International Journal of Advance Research in Science and Engineering
Volume No 06, Special Issue No. (02), September 2017, ICITTESE-17
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

STUDY ON UTILIZATION OF PLASTIC WASTE IN BITUMINOUS CONSTRUCTION MIXES

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ABSTRACT

The use of plastic bottle increasing rapidly and disposal of waste plastic bottle has become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. Utilization of waste plastic in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems. This study project has been developed to discuss in detail as how the plastic waste can be handled and used successfully in the construction of roads thus mitigating the environmental problems and economize the cost of construction of road with in the country.

The aim of this study is to reduce the waste plastic material and reuse in flexible road construction. These plastic wastes are used in bitumen as a modifier. In the study laboratory test result show the improvement in engineering property like Penetration value, Ductility test, Flash point test, and Softening point test, Marshall Stability test of modified bituminous mixes for different percentage of plastic i.e. 8%, 12%, and 16% of plastic mix as compared to unmodified mix.

Keywords: - Aggregates, Bitumen, Shredded Plastic.

I. INTRODUCTION

Plastic is a very versatile material. Due to the industrial revolution, and its large scale production plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, electronics, building construction, communication sector has been virtually revolutionized by the application of plastic. Plastic is a non-biodegradable material and researchers found that the material can remain on earth for 4500 years without degradation.

The growth in various types of industries together with population growth has resulted in an enormous increase in production of various types of waste material world over. The creation and disposal of non-biodegradable waste material such as Plastic, Blast furnace, Fly ash, Steel Slag, Scrap Tires etc. have been posing problems in the developed countries. Plastic is everywhere in today's lifestyle. Use this non-biodegradable product is growing rapidly and creating the problem its disposal.

Disposal of plastic waste particularly plastic bags are become a serious problem, especially in urban area, in terms of its issue its dumping in the dustbins clogging of drains reduced soil fertility and aesthetic problems etc.

In general there are two types of road rigid pavement roads and flexible pavement roads. For rigid roads material used in concrete and for flexible roads bitumen is used. In India mostly the flexible pavements roads are available. And for economical road construction new techniques, new material is used. Any improvement in the property of the binders is needed. Bitumen is a useful binder for road construction. Different grades of

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

bitumen like 30/40, 60/70 and 80/100 are available on the basis of their penetration values. The steady increases in high traffic intensity in terms of commercial. Any improvement in the property of binder is the needed.

Table1.1 : Plastic Consumption in India

Year	Consumption (Tones)
1996	61000
2001	400000
2006	700000
2011	13500000
2015	21600000

In India 60 cities generate over 15000 tones of plastic per day According to report ***Source: - Times of india.indiatimes.com Year 2015 (April – May)***

II. LITERATURE REVIEW

The polymer bitumen blend is a better binder compare to plain bitumen. Blend has increased softening point and decreased penetration value with a suitable ductility. When it is used for road construction it can withstand higher temperature and load the coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate mix shows higher Marshal stability value and suitable marshal coefficient Hence the use of waste plastic for the flexible pavement is one of the best method of easy disposal of waste plastic. Use of plastic bags in road helps in many ways like easy disposal of waste, better road prevention of pollution and so on. [11

Various additive like polymers and fibers have been utilized for purpose of improving the high and low temperature characteristics of bitumen composition, as well as to improve their toughness and durability Additives such as styrene based polymers, polyethylene based polymers gilsonite, various oils, and many other modifiers including tall oil have been added to bitumen to enhance various engineering properties of bitumen. [4]

Some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mix of road pavement. (Waste plastics polythene carries bags, etc.) on heating soften around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in temperature range of 130-180°C. Softened plastics have binding a property. Hence it can be used for road construction. [11]

In earlier studied the effective blending technique for use plastic waste into bitumen for road laying and polymer bitumen mixture of different composition were prepared and use for carrying out various tests. [11]

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ISSN (P) 2319 - 8346

The polymer bitumen blend is a better binder compare to the plain bitumen. Blend has increase softening point and decreased the penetration value with a suitable ductility. [10] In investigation concluded that the mix prepared with modifiers shows higher resistance to permanent deformation at higher temperature. [11]

The laboratory studies conducted by CRRI in Utilization of waste plastic bags in bituminous concrete mixes have proved that these enhance the properties of mix in addition to solving disposal problem. The indicated that there was an improvement in strength properties when compared to a conventional mix. There for, the life pavement surfacing using the plastic waste is expected to increase substantially in comparison to the use of conventional bitumen mix.

