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"Experimental Study of Bituminous Concrete Containg Plastic Waste Material"

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***Abstract**: Waste material Management is one of the powerful concept in recent year. To overcome the plastic waste by leaps and bond requires reuse of waste materials in road construction. Being non-degradable in nature, the plastic waste is a serious threat to environment. This threat has emphasized the need to find appropriate solutions for effective plastic waste management. Rapid growth of infrastructure in road construction needs natural resources. In recent year escalation of prizes of natural resources, so that required reuse of waste material in road construction. Now-a-days disposal of different wastes (plastic waste) produced from different Industries is a great problem. In recent years, applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries. Reuse of wastes material is a very simple but powerful concept. In this paper we use Low Density polyethylene (LDPE) in road construction. The waste shredded plastic of size 2mm to 8mm was used to coat stone aggregates so as to make them as polymer coated aggregate before they were mixed in hot mix plant (HMP). The bitumen polymer coated aggregate mixture, then, was used in road Construction. There is a need to explore the feasibility of use of plastic waste in road construction. This paper deals with study on the various test performed on aggregates, bitumen and methodology of using plastic waste in bituminous mixes.*
***Key words:** Plastic waste, low density polyethylene, Aggregate, Bitumen*

I. Introduction:

Most of the Highways in India constructed with flexible pavement having wearing course/surfacing course with bituminous concrete. This BC should be constructed to satisfy the recommendation and requirements of MORTH Section 509. This clause specifies the construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layers of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100mm in thickness. As per MORTH Section 500 clause 509 BC should be made with Bitumen Grade 60/70(VG 30) for nominal aggregate size 19 mm with bitumen content 5-6% has layer thickness 50-65 mm and for nominal aggregate size 13 mm with bitumen content 5-7% having layer thickness 30-45 mm.

Why use plastic:-

Polymer have a number of very important properties which exploited along or together make a Significance and expanding contribution to construction needs

- Durable and corrosion resistant
- Good insulation for cold heat and sound saving energy and reducing noise pollution
- It is economical and longer life
- Maintenance free

Plastic waste (PW) converted in the shredded form (2-8mm) was used in this study this types of plastic waste used my work.

II. Need Of Study

In present study Disposal of waste material (plastic and fly ash) is a major problem. Plastic waste is a non-biodegradable. Burning of these waste plastic bags causes highly environmental pollution. It mainly consists of low-density polyethylene. India is highest producer of fly ash in the present world which is the waste material. To use of waste material in Bituminous Road construction really impressive job, this material dumped into land leads to wastage of land. In this study, use of fly ash as a filler material bituminous concrete and waste plastic as coating material. Find its utility in bituminous mixes for road construction. Improvement in properties of bituminous mix provides the solution for disposal in a useful way.

Objective

Study has been carried out to satisfied following objectives:

1. To improve the volumetric properties of BC mix design.
2. To utilize waste plastic in bimanous mixes.
3. To utilize fly ash as filler material in bituminous mixes.
4. To evaluate laboratory performance of BC mix design.

III. Scope Of Study

This study will be conducted to explore the idea about use of waste material in bituminous concrete with detailed laboratory Investigation will be carry out to find whether it is viable to use or not in terms of suitability, economically and environmentally.

The present study will focus basically on these following points:

1. To study the basic physical and mechanical properties of waste plastic in order to contribute a better knowledge of its properties.
2. To study the effect on Marshall Stability of bituminous mix with the addition of waste plastic.
3. To reduce the bitumen content by the addition of Waste plastic in bituminous mix.

The laboratory investigations on the bituminous mix have been carried out as per the Indian Standards used for the road construction. The field application is out of the scope of work.

IV. Methodology

In this study Bituminous concrete mix has been design for 19 mm nominal size of aggregate. The Aggregate used in the study is crusher Aggregate from Quarry and VG30 60/70 grade of Bitumen used as binder. First, Laboratory testing has been carried out to find the physical properties of Aggregate by conducting tests like Grain size analysis, Aggregate Impact value, Abrasion Test, Crushing value test, Flakiness and elongation Index (combined), Water absorption, Specific Gravity etc. Also, by sieve analysis the Gradation of Aggregate has been decided which satisfied the requirement of Gradation of 19 mm nominal size of aggregate for BC design as per MORTH section 509.

