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Property Analysis of Nano modified Bituminous Concrete Mixes

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***Abstract*— The surface of aggregate is polar and are water loving and in order to change the polar surface of aggregate and to give a better covered coating with bitumen a nanomaterial is been used. The nano material used in this study is zycotherm. Tests were conducted to evaluate the effects of nano modifier on the volumetric properties, mechanical properties, creep characteristics and rutting potential of Bituminous Concrete mix. The tests undertaken comprise the Marshall test, indirect tensile strength test, boil test, indirect tensile stiffness modulus test, creep test and wheel rut test. The study reveals that the the basic properties of bitumen remains same even after the addition of nano material, all other properties have improved.**

Index Terms*—nano material,zycotherm. *(key words)

I. INTRODUCTION

The road system of transportation constitutes the main means of moving goods and services in a developing nation such as India. Flexible pavement are preferred over cement concrete roads as they have a great advantage that these can be strengthened and improved in stages with the growth of traffic. In a state like Kerala where monsoon season prevails for a long time, one of the greatest factor which will have an adverse effect on the performance of HMA is moisture or the water. It manifests itself as a reduction in overall strength and it will increase rutting potential, decrease fatigue life and accelerate stripping potential of the mixture. The reason for this problem on a micro scale is loss of adhesion between the bitumen and the aggregates.

II RAW MATERIALS AND METHODS

Raw material

An organosilane nanomaterial – zycotherm was used for the study. Laboratory tests were conducted on the VG 30 and nano modified bitumen and the results are summarised in table 1. The physical properties of the aggregates are summarised in table 2. Fig. 1 shows the selected aggregate gradation which was in accordance with MoRTH 2013 specification for bituminous concrete mix. Trial and error method was used for proportioning of aggregates. The additive zycotherm was supplied by zydex industries.

TABLE 1: Bitumen properties

Property	**Test Results**		**Requirements as per IS:73-2013 for VG 30**
	VG 30	***Nano modified VG30***	
Penetration at 25ºC, 100g, 5 s, 0.1 mm	65	62	45 Min
Ductility at 27ºC	75.4 cm	100+	40 Min
Softening Point	500C	510C	47 0C Min
Specific Gravity 27ºC	1.01	1	.99 Min
Viscosity	545	521	-

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Table 2: Aggregate Properties

Properties	Test results	Specification as per MORTH 2013
Aggregate impact value, %	21.385	Max 30
Los Angeles abrasion value, %	28.4	Max 40
Combined (EI &FI) index	18.83	Max 35
Specific gravity	2.67	2.5 – 3.0

Table 3 Mix design details

Binder	Bitumen content (%)	Bulk Specific Gravity (g/cc)	Theoretical maximum density (g/cc)	Air Voids (%)	Stability (kN)	Flow (mm)	VMA (%)	VFB (%)
VG30	4.5	2.359	2.478	4.8	17.94	2.72	15.66	69.07
	4.8	2.367	2.472	4.3	20.04	3.01	15.23	74.67
	5.0	2.371	2.470	4.1	20.54	4.45	14.99	77.47
	5.3	2.374	2.452	3.2	19.54	6.19	14.67	86.36
ZT-VG30	5.0	2.5395	2.484	4.2	22.53	4.4	16.58	74.66

Nano Modified Blend preparation

The formulation of the blend was done using an asphalt mixer at a temperature maintained between 150°c to 170°c for about 30 to 40 minutes. The blend was prepared by heating and mixing the bitumen and the additive in an asphalt mixing bowl fitted with a stirrer maintained at a required temperature. The bitumen sample required for making the blend should be fully melted so that blend could be prepared easily. When the bitumen was fully melted, additive required for preparing the blend should be fully melted so that blend could be prepared easily. When the bitumen was fully melted, additive required for preparing.

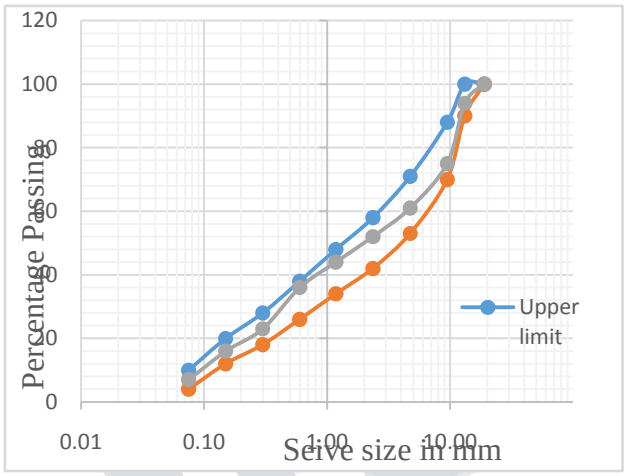

Fig 1 MORTH specified gradation and used gradation

Approximate blend was added in to the bitumen. The dosage of additive added depends on the type of bitumen used and the requirement of the study. Since the additive is in liquid form it get blended quite easily. Thus the blends required for the study was made prior and was stored separately in an air tight container. The dosage for the unmodified bitumen like VG30 was fixed as .1% weight by total weight of bitumen as per results from previous studies.

