International Journal of
Advances in Scientific Research and Engineering (ijasre)
E-ISSN : 2454-8006
Vol.3, Special Issue 1 Aug - 2017

Evaluation of Laboratory Performance of Sasobit and Zycotherm as An Additives for Warm Mix Asphalt on Performance Characteristic

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ABSTRACT

Warm Mix Asphalt (WMA) is a fast emerging green technology which has a potential to replace Hot Mix Asphalt (HMA) and significantly reduces the production temperature of asphalt mixtures through lowering the viscosity of asphalt binders. The technology can reduce production temperatures by as much as 30 percent. Asphalt mixes are generally produced at 150º C or greater temperatures depending mainly on the type of binder used. WMA mixes can be produced at temperatures of about 135ºC or lower.This paper presents the findings of an experimental study aimed at evaluation of Marshall mix design and moisture-induced damage properties of Sasobit and Zycotherm modified WMA mixtures and were compared with HMA mixtures. Marshall mix design and moisture-induced damage properties were evaluated for varying dosage rate of WMA additives (1% to 5% of Sasobit by weight of binder with increment of 1% and 0.05% to 0.2% of Zycotherm by weight of binder with increment of 0.05%). Marshall mix design properties which include bulk specific gravity of compacted mixes (Gmb), air voids (VTM) content, voids filled with mineral aggregates (VMA) and voids filled with asphalt (VFA) were evaluated. Moisture-induced damage was evaluated by the Tensile Strength Ratio (TSR) approach and boiling water test. Test results indicate that WMA mixtures satisfied requirements of mix design properties. Further, WMA mixtures exhibited higher resistance to moisture-induced damage and fulfilled the minimum TSR requirements. In addition, dosage rate of WMA additives had significant effect on both Marshall mix design and moisture-induced damage properties.

Keywords: Mix Design Properties, Moisture-Induced Damage, Boiling Water Test, Sasobit, Zycotherm.

INTRODUCTION

Hot mix asphalt (HMA) is used as the primary paving material, as most of the paved roads are made of HMA , which consists of aggregates and binder , which are mixed together by heating at a specified temperature. HMA is typically produced either by drum mixer or batch mixer at a temperature ranges from 160^0c to 180^0c. In order to reduce the emissions from the asphalt plant , the Warm mix asphalt (WMA) technology , as introduced by reducing the mixing and compaction temperatures of the mixes , without affecting the properties of the mixes. The temperature of the WMA ranges from the 100^0c to 140^0c. The asphalt industry has been experimenting with warm and cold mixtures for decades to reduce to energy requirements and for environmental benefits. Since the cold mixes have not achieved the same overall long term performances as hot mixes, they will not be able to replaces hot mixes as the primary road surfacing materials.

Warm mix asphalt (WMA) is a fast emerging new technology which has a potential of revolutionizing the production of asphalt mixtures. WMA technology can reduce production temperatures by 30%, reduces the carbon dioxide emission by 30% and dust emission is lowered by 50 to 60% when compared to HMA.

OBJECTIVES

The main objective of this study is to evaluate the performance characteristics of the bituminous concrete (BC) mix using sasobit and Zycotherm of varying percentage of 1% to 5% and 0.05% to 0.15% by weight of binder.

- To know about the Stability and flow value of the bituminous concrete mix using additive.
- To determine the Indirect Tensile Strength properties of bituminous mix.
- To determination the stripping properties.
- To Compare between WMA properties to that of HMA for the bituminous concrete mix as per the MORTH specification.
- To determine effective usage of sasobit and zycotherm in the warm mix asphalt.

MATERIALS AND METHODOLOGY

Materials

- **Aggregates** The aggregates used in the study are collected from a quarry near Bangalore (mittaganahalli) .
- **Asphalt Binder** The Asphalt binder to be used in present research is Straight-run (plain) bitumen of penetration grade 60/70 (equivalent to viscosity grade-VG 30)
- **WMA additives** The warm mix additive zycotherm and Sasobit.

