APPLICATION OF WASTE PLASTIC AS AN EFFECTIVE CONSTRUCTION MATERIAL IN FLEXIBLE PAVEMENT

Sasane Neha .B.[1], Gaikwad.Harish[2], Dr. J R Patil[3] and Dr. S D Khandekar[4]

[1 2] *Post graduate student, Department of Civil Engineering, RMD Sinhgad College of Engineering, Warje, Pune, Maharashtra, INDIA,*

[3]*Professor, Head of department , Department of Civil Engineering, RMD college of engineering, Pune (Maharashtra, India)*

[4] *Professor, Head of department , Department of Civil Engineering, SKN Nahare college of engineering, Pune (Maharashtra, India)*

Abstract—Preservation of road infrastructure requires a systematic approach for the good performance of roads keeping in mind the future condition and maintenance scenarios. Now-a-days pavements are subjected to various kinds of loading which affects the pavement performance condition that causes various distresses. These distresses include rutting, fatigue cracking, and temperature cracking. Looking forward to the environmental condition, complete ban on plastic cannot be made. Thus, using of plastic as an innovative technology not only strengthened the road construction but also increase the road life. This paper includes the results of the various laboratory tests conducted on bitumen, aggregate and bitumen-aggregate plastic mix.

Key words – Waste plastic, Aggregate, Bitumen, plastic-bitumen-aggregate mix, plastic modified bitumen and plastic ***modified aggregate.***

I INTRODUCTION

Today, for the developing countries, Flexible pavements are one of the most important infrastructures. Any damage to this may cause lots of inconvenience to the traffic which ultimately will affect the future scenario of countries. Now-a-days it is been observed that due to increase in axel 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 axel loads and traffic intensity.

Rapid industrial and enormous population growth has resulted in increasing the various types of waste materials. Considerable measures have been done for the disposal of these waste products. These plastics are considerably non-biodegradable thus can be used as a modifier in bitumen and aggregates to increase their strength.

This study presents the proper utilization of waste in hot bitumen and aggregate to enhance pavement performance, to protect environment and to provide low cost roads.

II LITERATURE REVIEWS

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.

Aggregate is one of the most important materials used for flexible pavement construction (See Figure 1). Properly selected and graded aggregates are mixed with bitumen to form hot mix asphalt (HMA) pavements. Aggregates are the principal load supporting components of HMA pavement. HMA can be divided into three types according to their size: coarse aggregate that generally retain on 2.36 mm sieve, fine aggregate are which pass through 2.36 mm sieve and retaining on 0.0075 mm sieve and mineral filler are the aggregate the one which pass through 0.075 mm sieve.

Figure 1 Aggregate of 10 mm

Bitumen is very well known as the binders in pavement construction (Refer Figure 2). It is one of the major highway construction materials. The important quality of bitumen

which has made bitumen a popular binding material is its excellent binding property and gets softens when heated.

Figure 2 Bitumen of grade 60/70

Plastic are known by their chemical structure which is generally known as polymer's backbone and side chain. There are usually two types of plastic's "Thermoplastic and Thermosetting polymers" (Refer Figure 3)

Plastic is one of the materials which enhanced its binding property when softened. Hence, this softened plastic material can be used as an effective binder in bitumen.

Figure 3 Plastic on road sides.

III RESEARCH METHODOLOGY

The research methodology for present study has adopted various tests to investigate the results on aggregate, bitumen and plastic and aggregate-bitumen-plastic mix. The tests conducted were Water Absorption, Aggregate Impact, Loss Angeles and Aggregate Crushing Test [IS: 2386 (part 4)-1963] for aggregates and Softening Point, Penetration Test and Ductility Test [IS: 1203-1978] for bitumen.

For mixing the ingredients of road mix, dry process was adopted. In this process, waste plastic is mixed with aggregates and blends of polymer modified aggregate are prepared by mixing bitumen in it. These blends are later tested in laboratory and required optimum results are obtained.

