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Study on Behaviour of Warm Mix Asphalt Using chemical additives.

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Abstract: *Warm mix asphalt (WMA) technology gaining popularity in recent period, which are broadly studied and gradually applied into the industries in past years. Warm Mix Asphalts (WMA) is modified Hot Mix Asphalt (HMA) which is produced, laid and compacted at temperature which is lower than conventional Hot Mix Asphalt. Warm Mix Asphalt is produced by mixing chemical additives to the conventional mix to improve the pavement performance. In this study an attempt is made to compare the mix design, drain down and moisture-induced damage properties of Warm Mix Asphalt produced with the chemical additive (Zycotherm and Sasobit) and Hot Mix Asphalt for Stone Matrix Asphalt (SMA) Grade 2. The most obvious benefit of the Warm Mix Asphalt is the reduction in fuel consumption, when Compared with Hot Mix Asphalt, Warm Mix Asphalt reduces the fossil fuel emissions significantly The adopted mixing temperatures for Hot Mix Asphalt was 150-165 °C and the mixing temperatures for Warm Mix Asphalt was 120-135°C, with an additive dosage rate of 0.05% and 0.1% (Zycotherm), and 1% and 3% (Sasobit) by weight of the binder. The Warm Mix Asphalt with Zycotherm of 0.05% has the maximum Optimum Binder Content value. The Warm Mix Asphalt with Zycotherm of 0.05% has the maximum Void filled Mineral Aggregates value. The Warm Mix Asphalt with Sasobit of 3% has the maximum Stability Value when compared to other mixes. The Warm Mix Asphalt with Zycotherm of 0.05% has the maximum Flow value when compared to other mixes.*

Key words*: Marshall Stability, Warm mix asphalts (WMA), Sasobit, Zycotherm.*

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I. Introduction

With the increasing depletion of energy resources and enhanced awareness of environmental protection, Warm mixture asphalt, as a new type of asphalt mix as emerges as in the times require. Warm mixture asphalt is a kind of new material whose mixing temperature lies between hot mix asphalt and cold asphalt mix and its road performance can be close to or exceed that of hot mixture asphalt. It results in about 30% energy consumption. Burning fuel in making asphalt mix results in emission of harmful gas and dust resulting in health problems amongst people. Warm mix technology has very important significance on energy saving, emission reduction and the health of the construction workers.

The conventional mix produced in the temperature range of 150^0c to 170^0c. However, compared to conventional HMA mix, warm-mix asphalt (WMA) mix have shown great possible, and offer benefit, since the WMA mix can produce at lower temperatures, without compromising an pavement performance. The Warm mix asphalt is the same as conventional hot mix asphalt, the mixing temperature varies from 100^0c to 135^0c, whereas for the WMA technology is made possible by using a additives that makes the binder thin and less viscosity at the lower temperatures, allowing sufficient coating of aggregates while maintain its workability.

Various issues like global warming and ever increasing fuel prices have made many researchers to look for hot-mix asphalt industry which reduce environmental issues related to global warming, longer paving distance and carrying distance, trim down wear tear on the plants, reduce aging of the binders. It has the ability to use the pavement early for traffic movement, reduce the cracking of the pavements, enhance the pavement, performance and improve the construction efficiency. WMA reduces the 30% of the fuel consumption, carbon emission by 30%, dust emission by 50% when compared to conventional mix. This technology does not involve any major modification to mixing plant and construction procedure that is in use. In order to study whether the additives mixed with asphalt mixture has good workability at low mixing temperature ,the workability of Zycotherm and Sasobit warm mix asphalt and has been compared and analyzed with the workability of hot mix. The Warm mix asphalt is the same as conventional hot mix asphalt, the mixing temperature varies from 100^0c to 135^0c, whereas for the WMA technology has made possible by using a additives that makes the binder thins and lesser the viscosity of the asphalt binder at the lower temperatures, allowing sufficient coating of aggregates while maintain its workability. WMA distinguishes it from other mixes, such as the temperature zone, the strength and durability of its producers and final products, and is typically in the range of 140°c to 170°c. The Warm mix is usually produced in the temperature range of 100°c to 135°c.

