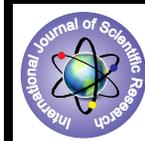


Study on Effect of Waste Plastic and Crumb Rubber on Physical Properties of Bitumen



Engineering

KEYWORDS : HDPE; Crumb Rubber; Wet process

Patel Chirag B

P.G. Student, Civil (Transportation) Engineering, P.I.E.T., Limda (M) 7567647301

Prof. S. M. Damodariya

Reader in Civil Engineering, P.I.E.T., Limda (M) 9879345303

ABSTRACT

Development of modified asphalt materials to improve the overall performance of pavements has been the focus of several research efforts made over the past few decades. Use of discarded waste plastics construction was one of the steps taken in this direction. Using the waste materials in road construction will not only bring out significant saving in road material costs but also help towards tackling the problems of disposal of such waste materials. In the present work, an attempt has been made to use waste plastic, HDPE and Crumb Rubber, blended using wet process. A physical property was carried out for different percentage of HDPE and Crumb Rubber.

INTRODUCTION

Traditional bituminous binders present various limitations to cope with the excessive overloading and increasingly severe climatic conditions which lead to important stress related problems. Binder modification is a major breakthrough and the continuous research in this area is aiming to produce new binders with better rheological and mechanical characteristics which allow the manufacturing and application of road bituminous mixes with higher performance. Today disposal of the dumps has become a crying necessity, not only to regain the vast valuable space occupied by them, but also to reduce the pollution and other hazards. Many researchers have tried to use the waste materials in road construction. Plastics are user friendly but not eco-friendly as they are non-biodegradable. Generally it is disposed by way of land filling or incineration of materials which are hazardous. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics, by using them in road laying. Modified Bitumen is one of the important construction materials for flexible pavements. Use of plastic waste (HDPE) and Crumb Rubber i.e. the rubber obtained from the waste tyres of vehicles, in the construction of flexible pavement is gaining importance. It is also worth mentioning that, the modifier raw-material has been sourced from disposed waste plastic and crumb rubber. This not only allows us to collect modifier raw material at low cost, but also provides a solution towards ecological menace posed by increased use of plastics (non-biodegradable). By using the waste plastic and Crumb Rubber as a modifier the properties of bitumen will be change and this change in physical properties like softening point, penetration value, and ductility was checked by different test. In this study we used modifier in proportion (1%,2%,3% and 4%) by the weight of bitumen and checked the physical properties of this modified bitumen.

WASTE SCENARIO

The consumption of plastics have increased from 4000 tons/annum (1990) to 4 million tons/annum (2001) and it is rise up to 1,35,00,000 tones/annum(2011). Nearly 50 to 60% of the total plastics are consumed for packing. Once used plastic materials are thrown out. They do not undergo bio-decomposition. Hence, they are either land filled or incinerated. Both are not ecofriendly processes as they pollute the land and the air.

Waste tyres in India are categorized as solid waste or hazardous waste. It is estimated that about 60% of (retreaded) waste tyres are disposed via unknown routes in the urban as well as rural areas. The hazards of waste tyres include- air pollution associated with open burning of tyres (particulates, odor, visual impacts, and other harmful contaminants such as polycyclic aromatic hydrocarbon, dioxin, furans and oxides of nitrogen), aesthetic pollution caused by waste tyre stockpiles and illegal waste tyre collecting and other impacts such as alterations in hydrological regimes when gullies and watercourses become waste sites.

