Use of Waste Plastic and Used Rubber in Bituminous Pavement

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Abstract— An upswing in various types of productions together with population growth has resulted in a massive increase in production of various types of waste material world over creating a problem of its disposal in Eco-friendly way. To deal with the problem here an attempt is made to study the use of waste as an alternative to conventional material along with partial replacement of bitumen with plastic and used rubber by the wet mix process. In the highway infrastructure, a large number of originate materials and technologies have been invented to determine their suitability for the design, construction and maintenance of these pavements. Plastics and rubbers are one of them. Also considering the environmental approach, due to excessive use of polythenes in day to day business, the pollution to the environment is enormous. Numbers of laboratory tests were conducted using marshal stability testing machine to check the suitability used rubber and plastic as an alternative to conventional materials. The main aim of this study is to focus on using the available waste recycled plastic materials and waste rubber tires present in abundant that can be used economically and conveniently. The results obtained in laboratory investigation indicate not only the increase in strength but also a considerable reduction in cost is seen. From the experimental work, it is clear that the properties of laboratories designed bituminous mix are much more superior to those of the conventional bituminous mixes. The use of these materials as a road construction proves Eco-friendly, economical and use of plastic will also give strength in the sub base course of the pavement and can be effectively used in practical applications.

Keywords: Waste Plastic, Rubber, Bituminous Pavement

I. INTRODUCTION

Worldwide, sustainability is the pressing need of the hour in the construction industry and towards this end use of waste material in road construction is being increasingly encouraged so as to reduce environmental impact. Flexible pavement design constitutes more than 98% of the total road network. India being a very vast country has widely varying climates, terrains, construction materials and mixed traffic conditions both in terms of loads and volumes. Increased traffic factors such as heavier loads, higher traffic volume and higher tire pressure demand higher performance pavements. So as to minimize the damage of pavement surface and increase durability of flexible pavement, the conventional bitumen needs to be improved. Disposal of different waste produced from different sources is a great problem. Naturally available materials are depleting and cost of materials is also high in road construction there is a huge scarcity of raw materials.

II. WASTE SCENARIO

Waste materials have become indispensable part of our life. Plastic and Rubber are non-biodegradable material. 15,342 tone plastic waste generated in India every day. According to reports, globally 15 million tons of waste tires are generated in India. The abundance and increase of waste tire disposal is a serious problem that leads to environmental pollution. Used rubber is the term usually applied to recycled rubber from automobile and truck scrap tires. Used rubber obtained from shredding of those scrap tires has been proven to enhance the properties of plain bitumen. It can be used as a cheap and environmentally friendly. Used Rubber as a modifier the properties of bitumen will be change and this change in physical properties like softening point, penetration value, elastic recovery and Marshall Stability was checked by different test.

A. Plastic Waste and Waste Tyre

Plastic is a very versatile material. Plastic waste scenario is a great concern due to industrial revolution and its large scale production plastic seen to be a cheaper and effective raw material. Today every vital sectors of economy has been virtually revolutionized by the application of 3 plastic. Researchers are found that the material can remain on earth for 4500 years without degradable. Studies have proven the health hazard caused by improper disposal of waste plastic. Disposal of plastic waste in an eco- friendly is a main thrust area of today's research work. Thus we are developing innovative technique to use the waste plastic for the construction of asphalt pavement. This process is eco-friendly and promotes value addition to the waste plastic. In conventional road making process bitumen can be modified with waste plastic and bitumen mix is made. Due to this conventional bituminous mix has to be modified. The use of bitumen as a binder material in construction of road this material can be altered by using different waste material such as plastic and rubber lead to good improvement in disposal problem. An alternative for treatment of plastic waste and waste rubber tires are required as early as possible. Thus we use plastic and used rubber as additive in bitumen mix. Basic properties of bitumen are modified by adding the used rubber and recycled plastic. Addition of waste tires reduces thermal cracking permanent deformation in high temperature. In this study, an attempt has been made to use high-density polyethylene (HDPE) obtained from plastic waste and used rubber obtained from worn out vehicle tires. The aim was to optimize the use of recycled wastes in improving the engineering properties of the bituminous pavement. HDPE and Used rubber was incorporated in the bitumen binder by using the wet process.