III. METHODOLOGY

Waste plastic bags were collected from roads, garbage truck, dumpsite and compost plant rag pickers, and waste-buyers. Household plastic was also collected for the project work. The collected plastic waste was shorted as per the required as per the required thickness. Less micron plastic is easily mixable in the bitumen at higher temperature (160°C-170°C). it is clean by de dusting or washing if required. Collected plastic piece were sieve through 4.75mm sieve and retaining at 2.36mm sieve was collected. Firstly Bitumen was heated up to temperature about 160°C-170°C which is melting temperature. Pieces were added slowly to the hot bitumen of temperature around 160°C-170°C. The mixture was stirred manually for about 20-30 minute in that time period temperature was kept constant about 160°C-170°C. polymer bitumen mixture were prepared and use for carrying out test i.e. Penetration test, Flash and Fire test, Ring and Ball value test and Marshall Stability test. [11]

3.1 Tests conducted on bitumen

Following test conducted on bitumen i.e.

- Penetration test
- Ductility test
- Softening point of bitumen
- Flash and fire point of bitumen
- Marshall stability test

3.1.1 MARSHALL STABILITY TEST-

Marshall Method of mix design

The mix design should aim at an economical blend, with proper gradation of aggregates and adequate proportion of bitumen so as to fulfill the desired properties of mix. Proportioning of aggregates

20mm =20%= 228gm
10mm= 30%=342gm
6mm= 20%=342gm
Dust= 20%= 228gm
= 100%=1160gm

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The final gradation of the cold gravel mix with the requirement of (ministry of surface transport) is shown in table 3.1

Sieve size	% of passing				Blending all in aggregate					Limit specification	
	20mm	10mm	6mm	S/Dust	20% 20mm	30% 10mm	30% 6mm	20% S/Dust	Blending %of passing		
26.5	100	100	100	100	20	30	30	20	100	100	100
19.0	78.56	100	100	100	15.71	30	30	20	95.71	90	100
9.5	2.20	38.60	100	100	0.44	11.58	30	20	62.02	60	80
4.75	0.32	0.38	81.47	99.5	0.06	0.11	24.44	19.9	52.61	35	65
2.36	0	0.26	62.37	90.25	0	0.08	18.71	18.05	36.84	20	50
0.30	0	0.12	10.77	52.25	0	0.04	3.23	10.45	13.72	3	20
0.075	0	0	1.70	11.20	0	0	0.51	2.24	2.75	2	8

Bitumen aggregate mixes for different percentage of plastic shown in fig

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ISSN (O) 2319 - 8354
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aBitumen mix with Marshall Stability is shown in table 3.2

S.No.	Type of mix	Load in KN	Stability in Kg	Correlation factor	Corrected stability	Flow value in mm
1	8% of plastic mix	195	1177.6	1.04	1224.70	5
2		240	1449.3	1.09	1579.74	6
3		200	1207.8	1.09	1316.50	5
4	12% of plastic mix	215	1298.38	1.04	1350.32	4
5		210	1268.19	1.00	1268.19	5
6		225	1358.77	1.04	1413.12	5
7	16% of plastic mix	175	1058	1.04	1099	4
8		165	996.43	1.0	996.43	4
9		185	1117.2	1.04	1161.90	5

IV. RESULT AND DISCUSSION

On the basis of experimental process bitumen and plastic modified mix for different percentage of plastic had prepared and various tests performed and results are obtained. These data help in understanding the utilize the suitable percentage of plastic to be used in bitumen.

