An Experimental Study on Behaviour of Warm Mix Asphalt by using Zycotherm

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Abstract: The asphalt industry has been aware of the energy savings and environmental benefits warm mix asphalt technologies.Keeping these two reasons in view, we came up with an idea of using warm mix asphalt technology which uses chemical additive. Using this technology, they can considerably reduce the temperature of asphalt pavement when compared to normal asphalt pavements. Warm mix asphalt is one technology that is gaining popularity in the industry in response to this effort. The Warm Mix Asphalts (WMA) which is produced, laid and compacted in temperature which is lower than conventional mix. The WMA 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 Marshall properties of WMA produced with the chemical additive "Zycotherm" with an additive dosage rate of 0.025% by weight of the binder and increasing the stability and workability of bituminous concrete mix by reducing OBC(Optimum Bitumen content) And Finding the best mixing percentage of Zycotherm to obtain a fully compacted bituminous layer for Semi Dense Bituminous cover (SDBC). The laboratory study concludes that Stability & Marshall properties were improved for the WMA mix by the addition of the additive.

Keywords: Bitumen, Stone dust, Aggregate, Zycotherm, Marshall Stability, Warm Mix Asphalt, Semi Dense Bituminous cover.

1 Introduction

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade,whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub-grade.

Bitumen is a sticky, black and highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product, Bitumen is a thermoplastic material and its stiffness is dependent on temperature. The temperature vs stiffness relationship of bitumen is dependent on the source of crude oil and the method of refining. It is assessed that the present world utilization of bitumen is roughly 102 million-tones every year. Around 85% of all the bitumen created is utilized as the cover as a part of black-top for streets. It is additionally utilized as a part of other cleared regions, for example, airplane terminal runways, auto parks and footways. Ordinarily, the creation of black-top includes blending sand, rock and smashed rock with bitumen, which goes about as the coupling operators. Different materials, for example, polymers, may be added to the bitumen to modify its properties as indicated by the application for which the black-top is eventually proposed.

A good design of bituminous mix is expected to result in a mix which is adequately (i) strong (ii) durable (iii) resistive to fatigue and permanent deformation (iv) environment friendly (v) economical and so on. The present research work tries to identify some of the issues involved in this art of bituminous mix design and the direction of current research. Asphalt concretes are widely used in pavements. Permanent deformation happens when pavement does not have sufficient stability, improper compaction and insufficient pavement strength. From practical experiences it is proved that the modification of asphalt binder with polymer additives, offers several benefits. To enhance various engineering properties of asphalt many modifiers such as styrene based polymers, polyethylene based polymers, polychloroprene, various oils have been used in asphalt.

Aggregate is a broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete, the aggregate serves as reinforcement to add strength to the overall composite material.

Zycotherm is an odor free, chemical warm mix additive 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 antistrip. It does not affect binder grading or change any other binder properties. It improves strength and compatibility at economicalcost.

Zycotherm is WMA additive developed by Zydex Industries, Gujarat, India. This is an odour free, chemical warm mix additive 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 antistrip. Mixes that have been modified with Zycotherm can be produced at 120°C - 135°C for and compacted at 90°C - 120°C. Overall, Zycotherm offers temperature reductions depending on the properties of the mix. Zycotherm has built in antistrip mechanism that allows it to dually function as an antistrip as well as a warm mix additive.

2 Materials and Methodology

The following are the materials used in the study
1) Bitumen of 80/100 Penetration grade.
2) Course aggregates.
3) Filler materials.
4) Zycotherm (Chemical additive).
In this project **80/100** Penetration grade of bitumen is chosen and comparison WMA with varying dosage of additive is chosen. The strength of WMA is compared with WMA with varying dosage of additives. Marshall Stability test is carried out on these moulds to determine the strength of bitumen mix with different dosage of additive

2.1 Bituminous Concrete Mix Design

2.1.1 Objective of Bituminous Mix Design: Asphaltic/Bituminous concrete consists of a mixture of aggregates continuously graded from maximum size, typically less than 25 mm, through the fine filler that is smaller than 0.075mm. Sufficient bitumen is added to the mix so that the compacted mix is effectively impervious and will have acceptable dissipative and elastic properties. The objective of the mix design is to produce a bituminous mix by proportioning various components so as to have
1) Sufficient bitumen to ensure a durable pavement
2) Sufficient strength to resist shear deformation under traffic a higher temperature.
3) Sufficient air voids in the compacted bitumen to allow for additional compaction by traffic.
4) Sufficient workability to permit easy placement without segregation.