III. METHODOLOGY

A. General

Preliminary test on VG-30 bitumen and Standard laboratory tests on conventional 60/70 grade bitumen added with varying percentages of HDPE (High Density Poly Ethylene). Standard laboratory tests on conventional 60/70 grade bitumen added with varying percentages of Used Rubber. Tests on conventional 60/70 grade bitumen added with varying percentage of HDPE and used rubber together.

B. Wet process

These are the method used for formation of polymer based modified bitumen, in which the waste polymer directly added with bitumen and heated up to temperature of 160oC so that proper blend is to be formed with proper dispersion of waste polymer into bitumen, then the hot mix is cooled up to 120 0C into another chamber, which is then added to the aggregate in paddling chamber. The mix is to be cooled because when hot mix poured on aggregate then there are chances to form air pocket into small gap of aggregate and chances in lower the strength of roads and chances of rutting of roads. After addition of modified bitumen at 1100C on aggregate, it is then laid on the road and then spreader material is compacted by 8 tone roller.

C. Marshall Stability of VG-30 Bituminous Mixture

This test is done to determine the Marshall stability of bituminous mixture as per MORTH. The principle of this test is that Marshall Stability is the resistance to plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface. It is the load carrying capacity of the mix at 60oC and is measured in kg. The apparatus needed to determine Marshall Stability of bituminous mixture is:

1) Marshall Stability apparatus ii) Balance and water bath.

D. Mixing of used rubber with VG-30 bitumen

In preparing the modified binders, about 500 g of the bitumen was heated to fluid condition in 2 liter capacity metal container. For blending of used rubber with bitumen, it was heated to a temperature of 160 °C and then used rubber was added. For each mixture sample used rubber is added in varying percentage of 8, 10, 12, and 14. The blend is mixed manually for about 3-4 minutes. The mixture is then heated to 160 °C and the whole mass was stirred using a stirrer for about 50 minutes. Care is taken to maintain the temperature between 160 °C to 170 °C. The contents are gradually stirred for about 45 minutes. The modified bitumen is cooled to room temperature and suitably stored for testing.

E. Mixing of HDPE with VG-30 bitumen

In preparing the modified binders, about 500 g of the bitumen was heated to fluid condition in 2 liter capacity metal container. For blending of HDPE with bitumen, it was heated to 19 temperature of 160°C and then HDPE was added. For each mixture sample HDPE is added in varying percentage of 4, 6, and 8. The blend is mixed manually for about 3-4 minutes. The mixture is then heated to 180°C and the whole mass was stirred using a stirrer for about 50 minutes. Care is taken to maintain the temperature between 160 °C to 180 °C. The contents are gradually stirred for about 50 minutes. The modified bitumen is cooled to room temperature and suitably stored for testing.

F. Mixing of HDPE and Used Rubber with VG-30 bitumen

Combination of used rubber + HDPE plastic waste was added in different load in weight percent into bitumen (60-70 penetration grade). In preparing the modified binders, about 500 g of the bitumen was heated to fluid condition in 2 liter capacity metal container. Bitumen was heated upto a temperature of 160°C and then mixture of HDPE and used rubber is added with varying percentage. The blend is mixed manually for about 3-4 minutes. The mixture is heated and temperature is maintained at 180°C and it is stirred. The modified bitumen is cooled to room temperature and suitably stored for testing.

IV. RESULTS AND DISCUSSIONS

A. Penetration Test Experimental Results

Test	Normal bitumen	5% plastic added bitumen	7% plastic Added bitumen	9% plastic Added bitumen	12% plastic added bitumen	15% plastic added bitumen
Ductility	38.9	42	23	16	4	0.5
Softening point	49.4℃	73	86	92	90	87
Specific gravity	0.97	1.04	1.05	1.03	0.97	0.93
Penetration test	49mm	31	26	19	13	7

B. Aggregate Crushing Value Test

Test	Normal aggregate	5 % Plastic Added Aggregate	7% Plastic Added Aggregate	9% Plastic Added Aggregate	12 % Plastic Added Aggregate	15 % Plastic Added Aggregate
Absorption Test (in %)	0.5	0.5	0.45	0.45	0.3	0.3
Stripping Test (in %)	2%(72 Hrs) 5%(96 Hrs)	0 (72Hrs) 0 (96 Hrs)	0 (72 Hrs) 0 (96 Hrs)	0 (72 Hrs) 0 (96 Hrs)	0 (72 Hrs) 2% (96 Hrs)	2%(72 Hrs) 4%(96 Hrs)

