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RHEOLOGICAL PROPERTIES OF RECYCLED LOW DENSITY POLYETHYLENE AND POLYPROPYLENE MODIFIED BITUMEN

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Abstract- Polymer-modified bitumen has been used in civil engineering practice from a long time. The addition of polymers in bitumen improves the deformational stability and durability of bitumen. In the present study, the effect of waste Low Density Polyethylene (LDPE) and Polypropylene (PP) obtained from waste carry bag, on various properties of bitumen such as penetration, ductility softening point have been evaluated. Waste plastics, whose disposal is a matter of concern can be used successfully to modify the bitumen, these waste polymers are added in 2%, 4%, 6%, 8%and 10% percentages in 60/70 penetration grade bitumen and its effect on different properties of bitumen are evaluated. The result of experimental study shows that there is significant improvement in the properties of bitumen due to LDPE and PP modification.

Key words*: Waste plastic, LDPE, PP, Modified bitumen*

1.1 INTRODUCTION

In recent years, many waste materials are produced from manufacturing operations, service industries and households. Problems are experienced due to insufficient capacity of landfills. Disposal of waste materials including waste plastic bags is a serious problem, specially in urban areas, its dumping causes clogging of drains, reduced soil fertility and aesthetic problem etc. Disposal of many million tons of non-decaying plastics waste is responsible for health hazards and degradation of environment. Waste utilization is an attractive alternative to disposal in that disposal cost and potential pollution problems are reduced or eliminated. This also leads to resource conservation.

Thousands of tonnes of waste plastic are produced every year. Although the amount of waste being recycled is increasing it is still not enough to efficiently alleviate the problem. The aim of this study is to evaluate the performance of waste polymer, LDPE and PP obtained from waste plastic carry bag, to modified bitumen and compared their properties with those of base bitumen.

1.2 EARLIER STUDIES

Some of the studies done this field during last decade are summarized here. Hadidy et al. [1] based on study on the utilization of LDPE in Stone Mastic Asphalt mixtures conclude that Penetration at 25^0C will generally decrease as LDPE content increases, which indicates an improved shear resistance in medium to high temperatures. The addition of LDPE kept the ductility values at a minimum range of ASTM specifications of 100+ cm up to 6% LDPE content. Softening point tend to increase with the addition of LDPE, which indicates improvement in resistance to deformation. Garcı´a et al. [2] have reported that, a polymer blend composed of EVA (Ethylene Vinyl Acetate) and LDPE quite suitable mainly at high in-service temperatures, showing favorable mechanical properties at temperatures for which neat bitumen undergoes permanent deformation processes. The amount of polymer in the blend should be adjusted, in order to get a proper value of viscosity at the temperatures involved in bitumen application and compaction.

Naskar et al. [3] reported that the performance of bitumen can be improved by addition of waste plastic. The optimum waste plastic content is found to be 5% by weight based on the thermal stability results. Praveen Kumar [4] based on his study on crumb rubber modified bitumen concluded that changes in physical properties of bitumen like penetration, softening point and penetration index are improved with addition of crumb rubber. Complex modulus increases with increase in modifier and decreases with increase in temperature. However, phase angle decreases with increase in modifier and increase with increase in temperature. Increase in complex modulus and decrease in phase angle of modified binder indicate higher resistance to deformation as compared to neat bitumen.

Yue Huang et al. [5] based on the study on waste material in asphalt pavement concluded that, tyre rubber is used in asphaltic mixture to reduce cracking, improve durability and mitigate noise. Depending on the application, different variable need to be considered when assessing the technical performance of asphalt containing tyre rubber, binder properties in the wet process, and mixture properties in the dry processes. The use of recycled material in pavement asphalt represents a valuable outlet for such material.

Murphy et al. [6] based on their experimental studies on bitumen modified with recycled polymers reported that, some of the waste polymers showed potential for enhancing the properties of bitumen but other are not. The addition of polyethylene increases the softening point although viscosity value remains low. In this case they showed some tendencies to separate from the bitumen. The addition of polypropylene increased the softening point but viscosity remains same. The blends with low density polyethylene and ethylene vinyl acetate are worthy of further consideration.