Similarly, The Bitumen test for VG30 has been done including Penetration test at 25 °C, Softening Point test, Ductility test at 27 °C ,Viscosity at 150 °C, Specific Gravity etc which satisfied the requirement of IS:73-2006.

Secondly, will prepare samples for Marshall mix design and determine the Optimum bitumen content for VG30. After determining the OBC prepare sample at different % of waste plastic like 0.25%, 0.5%, 0.75%,1% and based on this the Optimum waste plastic content has been determined..

Materials Used:-

1) Aggregate	2) Bitumen	3) Waste Plastic
Aggregate of 20mm, 10mm, 6mm,stone dust and cement as filler	60/70 grade bitumen	Waste plastic in the shredded form



V. Test Conducted On Materials

1) Bitumen

i. Penetration Test
ii. Ductility Test
iii. Specific gravity Test
iv. Softening Point Test

(Table 1)

Properties Tested	Test Result	Specification IS:73-2006	BIS code for Testing
Penetration Test (25 C)	67	50-70	IS :1203
Ductility Test(27 C)	66.2	Min 40	IS:1208
Specific gravity Test	1.02	Min 0.99	IS:1202
Softening point Test (Tem.C)	51	Min 47	IS:1205

2) Aggregate

i. Specific gravity
ii. Water Absorption Test
iii. Impact Value Test
iv. Abrasion Test
v. Crushing value Test
vi. Stripping value Test.

(Table 2)

Properties Tested	Test Result	MORTH Specification
Specific gravity Coarse aggregate Fine aggregate	 2.6 2.8	 2.5-3.0 2.5-3.0
Water Absorption Test	1.06	Max 2%
Impact Value Test	7.85	Max 24%
Los Angeles abrasion value Test	20.63	Max 30%
Crushing value Test	10.45	
Stripping value Test	98%	Min 95%

Marshall Mix Design:-

The mix design should aim at an economical blends, with proper gradation of aggregate and adequate proportion of bitumen so as to fulfil the desired properties of the mix bituminous concrete is the one of the highest and costliest types of flexible pavement layer used in surface course the desirable properties of a good bituminous mix are stability, flexibility, skid resistance, durability, workability.

Marshall Stability test Carrey out find the stability, flow value, air voids, voids fill with bitumen, density. Finally consist of an OBC, optimum plastic content and using gyratory compactor prepare performance evolution test sample.

Graduation Requirement Of Aggregate

Grading of aggregate has been carried out before mix design. For this purpose sieve analysis of aggregate has been done having size 20mm, 6mm and stone dust. Grading requirement of BC for this study should satisfy the MORTH section 509 Table 500-18 for 19 mm nominal size of aggregate. The aggregate has been sieved and final blend of aggregate has to be obtained by Heat and Trial. Grading requirement of aggregate shown in Table

Grading Requirements of Aggregate (Table3)

Grading	1	2
Nominal Aggregate Size	19 mm	13 mm
Later Thickness	50 - 65 mm	30 - 45 mm
IS Sieve (mm)	**Cumulative % by weight of total aggregate passing**	
45	---	---
37.5	---	---
26.5	100	---
19	79-100	---
13.2	59-79	100
9.5	52-72	90-100
4.75	35-55	35-51
2.36	28-44	24-39
1.18	20-34	15-30
0.6	15-27	---
0.3	10-20	9-19
0.15	5-13	---
0.075	2-8	---
Bitumencontent% bymass of total mix	5.0-6.0	5.0-7.0
Bitumen grade	65	65

Source: MORTH section 500 clause 509

VI. Marshall Stability Test:-

This test has been carried out to determine the Optimum Binder content for BC mixes. The properties incorporate with the test are stability, flow value, Bulk specific gravity, Air voids, Voids filled with bitumen and Voids in mineral aggregate. Marshall requirement of bituminous mixes shown in Table 4 .The Voids in mineral aggregate must satisfied the requirement as shown in Table 5.

