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Application of Waste Plastic in Modifying Bitumen Properties

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Abstract: ***Roads constructed in India mostly includes flexible pavement structure road, these pavement are subjected to different kinds of loading which result in affecting the performance of the pavement. Now a day's waste plastics are widely used in the bitumen as a modifier to increase the performance of the pavement. The use of waste plastic for modifying the bitumen properties, which will be used for the road construction, has resulted in the reduction of the construction cost and eco-friendly disposal method of the waste plastic. As use of waste plastic is increasing day by day due to industrialization and increase in population which leads to various environmental problem. Therefore using waste plastic in the construction of flexible pavement is economical and eco friendly method for the disposal of waste plastic. In this paper we will discuss the variation of the properties of bitumen on addition of waste plastic at different percentage.***

Keywords: Flexible pavement, Waste plastic, bitumen modifiers, eco friendly

1. Introduction

Roads play a vital role for economic growth and bring important social benefits. It helps in providing employment, education, health and social services to mankind thus road network is crucial in order to make a nation grow and develop. Extreme climatic condition and increased traffic volume on roads causes' necessity to develop feasible and economical road construction in India. Due to hike in price of crude oil, in recent years the cost of bitumen is raised. As highway construction and maintenance involves huge amount of money, appropriate engineering design and use of waste plastic can save considerable amount of cost. Waste plastic is mixed with the bitumen and aggregate, results in enhancing the properties of the bituminous mix. Plastics are feasible but not eco-friendly because they are non-biodegradable. At present in INDIA the plastic consumption is more than 15 M tones, which is 3rd largest plastic consumption in the world. Most of the plastic is used for packaging which are usually dropped and left to litter the surrounding. The scattered plastics get mixed with domestic waste due to which the solid municipal waste disposal becomes difficult. The solid municipal waste is either land filled or burned. Both method of disposal is not the best way to dispose the waste because both method cause soil and air pollution. Plastics also have a very long lifetime and incinerate under unchecked conditions can cause air pollutants to generations depending upon the polymer type and used additives. Rapid industrialization and very large population growth resulted in increase of different types of waste materials. For the disposal of the waste material considerable measures have been done.

2. Bitumen

Bitumen is a binding material used in road construction. It is non crystalline and dark brown in color and having viscous properties. It is obtained from crude petroleum.. In other words bitumen is any adhesive and solid mixture of hydrocarbons that are found naturally in tar, asphalt, mineral waxes, etc. used for constructing the road surface and roofing material. It is mainly used for:

- Construction of roads, platforms, runways etc.
- Water proofing
- Mastic flooring
- Canal lining
- Damp proof course
- Advantage of bitumen:

Production of bitumen is economical

- Rheological and physical properties of bitumen bring versatility
- Favorable melting point
- Bitumen can go under recycling
- Adhesive in nature

It is estimated that 102 million tones bitumen is used by the world and around 85% of the bitumen produced are used as a binder in road construction. It is also used in other pavements such as airport runways, car parking's, footways etc. The cluttered bitumen has the tendency to cause bleeding in summer season on road surface and may develop cracks in winters. Such bitumen has less bearing capacity and can cause damages because of higher axial load due to rapid increase in number of vehicles. In the both terms length and quality, India has to raise its transportation system. Generally, production of asphalt comprises blending crushed rocks, fine aggregate with bitumen, which acts as a binding agent. Materials such as polymers could be added to alter its chemical and physical properties according to the use for which the asphalt is basically destined. Around the world, road authorities are realizing the use of modified bitumen is profitable in the road construction. Polymer modified bitumen is developed as one of the best construction material used for the flexible pavement. It reduces medium and long term cost as the roads are less exposed to defects. This reduces maintenance cost, which is not only a financial problem but also a traffic problem as road has to be closed for repairing or bituminous mix not only modify the properties of mix but also solve the problem of disposal of plastic and also creates employment to plastic collector.

3. Methodology

3.1 Tests on Aggregate

3.1.1. Aggregate Impact Test
Movement of vehicle apply impact load on aggregates. Therefore aggregates should be tough enough to resist that impact. Through this test the toughness of aggregates is calculated. In this test the aggregate are been subjected to 15 blows of 14 kg hammer. The aggregate impact value is been determined by calculating percentage of fine passed through 2.36mm IS sieve to the total weight of the sample.