Table 1: Marshall properties of BC grade

Marshall properties	MORT&H Specification
Stability	Min 900kg
Bulk density	-
Flow	2-4mm
VMA	Min 16%
VFB	65-75%
ITS	Min 80%

Table.2: Gradation of the BC course

Grading	2
Nominal aggregate size (mm)	13
layer thickness (mm)	30-45
IS Sieve size (mm)	Cumulative % by weight of total aggregate passing
19	100
13.2	79-100
9.5	70-88
4.75	53-71
2.36	42-58

1.18	34-48
0.6	26-28
0.3	18-28
0.15	12-20
0.075	4-10
Bitumen content	5-7

Table 3: Gradation Of The Aggregates

Sieve size in mm	Achieved Limits	MoRT&H Lower Limits	MoRT&H Upper Limits
	% Passing	% Passing	% Passing
19.00	96	100	100
13.20	91.4	79	100
9.50	81.9	70	88
4.75	64.3	53	71
2.36	52.4	42	58
1.18	41.9	34	48
0.600	34.2	26	38
0.300	20.9	18	28
0.150	14.4	12	20
0.075	6.1	4	10

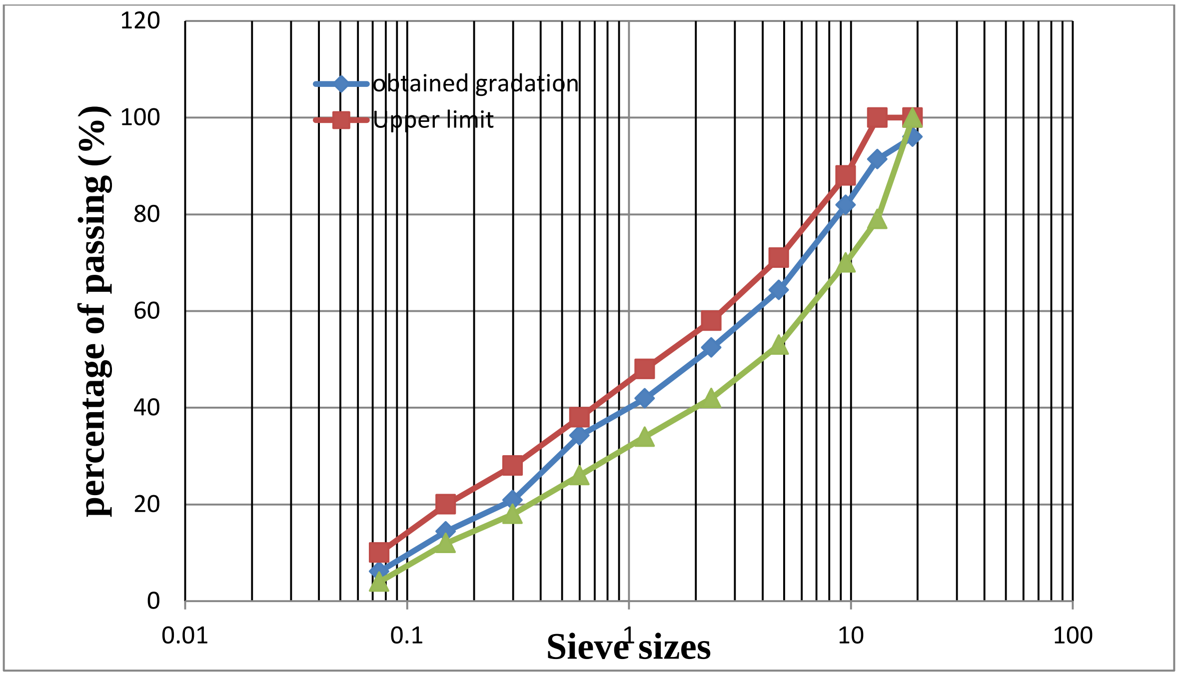

Figure 1: Gradation Of The Aggregates

Table 4 : Physical properties of aggregates

SL.NO	Test	Specification as per MORT&H	Obtained value	Test Method
1	Specific gravity	>2.5	2.72	IS 383-1970
2	Aggregate impact test	Max 27%	20.89%	IS: 2386 part 4-1963
3	Crushing test	Max 30%	24.4%	IS: 2386 part-4-1963
4	Los Angeles abrasion test	Max 40%	27.8%	IS:2386 part 4-1963
5	Flakiness and elongation index (combined)	Max 30%	27%	IS2386 part I - 1963