5) Sufficient flexibility to avoid premature cracking due to repeated bending by traffic.
6) Sufficient flexibility at low temperature to prevent shrinkage cracks.

2.2 Tests

The following are the tests conducted on the materials:

2.2.1 Tests on coarse aggregate:

1) Specific Gravity
2) Impact test
3) Crushing value

2.2.2 Test on Bitumen:

1) Softening point
2) Penetration test
3) Ductility test

3 Methodology

3.1 Marshall Stability Test

Marshall Mix design is a standard laboratory method, which is adopted world wide for determining and reporting the strength and flow characteristics of bituminous paving mixes. In India, it is a very popular method of characterization of bituminous mixes. This test has also been used by many researchers to test bituminous mixes .This test method is widely accepted because of its simplicity and low of cost. Considering various advantages of the Marshall method it was decided to use this method to determine the Optimum Binder Content(OBC) of the mixes and also study various Marshall characteristics such as Marshall Stability, flow value, unit weight, air voids etc. The Marshall properties such as stability, flow value, unit weight and air voids were studied to obtain the optimum binder contents(OBC).

Procedure

The aggregates are heated to a temperature of 165C to 175C the compactionmould assembly and rammer and cleaned andkept preheated to a temperature of 90C to145C.The bitumen is heated to atemperatureof 110Cto 130C and required amount of first trail of bitumen is added tothe heated aggregate andthroughtly mixed.The mix is placed in amould and compacted with75 blows. The sample is taken out of the mould after 24 hours using sample extractor. The bulk density of

the sample is usually determined by weighting the sample in air and water. It may be necessary to coat samples with paraffin before determining density. In conducting the stability test, the specimen is immersed in a bath of water at a temperature of 69C for a period of 30 minutes. It is then placed in the Marshall Stability Testing machine and loaded at a constant rate of deformation of 5mm per minute until failure .The total maximum in kg is taken as Marshall Stability. The Stability value so obtained is corrected for volume. The total amount of deformation is units of 0.25mm that occurs at maximum load is recorded as Flow Value. The total time between removing the specimen from the bath and completion of the test should not exceed 30 seconds.

This test is done to determine the Marshall Stability of bituminous mixture as per ASTM D 1559. The principle of this test is that Marshall Stability is the resistance to plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface. It is the load carrying capacity of the mix at 60C and is measured in kg. The apparatus needed to determine Marshall Stability of bituminous mixture is Marshall Stability value the sample is need for Marshall graph,select proportions of coarse aggregates,fine aggregate and filler in such a way, so as to fulfill the required specification.

Marshall Stability Test

The Marshall method was originally developed by Bruce Marshall Mississippi State Highway Department formulated this test and is applicable to hot mix design of bitumen and aggregates of maximum size 2.5 cm. In India, bituminous concrete mix is commonly designed by Marshall Method. This test is extensively used in routine test programmes for the paving jobs. The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature of 600°C. The flow is measured as the deformation in units of 0.25 mm between no load and maximum load carried by the specimen during stability test.

3.2 Doping of Zycotherm

For the present study **0.100%**, **0.125%, 0.150%, 0.175%** was adopted as the additive dosage for preparation of the specimens. Zycotherm was added **0.025%** volumetrically or by weight (Zycotherm density: 1.01 gm/cc) using 2.5ml plastic syringe and the molten bitumen 155°C was stirred manually using a glass rod while adding Zycotherm and additional stirring for 10 minutes was done for uniform mixing of the additive with the bitumen.