3.1.2. Aggregate Crushing Test
To resist compressive wheel load when there is a traffic movement the aggregate should be have high crushing strength. If aggregate are week, the pavement structure will get affected. Hence resistance to compressive load is necessary to be calculated by performing crushing value test. In this test aggregates are subjected to a compressive load of about 40 tons the crushing value is determined by calculating percentage fine passed through 2.36 IS sieve to total weight.

3.1.3. Flakiness/Elongation Index Test
The flakiness index of aggregate is defined as the percentage by weight of aggregate particles in it whose least dimension of those particles should not be less than 0.6 times their mean area. Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension is greater than one and four-fifth times their mean dimension.

3.1.4. Los Angeles Abrasion Test
In this test the resistance to abrasion is been determined. The sample of coarse aggregates of about 5 kg and steel balls are placed in the rotating drum. The steel balls also known as abrasive charges. The loss in weight of aggregate due to abrasion of is calculated in percentage. This percentage of wear of the aggregate is known as Los Angeles abrasion value or hardness value.

3.2 Tests on Bitumen

3.2.1. Penetration test
The hardness of bitumen which is used in road construction has been determined by the penetration test. It is a depth penetrated by the needle of penetrometer into the bitumen sample under the specific condition. The penetration value is measured as one tenths of a depth penetrated by needle. consistency of bitumen is also evaluated through this test. In this test, the sample with different percent of plastic such as 0%, 5%, 10%, 15% is been prepared and penetration value is been determined.

3.2.2. Ductility Test
The adhesive property of bitumen is been measured with the help of Ductility test. The bitumen used in construction should form a thin film around the aggregates so that a stable structure of aggregates and bitumen can be formed. The road surface usually cracked if the binder used in construction does not have sufficient ductility. Ductility is defined as the distance in centimeter to which bitumen elongate before breaking. In this test briquette specimen with the different percentage of plastic such as 0%, 5%, 10%, 15% are pulled apart at the specific speed and temperature.

3.2.3. Softening Point
Bitumen has a tendency to become soft at higher temperature. This softening temperature is determined with the help of ring and ball apparatus. If the softening point of bitumen is higher, then that bitumen is usually preferred in the warmer climate similarly lower the softening point bitumen is preferred in the cold climate.

3.3 Test on Bituminous mixture

3.3.1 Marshall Test
In this test the specimen of bitumen and aggregates mixture has been prepared and then the test is conducted on it. The load is been applied on the specimen and the deformation is been measured. The Marshall test uses standard test specimens of 64mm (2.5 inches) height and 102 mm (4 inches) mm diameter. They are prepared using a specific procedure for proportioning materials, heating mixing and then compaction of the specimen is done. It involves mainly 2 processes:
(a) Preparation of Marshall samples
(b) Application of load on Marshall Specimens.

4. Result

4.1 Aggregate test

1) The crushing value of aggregate is 17.44 %.
2) The abrasion value of aggregate is 11.36 %.
3) The impact value of aggregate is 30%.
4) The Flakiness index value is 17.42% and Elongation index value is 14.081%.

4.2 Bitumen Test

The results obtained from various test performed on bitumen having different plastic content has been shown in table no. 1.

Table 1: Properties of Bitumen having different percentage of waste plastic

S.No.	*Plastic cntent (%)*	*Penetration Value (mm)*	*Ductility Value (cm)*	*Softening Value (°C)*
1.	0	6.1	82	42.5
2.	5	2.5	78	61.5
3.	10	2.36	73	77
4.	15	2.3	64	87.5

