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STUDY ON USE OF POLYMERIC WASTE MATERIALS IN CONCRETE FOR ROAD PAVEMENTS

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ABSTRACT: Concrete is strong in compression but weak in tension and brittle also. Cracks also start forming as soon as the concrete is placed. These 3 drawbacks don't permit the use normal concrete in pavements as they lead to lack of ductility along with fracture and failure. These weaknesses in concrete can be mitigated by using fibers as reinforcement in the concrete mix. Waste materials in the form of polyethylene and tires cause environmental pollution which leads to various health problems. Polyethylene and waste tires can be recycled and used effectively in the concrete as reinforcement in the fiber form. Polyethylene is a synthetic hydrocarbon polymer which can improve the ductility, strength, shrinkage characteristics etc. This research deals with the effects of addition of polyethylene fiber on the properties of concrete. Polyethylene and tire fibers were cut into the size of 30mm x 6mm and they were used 1.5% each by volume. Grade of concrete used were M30, M35 and M40. IRC 44:2008 was followed for the design of concrete mix. In this study, the results of the Strength properties of Polyethylene fiber reinforced concrete have been presented. 4 point bending test and double shear test were performed in the laboratory for flexure and shear strength determinations. There was seen an increase of 18% in the 28 day compressive strength along with an increase of 39% in flexure and 32% in shear strength. 22% decrease in 4 point bending test and 36% decrease in double shear test in deflection was found out from the experiments. Theoretical analysis of deflection was carried out by the help of energy methods. Practical values were verified with the theoretical values within the permissible limits. Finally it can be concluded that polyethylene and tire can be used effectively in reinforced cement concrete.

KEYWORDS: Bitumen, High Density Polyethylene (HDPE), international bottled water association (IBWA), Low Density Polyethylene (LDPE), Marshall Stability method, Waste plastic. Bitumen, Glass Fiber, Modified bituminous mix, Pavement Materials,Bituminous Concrete (BC), Stone Matrix Asphalt (SMA), Sisal Fibre,Marshall Properties,Static Indirect Tensile Strength, Static Creep.

I. INTRODUCTION

As there is a increasing demand in highway construction, scientists and researchers are constantly trying to improve the performance of bitumen pavement. Asphalt concretes are widely used in pavements. Bitumen is the naturally occurring byproduct of crude oil. Due to increase in vehicles in recent years the road surfaces have been exposed to high traffic resulting in deformation of pavements due to excessive stress. Permanent deformation happens when pavement does not have sufficient stability, improper compaction and insufficient Pavement strength.

The performance of pavement is determined by the properties of bitumen. Bitumen is a viscoelastic material with suitable mechanical and rheological properties for water proofing and protective covering for roofs and roads, because of its good adhesion properties of aggregates. One of the most important properties of bitumen mixture is its ability to resist shoving and rutting under traffic. Therefore stability should be high enough to handle traffic adequately, but not higher than the traffic conditions require. Low stability causes unraveling and flow of the road surface. Some improvements in asphalt properties have been achieved by selecting the proper starting crude, to make asphalt. From practical experiences it is proved that the modification of asphalt binder with polymer additives, offers several benefits. To enhance various engineering properties of asphalt many modifiers such as styrene based polymers, polyethylene based polymers, polychloroprene, Gilsonite, various oils have been used in asphalt. Plastic usage has been increased in our daily life.

Because of all these there is an increased usage of plastic, the disposal of plastic has become difficult. Some studies shows that 10million tonnes of plastic are produced in India and only 2million tonnes of plastic waste are recycled.

Plastics have to be disposed or else it will be hazardous to nature and environment. Thus one of the best ways of disposal of these plastics is to use it in bituminous road construction by melting them. Many highway agencies are doing various studies on environmental suitability and performance of recycled products in high construction. Use of these waste plastic in bituminous road construction will help in disposal of vast quantities of plastic. Consumption of mineral water bottles which are made up of high density polyethylene has increased abnormally. These bottles are not readily biodegradable, environmental problems are created due to dumping; these are either land filled or incinerated which are not ecofriendly which pollute land and air.