3.3 Specimen Preparation

Approximately 1200gm of aggregates and filler is heated to a temperature of 175-

190°C. Bitumen is heated to a temperature of 121-1250C with the percentage of bitumen (say 3.5 or 4% by weight of the mineral aggregates). The heated aggregates and bitumen are thoroughly mixed at a temperature of 154-160°C. The mix is placed in a preheated mould and compacted by a rammer with 75 blows on either side at temperature of 138-149°C. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. Vary the Zycotherm content in the next trial by **0.025%** and repeat the above procedure. Number of trials is predetermined. The prepared mould is loaded in the Marshall Stability test. The sample is taken out of the mould after few minutes using sample extractor.

Table 1. Gradation for Bituminous Mix

Sieve size in mm	*% wt retained*	*Wt of aggregate in Gm*
Aggregate Impact Value	13.51	24% maximum
Aggregate crushing test	15.76	30% maximum
Specific Gravity Test • Coarse Aggregates • Filler Materials	2.68 3.02	2.9% maximum 3.1% maximum

4 Data Analysis

4.1 Basic Test Results and Tables

Table 2. Properties of Coarse Aggregates

Test	*Results*	*MORT&H Specifications*
Penetration (100 gram.5 seconds at 25°C) (1/10* of mm) for S 90 grade	86 mm	50-70 mm
Softening Point. °C (Ring & Ball Apparatus)	49°C	45°C- 60°C

Ductility at 27°C (5 cm/minute pull) (cm)	76 cm	Min 75 cm

Table 3. Gradation Values

Sieve size in mm	*Lower limit*	*Higher limit*	*Middle limit*	*Obtained limit*
13.2	100	100	100	100
9.50	90	100	95	94.25
4.75	35	51	43	49.36
2.36	24	39	31.5	36.92
1.18	15	30	22.5	25
0.30	9	19	14	18.75
0.075	3	8	5.5	7.88

5 Gradation

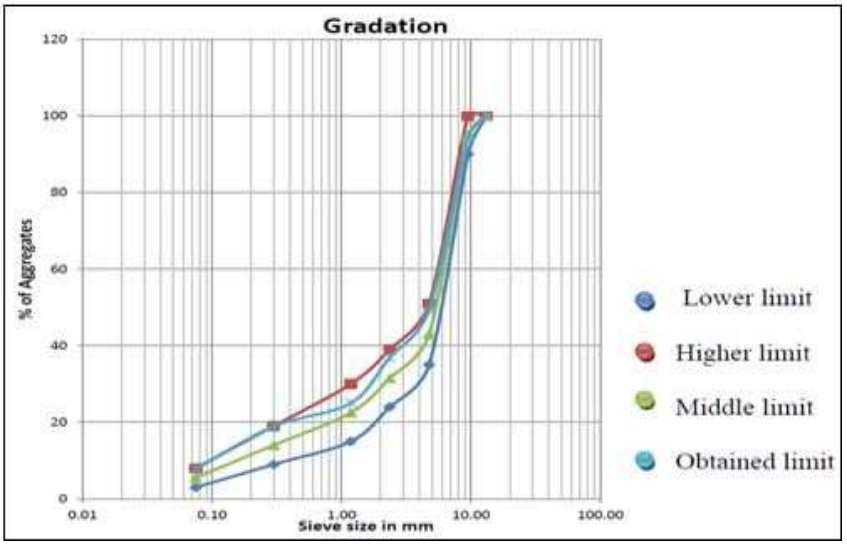

Fig.1. Graph showing Gradation for Aggregates

6 Marshall stability test results

6.1 Without Zycotherm

Table 4. Test results of different specimens without zycotherm

Wt. of Aggregates	*% of Bitumen*	*Wt of Bitumen*	*Height (cm)*	*Diameter (cm)*	*Wt of Specimen*		*Filler (Stone Dust)*	*Marshall Stability Value(KN)*	*Flow Value*
					Air	Water			
1500	2.8%	42	6.20	10.0	1196	730	2%	11.702	6.300
1500	3.2%	48	6.30	10.0	1277	732	2%	12.175	6.400
1500	3.6%	54	6.35	10.0	1242	725	2%	13.712	4.250
1500	4.0%	60	6.40	10.0	1212	738	2%	12.293	6.400