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Table 4.1 show the Comparison of modified bitumen of grade 60/70 and plain bitumen of grade 60/70

S.No.	Test Conducted	Modified bitumen of grade 60/70 with different percent of plastic mix			Permissible limit of plain bitumen of grade 60/70	Test Method
		8% plastic	12%plastic	16%plastic		
1	Penetration value	68mm	61mm	55mm	60-70mm	IS 1203:1978
2	Ductility test	98.5mm	83mm	75mm	100mm	IS 1208:1978
3	Softening point	49°C	52°C	57°C	48-56°C	IS1205:1978
4	Flash and Fire Point	260°C	243°C	230°C	250min	IS1209:1978

4.2 Graphical analysis and Discussion

4.2.1 Penetration value

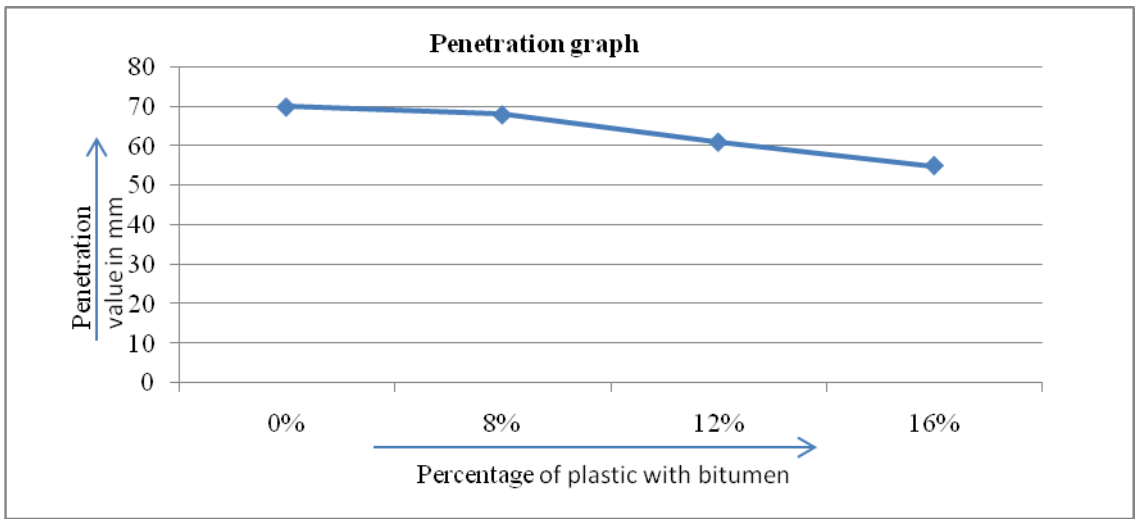

Fig 4.2.1

As above shown in Fig 4.2.1 show that the various percentage of plastic mixed with bitumen to the softening point of bitumen. Graph show the percentage of plastic increase in bitumen then penetration value decrease which show this show that the addition of polymer increase the hardness of bitumen. There is a significant decrease in penetration value for modified bitumen indicating the improvement in their temperature susceptibility resistance characteristics and hot climate lower penetration grade bitumen is preferred.