III EXPERIMENTAL SETUPS

Mix design BC mix

Marshall Samples were prepared by blending required amount of aggregate with varied percentage of bitumen ranging from 4% to 5.5%. The optimum bitumen content of the unmodified mix was obtained by observing the percentage corresponding to maximum Marshall Stability. The optimum bitumen content for Nano modified mix was also found out.

Marshall stability

Marshall Stability test was performed to evaluate the stability and flow of mix. The stability was evaluated for both control and Nano modified mix and to study the extend of improvement done on the control specimen with the incorporation of additive. The Marshall Test method uses cylindrical test specimens of 64 mm height and 102 mm diameter. This method was used to determine the optimum bitumen for control specimen as well as modified specimens. Compacting energy was applied as 75 blows.

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Boil Test

Boil test was performed for finding the stripping of bitumen from aggregate. It is done as per ASTM D 3625.For each sample tested pour distilled water into a clean container which is heat resistant such that the container is approximately half full and heat to boiling. Take approximately 250 gm. of the bituminous-coated aggregate mixture which is passing through 20 mm and retained in 12.5 mm IS sieve for placing in the boiling water. The temperature of hot mixtures shall be below the boiling temperature of water, but not less than 85°C (180°F), before placing in boiling water. Bring the water back to boiling and maintain boiling for 10 min. Take out some amount of aggregate at regular interval of 30 minutes, 1 hour, 2 hour and 4 hour and observe the aggregate surface visually after drying the surface.

Indirect Tensile Strength test

ITS tests were conducted on Marshall Samples of conventional bituminous mixes at 25°C. The ITS test was performed by loading a Marshall specimen with a single compressive load, which acts parallel to and along vertical diametrical plane. This loading configuration develops a uniform tensile stress perpendicular to the direction of the applied load and the vertical diameter. The load at which the specimen fails is taken as the indirect tensile strength also referred as the dry indirect tensile strength of the bituminous mix. The moisture-susceptibility of BC mixes was also evaluated using the retained tensile strength or Tensile Strength Ratio (TSR) method

TABLE 4 Results of Marshall Immersion Test

Description	Conditioning time	Stability (KN)	Marshall stability ratio (%)	Desired value
Control mix	40 min	20.94	81.66%	>75 % as per MoRTH(Fourth Revision) table 500-19
	24 hr.	17.10		
Zycotherm mix	40 min	22.53	85.15%	

IV. TEST RESULTS AND DISCUSSION

Marshall Stability

Marshall Stability tests were conducted on control specimen and modified specimens. The optimum bitumen content was obtained as 5%. Table 3 shows the variation in various Marshall Properties at various bitumen content. The OBC for control mix as well as modified mix was found to be 5 %.

From Table 4 it is observed that, there is a slight increase in retained stability ratio for the Nano modified mix. Thus the modified mix shows comparative increase in the Marshall Stability value compared to the control mix.

Boil test

It can be observed that, zycotherm modified mix showed no stripping at all for the first 30 minutes and retained 98% coating for 2 hours and 95% coating retention at 4hours while VG 30 mix showed 20% stripping in the first 30minutes and 40% stripping by first one hour.

TABLE 5: Boil test Results

Sample	10 min	30 min	1 hr	2hr	4hr
VG 30	90%	80%	~60%	~50%	~20%
Nano modified	100%	100%	99%	98%	95%

Indirect Tensile Strength (ITS) Ratio

ITS tests were conducted on Marshall Samples of conventional bituminous mixes and Nano modified mixes at 25°C. The ITS test was performed by loading a Marshall specimen with a single compressive load, which acts parallel to and along the vertical diametrical plane. This loading configuration develops a uniform tensile stress perpendicular to the direction of the applied load and along the vertical diameter. The load at which the specimen fails is taken as the indirect tensile strength (also referred as the dry indirect tensile strength) of the bituminous concrete mix.

TABLE 6 : ITS and TSR results

Description	Sample type	ITS (KN)	TSR (%)	Desired TSR (%)
Control mix	dry	16.648	81.556	Min 80% MoRTH specification
	soaked	13.577		
Zycotherm mix	dry	16.915	89.57	
	soaked	15.152		

The tensile strength ratio of the bituminous mix is used to determine the moisture susceptibility of the mixes. The Marshall specimens were placed in the water bath maintained at 25°C for 24 hours and placing at 25°C at air

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for 2 hours. These conditioned samples are tested for wet indirect tensile strength. The ratio of the wet to dry indirect tensile strength is recorded as Tensile Strength Ratio (TSR) of the bituminous mix.

CONCLUSIONS

Zycotherm being an organo silane nanomaterial promoted the adherence between the bitumen and aggregate their by making the aggregate bitumen loving. Due to this adherence property, the stability was improved compared to control mix, stripping of bitumen was reduced by 60 %,

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