A Sustainability Approach towards use of Plastic Waste in Bituminous Road

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Abstract - *Nowadays, disposal of plastic waste has become an issue of great concern for environmental engineers due its non-biodegradable characteristics and health Hazard.*

Plastic waste, if not recycled, is either land filled or incinerated, where both of them prove to be a disaster to the environment. Incineration and dumping of waste in open areas leads to environmental pollution as well as contamination of water bodies and soil. Thus, an alternative for treatment of plastic waste is required as soon as possible. In construction of flexible pavement plastic was found to be a potential binder for bitumen mixes used. In this paper, we are going to find out the result of ***LOW-DENSITY POLYETHYLENE*** *which we will be use as a replacement of bituminous by an amount of 6%, 8%, 10%, 12% & 14% by weight of bitumen in making bituminous mix design for pavement application. To know various properties of bitumen we are going to conduct Penetration test, ductility test, flash and fire point test, softening point test.* ***Marshall Stability Test*** *will be performed on all of the samples. The basic objective of the test is to find out the optimum percentage of plastic waste which can replace the bitumen content in the mix design of flexible pavements. Researches proved that the plastic wastes used after proper processing can enhance the life of the road and also a solution to environmental problems.*

Key Words**: Non bio-degradable, Polyethylene, Bitumen**

1. INTRODUCTION

Large amount of plastic waste is generated on daily basis. The disposal of this plastic waste is the challenging problem faced worldwide. Waste plastic gets mixed with municipal solid waste or get disposed on land. Various research attempts have been made to recycle and reuse plastic waste such as polyethylene covers, plastic bags, plastic bottles, etc. Best quality of road functionality is required with the rapid increase in traffic intensity, in addition to significant fluctuations in daily and seasonal temperature. Better road infrastructure is needed that requires less maintenance in developing countries where proper maintenance of road networks is difficult due to lack of funds and efficient machinery.

Extensive researches has shown that the strength of paving mixes can be improved by using different types of modifiers with bitumen such as tyre rubber, polypropylene and organic polymers. By use of these modifiers temperature susceptibility and viscosity properties are improved. It also solved problems such as binder bleeding at peak summer temperatures and aggregate stripping in moisture prone areas.

Many studies are being conducted to improve the bitumen quality used in bituminous road construction. One of the outcome of this study is the application of polymer-modified bitumen. Utilizing discarded plastic waste (especially plastic bags) is the need of today's society. Research into the conductive and thermal bonding properties of molten plastic encouraged study into the formation of the waste plastic-bitumen combination and its sustainably in road construction.

Energizing solid municipal plastic waste can take routes such as incineration of the waste in flow-driven incinerators, incineration of the waste in heat exchangers, pyrolysis, hydrogenation, and anaerobic digestion. It causes health and environmental problems when it is disposed in form of landfill and incineration. That's why you should dispose of plastic waste as bitumen modifier in road construction. Proper addition of plastic in bitumen improves the roads life of and minimizes the construction cost of roads. The exceptional growth of vehicle counts on our roads, including the commercial vehicles along with overloading of transport vehicles and changes in seasonal temperature in various parts of our country needs improved performance of roads and better binding properties of bitumen.

1.1 Plastic

Plastic is huge threat to the environment. The best way for the disposal of plastic is recycling. Various categories of plastic are LDPE, HDPE, Polypropylene, Polystyrene, PVC and Polyethylene Teryphthalate etc. Here we are using LOW DENSITY POLYETHYLENE which is originating from milk pouches because of its easy availability and flexibility.

1.2 Bitumen

Bitumen is viscous material having adhesive properties derived from crude oil either by natural or refinery processes possessing black or brown colour. There are different grades of bitumen available in market according to its viscosity and penetration values. It acts as a binder material for aggregate in bituminous mixes.

2. LITERATURE REVIEW

2.1 Prof.C.E.G. Justo (2014)

He concludes that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter of BC mix. Modified Bitumen enhance the stability & strength, life and other desirable properties of bituminous concrete mix.

