Utilization of Plastic Waste in Road Pavement

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***Abstract* - The population growth, industrialization, consumerism and technological development have led to uncontrollable accumulation of waste. Proper waste disposal is of great importance in both rural and urbanareas. This study discussed the suitability of plastic waste materials for pavement construction.. The waste ismixed in different proportions to the soil sample and their influences on geotechnical properties were studied.Thesestudies are reported in the present work to focus on blending of waste plastic materials (in the form ofshredded polyethylene bags) being used as a binding agent in bitumen for road construction.Main objectives of this paper is to check the properties of bituminous mix specimen by coating waste plastic materials and to compare the properties of normal bituminous mix specimen with the properties of bituminous plastic mix for road construction and to solve the plastic disposal problems and bad condition of roads.**

Keywords:- Utilization of waste plastic materials, optimum bitumen content, PETblends in bitumen, road materials standards.

I.INTRODUCTION

Today, all vital sectors of the economy starting from agriculture to packaging, electrical, building construction,automobile, electronics and communication sectors has been virtually revolutionized by the applications of plastics. Plastics degrade very slowly and are more durable, the chemical bonds that make plastic more durable also make it equally resistant to natural processes of degradation. According to recent studies, plastics can even stay unchanged for as long as 4500 years on earth. It is a common to find Empty plastic bags and other type of plastic packing material littering the roads as well as drains has now become a commonsight in both urban and rural areas. As plastic isnon-biodegradable it creates stagnation of water and associated hygiene problems.

If the waste plastics can be suitably utilized in highway construction, the pollution and disposal problems may be reduced to a great extent. Plastic waste when mixed with hot bitumen, melt to form anoily coat over the aggregate and the mixture can be laid on the road surface like a normal tar road. Use of plastic along with the bitumen in construction of roads not only increases itssmoothness and life but also makes it economically sound and environment friendly. Plastic Roads constructed are found to perform better compared to those constructed with conventional bitumen. The need of bitumen can be reduced by about 10%, by using higher percentage of plastic waste.The performance and strength of road is also increased. Plastic increases the melting point of bitumen and hence mixing can be done in more better and easier way.

Various experiments were conducted to determine the properties of bitumen and aggregate.

II.MATERIALS

A. BITUMEN

Bitumen is an oil based substance. It is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process.Paving bitumen from Assam petroleum denoted as A-type and designated as grades A35, A90, etc. Paving bitumen from other sources denoted as S-type and designated as grades S35, S90, etc. Bitumen should have certain properties. The viscosity of bitumen should be adequate at the time of mixing and compaction

Basic tests for bitumen:-

- Viscosity
- Softening point
- Ductility
- Specific gravity
- Penetration

Table 1: Bitumen tests results

Sl no.	Experiment	Observed value	Standard value
1	Viscosity	98 sec	60-140 sec
2	Softening point	45.1C	35-70C
3	Ductility	62.8cm	Min 40cm
4	Specific gravity	.98	.97-1.02
5	Penetration	63	50-70

B.AGGREGATE

Aggregate is a broad category of coarse particulate material used in various constructions.The aggregates are bound together either by bituminous materials or by cement. The quantity of aggregates used in first coat of surface dressing should be 0.15 m^3per 10 m^2 area of 12mm nominal size. On the other hand, the quantity of aggregate used in second coat of surface dressing should be 0.15 m^3 per 10 m^2 areas and of 10mm nominal size.

Basic tests conducted on aggregate are:-

- Specific gravity
- Flakiness & Elongation Test
- Impact Value Test
- Abrasion Test
- Crushing value Test
- Stripping value Test.

Table 2:Aggregate tests results are

Sl no.	Experiment	Observed value	Standard value
1	Stripping value(%)	2	Min: 5
2	Abrasionvalue(%)	28.23	Max: 30
3	Combined flakines(%)	21.02	Max: 30
4	Imapactvalue(%)	20.71	Max: 25
5	Crushing value(%)	21.3	Max: 30

C.PLASTIC MATERIAL

Plastic is a material consisting of any of a widerangeof synthetic orsemi-synthetic organics that are malleable and can bemolded into solid objects of diverse shapes.. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural.

III. GRADATION OF AGGREGATE

Gradation of aggregates is one of the most important factors for the design of SMA mixture. The particle size distribution, or gradation, of an aggregate is one of the most influential aggregate characteristics in determining how it will perform as a pavement material.