Table 1
Chemical Properties of Crumb Rubber

Content	Method	Percentage
Acetone –extract	ASTM D297-18	<13
Ash	ASTM D297 -18	<9
Carbon black	ASTM E1 131	31 ± 2
Polymer content	ASTM E1 131	54 ± 4

Table 2
Specifications for Properties of Plastics

Type of plastic	Low density polyethylene	High density polyethylene
Chemical unit	(-CH ₂ -CH ₂ -) _n	(CH ₂ =CH ₂) _n
Density (g/cc)	0.91-0.94	0.945-0.962
Softening point	100-120	120-130
Solubility	Nil	Nil

LITERATURE RIEWE

R. Vasudevan et. al. (2007), in this paper they study on the polymer modified bitumen and crumb rubber modified bitumen and they construct different stretches and perform field study with the help of National Transport Planning and Research Centre, Trivandrum. From this field study they concluded that the entire road having a good skid resistance value and from bump instigator study a good surface evenness.

Noor Zainab Habib et. al. (2011) From all the test results it was revealed that LLDPE &PP modified bitumen shows least variation in penetration and softening point in comparison to HDPE modified bitumen, when the concentration of polymer is kept below 3% which may be due to the formation of thermodynamically stable structure which may offer resistance in terms of rutting, fatigue and temperature susceptibility when investigated at later part of this study.

Amit Gawande (2012) In their paper they reviewed the techniques for use of waste plastic in flexible pavement and they conclude that the use of modified bitumen with the addition of processed waste plastic of about 5-10% by weight of bitumen helps in substantially improving the Marshall stability.

Nuha S. Mashaan (2012) In their review study presented the application of crumb rubber modifier in the asphalt modification of flexible pavement. From the results of previous studies, it aspires to consider crumb rubber modifier in hot mix asphalt to improve resistance to rutting and produce pavements with better durability by minimising the distresses caused in hot mix asphalt pavement. Hence, road users would be ensured of safer and smoother roads.

Intiyaz Khan and Dr. P.J.Gundaliya, (2012) concluded that the waste polythene utilized in mix will coated over aggregate of mixture and reduce porosity, absorption of moisture and improve binding property. The bitumen modified with 4%

polythene waste is showing better performance as compared to other mixes. The Marshall Stability which is strength parameter has shown increasing trend with a maximum increase percent of 34.26% as compared to conventional mix when modified with 4% Polythene Waste.

NEED OF MODIFIED BITUMEN

Modified bitumen acts as multi-grade due to their low susceptibility to daily and seasonal temperature variations.

- Higher resistance to deformation at elevated pavement temperature and resistance to brittle cracking at low pavement temperature.
- Better adhesion between aggregate and binder, higher fatigue life of mixes under heavy axle load & better resistance to ageing.
- Overall improved road performance in extreme climatic and heavy traffic conditions.

OBJECTIVE OF PRESENT STUDY

- To utilize waste materials as a pavement (in surface course) ingredients.
- To study the effect of crumb rubber powder and waste plastic on physical properties of 60/70 penetration grade bitumen and their indicative doses.

EXPERIMENTAL PROGRAM

Materials

Bitumen of 60/70 penetration grade were used for present study. The physical properties of bitumen described as per IS 73:1992 are given in Table 3.

Waste plastic (HDPE) and Crumb rubber were used as modifier in this study.

Table 3
Physical property of neat bitumen

Designation	Test Result	Permissible limit as per IS 73:1992	Test Method
Penetration at 25°C, 100g, 5 s, d mm	64	60-70	IS1203:1978
Softening Point, °C	45	40-55	IS1205:1978
Ductility at 27°C, cm	80	75(min)	IS1208:1978
Specific Gravity at 27°C, gm/cc	1.02	0.99(min)	IS1202:1978

Preparation of Modified Bitumen

About 500 gm of bitumen was heated to 160°C to a fluid condition. The mixing was performed in the laboratory with a mechanical stirrer at a frequency of 1500 rpm. After the mixing temperature was reached, 1 percent HDPE by weight of bitumen was added slowly in order to avoid agglomeration of the material. The typical time used for preparation of the blend was 1 hour. After the blend was prepared, it was allowed to settle for 1 hour. Similar procedure was adopted for other proportion of mixes. The percentage of modifier varied from 1 percent to 4 percent.