II. EXPERIMENTAL INVESTIGATION

Objective

The main objective of this experimental investigation is to provide tools to evaluate and to improve the properties of pavement using waste plastic such that it may be more confidently employed in roadways and driveways etc. Keeping in view of the above point the following specific objectives have been set for study.• Laboratory studies will be carried out on polymer modified asphalt mixtures to evaluate engineering properties using marshal stability.

• To study basic properties of aggregates and plain bitumen.
• To study the strength and stability characters of BC (Bitumen Concrete) mix for 80/100 grade bitumen.
• To study the effect of waste plastic on strength and stability characteristics of BC mix.

Experimental Program

Materials Used

The basic materials for Bitumen Concrete are required such as

Bitumen,

Waste plastic

Aggregate

Bitumen

Bitumen is a material which is a byproduct of petroleum refining process. It is a highly viscous at temperature above 100 degrees Celsius and is solid at room temperature. For the present investigation 80/100 is employed

Bituminous materials or asphalts are extensively used for roadway construction, primarily because of their excellent binding characteristics and water prolongs properties and relatively low cost. Bituminous materials consists of bitumen which is a black or dark colored solid or viscous cementations substances consists high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt, has adhesive properties, and is soluble in carbon disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen. Bitumen will be dissolved in petroleum oils where unlike tar doesn't.

Sl No	Test on Bitumen	Obtained Value	Bitumen Grade	Test method
1	Penetration	90	80/100	IS:1203-1978
2	Softening Point	50	80/100	IS:1205-1978
3	Ductility	75	80/100	IS:1208-1979
4	Flash & Fire point	240	80/100	IS:1209-1981
5	Specific Gravity	1.02	80/100	IS:1202-1980

Table 1: Properties of bitumen used in present study

Plastic

The bottled water is the fastest growing beverage industry in the world. According to the international bottled water association (IBWA), sales of bottled water have increased by 500 Percent over the last decade and 1.5 million tonnes of plastic are used to bottle water every year. Plastic bottle recycling has not kept pace with the dramatic increase in virgin resin polyethylene terephthalate (PET) sales and the last imperative in the ecological triad of reduce / reuse / recycle, has emerged as the one that needs to be given prominence. Waste bottle plastic of water cans is made up of either High Density Polyethylene (HDPE) or Low Density Polyethylene (LDPE).Waste plastic bottles were crushed and shredded.

Properties	Results Obtained
Specific Gravity	1.03
Melting Point	250-260
Sieve analysis	Passing 4.75 mm sieve retained on 2.36 mm sieve

Table 2: Properties of plastic used in present study

Aggregates

Crushed aggregate as per IS: 383-1970.The physical properties of aggregate were considered according IS: 2386(1963).

Sl No	Test on Aggregates	Obtained Value	Requirements as per Table 500-14 of MORTH (IV revision) Specifications
1	Crushing Value	24.8%	Max 30%
2	Impact Value	20.8%	Max 24%
3	Abrasion Value	32%	Max 30%
4	Flakiness Index	14.3%	-
5	Elongation Index	13.92%	-
6	Combined Flakiness & Elongation	28.28%	30%
8	Sp gr of Coarse Aggregates	2.76	2.5-3.0
7	Sp gr of Fine aggregates	2.72	2.5-3.0

Table 3: Properties of Aggregates used in present study

Specimen Preparation:

a) Approximately 1200gm of aggregates and filler is heated to temperature of 1750-1900C
b) Bitumen is heated to a temperature of 1210-1250 C with first trial percentage of bitumen(say 3.5 or 4% by weight of the mineral aggregates)
c) Heated aggregates and bitumen are thoroughly mixed at a temperature of 1540-1600 C
d) Mix is placed in a pre-heated mould and compacted by a rammer with 50 blows on either side at temperature of 1380 C to1490 C
e) Weight of mixed aggregates taken for the preparation of the specimen.