In present study an attempt has been made to compare the mix design properties of WMA produced with the chemical additives Zycotherm & Sasobit.

1.2 Objectives;

The main objective of this study is

- To evaluate the mix design properties as per the MORTH specification.
- To Compare between WMA properties to that of HMA for the bituminous concrete mix as per the MORTH specification.
- To evaluate the properties of the bituminous concrete (BC) mix using Zycotherm additive of varying percentage of 0.05% to 0.1% and Sasobit of 1% to 5% by weight of binder.

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II. Literature Review

Warm mix asphalt (WMA) technology is introduction to the transportation industry to overcome unsatisfactory performance of traditional road materials exposed to mixed traffic patterns. Various types of modifiers for bituminous mixtures like fibres and polymers are used to improve the performance of bituminous mixes used in the surfacing course of road pavements, The additives such as fibres, rubbers, polymers, carbon black, artificial silica, or a combination of these materials are used.

The various researchers have carried out research on warm mix asphalt using additives with Warm mix asphalt.(Metta Pavanchandra et.al (2017), Harpreet Singh et.al (2017), Manjunath S Sharanappanavar (2015) , Vatsal v. Raja, et.al (2015), Bheemashankar, Amarnath.M.S, Elsa Sanchez-Alonso et al. (2012),Mogawer et al. (2009), Mallick et al. (2008) ,Hurley and Powell (2006),.)

III. Materials Used

The following are the materials used in the present study.

- Aggregates : The aggregates used in the study are collected from a local quarry near Bangalore
- Bitumen : Bitumen of Penetration Grade 60/70, (VG – 30) grade bitumen
- Zycotherm : Zycotherm is an odourfree chemical warm-mix additive (WMA) that has been engineered to provide significantly improved benefits over current WMA technologies by offering lower production and compaction temperatures, while simultaneously enhancing the moisture resistance of pavements by serving as an anti-stripagent.
- Sasobit : Sasobit is a fine crystalline long chain aliphatic hydrocarbon. It is a synthetic hard wax that is free from Sulphur and other impurities. Sasobit is completely soluble in asphalt at temperatures above 115 °C.

Table 1: Physical Properties of Aggregates

Sl.No.	Test	Specification as per MORT&H	Obtained value	IS CODE
1	**Specific gravity** Bulk specific gravity Apparent specific gravity Water absorption	>2.5 Max 2%	 2.63 2.62 0.3%	IS 383-1970
2	**Shape tests** Flakiness index Elongation index Angularity number	Max 30%	14.34% 21.72% 10	
3	Aggregate impact test (Aggregate impact value)	Max 27%	24.60%	IS: 2386 part 4-1963
4	Crushing test (Aggregate crushing value)	Max 30%	27.44%	IS: 2386 part-4-1963
5.	Los Angeles abrasion test (Aggregate abrasive value)	Max 40%	27.8%	IS:2386 part 4-1963

Table 2: Physical properties of control and WMA modified binders

Sl. No.	Test	Requirement as per MORTH	Test method	Control binder (CB)	Sasobit modified binder (SMB)	Zycotherm modified binder (ZMB)
1	Penetration, Div	50-70	IS:1203-1925	67	39	34
2	Ductility Test ,cm	Min 75	IS:1208-1978	68	86	72
3	Specific gravity	-	IS :1202	0.99	1.02	0.99
4	Softening point, ^{O}C	Min 47	IS:1205-1978	50	70	45
5	Flash point Fire point , ^{O}C	Min 220	IS :1209-1978	305 340	318 335	318 330

Table 3: 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 4: Gradation adopted for bituminous concrete mixes as per MORT&H

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
20.36	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 5: Gradation of the aggregates

