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Experimental Investigation on Properties of Bitumen with addition of Plastic waste

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Abstract: In present days, disposal of solid waste is one of the problems that create nuisance to the environment. So there is a need to manage the disposal of solid waste .The solid waste can be managed & reduced by recovery, recycling & reuse. Out of which, recycling & reuse is a better method for managing the disposal of solid waste. With increased urban and industrial developments large quantities of wastes are being generated worldwide. The disposal of these wastes in landfills is not a sustainable solution for country like India due to limited land space. The solid waste can be mainly classified into two types such as organic and inorganic waste. Inorganic waste like plastic that has been used previously as mineral water bottles, pipes, electrical fittings etc…are biologically non degradable & posed an ominous environmental problems. But molten plastic has a binding property which can be reused with bitumen to reduce the cost of bitumen. At the same time, recycling of plastic waste saves disposal sites. The main objective of doing this experiment is to replace the molten waste plastic at different proportions by the weight of bitumen and checking the properties of bitumen with that of modified bitumen. On doing our experimentation with Polystyrene (PS) waste, we came to understand that the test results obtained followed the same pattern of the results when compared with other research works which utilised PP, PE and PVC.

Key words: polystyrene (PS), Bitumen, waste reduction.

1. Introduction

Environment means surroundings, which includes atmosphere, lithosphere and biosphere. Biosphere comprises of living and non-living organisms and it is affected by different types of pollution. Mainly pollution is due to releasing of contaminated water into the water bodies, emission of effluents into the air and disposal of solid waste. In present days, disposal of solid waste is one of the problems that create nuisance to the environment. There are two types of solid wastes which are bio-degradable and non bio-degradable. Bio-degradable wastes are the wastes which are decomposed in soil. The term "non bio-degradable" indicates that the wastes mixed with the soil remain un-disintegrated for many years that may pose environmental engineers a big challenge for the safe disposal of inorganic wastes.

Dealing with the inorganic wastes, the major problem is disposal of Plastic waste. From the past few years, plastic has become one of the regular needy items in our daily life. One can't avoid using plastic, so it is responsible to take care of its disposal difficulties. The disposal problems can be overcome by recovery, recycling & reuse.

Theory Of Plastics:

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow, is called as 'Plastic'. Plastics are durable and degrade very slowly. The chemical bonds that make plastic so durable make it equally resistant to natural processes of degradation. Plastics can be divided into two major categories such as Thermosets and Thermoplastics. A Thermoset solidifies or "sets" irreversibly when heated. They are useful for their durability and strength, and are therefore used primarily in automobiles and construction applications. These plastics are polyethylene, polypropylene, polyamide, polyoxymethylene, polytetrafluorethylene, and polyethyleneterephthalate. A Thermoplastic softens when exposed to heat and returns to original condition at room temperature. Thermoplastics can easily be shaped and moulded into products such as milk jugs, floor coverings, credit cards, and carpet fibers. These plastic types are known as phenolic, melamine, unsaturated polyester, epoxy resin, silicone, and polyurethane. The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time (Khan and Gundaliya, 2012). Waste plastic

such as carry bags, disposable cups and laminated pouches like chips, pan masala, aluminum foil and packaging material used for biscuits, chocolates and milk and grocery items can be used for surfacing roads. Use of plastic along with the bitumen in construction of roads not only increases its life and smoothness but also makes it economically sound and environment friendly. Plastic waste is used as modifier of bitumen to improve some of bitumen properties. Roads that are constructed using plastic waste are known as Plastic Roads and are found to perform better compared to those constructed with conventional bitumen. Further it has been found that such roads were not subjected to stripping when come in contact with water. Use of higher percentage of plastic waste reduces the need of bitumen by 10% (Bindu and Beena, 2010). It also increases the strength and performance of the road. Plastic increases the melting point of bitumen and hence mixing can be done in more better and easier way. Plastic waste replaces 10% to 15% of bitumen, and thereby saves approximately Rs.35000 to Rs.45000 per kilometer of a road stretch (Dr.R.Vasudevan, 2007). Inclusion of plastic waste in road construction eliminates the plastic shrinkage cracking of road surface and reduces the drying shrinkage to some extent.