2.2 YashMenaria, RupalSankhla (2015)

He stated that polyethylene, polypropylene, and polystyrene are the main constituents or source of waste plastics. Where the softening point of this type of material ranges from 120˚C - 160˚C. These heated materials will do not generate any poisonous gases on heating but it has good laminating property when spewed over the hot aggregate at 160˚C. the importance of this study shows reduction in the cost of construction as waste plastic used and increase in durability and strength is observed, the combination of plastic binding with aggregates provide good stability.

2.3 Prof.Jayesh Kumar Pitroda (2013)

"Plastic wastes opportunities for eco-friendly material of bituminous road constructions". In this article cost of construction of plastic road and bitumen road is compared, while bitumen requires for per km giving cost of 5,00,000/- and while bitumen mixed with plastics that giving cost per km of 4,55,000/-, hence plastic road is economical. It enhances resistance to surface initiated cracking due to higher binder content, improved oxidation resistance due to higher binder content.

2.4 Kurmadasu Chandramouli (2016)

"Plastic waste is use in the construction of roads" stated that asphalt concrete using polyethylene modified binders were more resistant to permanent deformation at high temperature and found better performance in stripping characteristics of the crumb rubber modified mix as compared to unmodified asphalt mix.

2.5 U Sathish, A.V.Sandeep (2020)

Recycled plastic along with aggregates can be used for the better performance of the roads. The properties displayed by plastic coated bitumen are beneficial without pursuing much cost leading for effective, economic and efficient laying of roads. In this way plastic waste can be recycled.

3. OBJECTIVE AND SCOPE

- To check the properties of bituminous mix specimen due to replacement of bitumen by waste plastic materials.
- To find a better bitumen-plastic mix option for improvement of quality of road pavement.
- To improve road Stability and life.
- To reduce the quantity of bitumen required for projectthereby reducing cost of materials.
- Select an optimum waste plastic content for the mixture after the analysing the test results.

4. METHODOLOGY

4.1 Materials used for bituminous mix

4.1.1Coarse Aggregate

The coarse aggregates should annex good impact value abrasion value, and also crushing strength. The function of coarse aggregates is to carry the stresses due to wheels. Function of Coarse aggregates is also to withstand wear due to abrasion. According to the Asphalt Institute the portion of the mixture which retained on 2.36 mm (No. 08) sieve is termed as Coarse aggregates. Coarse aggregate used was Basalt rock.

4.1.2 Fine Aggregate

Voids which remain unfilled in the coarse aggregates are filled by the fine aggregates. So, the purpose of fine aggregates is to fill the voids of coarse aggregates. Fine aggregates include crushed sand. Aggregates that passed through 2.36mm sieve and retained on 0.075 mm sieve were selected as fine aggregate. Crushing sand is used as fine aggregate.

4.1.3 Waste Polythene

The polythene Amul milk packets are used as raw material for preparation of the samples. This polythene was washed after collecting and cleaned by putting them in hot water for 3-4 hours. They were then dried.

4.1.4 Bitumen

Grades of bitumen used in the pavements must be selected on the basis of climatic conditions and their performance in the past. Asphalt binder VG40 is used in this research.

4.2 Preparation of Sample

4.2.1Collection of aggregates

It should confirm to IS 383 – 1983. IRC suggest two sizes of aggregates size 12mm, 10mm in our research we used 10mm size of aggregate.

4.2.2 Collection of plastic

There are many sources available for the collection of plastic like domestic, commercial & public sources.

Segregation: Plastic waste collected from various sources must be separated from other waste.
Cleaning process: Plastic waste must get cleaned and dried after cleaning.
Shredding Process: It is the process of cutting the plastic into small sizes between 2.36mm – 4.75mm with the help of the plastic shredding machine.
Collection Process: Plastic must be collected of the size of 2.36mm – 4.75mm for the blending process in plastic coated aggregate and mixing with the hot mix bitumen.

4.2.3 Coating of aggregate with plastic

The aggregates are heated up to 160°C. Shredded plastic waste is added over the hot aggregate in mixing chamber. Then plastic waste coated aggregate is mixed with hot bitumen.