Theoretical Specific Gravity

It is the ratio of total weight of sample and sum of volume of each fraction used in the mix.

$$Gt = \frac{W1+W2+W3+W4}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{W4}{G4}}$$

Where,
Gt = Theoretical specific gravity
G1 = Sp.gr. of coarse aggregate
W1 = Weight of coarse aggregate in total mix
G2 = Sp.gr. of fine aggregate
W2 = Weight of fine aggregate in total mix
G3 = Sp.gr. of filler material
W3 = Weight of filler material in total mix
G4 = Sp.gr. of bitumen
W4 = Weight of bitumen in total mix.

Bulk Density of mix

It is the ratio of weigth in air of sample to difference in weight of sample in air and water and is denoted by Gm.

Air Voids

It is the total volume of the small pockets of air between coated aggregate particles throughout a compacted paving mixture, expressed as percentage of the total volume of the compacted paving mixture.

$$Vv = \frac{Gt - Gm}{Gt} \times 100$$

Where,
Vv = Air voids (%)
Gt = Theoretical specific gravity
Gm = Bulk density of mix (g/cc)

Voids in Mineral Aggregate

It is the volume of inter granular void space between the uncoated aggregate particles of a compacted paving mixture that includes the air voids and effective bitumen content. VMA is expressed as percentage of the total volume of the compacted paving mixture.

VMA = Vv + Vb
Where,
Vv= Air voids (%)
Vb= Volume of bitumen

Voids Filled with Bitumen

It is the percentage of VMA that is occupied by the effective bitumen.

$$VFB = \frac{Vb}{VMA} \times 100$$

Where,
Vb= Volume of bitumen
VMA= Voids in mineral aggregate.

Marshall Requirements of Bituminous concrete

TABLE (4)

	Requirement
Minimum stability (kN at 60^0C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the Two face of specimen
Percent air voids	3 - 6
Percent voids filled with bitumen (VFB)	65 - 75
Loss of stability on immersion in water at 60^0C (ASTM D 1075)	Min. 75 percent retained strength

Source: MORTH section 500 clause 509, Table 500-19

Requirement of Voids in Mineral Aggregate

Table (5)

Nominal maximum Particle size (MM)	Minimum VMA %Related to Design Air Voids(%)		
	3.0	4 .0	5.0
9.50	14.0	15.0	16.0
12.50	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Source: MORTH section 500 clause 509, Table 500-12

Determination of Optimum Binder Content Apparatus
Marshall Stability testing machine
Cylindrical mould – 10 cm. diameter and 7.5 cm. height
Rammer – 4.5 kg. weight with free fall of 45.7 cm
Compacting Machine
Oven

Thermometer
IS Sieves

Procedure

Take about 1200 gm of aggregate sample from design Gradation and kept in oven until dried.
The aggregate should be heated to 135°C temperature before addition of bitumen.
For BC mix bitumen should be added in the aggregate varying from 5-6% at an increment of 0.5% by weight of total mix.
Three samples should be prepared for each binder content by compacting 75 blows on both side of sample in Marshall Compactor
After 24 hrs. Sample should be de-molded and noted down the weight of sample in Air and in water to determine the bulk density of mix.
The sample should be immersed in water bath at 60°C for 40 minutes prior of testing and tested on Marshall Apparatus which gives the Stability and Flow value for each sample.

At each bitumen content and from the volumetric properties of the mix plot the Graph of followings:

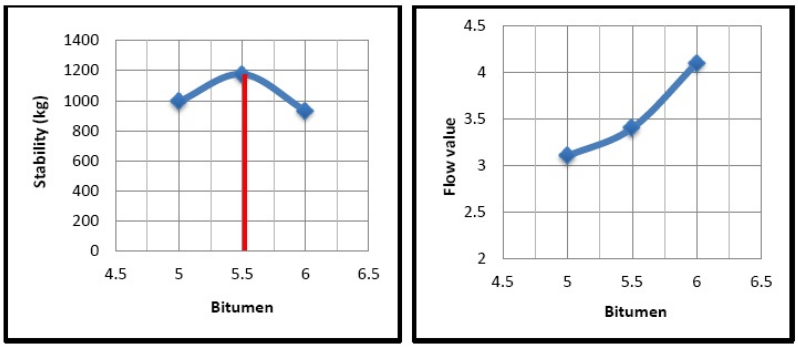
Binder content versus corrected Marshall stability
Binder content versus Flow Value
Binder content versus Air void (Vv) in the total mix
Binder content versus voids filled with Bitumen (VFB)
Binder content versus Unit weight or Bulk Density (Gm)

