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Experimental Investigation on the Performance of Polyethylene Modified Bitumen

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Abstract-
In the present study, an attempt has been made to examine the properties of bitumen modified with polyethylene. The low density polyethylene in the form of used carry bags are used as a modifier. The grade of bitumen taken is 80/100. Various standard tests like penetration, softening point, ductility and specific gravity were conducted on bitumen with and without polyethylene. The results of penetration, softening and ductility values show that the stiffness of the binder increases with addition of increasing quantity of polymer. Storage stability test are also conducted on modified binder. The results confirm that the modified binder have stability during prolonged storage at high temperature. Marshall Stability tests are performed on samples using 1, 2, 2.5, 3 & 4% of polyethylene.

Key Words—Recycled Plastic Roads, Polyethylene Modified Bitumen, Flexible Pavements, etc

I. INTRODUCTION

Bitumen is used as a binder in pavement construction. Bitumen may be derived from the residue left by the refinery from naturally occurring asphalt. As per definition given by the American Society of Testing Materials (ASTM) bitumen has been defined as ”Mixtures of hydrocarbons of natural or pyrogenous origin, or combination of both, frequently accompanied by their non- metallic derivatives, which may be gaseous, liquid, semi-solid or solid, and which are completely soluble in carbon disulphide.”

Bitumen found in natural state known as asphalt contains large quantities of solid mineral matter. When petroleum crude is refined in a refinery, they are separated by fractional distillation in the order of decreasing volatility. On distillation of the residual bituminous residue, straight-run bitumen is obtained. This bitumen is known as penetration grade bitumen or steam refined petroleum bitumen.

The grades of bitumen used for pavement construction is known as paving grades and that used for water proofing of structures is known as industrial grades. The grade of straight run bitumen is chosen depending upon the climatic conditions of the region in which surface dressing is to be constructed. In most parts of India 60/70 and 80/100 grades bitumen is used. Heavier grade cut backs, rapid setting emulsions or heavier grade tars may also be used. The grade of basic bitumen is altered either by controlled re fining or by mixing with diesel oil or other oils. For single dressings on WBM base course, quantity of bitumen needed ranges from 17 to 195 kg per 10 m^2 areas and 10 to 12 kg per 10 m^2 area in case of renewal of black

top surfacing. For second coat of surface dressing, the quantity of bitumen needed ranges from 10 to 12 kg per 10 m^2 area. Bulk bitumen Lorries with tanks of capacity ranging from 5000 to 15000 liters are used to transport bulk bitumen.

1.1 TYPES AND PROPERTIES

The paving bitumen available in India is classified into two categories:

- Paving bitumen from Assam petroleum denoted as A-type and designated as grades A35, A90, etc.
- Paving bitumen from other sources denoted as S-type and designated as grades S35, S90, etc.

1.2 Important properties of bitumen are

- Viscosity of bitumen should be adequate at the time of mixing and compaction.
- It is achieved by heating prior to mixing and by use of cutbacks and emulsion.
- In presence of water bitumen should not strip off from aggregate.
- Bitumen should be durable in all seasons. It should not become too soft during summers and develop cracks during winters.

1.3 OBJECTIVES OF THE STUDY

- To propose an effective method of disposal of waste plastic Carry bags by using them in flexible pavements.
- To conduct a series of laboratory tests conventional and modified bitumen binders and to study the suitability of the same for use in flexible pavement.
- To improve the quality of flexible pavement construction by combining the bituminous binder with identified recycled materials.

II EXPERIMENTAL INVESTIGATIONS

2.1 MATERIALS USE FOR THE STUDY

2.1.1 Aggregate

There are two types of aggregate using our study, one is fine and other is coarse aggregate. Coarse aggregate fraction retained on IS sieving 4.75mm and fine aggregate fraction retained IS sieve 1.18 mm.

2.1.2 Bitumen

Bitumen of penetration grade 80/100 was used.

2.1.3 Polyethylene (PE)

Recycled low density polyethylene (LDPE) in the form of waste plastic carry bags shredded to 3x 3 mm size was used.

Fig1: Shredded waste plastic carry bags

2.2 STANDARD TESTS CONDUCTED ON BINDER

The tests have been carried out on the modified bituminous mixes containing 1, 2, 2.5, 3 & 4% of Polyethylene.