Table 5 : Physical properties of binder

Sl NO	Test	Requirement as per MORTH	Test method	Control binder (CB)	Sasobit modified binder (SMB)	Zycotherm modified binder (ZMB)
1	Penetration	50-70	IS:1203-1925	67	39	68
2	Ductility Test	Min 75	IS:1208-1978	79	86	90
3	Specific gravity	-	IS :1202	1.01	1.02	1.06
4	Softening point	Min 47	IS:1205-1978	58	70	58
5	Flash point	Min 220	IS :1209-1978	295	318	316

Table 6 : Marshal stability of varying% of with and without additive

Mix	Dosage (%)	OBC	% air voids	VMA (%)	VFA (%)	Gb (Kg/m$^{3)}$	Stability (KN)	Flow (mm)
HMA	0	5.63	3.80	16.81	77.58	2357.85	12.50	5.00
W-Z	0.05	5.81	4.40	17.60	76.00	2330.50	9.00	5.80
W-Z	0.1	5.48	4.20	16.90	73.85	2345.80	11.20	4.30
W-Z	0.15	5.64	3.90	16.70	77.20	2362.50	12.20	4.10
W-S	1	5.69	3.90	17.15	77.54	2353.50	9.70	5.20
W-S	3	5.47	3.79	16.53	77.06	2361.90	12.80	4.50
W-S	5	5.37	3.37	16.10	79.10	2372.21	13.00	4.00

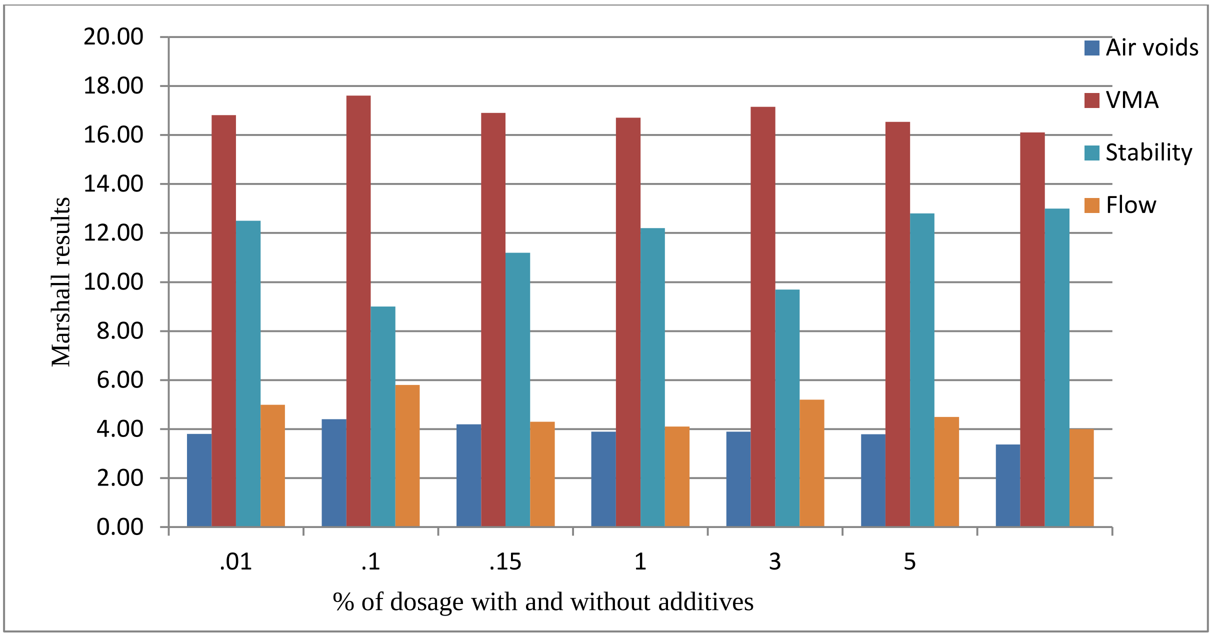

Figure 2 : Marshall stability of varying % of with and without additive

Table 7: Tensile strength ratio result

Dosage(%)	Mix	Unconditioned(kPa)	Conditioned(kPa)	TSR(%)
0	HMA	593.53	538.91	90.80
0.05	W-Z	438.50	345.20	78.72
0.1	W-Z	458.45	378.20	82.49
0.15	W-Z	465.20	392.50	84.37
1	W-S	450.20	375.25	83.35
3	W-S	463.53	398.50	85.97
5	W-S	482.50	421.50	87.36