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4.2.2 Ductility value

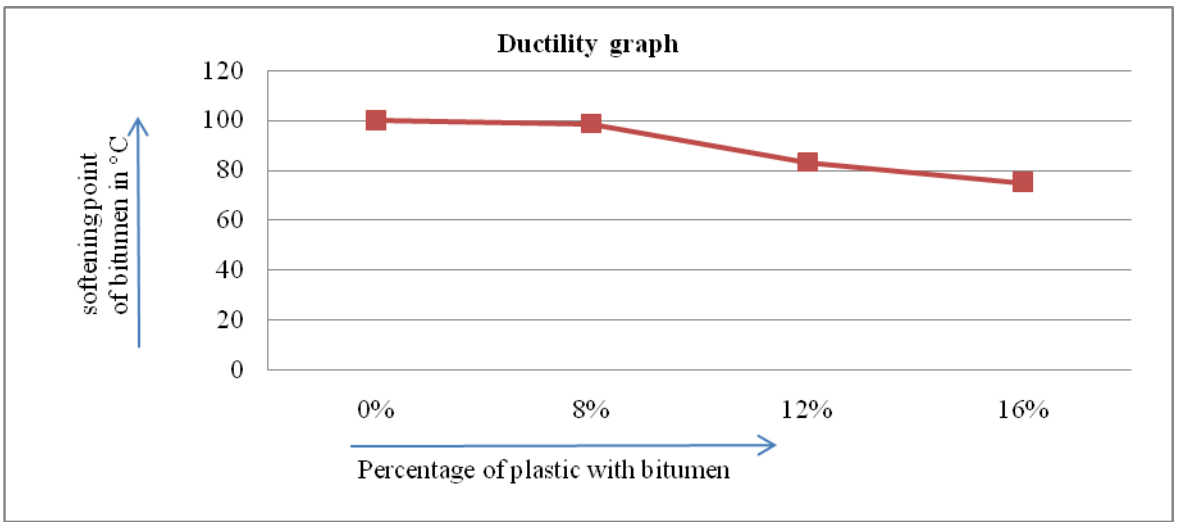

Fig 4.2.2

As above shown in Fig 4.2.2 that ductility value of various percentage of plastic mixed with bitumen. Ductility graph show the decrease in ductility value when the addition of plastic waste in bitumen. The decrease in ductility value may be due to interlocking of polymer molecules with bitumen. The ductility value less then 50 mm should not be used in road construction but may be used as crack and joint filler material.

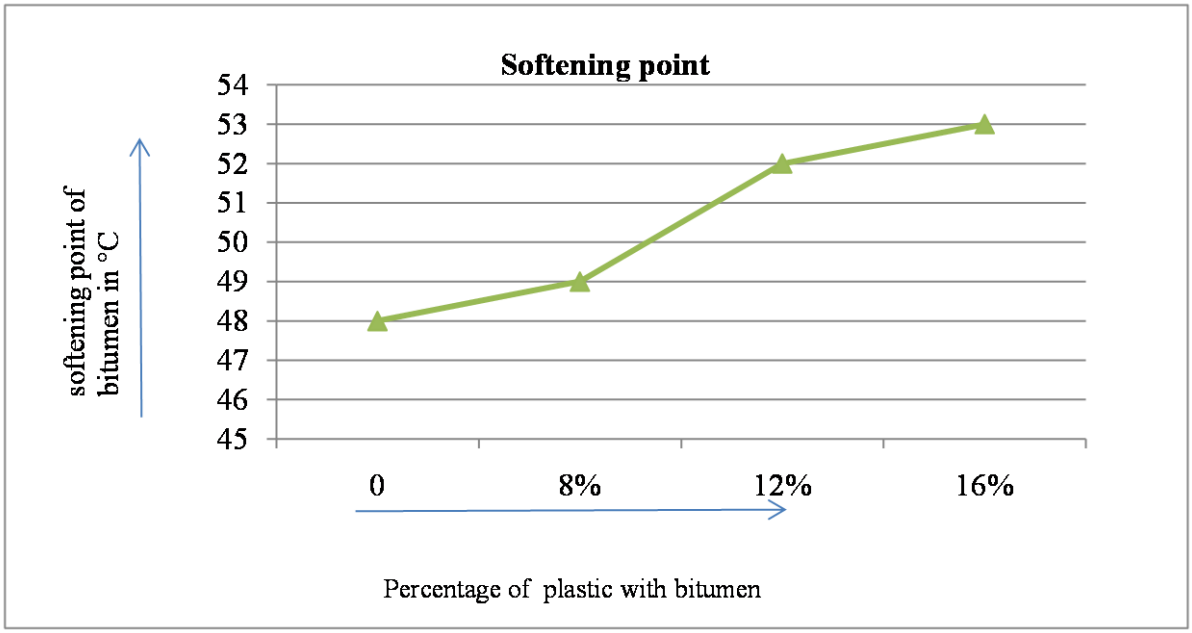

Fig 4.2.

4.2.3 Softening point of bitumen

Graph show the percentage of plastic with bitumen and softening point of bitumen. The softening point increase with the addition of waste plastic to the bitumen. Higher the Percentage of plastic waste added higher in softening point. The influence over the softening point may be due to chemical nature of polymer added. The

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

increase in softening point shows that there will be less bleeding during summer. Bleeding accounts increased friction for the moving vehicles which can be safe by the increasing in softening point of bitumen.

