LABORATORY EVALUATION OF POWDERED WAX MODIFIED BITUMEN (PWMB) FOR BITUMINOUS CONCRETE MIX

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ABSTRACT

Increased traffic factors such as heavier loads, higher traffic volume, and higher tire pressure demand higher performance pavements. The use of modifiers is becoming one of the prime solutions to achieve high performance pavements which can minimize stripping, rutting, raveling and inadequate durability, the leading causes for pavement failure. Various modifiers ranging from polymers and fibers to lime are used. Powdered wax is a modifier, which is studied in this project. This paper presents the comparative experimental investigation of the powdered wax modified hot asphalt mix (HMA) with the conventional 80/100 mix. Marshall Mix design was adopted. These mixes at their optimum binder content were subsequently evaluated with respect to various performance related tests: Marshall stability and flow, indirect tensile strength, diametrical resilient modulus, dynamic creep and wheel tracking test. The results of these tests for conventional bitumen mix and modified mix were compared to know their respective performance.

The results have shown that modified mix has higher stability, tensile strength and resistance to creep and lesser moisture susceptibility and permanent deformation as compared to the conventional mix.

1. INTRODUCTION

1.1 General

Cracking, rutting, stripping, raveling and because it is soft in a hot environment inadequate durability are the leading and brittle in cold weather. Therefore, causes for pavement failure. These there is need to modify the asphalt to pavement stresses lead to huge financial improve its mechanical properties. losses every year, added traffic delays and inconvenience to the driving public. The use of modifiers to improve the increased traffic factors such as heavier performance of bituminous road paving loads, higher traffic volume and higher materials is increasing worldwide. These tire pressure demand higher performance additives range from polymers and fibers pavements. A high performance to lime. Various products are now being pavement requires asphalt cement that is considered very seriously by road paving less susceptible to high temperature engineers and paving contractors who rutting or low temperature cracking. are concerned both with high Asphalt exposed to a wide range of load performance and cost effectiveness. One and weather conditions, however, does such product is powdered wax, known as not have good engineering properties a hardening agent. The increased stability at high temperature of powdered wax makes them more resistant to deformation problems such as rutting and shoving, and increases the pavement's load carrying capacity. In addition, the laboratory tests show that improved deformation resistance can be obtained while the pavement retains much of its original ductility and ability to resist low temperature cracking. Other positive benefits include increased resistance to moisture sensitivity.

2. LITERATURE REVIEW

2.1 Modifiers in Bituminous Mixes

Modification in general will improve pavement durability and lower the life cycle costs. Further, it increases serviceable temperature range – i.e. stiffening at high temperature and softening at low temperature and improve flexibility at all temperatures. Modification helps in improving the aggregate-bitumen bond and reduces the problems like cracking, rutting, raveling, etc. Different additives having different / specific functions are used to modify properties of mixes depending on the specific requirements and situations.

3. POWDERED WAX FOR BITUMEN MODIFICATION IN ROAD CONSTRUCTION

Powdered wax is a derivative of fatty acids. Powdered wax modified bitumen improves the following properties:

- Improved paving behavior and high compatibility
- Increased deformation resistance at high temperatures
- No increased danger of cracking at low temperatures
- Increased adhesion onto the mineral

3.1 Applications

Because of their high durability and excellent deformation resistance at high temperatures, powdered wax modified asphalt base and surface courses are especially suitable for target reinforcement for heavily stressed areas such as

- Crossing and bus-stops
- Bends and turnabouts
- Uphill and downhill sections
- Bridge surface
- Airports – Runways
- Hard – standing areas for containers

Because of its chemical structure, powdered wax is highly interfacial active and improves the wetting and adhesion of the bitumen onto the mineral (stones and filler) in the asphalt. This results in better water resistance and density, prevents breaking off of mineral pieces and reduces abrasion of top layers. The addition of hydrated lime, frequently used as an adhesion promoting filler, is therefore unnecessary.

