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UTILIZATION OF PLASTIC WASTE IN THE CONSTRUCTION OF FLEXIBLE PAVEMENT

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ABSTRACT

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. 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. To analyze & study how the waste plastic will be effectively utilized in construction of pavement as a binder material for replacing the content of bitumen. This paper deals with study on the various laboratory test performed on aggregates, bitumen and methodology of using plastic waste in bituminous mixes

Key words: Los Angeles Abrasion Value, Aggregates Impact Value, Aggregates Crushing Value, Specific Gravity And Water Absorption Test, Penetration Value, Ductility Value, Softening Point Value, CBR Test.

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1. INTRODUCTION

Today, for the developing countries, Flexible pavements are one of the most important infrastructures. Now-a-days it is been observed that due to increase in axle load and traffic intensity the capability of the bituminous binders is been reduced causing bleeding in hot climate, cracks in cold climate, rutting and pot holes. This makes an essentiality in modification of bitumen binder to meet the increasing demand of axle loads and traffic intensity

The plastic waste quantity in municipal solid waste is increasing day by day due to increase in population and changes in life style. Thus disposal of waste plastic is a hazardous and become a serious global problem due to their non-biodegradability.

Thus, using of plastic as an innovative technology not only strengthened the road construction but also increase the road life.

2. LITERATURE REVIEW

The concept of using plastic in flexible pavement has been done sine several years ago in India. Plastic has played a very vital role in increasing the strength of bitumen as well as aggregate. Prof. C.E.G.Justo states that addition of plastic in bitumen improves the stability, strength, life and other desirable properties of bitumen. Similarly, Dr. R.Vasudevan states that the polymer bitumen blend is a better binder compared to plain bitumen. Rema Devi et. all. Stated that the concept of utilization of waste plastic in the construction of pavement has shown better resistance to water which reduces the stripping of bitumen from aggregate. Amit Gawande et.al, investigations the use of waste plastic in road construction as an effective way to reutilize the plastic waste

For many years, researchers and development chemists have experimented with modified bitumen mainly for industrial uses, adding asbestos, special filler, mineral fibers and rubber. In the last thirty years many researchers have looked at a wide spectrum of modifying materials for bitumen's used in road construction. The study was done by Mahabir Panda and Mayajit Mazumdar using 80/100 penetration grade bitumen and Ethylene Vinyl Acetate (EVA) copolymer. The study that there was a increase in stability value in case of polymer modified bitumen. Stability value was high as 14 KN in case of polymer modified bitumen. Tensile strength was also increased and stripping properties were improved.

Another study was done by Sharma D K and others using 60/70 penetration grade bitumen. Here waste plastic/polymer was used as modifiers. The waste plastic/polymer was added on the aggregate before mixing Optimum Binder Content (OBC) in dry process at 150-160o C temperature. This type of mixing increases the bonding between aggregates coated with plastic/polymer which increases the strength of the bituminous concrete mixes. Stability values and indirect tensile strength values were observed to be more in polymer modified bitumen than in conventional bitumen. Rutting values were also higher in polymer modified bitumen mixes than in conventional mixes.

Another study was carried out by Shivangi Gupta and Veeraragavan. They used 60/70 penetration grade bitumen and Styrene Butadiene Styrene (SBS) modified binder. Here tests were conducted by two methods, marshal stability and Superpave Gyratory Compactor (SGC) and results of these two methods were compared. The test results showed that SBS modified bitumen mixes were superior to the conventional mixes. But as far as Marshall Method is concerned SGC method shows better results. Strength parameters like tensile strength, marshal stability values of SBS modified mixes were higher than 21% to 25% than that of conventional mixes. Fatigue life of SBS modified binder mix was 2.1% to 2.4% higher than the conventional mix.

3. RESULTS

Aggregates Impact Value

The property of a material to resist impact is known as toughness. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact.

The apparatus required for the test are impact testing machine, taming rod, sieves size 12.5, 10 & 2.36mm and weighing balance etc.

Calculation

Aggregate Impact Value (percent) = $(W_1-W_2) / W_1 *100$

Where W1 = Total weight of dry sample in gm.

W2 = Weight of portion retained on 2.36 mm sieve in gm.

Table 1 Observation for Aggregates Impact Values:

Description of item	0% of plastic	3% of plastic	5% of plastic	8% of plastic	10% of plastic
Total weight of dry sample (W_1 gm.)	500	500	500	500	500
Weight of portion retained 2.36 mm sieve (W_2 gm.)	436	440	447	441	437
Aggregate Impact Value (percent) =$(W_1-W_2)/ W_1 *$ 100 in %	12.8	12.0	10.6	11.8	12.6

Recommended Values

Classification of aggregates using Aggregate Impact Value is as given below:

Aggregate Impact Value	Classification
<20%	Exceptionally Strong
10 – 20%	Strong
20-30%	Satisfactory for road surfacing
>35%	Weak for road surfacing

Los Angeles Abrasion Value

The aggregate used in surface course of the highway pavements are subjected to wearing due to movement of traffic. When vehicles move on the road, the soil particles present between the pneumatic tyres and road surface cause abrasion of road aggregates. The road aggregates should be hard enough to resist abrasion. The principle of Los Angeles abrasion test is to produce abrasive action by use of standard steel balls which when mixed with aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates. The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value.