III. RESULTS AND DISCUSSION

Marshal test moulds were prepared for different percentages of plain bitumen by varying the bitumen percentage from 3.5% – 6.5% by increment of 0.5%. The specimens were kept for 24hrs and then were de molded. Marshall Stability test was conducted and parameters like flow value, bulk density, percentage air voids, voids filled with bitumen (VFB) and voids filled with mineral aggregates (VMA) were calculated. The optimum bitumen content, maximum bulk density and 4% volume of voids for bitumen grade 80/100 were calculated using the above properties. Also maximum stability was evaluated. Marshall Stability method was also conducted by adding waste bottle plastic of varying percentage from 0-10% for the know binder content of 80/100 grade bitumen. The maximum stability attained for a particular percentage of plastic is noted down in table 3.

Waste plastic %	Gt	Gb	Vv	VMA	VFB	Vb	Stability Value Kg	Flow value in 0.25mm
0	2.6	2.33	11.9	23.61	49.26	11.63	1529	5
2	2.56	2.33	9.13	20.89	56.25	11.75	1508	5
4	2.53	2.34	7.63	19.43	60.71	11.8	1609	4.7
6	2.51	2.32	6.49	18.29	64.51	11.8	1672	4.3
8	2.49	2.39	4.65	16.58	71.94	11.92	1963	4.7
10	2.46	3.32	5.84	17.5	66.62	11.66	1736	4.7

Table 4: Properties of bituminous mix after adding waste plastic for 80/100 grade bitumen