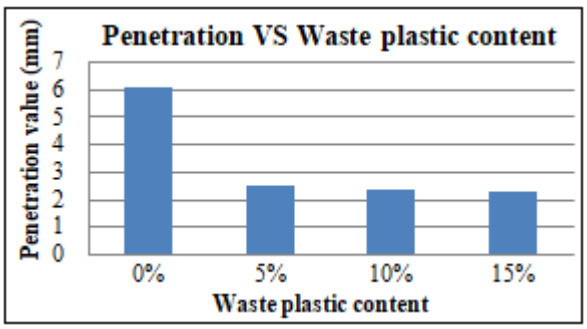

Figure 1: Penetration Value of Bitumen

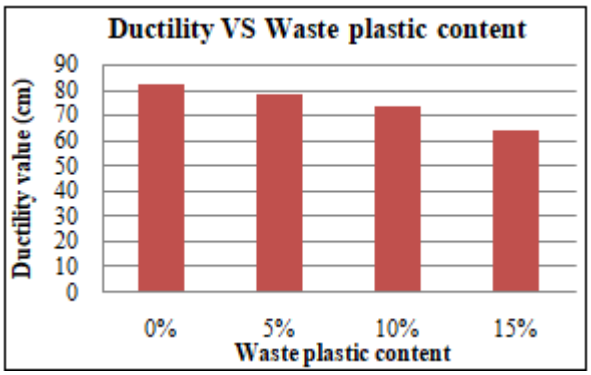

Figure 2: Penetration Value of Bitumen

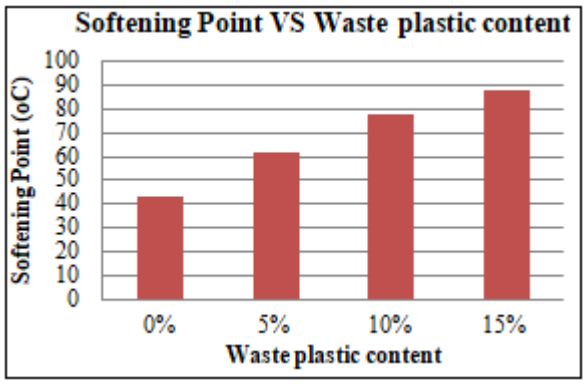

Figure 3: Penetration Value of Bitumen

The Penetration value and ductility value of bitumen decreases as the plastic content added is increased. The softening point of bitumen increases with an increase in amount of plastic content.

4.3 Marshall Test

The various properties of bituminous mix has been obtained and calculated using Marshall Test. Table no. 2, 3, 4, and 5 shows the results of test for bituminous mix containing different amount of plastic waste.

Table 2: Properties of Bituminous mix having different 0% waste plastic content

Bitumen with 0%waste plastic					
S.No	*Bitumen*	*Stability Value (kg)*	*Flow Value (mm)*	*Unit weight (kg/m^3)*	*Air Voids (%)*
1.	3%	720	6.25	2.286	8.596
2.	4%	2000	7	2.274	7.897
3.	5%	1760	7.5	2.351	7.632
4.	6%	1600	12.5	2.288	4.023

Table 3: Properties of Bituminous mix having different 5% waste plastic content

Bitumen with 5% waste plastic					
S.No	*Bitumen*	*Stability Value (kg)*	*Flow Value (mm)*	*Unit weight (kg/m^3)*	*Air voids (%)*
1.	4%	1428	7.5	2.299	6.88
2.	5%	3720	11.25	2.403	5.744
3.	6%	3584	12.5	2.236	3.820

Table 4: Properties of Bituminous mix having different 10% waste plastic content

Bitumen with 10% waste plastic					
S.No	*Bitumen*	*Stability Value (kg)*	*Flow Value(mm)*	*Unit weight (kg/m^3)*	*Air Voids (%)*
1.	4%	2920	7.5	2.191	11.25
2.	5%	3840	8.75	2.346	3.734
3.	6%	3240	9.25	2.331	3.157

Table 5: Properties of Bituminous mix having different 15% waste plastic content

Bitumen with 15% waste plastic					
S.No	*Bitumen*	*Stability Value (kg)*	*Flow Value (mm)*	*Unit Weight (kg/m^3)*	*Air Voids (%)*
1.	4%	3400	6.25	2.202	10.810
2.	5%	3720	7	2.204	9.560
3.	6%	3200	7.5	2.288	4.043