Test Conducted

Penetration measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. BIS had standardized the equipment and test procedure. The Penetrometer consists of a needle assembly with a total weight of 100g and a device for releasing and locking in any position. The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 25°C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 60/70 bitumen means the penetration value is in the range 60 to 70 at standard test conditions. In hot climates, a lower penetration grade is preferred.

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5°C per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking. Dimension of the briquette thus formed is exactly 1 cm square. The bitumen sample



Fig. 1 Softening point test

These samples with moulds are cooled in the air and then in water bath at 27°C temperature. The excess bitumen is cut and the surface is leveled using a hot knife. Then the mould with assembly containing sample is kept in water bath of the ductility machine for about 90 minutes. The sides of the moulds are removed, the clips are hooked on the machine and the machine is operated. The distance up to the point of breaking of thread is the ductility value which is reported in cm. The ductility value gets accepted by factors such as pouring temperature, test temperature, rate of pulling etc.



Fig. 2 Ductility Test

TEST RESULT

Different percentage of waste plastic (HDPE) added to 60/70 grades of bitumen affected the physical properties of the binder in terms of penetration, softening point and ductility which is presented in graphical and tabular form.

Table 4: Physical properties at different % of modifier

% of Modifier	Softening point (°C)(IS: 1205 - 1978)		Penetration value (dmm) (IS: 1203 - 1978)		Ductility (cm) (IS: 1208 - 1978)	
	HDPE	CR	HDPE	CR	HDPE	CR
0	45	45	64	64	80	80
1	47	48.5	61	63	59	54
2	48	51	57	59	43	48
3	52	54	55	54	30.5	32
4	55	56	51	52	21.5	24

The penetration values are decreasing significantly when bitumen is mixed with the modifier. Thus there is significant decrease in penetration value for modified blends, indicating the improvement in their temperature susceptibility resistant characteristics.

The softening point increase with increase in percentage of modifier and this is so because the bitumen becomes increasingly viscous.

The binders possessing high ductility have good cementing qualities in road surface and adhere well to aggregates. The ductility values are decrease with increase in percentage of modifier. The ductility value less than 50 cm should not be used in road construction, but may be used as crack and joint filler material.