Gradation helps determine almost every important properties including

- stiffness and stability
- durability
- permeability
- workability
- fatigue resistance
- frictional resistance
- moisture susceptibility

Table 3:Grading requirements of aggregate

Specification	BC
Nominal max size = 13.2mm	Layer thickness - 25/40mm
IS Sieve size	Cumulative percentage of weight of total aggregate passing the sieve
19.0	100
13.2	90-100
9.50	70-88
4.75	53-71
2.36	42-58
1.18	34-48
0.6	26-38
0.3	18-28
0.15	12-20
.075	4-10

Table 4:Specific gravity of aggregate

Sl.No	Size	% of aggregate	Bulk Specific Gravity	Apparent Specific Gravity	Std-value
1	12.5 mm	30	2.73	2.785	2.5-3
2	6mm	25	2.66	2.72	2.5-3
3	Dust	43	2.65	2.72	2.5-3
4	Cement	2	3.14	3.15	2.7-3.14

IV. MARSHALL MIX DESIGN

This test procedure is used in designing and evaluating bituminous paving mixes and is extensively used in routine test programs for the paving jobs. There are two major features of the Marshall method of designing mixes namely, density – voids analysis and stability – flow test.

Strength is measured in terms of the 'Marshall's Stability' of the mix following the specification ASTM D 1559 (2004), which is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60˚C. In this test compressive loading was applied on the specimen at the rate of 50.8 mm/min till it was broken. The temperature 60˚C represents the weakest condition for a bituminous pavement.

The flexibility is measured in terms of the 'flow value' which is measured by the change in diameter of the sample in the direction of load application between the start of loading and at the time of maximum load. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The associated plastic flow of specimen at material failure is called flow value. The density- voids analysis is also done.

A. EXPERIMENTAL PROCEDURE

The coarse aggregate, fine aggregate, as well as the filler material were taken in the proportion .On mixing plastic with asphalt, polymerized bitumen was formed. The collected plastic waste products (PET) were separated and cleaned. The plastic were shredded into small pieces and were passed through a 4.5 mm sieve. The aggregate (table 3) was heated to 170°C.The Bitumen was heated at160°C and mixed well with the aggregate. Mixing temperature was 160-165°C. Marshall Mold compaction was made at the temperature of 145°C by using 75 blows on each side.

Fig 1:Marshall Stability Apparatus

Table 5: Test results for optimum bitumen content

Bitumen % in mix	Density(gm/cc)	Stability	Flow (mm)	Void in mix	Void of mix	VFB (%)	Retained stability (kN)
5	2.452	18	3.37	4.25	14.69	71.05	83.23

V.RESULTS AND DISCUSSION

A.BITUMEN RESULTS

The experimental results are discussed with reference to the following tests:

