall Properties with binder content are like normal HMA and furthermore denoted that stability and unit weight increases with binder content and there after decreases. The maximum unit weight and stability values obtained at their optimum binder content. Moreover, the flow value and air voids accordingly decrease and increase with increase in binder content. It has been observed that with increment in bitumen concentration in mix VMA reduce up certain binder content and after that increases sharply and furthermore observed that VFB increases sharply with increase in binder content.

7.3 Other Engineering properties of warm mixes are

7.3.1 Indirect tensile strength of DBM mixes

Indirect elasticity of the mix decides the resistance against thermal cracking. These tests have been conducted on DBM mixes with modified binder at their respective mix temperatures and binder content having changing additive contents. The effects of additive concentration and temperature in DBM mixes are studied.

Table 23: Test reults of Indirect tensile strength and Ductility experiments

Percentage of Sasobit	Ductility at 27°C	Elastic Recovery at 15°C
0	80.2	76
1	68	68
2	66	64
3	60.1	60.1

7.3.2 Tensile strength ratio of warm mix

Moisture susceptibility is main cause of distress in pavement. The evaluation of moisture sensitivity of DBM warm mix has mostly conducted using a standard method, AASHTO T283.

7.3.3 Retained stability for DBM warm mix.

Another way of assessing the resistance to moisture damage of mix is find out by conducting retained stability test. For this additive modified DBM warm mix, retained stability and additive modified DBM has been measured at their respective optimum mixing temperatures.

8. CONCLUSION

Performance evaluation of WMA using Sasobit additive with different percentages and test temperatures are done. The following conclusions were obtained.

- Penetration values are found to decrease with the addition of Sasobit additive. The reduction in penetration value with 1% of Sasobit is found to higher than 2 and 3 percentages of Sasobit.
- Addition of Sasobit additive has increased the softening point of WMA. 1% of Sasobit has higher increment of softening point value than2 and 3 percentages of Sasobit.
- Viscosity of WMA has reduced with the addition of Sasobit additive. There found higher value reduction of viscosity by 1% Sasobit at 130 °C.
- Addition of Sasobit additive has reduced the elastic recovery values.
- Ductility values increased with addition of Sasobit additive and it is found to be higher in increment at 1% than 2 and 3 percentages.

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