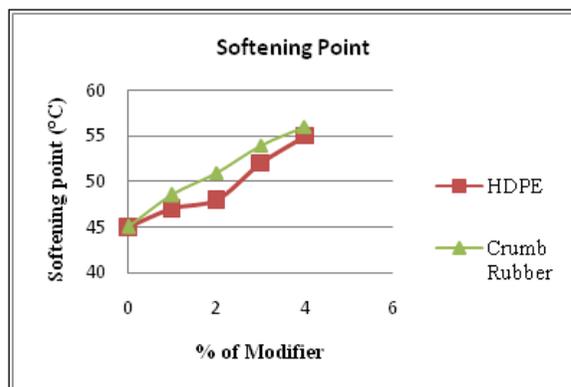


Fig. 3 Variation in softening point with different % of Modifier

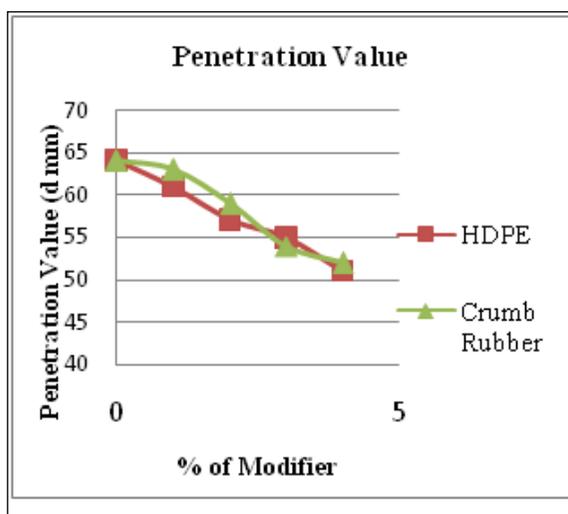


Fig. 4 Variation in Penetration value with different % of Modifier

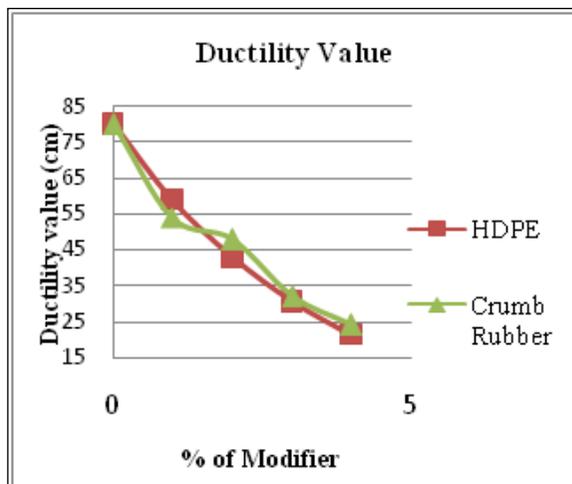


Fig. 5 Variation in Ductility value with different % of Modifier

CONCLUSION

The following conclusions are drawn based on the result obtained in the present study:

The properties of bitumen such as penetration, softening point and ductility were improved with addition of the waste plastic and crumb rubber. There is significant decrease in penetration values for modified blends, indicating the improvement in their temperature susceptibility resistant characteristics.

The softening point increase with increase in percentage of waste plastic and crumb rubber this is so because the bitumen becomes increasingly viscous. The result shows for 4% modifier the softening point increased by 22% and 24% for waste plastic modified bitumen and Crumb Rubber modified bitumen respectively.

The ductility value decrease with increase in percentage of modifier, the ductility less than 50 cm should not use for road constructions, but may be used as crack and joint filler material.

REFERENCE

- [1] Afroz sultana. SK and K.S.B.Prasad, "Utilization of Waste Plastic as a Strength Modifier in Surface Course of Flexible and Rigid Pavements", International Journal of Engineering Research and Application, July-August 2012, Vol. - 2, Issue 4, pp 1185-1191. | [2] Gawande, Amit, et. al., "An Overview On Waste Plastic Utilization In Asphaltting Of Roads", Journal of Engineering research and Studies, Vol. III, Issue II, April-June 2012, pp 01-05. | [3] Khan, Imtiyaz, and Dr. P.J.Gundaliya, "Utilization of Waste Polyethylene Material in Bituminous Concrete Mix for Improved Performance of Flexible Pavements", International Journal of Scientific Research, September-2012, Vol.-1, pp 57-58. | [4] Mrs.Vidula Swami et. al., "Use of Waste Plastic in Construction of Bituminous Road", International Journal of Engineering Science and Technology, May-2012, Vol.-4, pp 2351-2355. | [5] Vasudevan, R. et. al., "Utilization of Waste Polymers for Flexible Pavement and Easy Disposal of Waste Polymers", International Conference on Sustainable Solid Waste Management, 5 - 7 September 2007, Chennai, India. pp. 105-111 | [6] Noor Zainab Habib et. al., "Rheological Properties of Polyethylene and Polypropylene Modified Bitumen", International Journal of Civil and Environmental Engineering 3:2 2011, pp. 96-100. | [7] Nuha S. Mashaan et. al., "An overview of crumb rubber modified asphalt", International Journal of the Physical Sciences, Vol. 7(2),9 January 2012, pp. 166 - 170. | [8] Pravin Kumar and Rashi Garg, "Laboratory Studies on Waste Plastic Fibre Modified Bitumen", Highway Research Journal, January-June 2010, pp 45-60. | [9] S, Rokade, "Use of Waste Plastic and Waste Rubber Tyres in Flexible Highway Pavements", international conference on future environment and energy, 2012, Vol. - 28, pp 105-108. |