- Bulk density
- Stability
- Flow
- Void tests

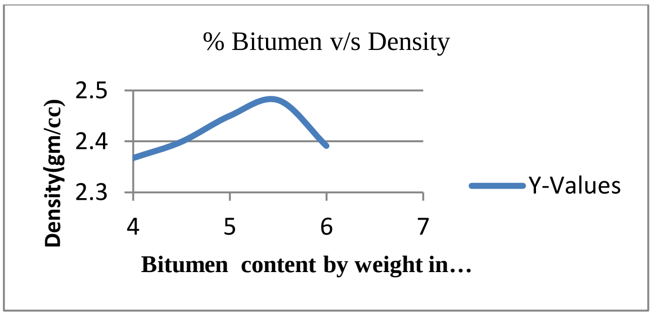

Fig.2 Marshal density curve

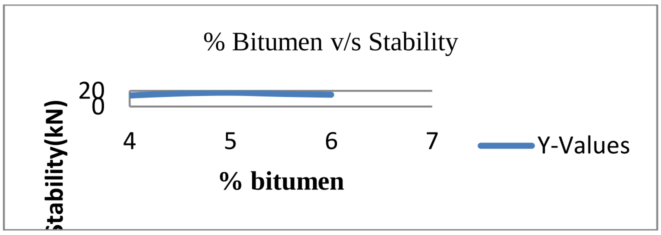

Fig.3Marshal stability curve

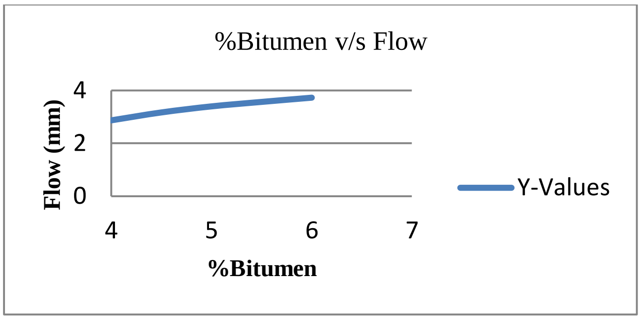

Fig.4Marshal flow curve

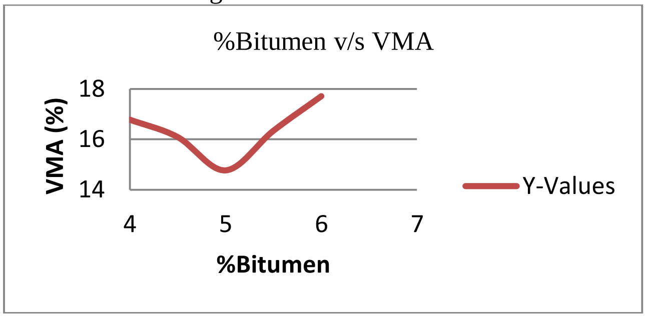

Fig.5 Marshal VMA curve

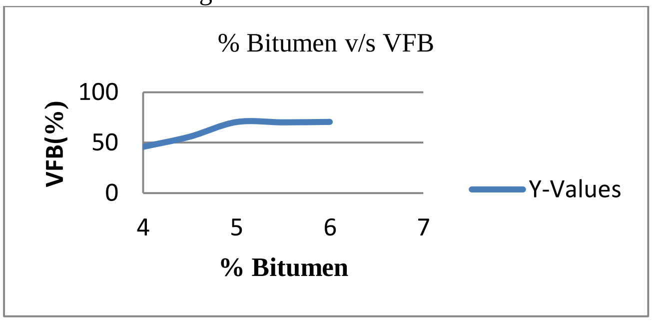

Fig.6Marshal VFB curve

Table 7:Graphical interpretation

Optimum bitumin content	Density (g/cc)	Stability (Kn)	Flow (mm)	Va (%)	VMA (%)	VFB (%)
5	2.45	17.84	3.40	4040	14.77	17.30

B.STABILITY& FLOW OF SAMPLE WITH PLASTIC

There were 18 sample molds which were tested for stability and flow. Three molds for each binder type contained 2 % of plastic with 98% of bitumen, 4% of plastic with 96% of bitumen, 6% of plastic with 94 % of bitumen, 8% plastic with 92% of bitumen, 10% of plastic with 90% of bitumen and 12 % of plastic with 88% respectively.

The stability and flow data of each of the six binders are shown in table 8 and optimum bitumen value as per stability and flow values are shown in table 9.

Table 8: Test results of samples with plastic

Batch	Plastic percentage	Stability (kN)	Flow (mm)	Marshall quotient
A	2	17.66	3.256	5.426
B	4	18.649	3.081	6.052
C	6	20.414	2.980	6.832
D	8	21.686	2.839	7.604
E	10	22.813	2.673	8.538
F	12	19.35	3.11	6.227

Table 9 :Optimum plastic percentage

Batch	Plastic percentage	Stability (kN)	Flow (mm)	Marshall quotient
E	10	22.813	2.673	8.538

From the stability data of all the six binders, we noted that the binders D and Ehad a better stability as compared to C. Although binder F(with 12% Plastic) contained more plastic and had better stability than mold made with optimum bitumen content, one of the molds of F broke down after curing (being immersed in a bath at 60^0C). Thus, the most suitable stability-tested binder was E with 10% of plastic.

The effect on the flow was minimal but well within the range. There was hardly any distortion when the load was applied which was only 2.9 mm on an average (Table 8).

Since the binder E was noted to be the best from the Marshall stability and flow data, further studies on void analysis or volumetric analysis are to be carried out in future to confirm the optimum plastic percentage.

IV APPLICATIONS

The areas where this could be used are;

- Road construction,
- Ground improvement technique.

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CONCLUSION

- ➢ As the plastic is a waste material it can be effectively used in construction of roads .the study on plastic road construction shows that durability and strength of roads can be improved by use of plastics.
  - Various mixes were prepared
  - Optimum bituminous content was calculated from the Marshall Test
  - Optimum bitumen content is obtained as 5%.
  - Optimum plastic content is obtained as 10% of bitumen quantity
- ➢ The optimum use of plastic can be done up to 10%, based on Marshal Stability test.
- ➢ Thus this can add more value in minimizing cost of disposal of plastic waste and also can be developed as an eco-friendly technique.
- ➢ Replacement of a portion of bitumen with plastic the surface has resulted in many advantages, which ultimately helps to improve the quality and durability of flexible pavement

REFERENCES

[1] Sultana ASK and Prasad KSB; Utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements, International Journal of Engineering Research and Analysis, 2012; 2 (4):1185-1191
[2] Vasudevan R, “Utilization of waste plastics for flexible pavement”, Indian Highways (Indian Road Congress), vol. 34, no.7, pp 105-111, 2006
[3] Available from www.motc.gov.om.
[4] IRC SP-98-2013 - Use of waste Plastics in Bituminous mixes
[5] IRC SP-53.2010
[6] IS: 2720 (Part 3). 1979. Method of test for Soils: Part 3, Determination of Specific Gravity.
[7] http://www.wikipedia.com
[8] Prasad, PrasadaRaju, Ramana Murthy „Use of Waste Plastic and Tyre in Pavement Systems‟, IE(I) Journal-CV, Vol.89, pp 31-35, 2008.
[9] IS: 2720 (Part 4). 1979. Method of test for Soils: Part 4, Grain Size Analysis.
[10] Amitgawande, g. S. Zamre, V. C. Renge, g. R. Bharsakalea and Saurabhtayde, utilization of waste plastic in asphalting of roads,Scientific Reviews and Chemical Communications, 2(2), 2012, 147-157.