The blends using aggregates and bitumen were prepared along with the use of different percentage of waste plastic in it separately (See Figure 4) and were kept for water bath at least 24 hrs. Later these blends were tested under marshal stability apparatus to check its stability for road pavements.

Figure 4 Blends of Aggregate and Bitumen and blends of Aggregate-bitumen-plastic mix

The results of various tests conducted on aggregate and bitumen and aggregate-bitumen-plastic mix are given in subsequent section.

IV RESULTS AND DISCUSSIONS

Laboratory Tests on Aggregate

For the asphalt pavement, stone aggregate with specific Characteristics are used for road laying. The aggregates are chosen on their strength, porosity and moisture absorption capacity.

The shredded waste plastic was sprayed over the hot aggregate which got coated on aggregate when molted. The extent of coating was varied by using different percentage of plastic. Increase in the percentage of plastic increases the properties of aggregates.

Following are the tests conducted in laboratories

Impact Test (IS: 2386 Part IV-.1963)

Toughness is the property of a material to resist impact. Due to traffic load and intensity, the road stones are subjected to various actions leading in formation of pounding impact or breaking into smaller pieces. Thus, road stones should therefore be tough enough to resist fracture under impact. Hence, a test is designed to evaluate the toughness of stone.

The results of Impact test with various percentage of plastic in aggregates are shown in Table 1 and Figure 5. Loss Angel's Abrasion Test (Is: 2386 Part Iv 1963)

The repeated movement of the vehicle with iron wheeled or rubber tire will produce some wear and tear over the surface of the pavement. This wear and tear percentage of an aggregate is determined with the help of "Loss Angeles Abrasion Study".

Table 1 Observations for aggregate impact test

Stone aggregate	% of plastic	Aggregate impact vale
Without plastic coating	0	10.79 %
With plastic coating	5	10.59 %
	10	10.03 %
	15	9.93 %

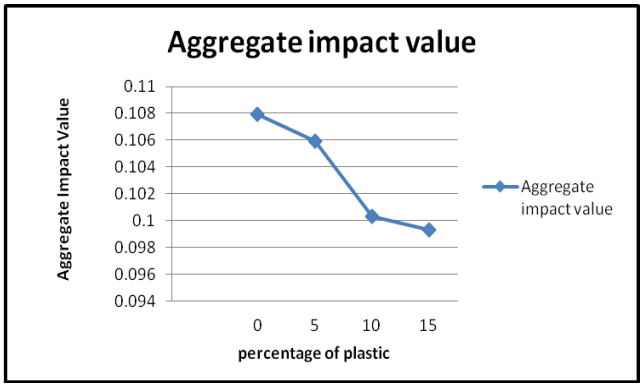

Figure 5 Variation in aggregate Impact Value of Aggregate with increase in percentage of plastic

The results of Loss Angeles Abrasion Test with various percentage waste plastic in aggregates are given in Table 2 and Figure 6.

Table 2 Observation for the Loss Angeles Abrasion test

Stone aggregate	% of plastic	Loss Angeles Value
Without plastic coating	0	12.99%
With plastic coating	5	11.70%
	10	10.65%
	15	8.94%

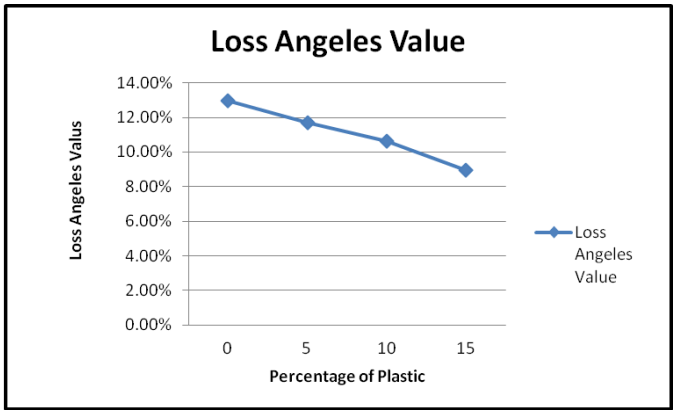

Figure 6 Variation in Loss Angeles Value of Aggregate with increase in percentage of plastic

LABORATORY TESTS ON BITUMEN:

The studies on the behavior and binding properties enhanced for the preparation of plastic waste-bitumen blend to find suitability properties of material for road construction.