Sieve size (mm)	19 mm	12.5 mm	6 mm	Stone dust	Achieved Limits	MoRT&H Lower Limits	MoRT&H Upper Limits
	42%	20%	18%	20%	% Passing	% Passing	% Passing
19.00	100.00	100.00	100.00	100.00	100	100	100
13.20	41.13	100.00	100.00	100.00	89.5	79	100
9.50	32.07	84.11	100.00	100.00	79	70	88
4.75	3.33	48.99	100.00	100.00	62	53	71
2.36	0.00	23.23	91.78	100.00	50	42	58
1.18	0.00	0.00	88.24	100.00	41	34	48
0.600	0.00	0.00	71.69	100.00	27	26	38
0.300	0.00	0.00	53.46	100.00	23	18	28
0.150	0.00	0.00	32.91	100.00	16	12	20
0.075	0.00	0.00	8.89	100.00	7	4	10

IV. Methodology:

The Marshall method of mix design has been carried out for the HMA and WMA of varying percentage of additives. This method is used in pavement design to determine the optimum binder content (OBC) in bituminous pavement. As per MoRT&H standards Marshall Stability test is used to determine the stability value, flow value and percentage air voids. This method is applicable to warm-mix asphalt, aggregates and additives like Zycotherm and Sasobit . The grading of BC aims at providing a fairly dense layer and the nominal maximum size is 19 mm to provide a construction thickness of 30 to 45 mm bituminous concrete surface layer.

V. Results and Discussions:

Experimental results of the Marshall Mix design carried out for hot mix asphalt and Warm mix asphalt of varying percentage of additives Zycotherm and Sasobit. l Graphs have been drawn between various parameters as shown Fig 1 to Fig 6. 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. From the Fig.1 to Fig.6,The following conclusions can be drawn. The OBC (Optimum Binder Content) for the HMA (Hot Mix Asphalt) mix has found to be 5.6 %. The WMA (Warm Mix Asphalt) mix using Sasobit with a varying percentage of 1% and 3% has an OBC of 5.8% and 5.7%. The WMA mix using a Zycotherm of 0.05% and 0.1% has an OBC of 6% and 5.9%. The Marshall Stability value for the Hot Mix Asphalt without additive are found to be 11.48KN .with the Warm Mix Asphalt of Sasobit of 1% and 3% dosage are found to be 12.22KN and 12.35KN respectively. The Zycotherm of 0.05% and 0.1% dosage are found to be 8.47KN and 11.05KN. The Marshall Stability values are found to increase with the additive dosage. The increasing stability value may be due to the better coating and bonding of the mixes.