The apparatus required for abrasion test are los Angeles machine, abrasion charges, sieve sizes 12.5,10 &1.70 mm, oven and weighing balance etc.

Table 2 Observation for Aggregates Abrasion Values

Description of item	0% of plastic	3% of plastic	5% of plastic	8% of plastic	10% of plastic
Total weight of dry sample(W_1 gm.)	5000	5000	5000	5000	5000
Weight of portion retained1.70 mm sieve (W_2 gm.)	3681	3941	4020	3851	3720
Aggregate abrasion Value =$(W_1-W_2)/ W_1 *$ 100 in %	26.38	21.18	19.6	22.98	25.6

Aggregates Crushing Value

The aggregate crushing value gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. With aggregate crushing value 30 or

higher the result may be anomalous and in such cases the ten percent fines value should be determined instead. The apparatus required for the test are compression testing machine, sieve sizes 12.5,10 &2.36mm, tamping rod and weighing balance etc.

Calculation

Aggregate crushing value = $((W_1 – W_2) *100) / (W_1-W)$

Where W_2 =Weight of fraction retained on sieve size 2.36 mm

W_1-W =Weight of surface dry sample.

Table 3 Observations for Aggregates Crushing Values

Description of item	0% of plastic	3% of plastic	5% of plastic	8% of plastic	10% of plastic
Total weightof dry sample(W_1)gm	2850	2800	2762	2820	2845
Weight of portion retained 2.36 mm sieve (W_2 gm.)	2806	2764.5	2734	2788.4	2804.5
Aggregate crushing Value =(W_1-W_2)/ (W_1)* 100%	1.54	1.28	1.0	1.12	1.42

Specific Gravity and Water Absorption Test

Specific gravity is defined as the ratio of the weight of the given volume of soil solids at a given temperature to the weight of the weight of equal volume of distilled water at the temperature. The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values. the apparatus required for the tests are wire basket, weighing machine, tray etc.

Calculation

- Specific gravity = (dry weight of the aggregate /Weight of equal volume of water)
  $=W_4 / (W_3– (W_1– W_2))$
- Water Absorption = $((W_3 – W_4) / W_4) * 100$

Where

W_1=Weight of saturated aggregate suspended in water with basket in gms

W_2 =Weight of basket suspended in water in gms

W_3=Weight of saturated surface dry aggregate in air in gms $W_{4=}$Weight of oven dry aggregate in gms

Table 4 Observations for aggregates specific gravity & Water absorption values

S.No	Description of item	0% plastic of	3% plastic of	5% of plastic	10% of plastic
1.	Weight of saturated Aggregate suspended in water with basket W_1 g	2133	2142	2145	2145
2.	Weight of basket suspended in water W_2 g	610	610	610	610
3.	Weight of saturated surface dry aggregate in air W_3 g	2255	2251.40	2230	2216.40
4.	Weight of oven dry aggregate = W_4 g	1950	1963	1970	1983
5.	Specific gravity =W_4 /((W_3– (W_1– W_2))	2.66	2.73	2.83	2.91
6.	Water Absorption = $((W_3 – W_4) / W_4) * 100$	1.56	1.46	1.30	1.1

RECOMMENDED VALUE

The specific gravity of aggregates of size10 mm normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68. Though high specific gravity is considered as an indication of high strength, it is not possible to judge the suitability of a sample road aggregate without finding the mechanical properties such as aggregate crushing, impact and abrasion values. Water absorption shall not be more than 0.6 per unit by weight.

Penetration Value

Penetration value is a measure of hardness or consistency of bituminous material. It is the vertical distance traversed or penetrated by the point of a standard needle in to the bituminous material under specific conditions of load, time and temperature. This distance is measured in one tenths of a millimeter. This test is used for evaluating consistency of bitumen. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials.

The apparatus required for test the bitumen are container, needle, water bath, tray, Thermometer, Penetration apparatus and stop watch etc.

Table 5 Observations for Bitumen Penetration Value:

Penetration dial reading	0% plastic	3% of plastic	5% of plastic	10% of plastic	12% of plastic
(a) Initial reading	0	0	0	0	0
(b) final reading	76	68	62.1	57	53
Penetration Value (mms)	76	68	62.1	57	53

RECOMMENDED VALUE

Penetration test is a commonly adopted test on bitumen to grade the material in terms of its hardness. A 80/100 grade bitumen indicates that its penetration value lies between 80 & 100.Grading of bitumen helps to assess its suitability in different climatic conditions and types of construction. IRC suggests bitumen grades 30/40, 60/70, 80/100. In warmer regions, lower penetration grades are preferred to avoid softening whereas higher penetration grades like 180/200 are used in colder regions to prevent the occurrence of excessive brittleness.