Polyethylene carry bags were cut into pieces using cutter in to small pieces.

These plastic pieces were slowly added to the hot bitumen and the mixture was stirred well using mechanical stirrer. Polymer-bitumen and polymer-aggregate mixtures of different compositions were prepared and used for carrying various tests.

Following are the test conducted in laboratories:

Softening Point

The softening point is the temperature at which the substance attains a particular degree of softening under specified condition of tests. Higher softening point is generally preferred in warm climate, whereas lower the softening point lower will be preferred in cold climate.

As per IRC recommendation the softening point of bitumen is 50^0C.

The following result is shown in Table 3 and Figure 7.

Table 3 Observations for tests on bitumen

% of bitumen	% of polymer	Softening point
100	0	50
95	5	52
90	10	60
85	15	62

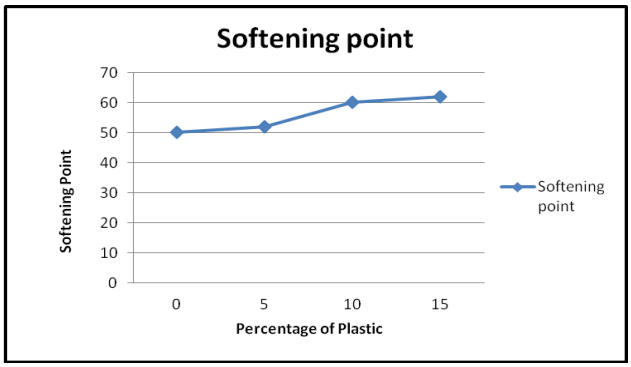

Figure 7 Variations in Softening Point of Bitumen with Increase in percentage of plastic

PENETRATION TEST (IS: 1203-1978)

The penetration test is carried out to know the hardness or softness of bitumen used in road construction by measuring the distance to which the needle penetrates. Samples having different percentage of plastic waste in bitumen is prepared and their penetration values are determined as per IS code .The penetration values of the blends are decreasing depending upon the percentage of polymer added.

As per IRC recommendation the penetration values of Bitumen is from 20-225 mm. The following results of penetration test are shown in Table 4 and Figure 8.

Table 4 Observation for the penetration test

% of bitumen	% of polymer	Penetration value in mm
100	0	70
95	5	68
90	10	67
85	15	64

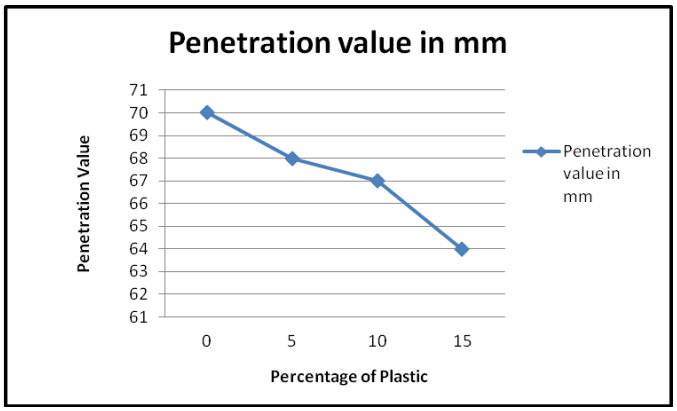

Figure 8 Variations in Penetration Value of Bitumen with Increase in percentage of plastic

DUCTILITY TEST (IS: 1208-1978)

This test is done to determine the ductility of bitumen. The principle of this test is that: the ductility of a bituminous material is measured by distance in cm to which it will elongate before breaking.

The following results of ductility test are shown in Table 5 and Figure 9.