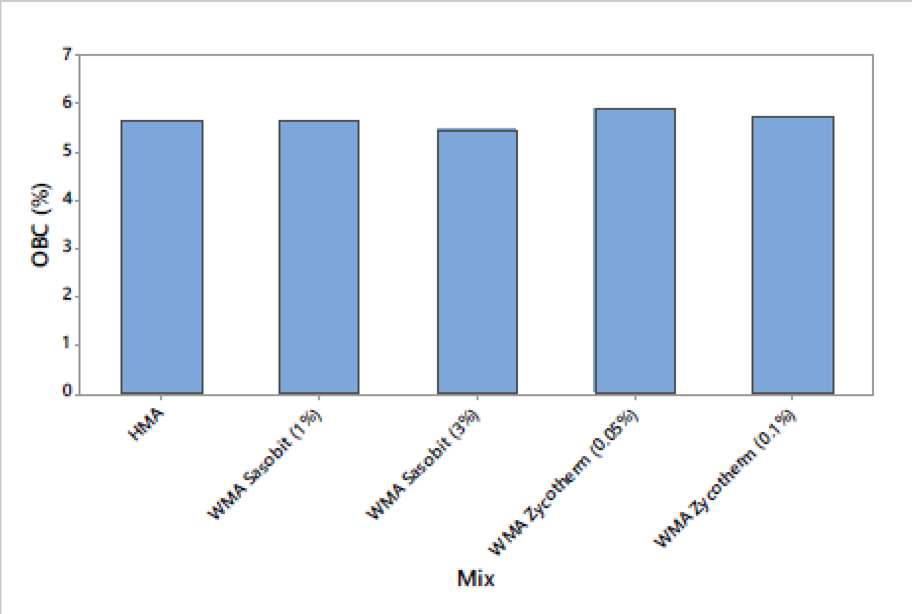

Fig 1 Shows the Variation of percentage Optimum Binder content (OBC) value of Warm Mix Asphalt without and with Chemical additives. (Zycotherm and Sasobit).

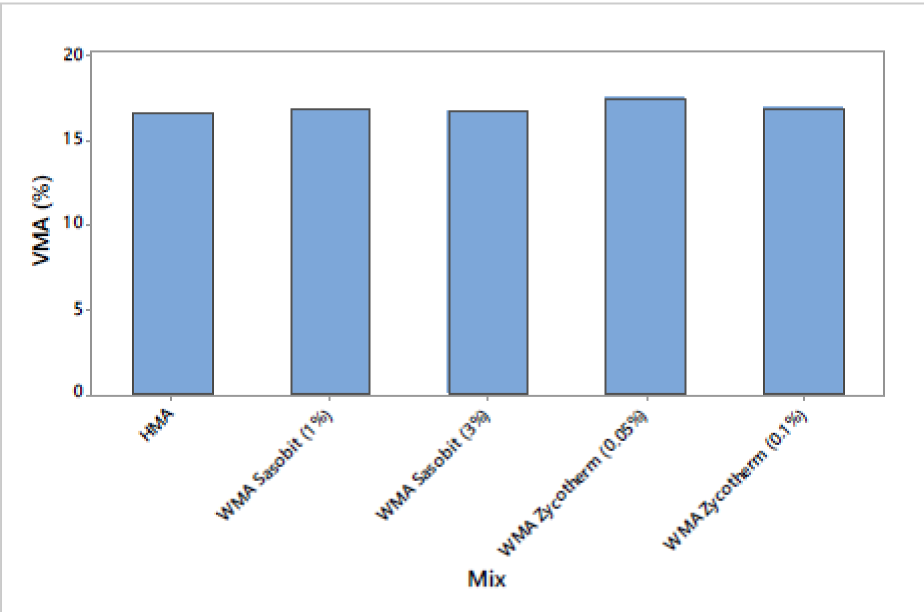

Fig:2. Shows the Variation of Void filled Mineral Aggregates value of Warm Mix Asphalt without and with Chemical additives. (Zycotherm and Sasobit).