4. PROPERTIES OF POWDERED WAX MODIFIED BITUMEN (PWMB) AND ITS MIXES

The following tests were performed on PW modified bitumen to find out the change in the properties of binder and the obtained results are compared with those of unmodified 80/100 bitumen.

- The penetration value of PWMB was found out to be 48 as compared to the value of 90 of unmodified bitumen.
- The softening point of PWMB was found out to be 92^{0}C as compared to the value of 50^{0}C obtained for

unmodified bitumen.

- The elastic recovery test performed on PWMB showed a 9% recovery of the elongation that the sample of bitumen was subjected to standard testing conditions at 15^{0}C.

5. MIX DESIGN OF BITUMINOUS CONCRETE USING POWDERED WAX MODIFIED BITUMEN

Table 1: Proportioning of Aggregates

Sieve Size	20 mm	13.2 mm	Stone Dust	Filler	Combined Grading	Specified Limit
26.5 mm	100	100	100	100	100	100
19.0 mm	83	100	100	100	94	79 – 100
13.2mm	3	96	100	100	65	59 – 79
9.5mm	0	61	100	100	58	52 – 72
4.75mm	0	0	96	100	47	35 – 55
2.36mm	0	0	75	100	38	28 – 44
1.18mm	0	0	62	100	32	20 – 34
600	0	0	28	100	17	15 – 27
300	0	0	22	100	14	10 – 20
150	0	0	16	100	11	5 – 13
75	0	0	4	99	6	2 – 8

Table 2: Properties of Bituminous Concrete Mix at Optimum Binder Content

Bitumen Used	80/100	PW Modified
OBC % (by weight of mix)	5.12	5.20
Stability (kN)	9.9	11
Flow Value (mm)	3.8	3.20
Bulk Density (gm/cc)	2.446	2.488
Air Voids, %	3.3	3.5
Voids Filled with Bitumen, %	75	74

6. PERFORMANCE TESTS ON BITUMINOUS CONCRETE MIX USING POWDERED WAX MODIFIED BITUMEN

The optimum binder content was obtained from the mix design analysis of bituminous concrete for both PW and unmodified 80/100 bitumen. Further, laboratory analysis of the bituminous mixes was conducted for determination of various performance parameters of bituminous mix including strength as well as recoverable and irrecoverable properties. The following tests were conducted on bituminous concrete mix using both modified as well as unmodified bitumen prepared at the obtained optimum binder content.

6.1 Tensile Strength Ratio

The results of the test indicate that bituminous mix using powdered wax modified bitumen possesses greater tensile

strength than that using conventional 80/100 bitumen. Also, the amount of tensile strength retained after water-bath treatment at 60^0C is higher in modified bitumen (94.8 %) compared to unmodified bitumen (88 %) as shown in fig 1. Higher value of percentage of tensile strength retained implies that the bituminous mix is less susceptible to stripping action due to moisture.

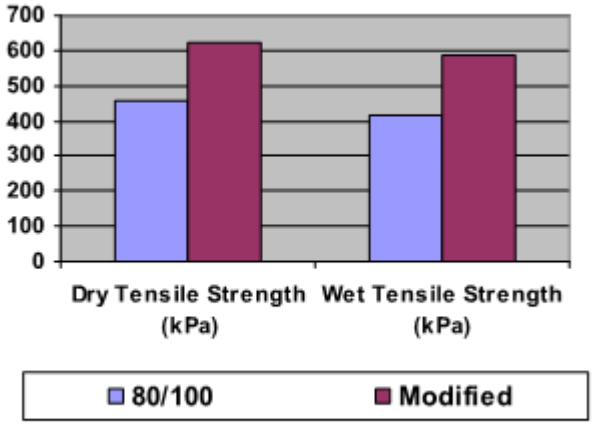

Figure 1: Indirect Tensile Strength Test Results

6.2 Diametrical Resilient Modulus Test

The diametrical resilient modulus test was conducted at a test temperature of 25^0C for 5 preconditioning pulses at applied load of 2000N and Poisson's ratio of the bituminous mix taken as 0.4

The results of the resilient modulus test are as shown in Table 2 and Figure 2.