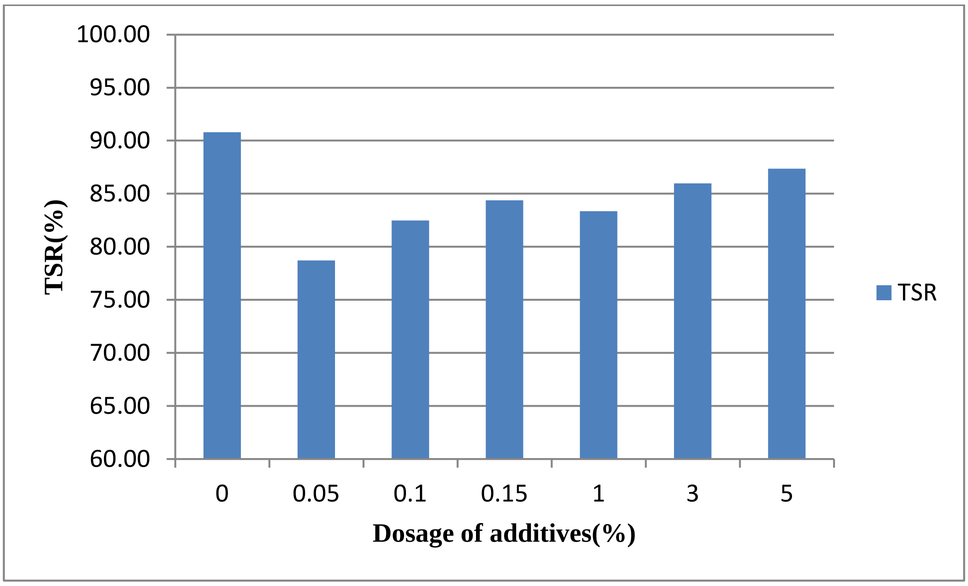

FIGURE 3: TENSILE STRENGTH V/S DOSAGE OF ADDITIVE IN %

TABLE 8: STRIPPING VALUE TEST RESULT OF HMA AND WMA

Type of bitumen	Percent stripping (%)	As per MORT&H
HMA	3	Stripping value should not be more than 10%
Zycotherm of 0.1%	0	
Sasobit of 3%	1	

CONCLUSION

1. The physical properties were conducted on the aggregates used in the present studies satisfies the requirements as per the MORT&H specifications.
2. The physical properties were conducted on the 60/70 (VG – 30) grade bitumen and warm mix binder used for the present studies and satisfies the requirements as per MORT&H specifications.
3. Increasing percentage of additive dosage to rate of Marshall Properties also increases and satisfies the MORT&H specifications.
4. The Marshall properties of HMA in the present studies satisfies the MORT&H specifications.
5. The optimum bitumen content was found to be 5.65% for HMA mix at 160^{0}c temperature.
6. The maximum stability for 60/70 grade bitumen is achieved at 135^{0}c temperature with the additive dosage rate of 3% of sasobit and 0.15% of Zycotherm by the weight of binder.
7. The addition of additive of sasobit and zycotherm improves bulk density of the mix. The percentage air voids in the mix were found to decrease with the increase of WMA additive 5% of sasobit and 0.15% of zycotherm at 135^{0}c was lowest when compared to the conventional mix or HMA.
8. The indirect tensile strength of a mix with WMA additive sasobit of 5% and zycotherm of 0.15% has 0.48 N/mm^2 and 0.46 N/mm^2 respectively. The WMA additive meets the requirement of HMA .

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