2.2.1 Penetration Test (IS 1203-1978)

The penetration test determines the hardness or softness of bitumen by measuring the depth in tenths of an mm to which a standard loaded needle will penetrate vertically in 5 seconds.

2.2.2 Ductility Test (IS 1208 -1978)

The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread breaks. The test is conducted at 27 ^{0}C and at a rate of pull of 50mm per minute.

2.2.3 Softening Point Test (IS 1205-1978)

The softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test. The temperature at which the softened bitumen touches the metal plate at a specified distance below the ring is noted as softening point of bitumen.

2.2.4 Specific Gravity (IS 1202 -1978)

The specific gravity of bituminous materials is determined by preparing a specimen in semisolid or solid state and by weighing in air and water.

2.2.5 Storage Stability Test

This test is used to determine the susceptibility of a pre-blended modified blinder to separation or instability during prolonged storage at high temperatures. A sample of modified binder contained in a closed vessel of 320 mm long and 60 mm internal diameter having a removable lid and was maintained at 160 ±2°C for 7 days ± 2 hours. The binder sample taken from the top and bottom thirds of the vessel was tested to determine the penetration and softening point, in accordance with IS 1203 and IS 1205.

III EXPERIMENTAL INVESTIGATION

3.1 Discussion on Binder Tests

The Results of penetration, Softening point, Ductility and Specific Gravity are presented in table1.

Table 1. Properties of Bitumen with different % of PE

S.No	Properties of Bitumen	Percentage of Polyethylene added					
		0%	1%	2%	2.5%	3%	4%
1	Penetration at 25^0 C (dmm)	92	85.5	78	72	65	52
2	Softening Point (^{0} C)	38.2	40	41	41.8	42.6	43.4
3	Ductility 27^0 C (cm)	>100	60	56	48	43	39
4	Specific Gravity	1.028	1.049	1.044	1.042	1.041	1.039

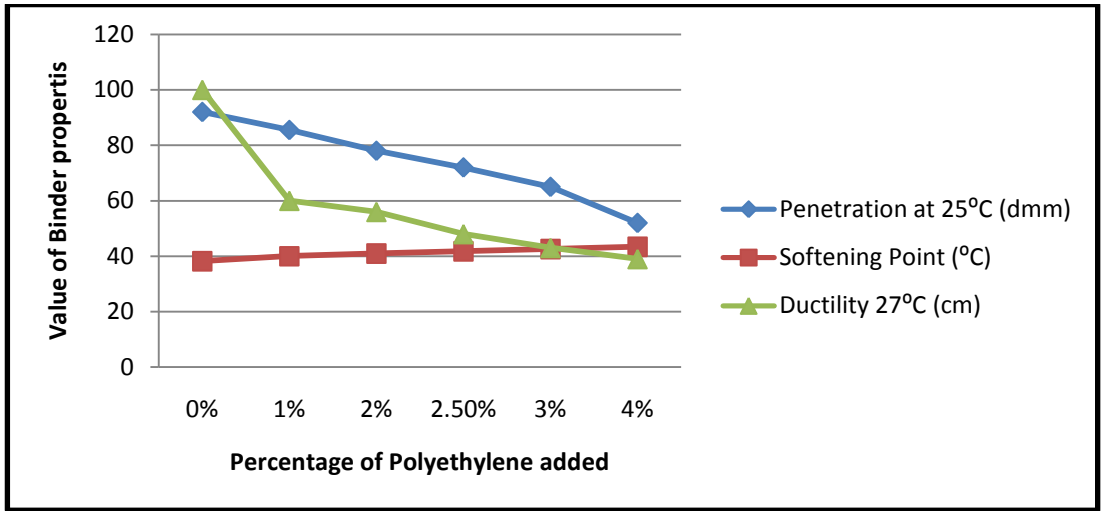


Fig 2. Properties of Bitumen with different % of PE

3.1.1 Penetration test

The results have shown a decrease in penetration value with increase in the Percentage of Polyethylene. This result indicates that there is increase in viscosity and hardness of the bitumen due to addition of Polyethylene.