1.3 MATERIALS

1.3.1 Base Bitumen

For present study 60/70 penetration grade bitumen, obtained from Shell Corporation India is used as base material. The physical characteristic of the base bitumen is shown in table 1.

Table: 1 Characteristics of Base Bitumen

Penetration, 25 ^{0}C, 100 g, 5 s (dmm)	67
Ductility, 25 ^{0}C, 5 cm/min (cm)	>120
Softening point (^{0}C)	40
Viscosity at 120^{0}C (Seconds)	08

1.3.2 Low density polyethylene (LDPE)

Polyethylene belongs to polyolefin of polymers, it is a thermoplastic polymers. Many types of polyethylene exist but, low and linear density and high density polyethylene are the most common. High Density Polyethylene (HDPE) are used when, strength, heat tolerance, stiffness and shrinkage are required. They are commonly used in food packaging, like milk bottles, soft drink bottles, and industrial drums for chemical. Low density polyethylene (LDPE) is used where impact strength, toughness and high elongation are important. Some applications of LDPE include carry bags bread packaging, sandwich bags, house wares, toys, buckets, wire and cable jacketing, carpet. Fig.1 shows the molecular structure of polyethylene.

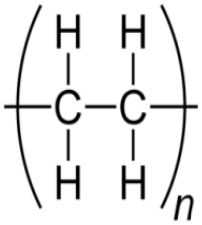

Fig.1: Molecule of polyethylene

1.3.3 Polypropylene (PP)

Polypropylene is the lightest known industrial polymer. It is produced by polymerization of propylene. Polypropylene is a stiffer material than polyethylene. Polypropylene has good heat and chemical resistance, resistance to deformation at elevated temperatures, high stiffness, surface hardness and toughness at normal temperatures. The molecular structure of polypropylene is shown in Fig. 2

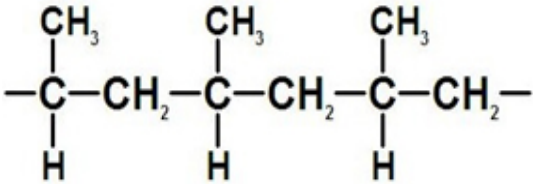

Fig.2: Molecule of Polypropylene

The waste LDPE and PP are obtained from the waste plastic bag in the form of pellets, manufacture by a minor local industry from Aurangabad state of Maharashtra India.

1.3.4 Experimentation

Waste LDPE and PP modified bitumen is prepared in laboratory by heating bitumen at 200 ^{0}C and waste plastic mixed and stir for one hour. The penetration test is carried out by standard bitumen penetration test apparatus, measured in terms of 1/10th of mm under weight of 100gm for 5 second at 25 ^{0}C.The softening point is determined by ring and ball method. The ductility is determined in terms of centimeter at 27^{0}C.

1.4 RESULT AND DISCUSSION

1.4.1 Penetration

The penetration of bitumen reduces with increase in concentration of LDPE which indicate the increase in stiffness. The reduction in penetration is 4 to 60% for LDPE concentration of 2 to 10 % respectively. The effect of LDPE concentration on penetration is shown in fig.3.

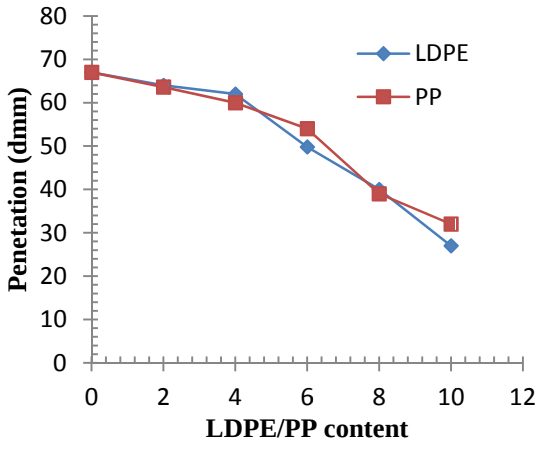

Fig.3: Effect of LDPE on Penetration

In case of PP also the penetration reduces with increasing the PP content in bitumen. The reduction in penetration is 5 to 50% for PP concentration of 2 to

10% respectively. The effect of PP on penetration value is shown in fig.3. Almost same trend was found in reduction of penetration in waste LDPE and PP.