Ductility Value

The ductility test gives a measure of adhesive property of bitumen and its ability to stretch. In flexible pavement design, it is necessary that binder should form a thin ductile film around aggregates so that physical interlocking of the aggregates is improved. Binder material having insufficient ductility gets cracked when subjected to repeated traffic loads and it provides pervious pavement surface. Ductility of a bituminous material is measured by the distance in centimeters .The apparatus required for testing the bitumen are Briquette mould, Water bath, ductility testing machine and water bath etc.

Table 6 Observation for bitumen ductility value

Ductility reading	0% plastic	3% of plastic	5% of plastic	10% of plastic	12% of plastic
(a) Initial reading	0	0	0	0	0
(b) final reading	100	92	86	75	63
Ductility value in cms	100	92	86	75	63

RECOMMENDED VALUE

Suitability of bitumen is judged depending on its type and proposed use. Bitumen with low ductility value may get cracked especially in cold weather. Minimum values of ductility specified by ISI for various grades are as follows.

Source of paving bitumen and penetration grade		Min ductility value (cms)
Assam Petroleum	A25	5
	A35	10
	A45	12
A65, A90 & A200		15
Bitumen from sources other than Assam Petroleum S35		50
S45, S65 & S90		75

Softening Point Value

The Softening Point of bitumen is the temperature at which the substance attains particular degree of softening. The binder should have sufficient fluidity before its applications in road uses. The determination of softening point helps to know the temperature up to which a bituminous binder should be heated for various road use applications. The apparatus required for testing the bitumen ring and ball apparatus, thermometer etc.

Table 7 Observation for bitumen Softening point value:

Description of item	**0%of plastic**	**3% of plastic**	**5% of plastic**	**10%of plastic**	**12%of plastic**
Temperature when the ball touches bottom(°C)	40	44	49	52	57

RECOMMENDED VALUE

Softening point indicates the temperature at which binders possess the same viscosity. Softening point has particular significance for materials to be used as joint and crack fillers. Higher softening point ensures that they will not flow during service. Higher the softening point, lesser the temperature susceptibility. Bitumen with higher softening point is preferred in warmer places.

Table 11 Observation on mix proportion:

S.No	**Plastic content (%) adding to aggregates**	**Bitumen content (%)**	**Wt.in air in gms**	**Wt. in water in gms**	**Volu (v)**	**Density (g/cc)**
1	0	4	1212	742	531.13	2.28
2	0	5	1194	740	526.21	2.26
3	0	6	1226	761	528.78	2.31
4	5	5	1215	746	510.50	2.38

Theoretical specific gravity (Gt)	Bulk specific gravity (Gm)	Air void percent (Vv)	Percent volume of bitumen (Vb)	Voids in Mineral Aggregate (VMA)	voids filled with Bitumen (VFB)	Stability values in kgs	Flow value
2.68	2.57	4.3	9.69	13.99	69.26	946	4.60
2.71	2.62	3.5	12.53	16.03	78.16	1053	4.10
2.70	2.63	2.7	14.70	17.4	84.4	930	3.20
2.65	2.59	2.4	12.18	14.58	83.53	1103	3.40

California Bearing Ratio (CBR) test

California bearing ratio test is penetration test meant for evaluating the stability of soil subgrade and other flexible pavement materials. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

The apparatus required for the testing subgrade are CBR testing machine, mould, rammer etc.

Calculation

C.B.R. = (Test load/Standard load)*100

The standard load values obtained from the average of a large number of tests on crushed stones are 1370 and 2055 kg(70 and 105 kg/cm^2) respectively at 2.5 and 5.0 mm penetration.

Table 12 Observation on penetration of plunger and load dial reading

Penetration of plunger, mm	Load dial reading ,divisions
2.5	19
5.0	36

Load dial reading at 2.5 mm penetration = 19 divisions

Load at 2.5 mm penetration = (19*190)/100 =36.1 kg

CBR value at 2.5 mm penetration = (36.1*100)/1370 =2.63 %

CBR value at 5.0mm penetration = (36*190*100)/(100*2055) =3.32%

CBR value of a specimen =3.32%

4. CONCLUSIONS

By conducting the detailed laboratory investigation on aggregates and bitumen with and without mixing polymers, the following conclusions are drawn.

- 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 5 % by weight of aggregate 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
- Use of waste plastic 10% by weight of bitumen significantly increases the melting point of the bitumen.

- Plastic will decrease the penetration value and ductility value of bitumen binder.
- 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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