3.1.2 Softening point

From the fig1 it can be concluded that the softening point increases with increase Percentage of Polyethylene.

3.1.3 Ductility

From the fig1 it can be concluded that the Ductility decreases with increase Percentage of Polyethylene.

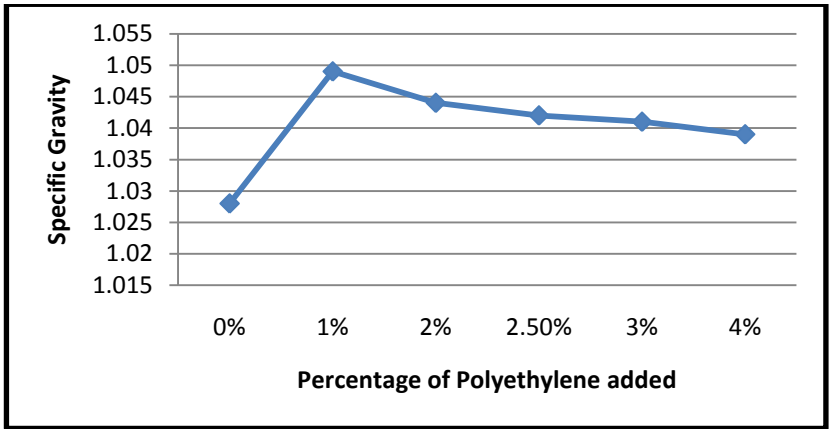


Fig 3. Specific Gravity of Bitumen with different % of PE

3.2 Test Results on Bituminous Mix

The optimum binder content has been calculated on the average of maximum stability value, maximum unit weight and average % of air voids in the total mix.

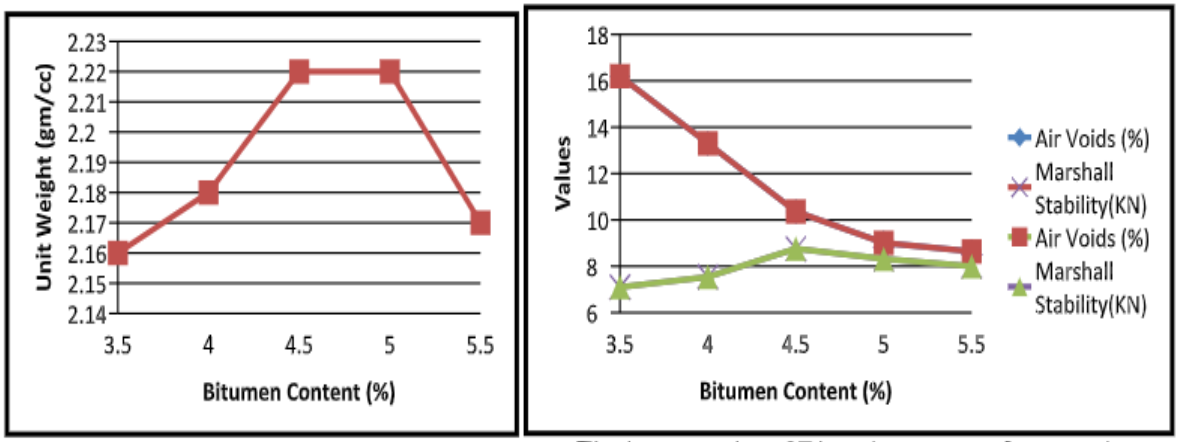
The properties of open graded bituminous macadam samples prepared with plain bitumen (80/100 grade) are shown in Table 2 and fig 4. It is found that optimum binder content for the plain bitumen is 4.5% by weight of aggregate. This optimum binder content is taken for further polymer modified binder study.