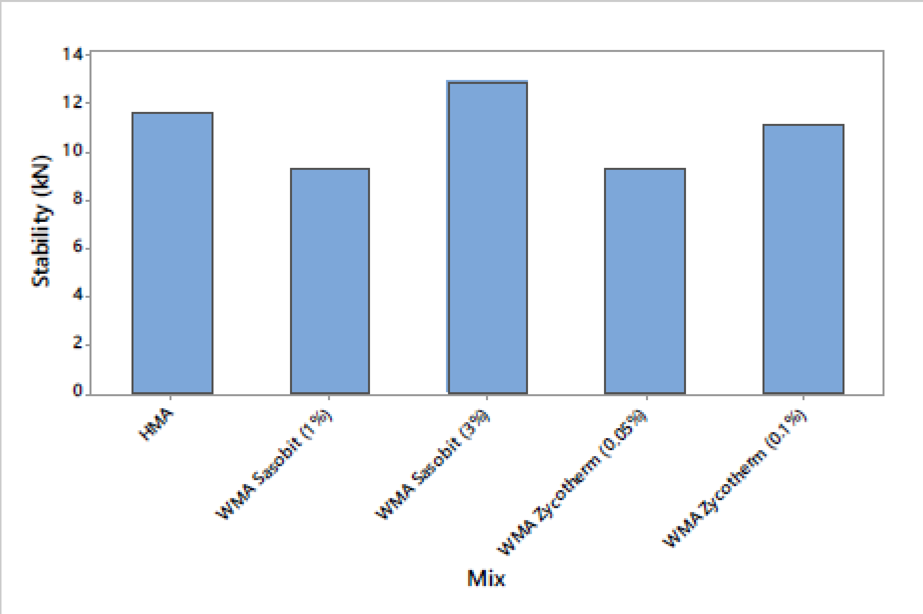

Fig.3. Shows the Variation of maximum Stability value of Warm Mix Asphalt without and with Chemical additives. (Zycotherm and Sasobit).

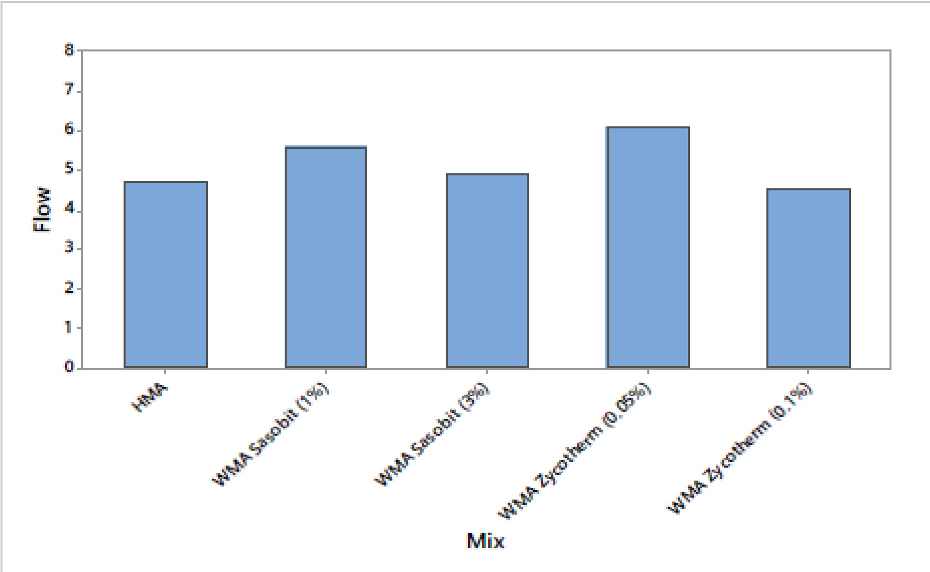

Fig.4 Shows the Variation of Flow value of Warm Mix Asphalt without and with Chemical additives. (Zycotherm and Sasobit).