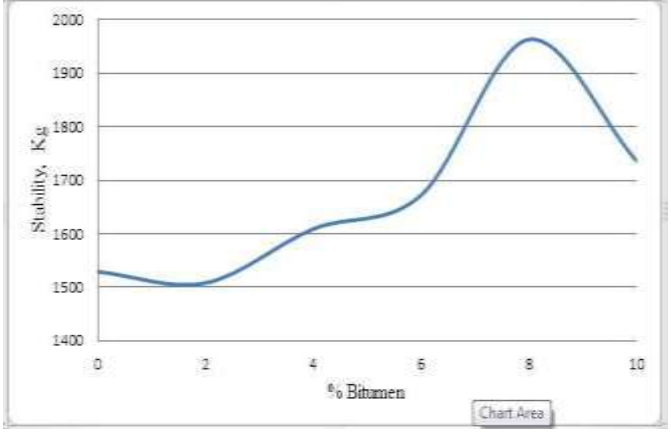

Figure 1: Relation between stability and bitumen content

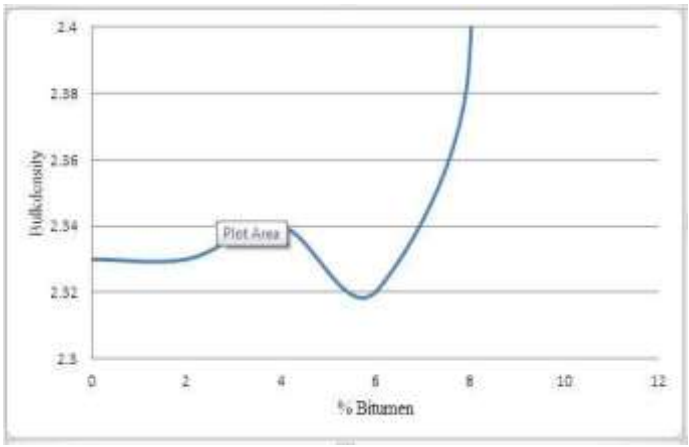

Figure2: Relation between bulk density and bitumen content

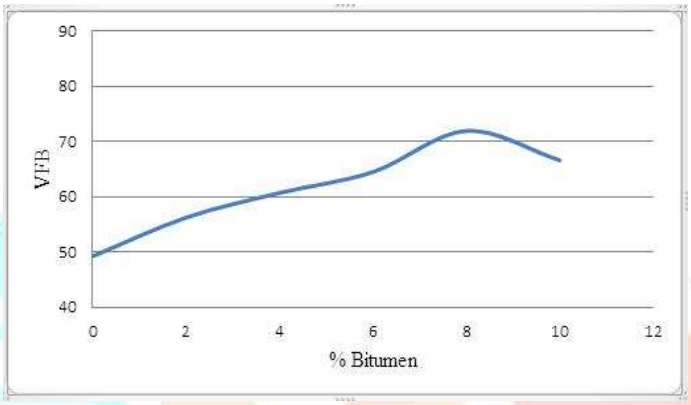

Figure 3: Relation between voids filled with bitumen (VFB) and bitumen content

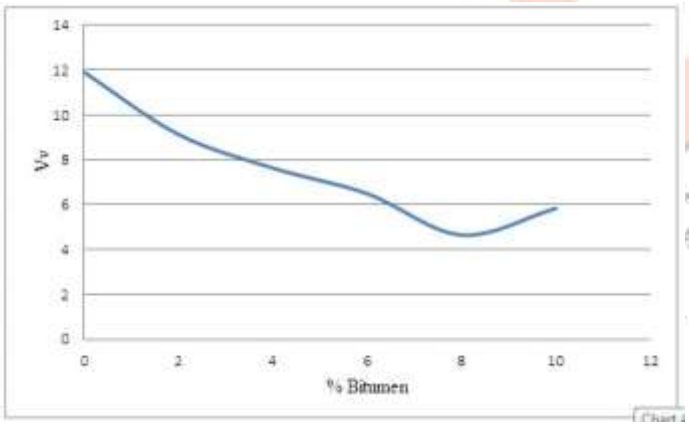

Figure 4: Relation between voids ratio (Vv) and bitumen content

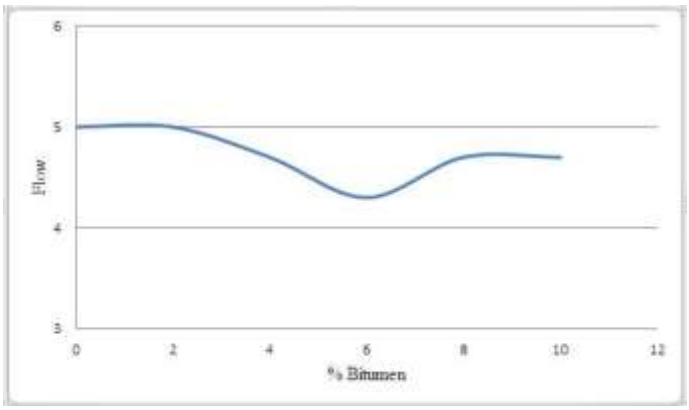

figure 5: Relation between flow and bitumen content

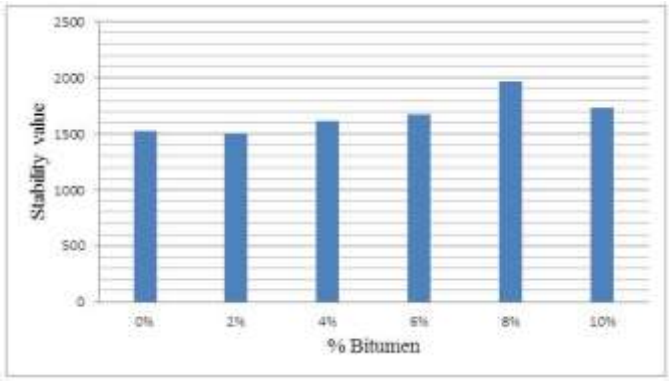

Figure 6: Comparison of stability values of 80/100

IV. DISCUSSIONS

From the above investigation it is observed that Optimum bitumen content obtained for bituminous concrete grade I mix for 80/100 grade bitumen was 5.1% as per the specification of MORT&H standards. The stability obtained for the respective OBC was 17.334 Kn. Waste shredded plastic bottle were added in the increasing percentage of 0% - 10% to bituminous concrete mix and Addition of 2% to 10% waste shredded plastic bottles by the weight of bitumen to BC mix has resulted in following.