Powdered wax modified has a very high resilient modulus compared to that of 80/100 bitumen. This shows that for a particular amount of strain to be produced in the pavement, modified bitumen can resist much higher stresses than 80/100 bitumen.

Table 2: Resilient Modulus of Various Mixes

Licomont Modified 80/100 Bitumen – Resilient Modulus

	Mean	S.D	C.V %
Total Resilient Modulus (MPa)	6605	106.76	1.62
Total Recoverable Horizontal Deformation	3.25	0.05	1.61
Repeated Load (N)	1971.6	2.19	0.11

80/100 Bitumen – Resilient Modulus

	Mean	S.D	C.V %
Total Resilient Modulus (MPa)	4516	300.90	6.66
Total Recoverable Horizontal Deformation	4.78	0.31	6.41
Repeated Load (N)	1973.9	1.44	0.07

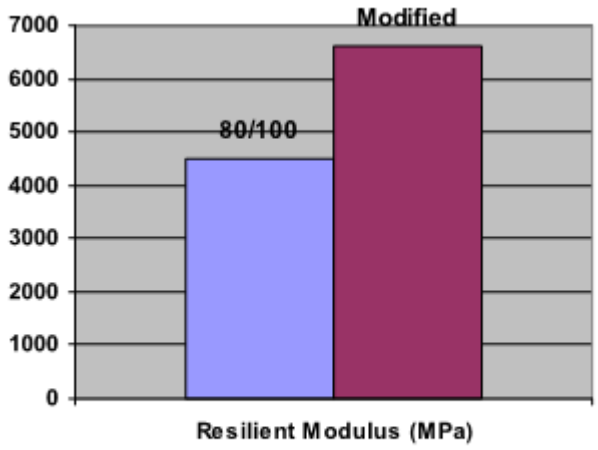

Figure 2: Resilient Modulus of Mixes

6.3 Creep Test

PW modified binder has half the accumulated axial strain compared to the 80/100 binder. This shows that PW modified binder is highly resistant to creep strain than the conventional binder. The following graph shows the deformation of both mixes under test conditions at 50^{0}C and an axial stress of 100 MPa as shown:

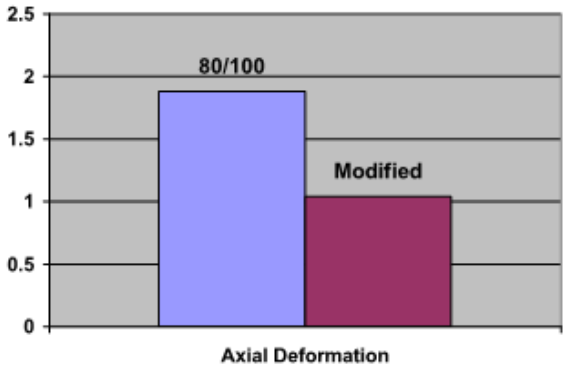

Figure 3: Accumulated Creep Strain

7 CONCLUSIONS

The following conclusions emerge based on the laboratory studies of Powdered Wax modified bitumen (PWMB) mixes:

- Penetration value of powdered wax modified bitumen is much lesser than that of conventional bitumen which improves its hardness
- Softening point is found out to be very high, making it suitable for hot climatic conditions
- The elastic recovery value for modified bitumen is very low, suggesting low visco-elastic properties
- The stability values of PW modified mix were found to be almost 12% better and the retained stability has improved by 6% as compared to the conventional mix, suggesting better resistance to deformation
- The indirect tensile strength has improved by more than 35% for PW modified mix, indicating its ability to take stresses. The increase of 6% of TSR value implies that loss of tensile strength is far less in PW modified mix as compared to conventional mix. Hence, it is less susceptible to moisture-induced stripping
- Resilient modulus value has improved at 25^{0} C in PW modified mix by almost 50%. The results have shown better recovery of pavement under repeated loading
- There was a substantial decrease of 45% in the accumulated strain in dynamic creep test of PW modified mix as compared to the conventional mix, thus reducing the permanent deformation to a large extent and in turn increases the life of the pavement

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