6.2 With Zycotherm

Table 5. Test results of different specimens with zycotherm

Wt.of Aggregates	*% of Bitumen*	*Wt of Bitumen*	*% of Zycotherm*	*Wt. of Zycotherm*	*Height (cm)*	*Diameter (cm)*	*Wt. of Specimen*		*Filler (Stone Dust)*	*Marshall Stability Value(KN)*	*Flow Value*
							Air	Water			
1500	5%	60	0	0	6.25	10.0	1227	730	2%	13.238	4.150
1500	2.8%	42	0.100	0.04	6.20	10.0	1242	725	2%	13.593	4.200
1500	3.2%	48	0.125	0.06	6.25	10.0	1243	735	2%	14.539	2.700
1500	3.6%	54	0.150	0.08	6.30	10.0	1240	730	2%	15.839	3.800
1500	4.0%	60	0.175	0.105	6.25	10.0	1248	742	2%	14.893	6.000

6.3 Graphs

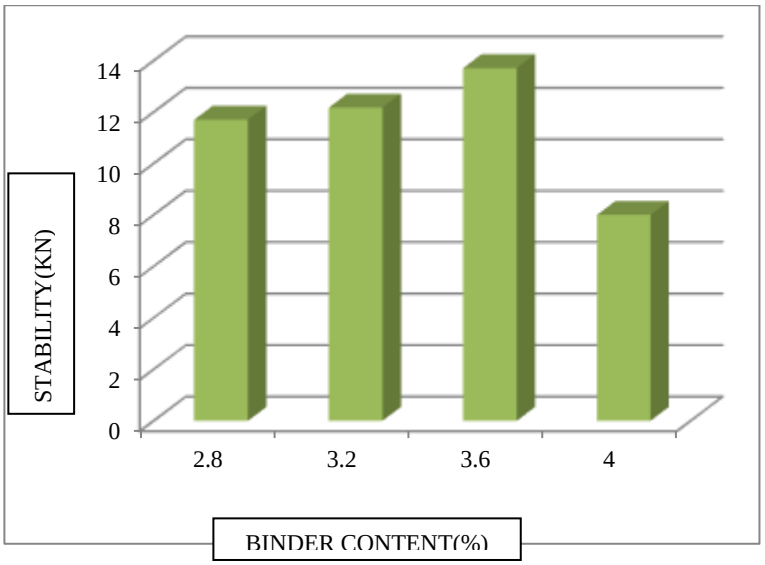

Fig.2. Comparison of Stability of Varying Bitumen Content

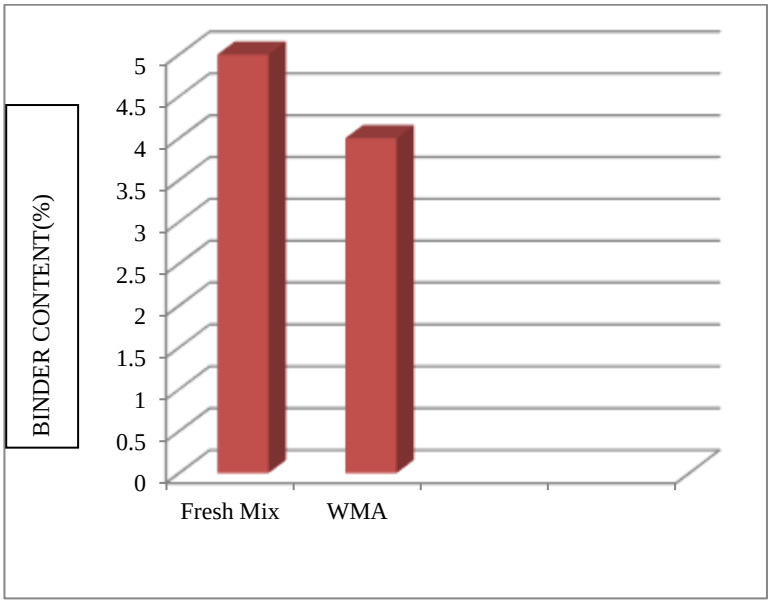

Fig.3. Comparison of Fresh Mix and WMA With Respect to Bitumen Content

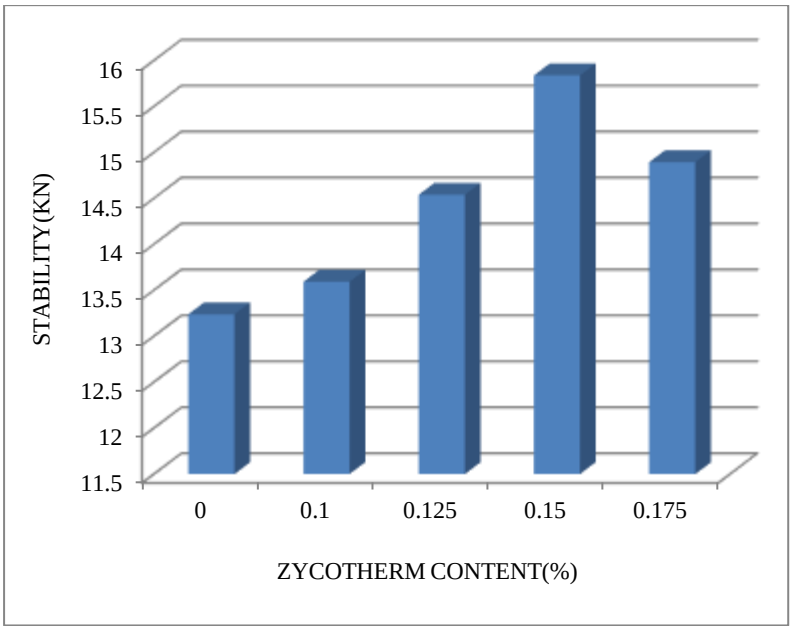

Fig.4. Comparison of Stability of Varying Zycotherm Content