The water sensitivity measured in terms of the Marshall stability shows the following results

a) The stability value of the mix in unsoaked condition has high values than compared to the soaked specimens

b) Stability value decreases as the soaking time of the specimen increases. Specimen with 3days soaking results in least stability than that of 1day and 2day soaking periods.

FOR PLAIN 80/100 BITUMEN

It has been observed that the waste plastic which was added to aggregate mix by heating up to 260-2800C. Then the bitumen is added to form the grade I bituminous concrete and optimum bitumen content of 5% has showed the following results.

a) The maximum stability was 1963 Kg at 8% waste plastic by the weight of bitumen, 4.7mm flow at 8% waste plastic and 71.942 VFB at 8% waste plastic b) Bulk density was found to be maximum of 2.394 gm/cc at 8% waste plastic and then reduces to 2.315 gm/cc at 12% waste plastic.

c) Voids in the total mix Vv varies from 8% to 10% by varying the waste plastic content from 2% - 12% and at 8% waste plastic Vv was found to be 4.652%.

d) By blending shredded waste plastic to the bitumen by heating and then adding the required aggregate to form BC mix grade I resulted in improper mix and stability obtained is less than that of the optimum binder content [OBC]. This is due to following,

i) Improper blending of plastic in bitumen. This is because the melting point of poly ethylene teraphthalate [PET] is 260-2800C.

ii) Since the melting temperature of plastic is too high it is difficult to melt plastic in bitumen to get a proper blend.

iii) Bitumen should be heated up to the temperature of 260-2800C in order to obtain the proper blend. If this is done there will be a chance of bitumen to catch fire and also there will be a loss in weight of bitumen.

The water sensitivity measured in terms of the Marshall stability shows the following results

a) The stability value of the mix in unsoaked condition has high values than compared to the soaked specimens

b) Stability value decreases as the soaking time of the specimen increases. Specimen with 3days soaking results in least stability than that of 1day and 2day soaking periods.

Along all with these rests of the parameters like stability, flow, bulk density, voids and VFB shows that, the addition of waste plastic in mix has no much change in fluidity and rigidity parameters as compared to that of plain bituminous mix. Form the above discussion it is clear that the Stability of 80/100 bitumen at 8% of waste plastic coated on aggregates has shown higher value than compared to other percentages.

V. CONCLUSION

1. In the present study, the importance was to add the shredded waste plastic bottles to bituminous concrete (BC) mix and to evaluate the various mix properties like Marshall Stability, flow, bulk density, voids in the mix and VFB. Also the effect of soaking conditions of the mix was investigated.
2. Indirect tensile strength was investigated for OBC and 8% plastic coated on aggregates which had yielded the highest marshal stability.
3. The optimum plastic content for 80/100 grade bitumen was 8%.
4. The optimum plastic content for 80/100 grade bitumen was 8%.
5. Wet process i.e. blending of plastic and bitumen cannot be carried out due to the plastic which is used has a very high melting point.
6. There is an increase in stability up to 15% and 10% after adding waste plastic to the 80/100 grade bitumen.
7. There is a decrease in stability value in water sensitivity test results. Unsoaked specimens show high stability value but soaked specimens showed a decreasing stability value.
8. Hence there is an increase in stability with the addition of PET plastic in asphalt mix by incorporating dry process this can be used in highway construction for better stability for the appropriate traffic.

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