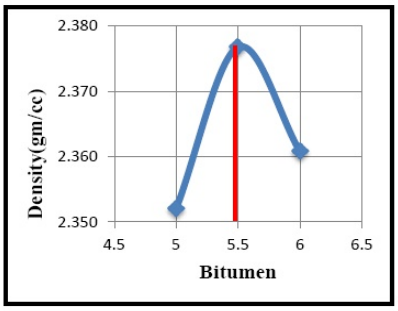
Optimum Binder Content for mix should be determine by average of this three:
Binder content corresponding to maximum stability
Binder content corresponding to maximum Unit weight or Bulk Density (Gm)
Binder content corresponding to 4.5% Air voids (Vv) in the total mix.

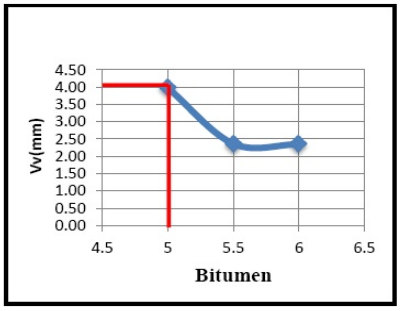
Bitumen Content (Table:6)

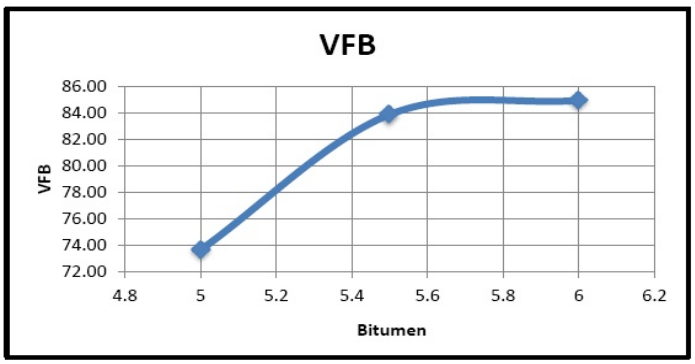
Sr. No	Sample	Wt. in Air	Wt. in Water	Volume	Density	Gt	VV	Vb	Vma	VFB	Stability (kg)	Flow value
1	5	1260	724.5	535.5	2.35	2.45	4.0	11.09	15.08	73.57	998	3.1
2	5	1259	722	537	2.34	2.45	4.3	11.06	15.32	72.23	991	3.3
3	5	1259	725.2	533.8	2.36	2.45	3.7	11.13	14.81	75.15	995	3.2
4	5.5	1266	735	531	2.38	2.43	2.1	12.31	14.36	85.70	1175	3.4
5	5.5	1266	733	533	2.38	2.43	2.4	12.26	14.68	83.51	1178	3.5
6	5.5	1266	732	534	2.37	2.43	2.6	12.24	14.84	82.46	1176	3.3
7	6	1271	733	538	2.36	2.42	2.2	13.25	15.47	85.63	933	4.1
8	6	1272	734	538	2.36	2.42	2.2	13.25	15.47	85.63	931	3.9
9	6	1272	732	540	2.36	2.42	2.6	13.20	15.79	83.62	935	4.2

Sr. No	Sample	Wt. in Air	Wt. in Water	Volume	Density	Gt	Vv	vb	VMA	VFB	Stability (kg)	Flow value
1	5.00	1259.33	723.90	535.43	2.35	2.45	3.97	11.09	15.07	73.65	994.67	4.07
2	5.50	1266.00	733.33	533.93	2.38	2.43	2.36	12.27	14.63	83.89	1176.33	3.40
3	6.00	1271.67	733.00	532.60	2.36	2.42	2.34	13.23	15.58	84.96	933.00	3.20









Studies were carried out on Bituminous mixes using 60/70(VG30) grade bitumen having max value of Marshall Stability ,density and 4% air voids average at optimum bitumen content of 5.33 % by weight of the mix.