5. EXPERIMENTAL INVESTIGATION

5.1 Marshall Stability Test

To determine the Marshall Stability of bituminous mixture as per ASTM D 1559 this test is performed. The resistance to plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface is the principle of marshall stability. The load carrying capacity of the mix at 60^0 C was measured in kg.

Total weight of the mould is 1200g.

5.1.1 Test Procedure

Heat the weighted aggregates and bitumen-plastic mix separately up to 170°C.

Mix them proper and transfer mix to compaction mould arranged on compaction pedestal.

Give 75 blows on the top side of the specimen mix with a standard hammer (45cm, 4.86kg) and repeat the same procedure by reversing specimen.

allow the mould with the specimen to cool for few minutes then remove the specimen from the mould by gentle pushing. Mark the specimen and allow it to cure for a day.

A series of specimens with increasing amounts of bitumen content are created using a similar process, with an increment of 2 percent.

Place the mould in a water bath for minimum 45mins at a temperature of 60°C.

Check the moulds stability using the MARSHALL STABILITY apparatus.

Fig. 1 Marshal stability equipment

Fig. 2 Sample of bitumen

SR NO.	% Bitumen replaced by plastic	Marshall Stability value (KN)	Range (KN)
1	6	18.79	9
2	8	18.85	9
3	10	18.99	9
4	12	19.3	9
5	14	20.25	9

Table 1 Marshal Stability of Bituminous Mix

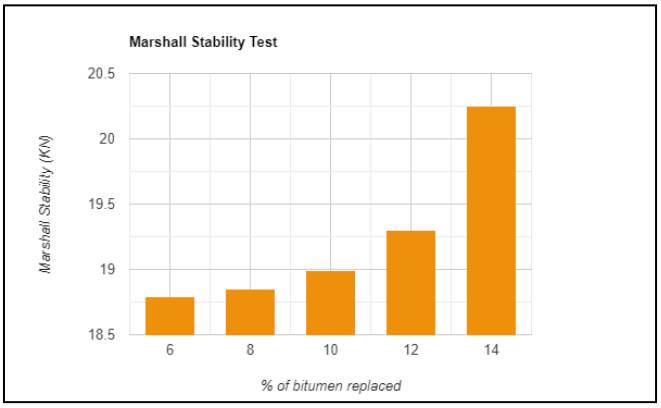

Fig 3 Marshal Stability of Bituminous Mix

SR NO.	% Bitumen replaced by plastic	Marshall Stability Flow value (mm)	Range (mm)
1	6	2.3	2-4
2	8	2	2-4
3	10	1.6	2-4
4	12	1.2	2-4
5	14	1	2-4

Table 2 Marshal Stability Flow of Bituminous Mix

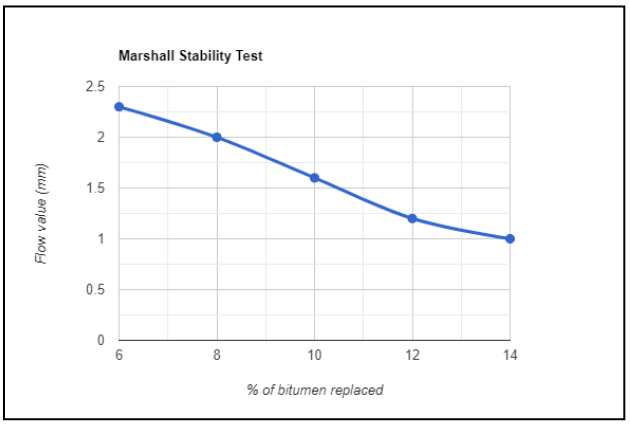

Fig 4 Marshal Stability Flow of Bituminous Mix

5.2 Penetration Test

In road construction bitumen has good hardness or softness. To determine this softness, we carried out this test. This test is conducted as per IS 1208 – 1978. Bitumen sample is taken in mould and then needle having weight of 100gms is penetrated in sample then the penetration is taken.