Table 2. Test properties of Bituminous macadam specimen prepared with plain bitumen (80/100 grade)

S.No	Property Used	80/100 Grade Bitumen				
1	Bitumen Content by weight of aggregate (%)	3.50	4.00	4.50	5.00	5.50
2	Theoretical Density	2.51	2.47	2.45	2.42	2.39
3	Unit Weight (gm/cc)	2.16	2.18	2.22	2.22	2.17
4	Air Voids (%)	16.20	13.3	10.36	9.01	8.64
5	Voids In Mineral Aggregate VMA (%)	25.25	22.43	19.66	18.31	17.80
6	Voids filled with Bitumen VFB (%)	35.84	40.70	47.30	50.79	51.50
7	Marshall Stability(KN)	7.10	7.54	8.76	8.32	8.00
8	Flow Value (mm)	2.15	2.45	2.70	3.00	3.00

Fig 4. properties of Bituminous macadam specimen prepared with plain bitumen (80/100 grade)

3.3 Test properties of Bituminous Macadam Specimen Prepared with Plain Bitumen, different proportions PE.



The Various results of marshal specimen for the open graded bituminous macadam mixture have been shown in fig 5-9.

Table 3. Test properties of Bituminous Macadam Specimen Prepared with Plain Bitumen, different proportions PE

S.No	Properties tested	Polyethylene by weight of Bitumen				
		1%	2%	2.5%	3%	4%
1	Theoretical Density (gm/cc)	2.44	2.44	2.45	2.45	2.45
2	Unit Weight (gm/cc)	2.20	2.21	2.22	2.24	2.24
3	Air Voids (%)	10.90	10.40	10.36	9.38	9.37
4	Voids In Mineral Aggregate VMA (%)	19.93	19.52	19.63	18.59	18.51
5	Voids filled with Bitumen VFB (%)	45.30	46.72	47.22	49.54	49.37
6	Marshall Stability(KN)	8.90	9.11	9.32	9.44	8.02
7	Flow Value (mm)	2.20	2.20	2.70	2.70	2.60