Abrasion Value Test (in %)	25.2	18.4	17.6	16.9	16.6	16.4
Impact Value Test (in %)	22.3	17.3	15.6	12.2	10.6	9.3
Crushing Value Test (in %)	21.46	19.8	18.2	17.4	15.7	12.9

C. Marshall Stability and Flow with Varying Plastic Content

Plastic (in %)	Bitumen (in %)	Vv	V_b	VMA	VFB	Stability (kg)	flow value (mm)
5	4	6.73	9.62	16.35	58.84	1651	4.64
7	4	6.03	9.41	15.44	60.95	1944	4.63
9	4	5.27	9.2	14.47	63.58	1700	4.71
12	4	8.9	10.02	18.92	52.96	1492	4.51
5	5	7.35	13.36	20.71	64.51	1626	4.53
7	5	6.58	13.08	19.66	66.53	1676	4.61
9	5	5.59	12.83	18.42	69.65	1966	4.64

D. Marshall Stability and Flow with Varying Bitumen Content

Bitumen (in %)	Gt	Gm	Vv	Vb	VMA	VFB	Stability (kg)	flow (mm)
4	2.55	2.39	6.27	9.10	15.37	59.21	1495	3.48
5	2.51	2.41	3.98	11.48	15.46	74.26	1581	3.53
6	2.49	2.42	2.81	13.83	16.64	83.11	1380	3.55

E. Marshall Stability of Modified Bitumen with HDPE

Sl. No.	Modified Bitumen Content	Marshall Stability (kg)	Flow Value (mm)
1	Bitumen + 4% HDPE	1380	2.3
2	Bitumen + 6% HDPE	1660	2.9
3	Bitumen + 8% HDPE	1550	4.7

F. Physical Properties of Modified Bitumen with HDPE

S`l. No.	Properties Tested	Results
1	Penetration (mm)	42
2	Softening point(oC)	63
3	Ductility (cm)	82
4	Flash point(oC)	273
5	Specific Gravity	998

G. Marshall Stability of Modified Bitumen with Used Rubber

Sl. No.	Modified Bitumen Content	Marshall Stability (kg)	Flow Value (mm)
1	Bitumen + 8% Rubber	1115.3	2.3
2	Bitumen + 10% Rubber	1235.6	3
3	Bitumen + 12% Rubber	1480	3.8
4	Bitumen + 14% Rubber	1530	4.7

H. Physical Properties of Modified Bitumen with Used Rubber

S`l. No.	Properties Tested	Results
1	Penetration (mm)	51
2	Softening point(oC)	58
3	Ductility (cm)	101
4	Flash point(oC)	216
5	Specific Gravity	1.01

I. Marshall Stability of Modified Bitumen with HDPE and Used Rubber

Modified bitumen content (%)	Stability (kg)	Volume of mould (cc)	Correction ratio	Corrected stability (kg)	Flow value (mm)
BITUMEN+CR 6%+ HDPE 2%	3100.3	590	0.8	3050.3	2.5

BITUMEN+CR 8%+ HDPE 4%	3250.6	567	0.9	3314.6	3.3
BITUMEN+CR 10%+HDPE6%	2600.3	589	0.87	2433.3	5.3
BITUMEN + CR 12% + HDPE 8%	1560.2	579	0.79	1432.3	7.4

J. Physical Properties of Modified Bitumen with HDPE and used Rubber

S`l. No.	Properties Tested	Results
1	Penetration (mm)	33
2	Softening point(oC)	76
3	Ductility (cm)	80
4	Flash point(oC)	180
5	Specific Gravity	1.09

V. CONCLUSION

- In penetration test (0.1 mm) of bitumen with plastic, the value diminished from 47mm to 31 mm for 5 % plastic waste in bitumen and decreasing persistently on expanding plastic squanders rate and for 15 % plastic waste, the esteem lessened to 0.7mm when contrasted with ordinary bitumen on account of expanded hardness.
- Softening point and specific gravity values expanded with the expansion in rate of plastic waste however subsequent to achieving the ideal level, the qualities began diminishing.
- The addition of used rubber and HDPE waste optimum result were obtained up to 12%. i.e. 8% used rubber and 4% HDPE.
- 12% of bitumen can be replaced by used rubber in bituminous layer having 5.5% optimum bitumen content
- It is observed that 6% of bitumen can be replaced by HDPE in bituminous layer having 5.5% optimum bitumen content.

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