SR NO.	% Bitumen replaced by plastic	Penetration Value	Rangeas per IS73: 2013
1	6	45	Min 35
2	8	43	Min 35
3	10	41	Min 35
4	12	39	Min 35
5	14	37	Min 35

Table 3 Penetration value test

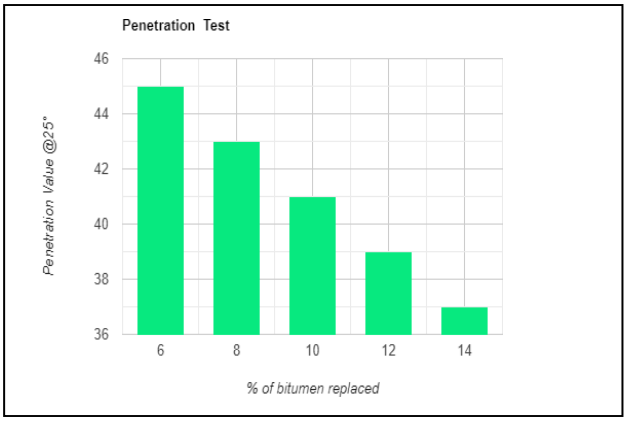

Fig 5 Penetration value test

6.2 Ductility test

In the road construction the bitumen is the important material used as binder. It is important that the binder should have enough ductile thin film around the aggregate. This serves to improve a physical interlocking of an aggregate. This test is conducted as per IS 1208 – 1978. This test is carried out to determine the quality of bitumen. The bitumen is placed in mould, that mould is placed in water bath and stretched till the sample breaks in two parts, then length is measured.

SR NO.	% Bitumen replaced by plastic	Ductility @25°C	Range as per IS73:2013
1	6	49	Min 25
2	8	44	Min 25
3	10	40	Min 25
4	12	36	Min 25
5	14	30	Min 25

Table 4 Ductility Test

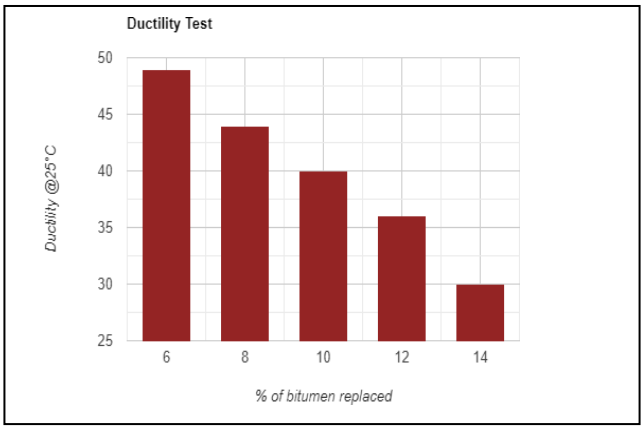

Fig 6 Ductility Test

6.3 Softening Point test

Softening point test is the temperature at which the substance attains a particular degree of softening under specified condition of test. Higher softening indicates lower temperature and it is preferred in warm climate. Bitumen is tested in softening point apparatus. As bitumen sample is touched the bottom flange that temperature is obtained as a result 52° - 53° C. The softening point of various bitumen grades used in paving jobs vary between 35°-70°c. This test is conducted as per IS: 1205 – 1978.

SRNO.	% Bitumenreplaced by plastic	Softening Point °C	Range as per IS73:2013
1	6	54.5	Min 50
2	8	55	Min 50
3	10	56.5	Min 50
4	12	58	Min 50
5	14	58.5	Min 50

Table 5 Softening point test

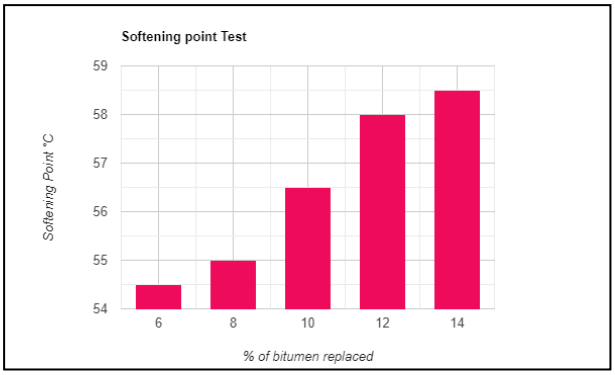

Fig 7 Softening point test

6.4 Flash Point test

Flash point the temperature at which, bitumen vapour will ignite for an instance when a small flame is brought into contact with the vapour during heating.