1.4.2 Ductility

The ductility of bitumen decreases with increase in LDPE and PP concentration. In case of LDPE ductility of modified bitumen is reduces by 5 to 60% for 2 to 10% of respectively. The variation of ductility with concentration of PP and LDPE is shown in fig. 4. The ductility of bitumen is reduces to approximately 10cm for LDPE and PP. It is necessary to decide optimum dose of these waste polymer by considering minimum ductility requirement criteria. As per the Indian Standards the minimum ductility should be 75cm, from this consideration the percentage of waste plastic should not be more than 5%.

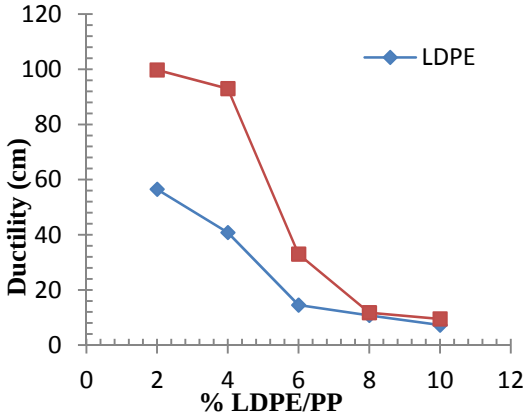

Fig.4: Effect of LDPE/PP on Ductility

1.4.3 Softening Point

Experimental study reveals that the softening point of bitumen is increasing with increase in LDPE content. The softening point for neat bitumen is 40ºC, which increase to 70^0C for 10% LDPE content, which indicate greater temperature susceptibility. Same trend was found in case of PP, the softening point increases with increase in concentration of PP content in bitumen. The softening point of bitumen modified with 10% of PP was 66.5 ^{0}C. The effect of LDPE/PP on softening point of bitumen is shown in fig. 5. In general LDPE and PP are improving the softening point of base bitumen.

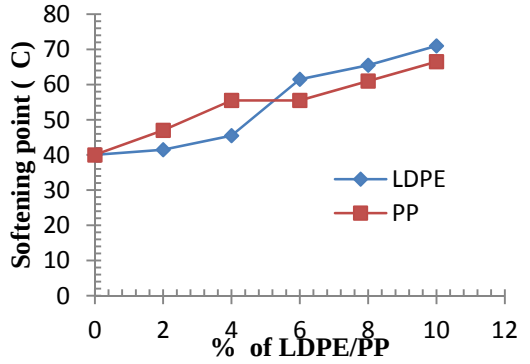

Fig.5: Effect of LDPE/PP on Softening Point

1.5 CONCLUSION

The observations brought out through the experimental studies on neat bitumen and bitumen modified by LDPE and PP have been summarized as below

1. The penetration value of bitumen is decreasing with increase in percentage of LDPE which indicate the increase in stiffness penetration value decreases from 50 dmm to 26 dmm when the LDPE content increase from 6% to 10%.
2. The softening point of bitumen is increasing with increase in LDPE content. The softening point for neat bitumen is increase from 40ºC to 70 ^{0}C for 10% LDPE content, which indicate greater temperature susceptibility. It is found that the ductility of bitumen is greatly affected due addition of LDPE in bitumen. The ductility reduces to approximately 50cm at 4% LDPE content and rapidly reduces to 7cm at 10% LDPE content , it indicate that the higher percentage of LDPE content for bitumen modification is not suitable. The optimum percentage of waste polymer content can decided on the basis of minimum requirement of ductility. For PP the softening point increases with increase in concentration of PP content in bitumen. The softening point of bitumen modified with 10% of PP was 66.5 ^{0}C
3. In general the physical properties of the bitumen modified by waste propylene and low density polyethylene are better than the neat bitumen.
4. By considering the factor of minimum requirement of ductility the optimum waste polymer content is about 4 to 5%.

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