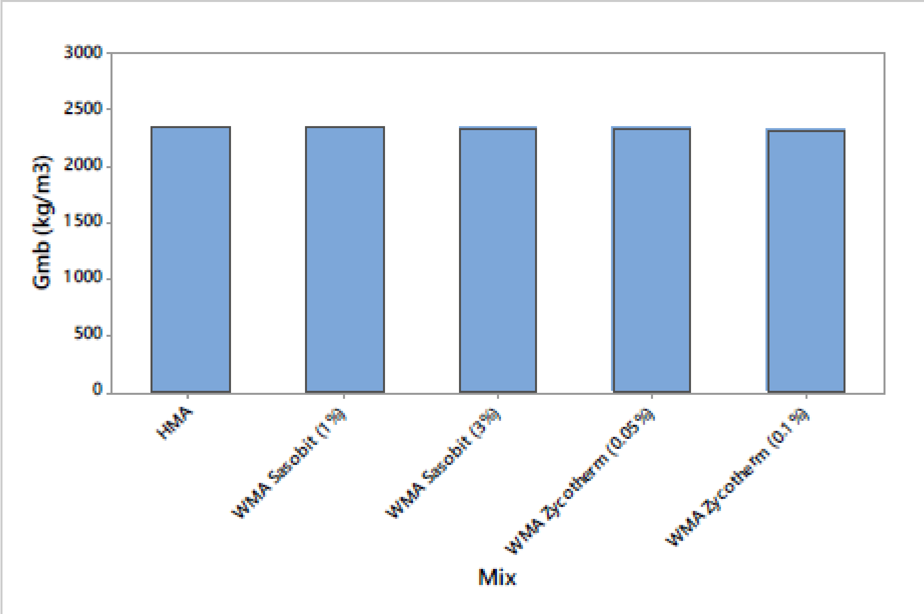

Fig 5. Shows the Variation of Bulk Density of Warm Mix Asphalt without and with Chemical additives. (Zycotherm and Sasobit).

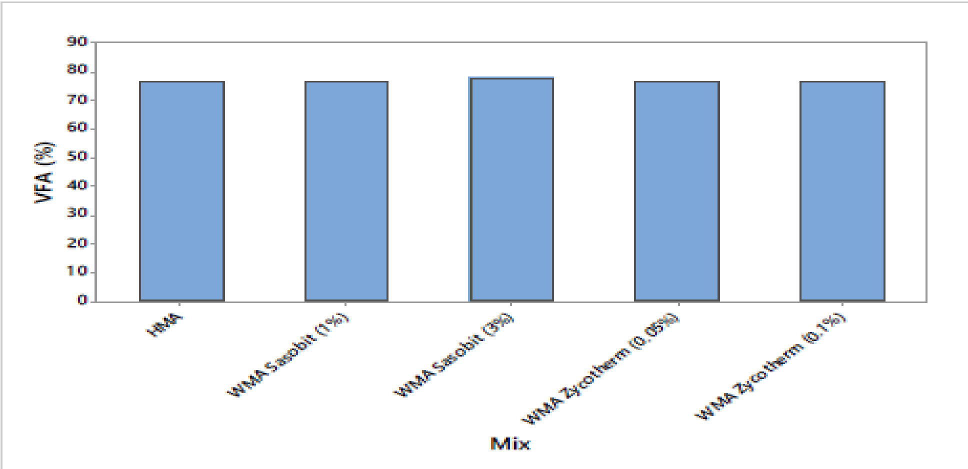

Fig.6. Shows the Variation of Void filled Asphalt of Warm Mix Asphalt without and with Chemical additives. (Zycotherm and Sasobit).

VI. Conclusions

1. The physical properties of the aggregates and bitumen of 60/70 (VG – 30) grade and warm mix binder used for the present studies satisfies the requirements as per MORT&H specifications.
2. The Optimum Bitumen Content was found to be 5.6% for HMA mix at 160^{o}C mixing temperature.
3. The maximum stability for 60/70 grade bitumen is achieved at 135^{0} C temperature with the additive dosage rate of 1% and 3% of Sasobit and 0.05% and 0.1% of Zycotherm by the weight of binder.
4. The Warm Mix Asphalt with Zycotherm of 0.05% has the Optimum Binder Content value. The Warm Mix Asphalt with Zycotherm of 0.05% has the maximum Void filled Mineral Aggregates value. The Warm Mix Asphalt with Sasobit of 3% has the maximum Stability value when Compared to other mixes.
5. The Warm mix asphalt with Zycotherm of 0.05% has the maximum Flow value when compared to other mixes.
6. 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 1% and 3% of Sasobit and 0.05% and 0.1% of Zycotherm at 1350C was lowest when compared to the conventional mix or HMA.The

additives reduces the mixing and the compacting temperature with improves workability and insignificant effect on moisture susceptibility at low temperature.

7. Air voids of bituminous concrete mix with WMA additive was lowest when compared to mix with HMA which indicates that the WMA additives are effective in compacting mixtures at a lower temperature.

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