This test is conducted as per IS: 1205 – 1978.

SR NO.	% Bitumen replaced by plastic	Flash Point	Range as per IS73:2013
1	6	290	Min 220
2	8	275	Min 220
3	10	258	Min 220
4	12	245	Min 220
5	14	225	Min 220

Table 6 Flash point test

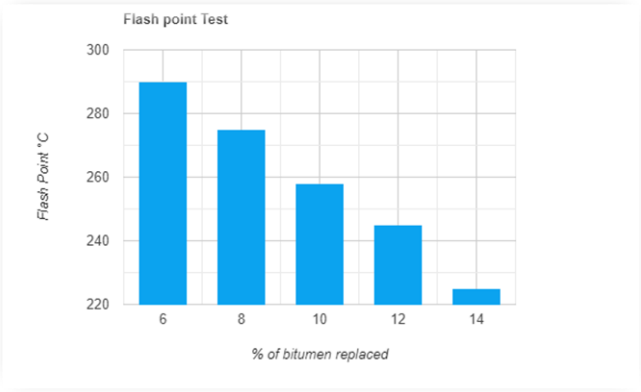

Fig 8 Flash point test

3. CONCLUSIONS

1) From table 1 and 2 it is observed that the marshall stability value and flow value are within the prescribe range according to MORTH (Ministry Of Road Transport And Highways for 6% and 8% replacement of waste plastic with bitumen than 10%,12%,14%.

2) From table 3 it has concluded that penetration value decreases with the increase in plastic content which shows that addition of polymer increases the hardness of bitumen.

3) From table 4 it has concluded that ductility value decreases with the increase in plastic content which shows interlocking of the polymer molecules with bitumen.

4) From table 5 it has concluded that softening point increases with the increase in plastic content which shows less bleeding during summer.

5) From table 6 it has concluded that flash point of bitumen mix decreases with increase in plastic content which makes useable in colder climate.

REFERENCES

1. Amit Gawande, G. Zamare, V.C. Rengea, SaurabhTayde, G. Bharsakale, "An Overview On Waste Plastic Utilization In Asphalting Of Roads" - journal of engineering research and studieseissn0976-7916vol. Iii/ issue ii/april-june,2012/01-05

2. Miss Apurva J Chavan, "Use Of Plastic Waste In Flexible Pavements", international journal of application or innovation in engineering & management (IJAIEM), volume 2, issue 4, april 2013 pp 540-551.

3. U Sathish, A.V.Sandeep "Partial replacement of bitumen with waste plastic in flexible pavements." International Research Journal of Engineering and Technology Volume:7 Issue:7.

4. IRC, "Tentative Specifications For Bituminous Surface Dressing Using Pre-Coated Aggregates".

5. IRC: 48-1972, Indian Roads Congress ISI, "Indian Standards Specifications For Roads Tar", is: 215, indian standard institution.

6. Vikas R Agrawal, SauravAnand Agrawal, Nikhil Kale "Performance Evaluation Of Plastic Modified Bitumen In Flexible Pavement" department of civil engineering, priyadarshin

7. Ge OfEnzahraNiloofarKalantar, Mohamed Rehan Karim, AbdelazizMahrez "A Review Of Using Waste And Virgin Polymer In Pavement" - construction and building materials 33 (2012) 55–62.

8. Athira R Prasad "Bituminous Modification With Waste Plastic And Crumb Rubber" - iosr journal of mechanical and civil engineering (iosr-jmce) volume 12, issue 3 ver. Ii (may - jun. 2015).

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