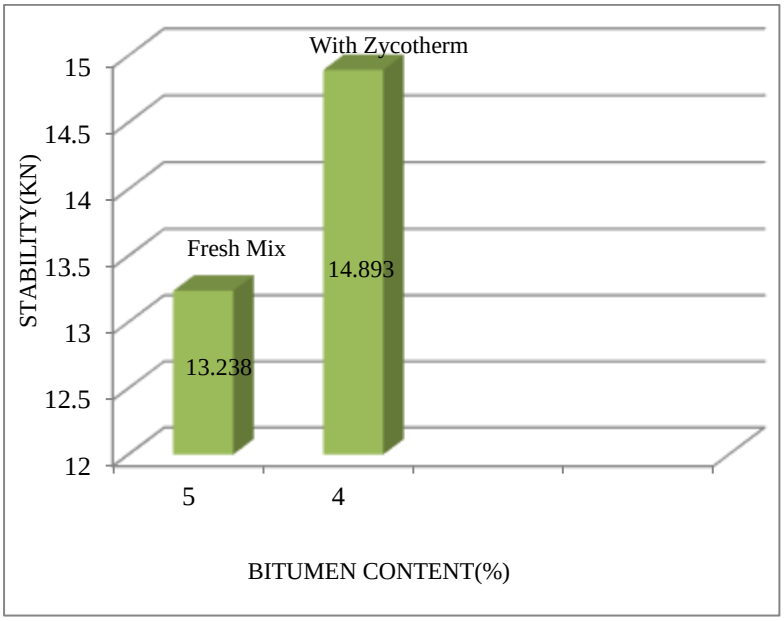

Fig.5. Comparison of Fresh Mix and WMA With Respect to Stability

7 Conclusion

Addition of Zycotherm to Warm Mix asphalt effectively improves the stability of the mix. The physical properties of the aggregate and bitumen of 80/100 (S90) grade and warm mix binder used for the present studies the requirements as per MORTH specificatins. The Optimum binder content was found to be 0.175% of Zycotherm for Warm Mix at 130°C mixing temperature. Air voids of bituminous concrete mix with WMA additive was lowest when compared to mix HMA which indicates that the WMA additives are effective in compacting mixtures at a lower temperature.Maintainance cost will be low compares to HMA and reduced the frictional force by adding Zycotherm.The Marshall Stability value is increased strong pavement section.

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