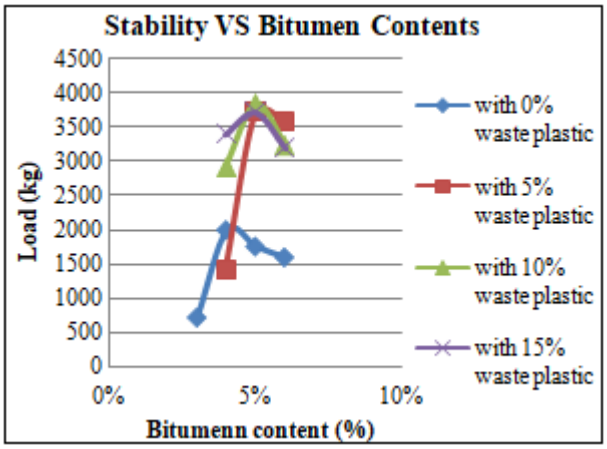

Figure 4: Stability curve of bituminous mixes

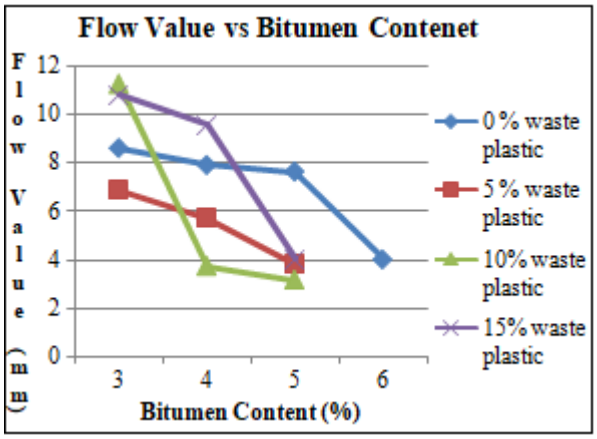

Figure 5: Flow value curve of bituminous mixes

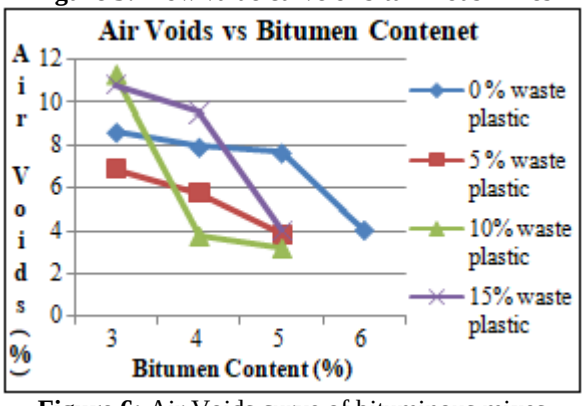

Figure 6: Air Voids curve of bituminous mixes

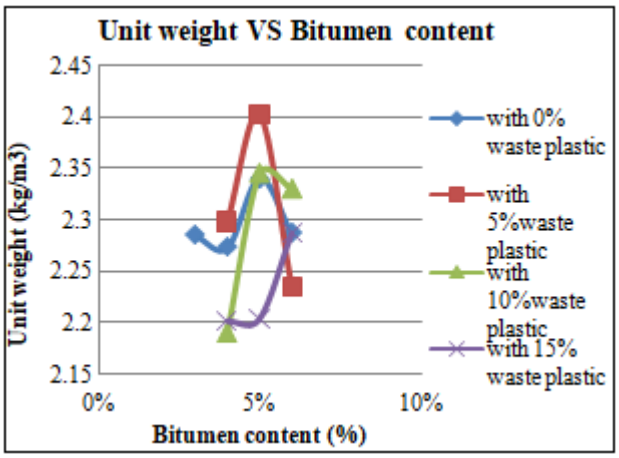

Figure 7: Unit Weight Curve of bituminous mixes

5. Conclusion

From the research conducted following points can be concluded

1) The stability value i.e. the load at which marshal sample fails or break , of bituminous mix increases on addition of waste plastic in it as compare to normal mixture without any plastic material.
2) The flow value showed the decrement as compare to the normal mix.
3) No significant variation in the optimum bitumen content was observed even with the addition of waste plastic. With this it can be concluded that additional bitumen is not required to prepare waste plastic bituminous mix.
4) The variation in Stability and Flow value improve the structural resistance of bituminous concrete to distress occurring in flexible pavement.
5) The Optimum Bitumen Content for 0%, 5%, 10%, and 15% Waste Plastic Content is 5%, 5.433%, 5.033%, 5.667% respectively.

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