4.2.4 Flash point of Bitumen

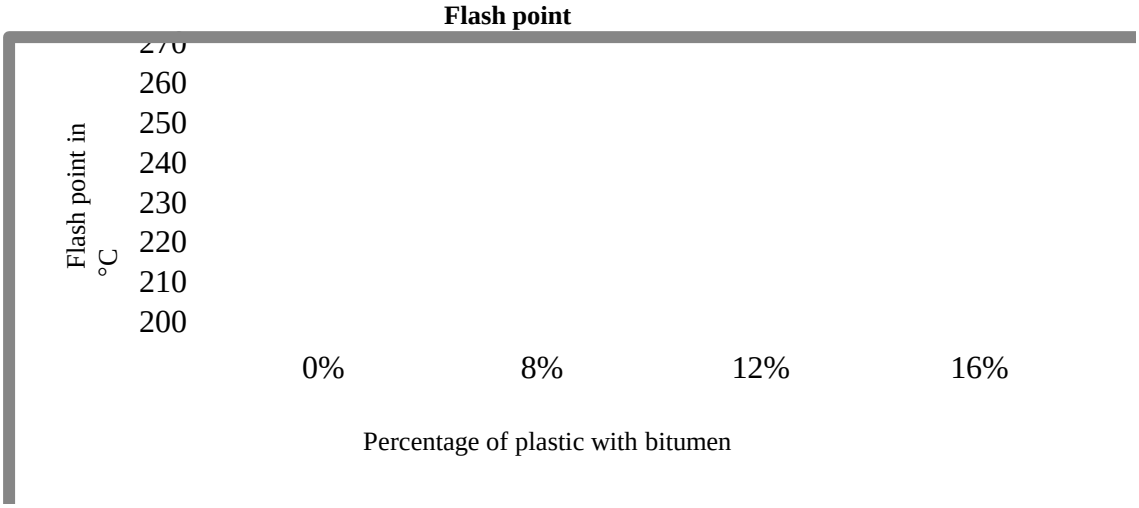

Fig 4.2.4.

Flash and fire point decrease with the increase in percentage plastic with the bitumen which show the higher flash point bitumen can be used in colder climate

4.2.5 Marshall Stability graph

Marshall Stability value for different percentage of plastic mix shown in fig 4.2.5

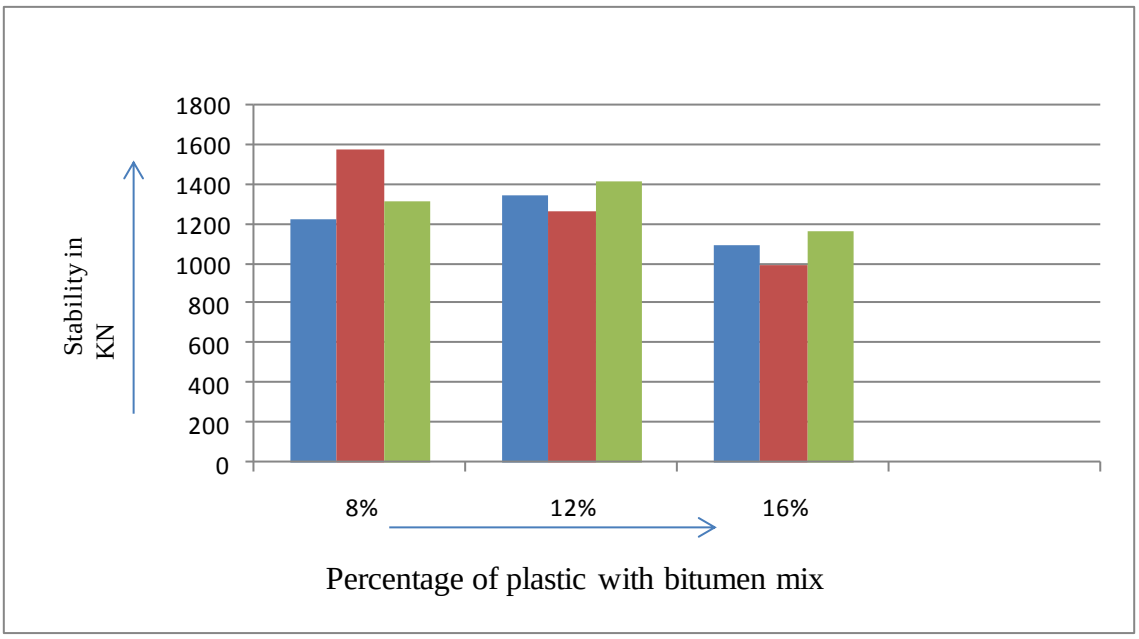

Fig 4.2.5

Show the stability value decrease when the addition of plastic percentage increases. Graph show the 8% to 12% percent of plastic show the suitable stability so that 8 to 12% percentage of plastic waste can be use in flexible road construction.