Sr. No	Description	Bitumen (%)
1	Binder content corresponding to maximum Stability	5.5
2	Binder content corresponding to maximum Bulk Density of mix (Gm)	5.5
3	Binder content corresponding to 4.0 % Air Voids (Vv) in the total mix	5.0
	Average	**5.33**

Optimum Waste Plastic Content

Plastic contain added to 0% to 1% by increment of 0.25%. Varying percentages of waste plastic by weight of total mix was added into the heated aggregates.

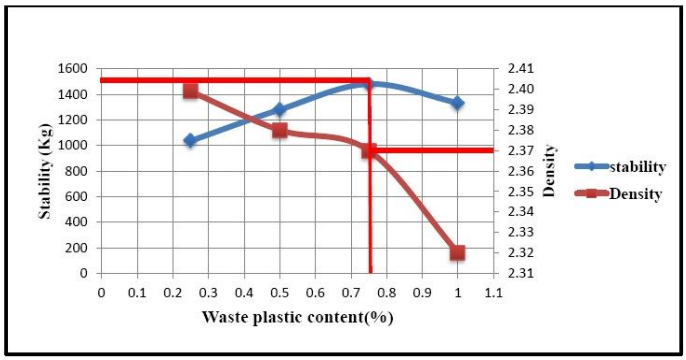
Marshall specimen with varying waste plastic content was tested for bulk density and stability

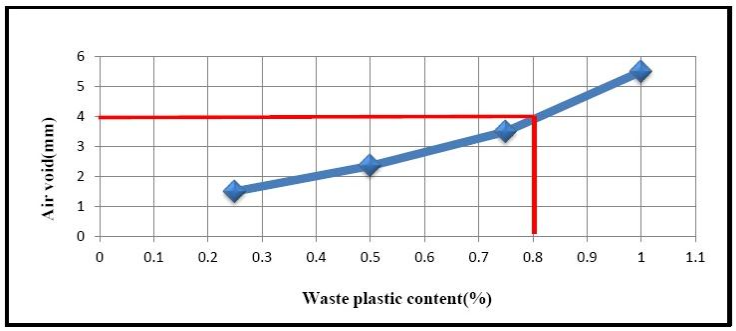
Finally Avg. of max Maximum value of stability and 4% of air voids was considered as criteria for optimum waste plastic Content.

Avg. Optimum Waste Plastic Content value. 0.76%.

%in plastic content (Table:8)

Sr. No	% in pl	Wt. in Air	Wt. in Water	Volume	Density	Gt	Vv	Vb	VMA	VFB	Stability (kg)
1	1	1269.3	722.4	546.9	2.32	2.455	5.5	11.4	16.88	67.53	1332
2	0.75	1269.25	733.5	535.75	2.37	2.455	3.5	11.4	14.92	76.47	1480
3	0.5	1260.1	730.7	729.4	2.38	2.44	2.4	11.48	13.84	83.09	1280.5
4	0.25	1259.4	734.4	525	2.40	2.44	1.5	11.49	12.99	88.46	1036.5





Sr. No	Description	PL Contain (%)
1	Waste pl content corresponding to maximum Stability	0.75
2	Waste pl content corresponding to maximum Bulk Density of mix (Gm)	0.75
3	Waste pl content corresponding to 4.0 % Air Voids (Vv) in the total mix	0.8
	Average	**0.76**

VII. Conclusion:-

- Waste Plastic can be used as coating material in bituminous concrete mixture for road construction.
- Properties of BC can be further improved by use of waste plastic.
- Use of waste plastic 0.76% by weight of aggregate and3% filler significantly improve the volumetric properties of bituminous mixes resulting better performance of BC with plastic waste than control mix(without plastic waste).

The only problem faced during this project is the shredding of plastics. To overcome this problem the shredding machines used should be easily available

- Plastic will increase the melting point of the bitumen.
- Use of the innovative technology not only strengthened the road construction but also increased the road life.
- Help to improve the environment.
- Plastic road would be a boon for India's hot and extremely humid climate where durable and eco-friendly roads which will relive the earth from all type of plastic waste.
- This small investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period.

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