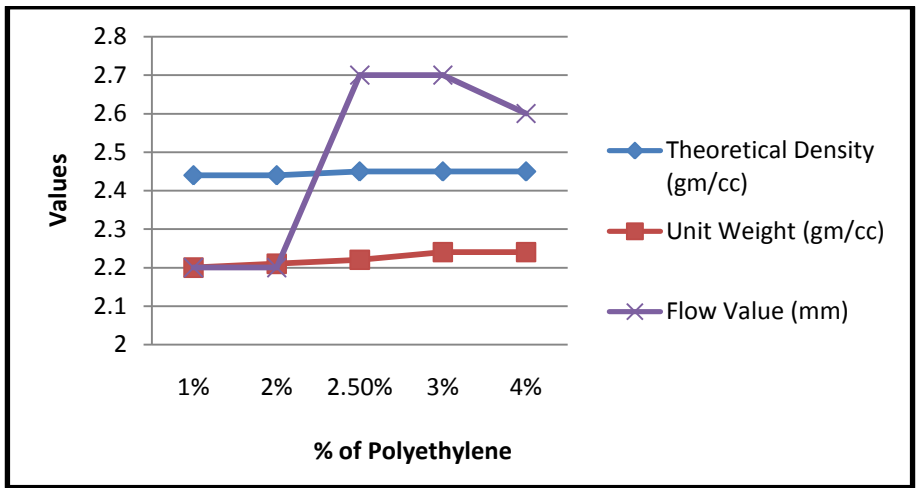


Fig 5. Properties of Bitumen with different proportions PE

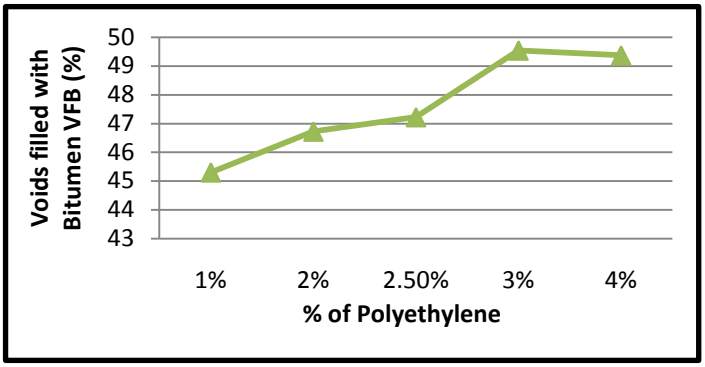


Figure 6: Variation of Air VFB for Different PE

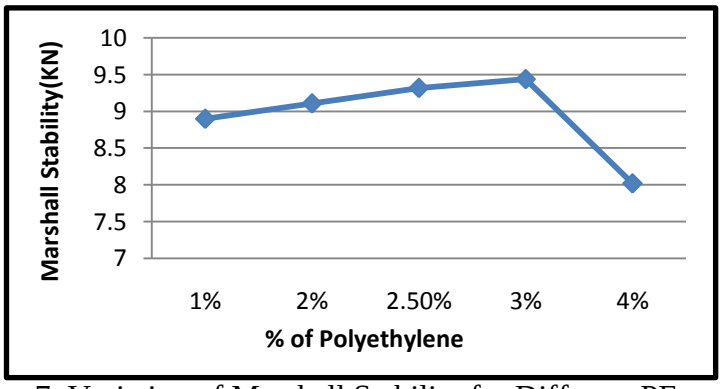


Figure 7: Variation of Marshall Stability for Different PE

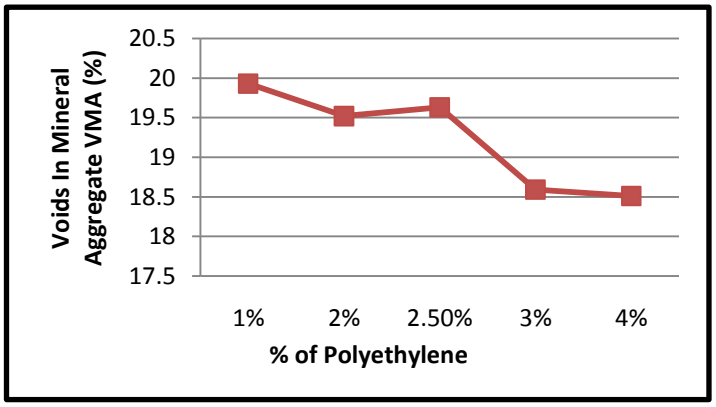


Figure 8: Variation of VMA for Different PE

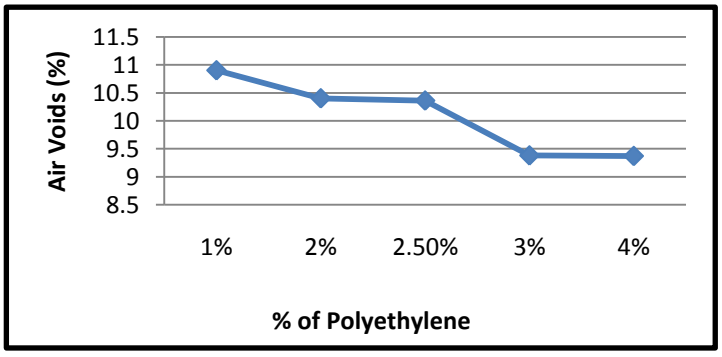


Figure 9: Variation of Air Voids for Different PE

IV DISCUSSION ON TEST RESULTS

4.1 Marshall Stability

From Fig 7: a Marshal Stability value increase with increasing PE content, maximum stability attained at 3% PE and then starts decreasing. The Stability values are found to increase from 8.7KN for plain bitumen to 9.44KN for binder with 3% PE. The higher stability value indicates that modified binder would be less susceptible to plastic deformation.

4.2 Unit Weight

From fig5: it indicates that the unit weight increases with increase in % of PE

4.2 Air Voids

From fig 9: the Air Voids decreases with increase in modified binder content.

V CONCLUSION

Based on the laboratory tests conducted, it is proved that the addition of Polyethylene produces favorable changes in the properties of bitumen and mixes prepared using binder. On the basis of observation and analysis of the results following conclusion are drawn

- The low Density Polyethylene (LPDE) is compatible with 80/100grade bitumen to get a homogeneous mix.
- The penetration and ductility value decreases with increasing percentages of polyethylene.
- The softening point value increases with increasing percentages of PE content.
- Marshall Stability value as high as 9.44KN was obtained as a result of modification with 3% PE by weight of bitumen in 4.5% binder content.
- The Marshall Stability value of modified binder when compared with plain bitumen increases. Maximum value is attained at 3% PE stability value is decreases.
- The environmental crisis due to the stock piling of the non-bio-degradable waste of PE in Municipal wastes can be partly solved.

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