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V.ECONOMY SIMPLIFICATIONS:-

Cost comparison for 1 m^3 for plain bitumen road and plastic modified bitumen road.

Cost of bitumen of Grade 60/70 = 35000/tone

Cost of shredded plastic waste = 25000/tone

Note: - Shredded waste plastic vary from non organized sector hence rate of shredded not specified and rate vary 25 to 35 Rs/kg.

Density of bitumen ρ = (960 to 1020 kg/m³)

Source: - online pubs.trb.org/…

ρ = M/V

M = 1020 x 1 = 1020kg

Let Assume density of bitumen is 1000 kg/m³

8 to 12% plastic can be replace in bitumen

(Let take 12% plastic can be replace in bitumen)

For 1 m³ of road surface

1000 x 12% = 120 kg plastic can replaced in bitumen

Cost comparison for plain bitumen of grade 60/70 and plastic modified bitumen for 1m³ is shown below in table 5.1:-

Plain bitumen of grade 60/70		Plastic modified bitumen of grade 60/70	
Quantity	Rate	Quantity	Rate
1 tone = 1000kg	1000 x 35 = 35000/-	1 tone = 1000 x 12% = 880 kg bitumen = 120 kg plastic	880 x 35 = 30800/- 120 x 25 = 3000/-
	Total = 35000/-		Total = 33800/-
			Cost of saving = 1200/-

In the cost simplification 1200/- rupee were saved for 1m³ and much higher percentage of plastic were utilize in bitumen. Hence the process is cheap and eco-friendly.

VI. CONCLUSION

After conduction of various test conducted of bitumen mix 8%, 12% and 16% in laboratory, the results were found which is discussed below

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

- Penetration values were obtained 68, 61, and 55 of 8%, 12% and 16% of plastic mix in bitumen. The standard Penetration value of bitumen of grade 60/70 lies between 60/70 mm , so the results of 8% and 12% bitumen mix is the comparable value of pure bitumen
- Ductility values were obtained 98.5, 83 mm, 75 mm of 8%, 12% and 16% of plastic mix in bitumen. Whereas the ductility of pure bitumen of grade 60/70 lies about 100mm (max) so the suitable value by the ductility test is near about 98.5mm and 83mm. So the ductility value are within limits up to 8 to 12% are satisfactory in bitumen mix.
- . In laboratory investigation flash point were obtained for 8%, 12% and 16% of plastic mix in bitumen respectively 260°C, 243°C and 230°C and the permissible value of flash point is 250°C. In the result obtained 8% plastic mix bitumen giving satisfactory result and relevant to pure bitumen.
- Softening point result were obtained 49°C, 52°C and 57°C for different 8%, 12% and 16% of plastic mix and permissible limit of softening point is up to 48°C-56°C for pure bitumen, which show the 8% to 12% of plastic can be safely utilize for flexible road construction.
- Marshall Stability average value of 3 trial found for aggregate, bitumen plastic mix of 8%, 12% and 16% was 1373.65kg, 1343.88kg and 1085kg and in 1st trial (2nd specimen) has got 1579.4 kg which is much higher than the permissible value. As per the economic evaluation for 12% plastic mix in bitumen for 1m^3 of road construction is 33800/- and cost of pure bitumen of grade 60/70 is 35000/- which is higher than the plastic modified bitumen. After considering as above test result the 8% and 12% plastic waste mix in bitumen were found near to pure bitumen grade 60-70 as per the Indian standard specification which are commonly use for flexible road construction.

Future scope of the study

This study will be conducted to explore the idea about use of waste material in bituminous concrete with detailed laboratory investigation will be carry out to find whether it is viable to use or not in term of suitability, economically and environmentally.

The present study will focus basically on these following points:

1.To study the effect on Penetration, Ductility, Softening point and Flash point and Marshall Stability of bituminous mix with the addition of waste plastic.

2. To reduce the bitumen content by the addition of waste plastic in bituminous mix.

3. To reduce the cost of bituminous road and utilize the plastic waste in bituminous mix.

The laboratory investigation on the bituminous mix has been carried out as per the Indian standard used for road construction which is satisfied.

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