Table 5 Observation for the ductility test

% of bitumen	% of polymer	Ductility value
100	0	83
95	5	68
90	10	57
85	15	52

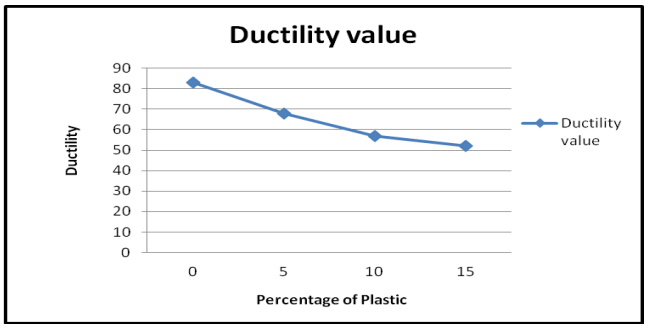

Figure 9 Variation in Ductility of Bitumen with increase In percentage of plastic

Marshal Stability Test

In marshal stability test, the deformation of specimen of bituminous mixture is measured when the same load is applied. This test procedure is used in designing and evaluating bituminous paving mixes. The marshal stability of mix is defined as a maximum load carried by a compacted specimen.

The following results of Marshal Stability test are shown in Table 6 and Figure 10

Table 6 Observation for the Marshal Stability

Sr No	Plastic Added (%)	Stability (kg)
1	0	1010
2	5	1680
3	10	1957
4	15	1181.23

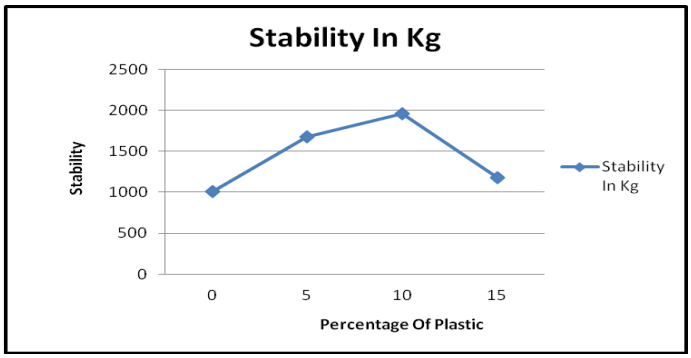

Figure 10 Variation in Stability of Bitumen with increase In percentage of plastic

V CONCLUSION

- It shows that with the increase of waste plastic in bitumen increases the properties of aggregate and bitumen.
- Use of waste plastic in flexible pavements shows good result when compared with conventional flexible pavements.
- The optimum use of plastic can be done up to 10%, based on Marshal Stability test.
- This has added more value in minimizing the disposal of plastic waste as an eco-friendly technique.
- Coating of polymer on the surface of the aggregate has resulted in many advantages, which ultimately helps to improve the quality of flexible pavement.

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BIOGRAPHIES

Miss. NEHA.B.SASANE
B.E. (K.I.T College, Kolhapur), Pursuing M. E. in Construction and Management, (RMD Sinhgad School of Engineering, Warje, Pune)

Dr. JALINDAR R. PATIL
B.E., M.E., Ph.D. (Engg.: Civil-Geotechnical, National Institute of Technology, Warangal), MISSMGE, FIGS, MIRC, MISTE, MISRMTT, Professor of Civil Engineering, RMD Sinhgad School of Engineering, S.No.111/1, Warje, PUNE, 411058 M.S. INDIA, Teaching and Administrative Experience of 24 years and 3.5 years of experience of Research, Published more than 35 international/national papers in journal and conference, Received 3 merits and awards at national level.

Mr. HARISH GAIKWAD
B.E. (civil), PG Scholar in Construction and Management, (RMD Sinhgad School of Engineering, Warje, Pune)

Dr. S D Khandekar
Professor, Head of department , Department of Civil Engineering, SKN Nahare college of engineering, Pune (Maharashtra, India),