Aim and Objective of the Project

Aim:

- The aim of this research is to investigate the possibility to reuse Waste Plastic in Bitumen.
- Comparing the properties of conventional bitumen with that of modified bitumen.

Objective:

- Study the effect of adding different percentages of Plastic waste proportionate to the weight of bitumen on the properties of traditional bitumen, comparing it with polymer modified properties.
- Identify the optimum percent of plastic waste to be added to the bitumen for any construction activities.

2. Materials:

The main categories of Plastics include;

a. Recyclable Plastics (Thermoplastics): PET, HDPE, LDPE, PP, PVC, PS, etc.

b. Non Recyclable Plastics (Thermosets & others): Multilayer & Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon, etc.

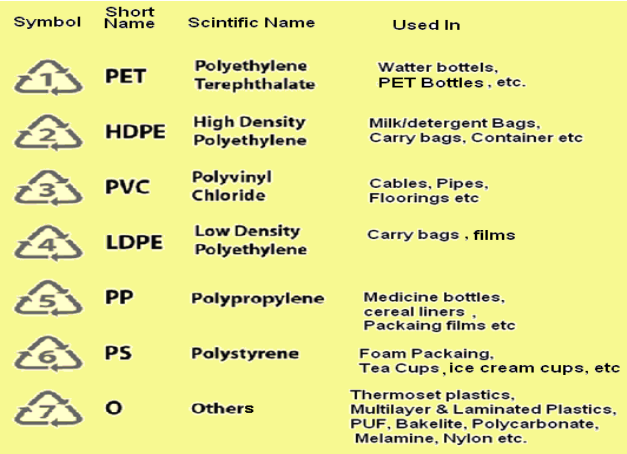

Fig 1. Various types of plastics and their uses

Sources of Materials Used:

a. Plastic Waste of Type Polystyrene (Ps):

There are many categories of plastic polymers like Polyethyleneteryphthalate (PET), Polypropylene (PP), PolyvinylAcetate (PVA), Polyvinyl Chloride (PVC), Polystyrene (PS), Polyethylene (PE), etc. Out of which our project work utilizes Polystyrene. The Polystyrene waste was taken from a plastic industry located in ChinnaErikapaduvillage near Gudivada.

Polystyrene is a synthetic aromatic polymer made from the monomer styrene. Polystyrene can be solid foamed which is clear, hard, and rather brittle. Polystyrene is in a solid state at room temperature but flows if heated above about 100◦C, it becomes rigid again when cooled and is very slow to biodegrade and is therefore a focus of controversy. It is often abundant as a form of litter in the outdoor environment, particularly along shores and waterways, especially in its foam form.

b. Bitumen

Bitumen is used as binders in pavements constructions and it may be derived from the residue left by the refinery from naturally occurring asphalt which may be in gaseous, liquid, semi-solid or solid, and which are completely soluble in carbon disulphide. When petroleum crude is refined in a refinery, they are separated by fractional distillation in the order of decreasing volatility. On distillation of the residual bituminous residue, straight-run bitumen is obtained. This bitumen is known aspenetration grade bitumen or steam refined petroleum bitumen.

The grades of bitumen used for pavement construction is known as paving grades. The grade of straight run bitumen is chosen depending upon the climatic conditions of the region in which surface dressing is to be constructed. In most parts of India 80/100 and 180/200 grades bitumen is used. As per PMC, the bitumen content in a mix should be 4% of weight by total mix for B.M. For Carrying out our experimentation, Bitumen was brought from a bitumen mixing plant in Addada, a village 7 km away from Gudlavalleru. After conducting penetration test on pure bitumen, it was clear that the grade of the bitumen is 60/70.

3. Experimentation On Bitumen

3.1 Penetration Test: [IS: 1203-1978]

It is measured using Penetrometer. The penetration of a bituminous material is the distance in tenths of a millimeter, which a standard needle would penetrate vertically, into a sample of the material under standard conditions of temperature, load and time.

Table 1. Bitumen Penetration Test Results

S. No	% of Plastic	Penetration Reading(mm)			
		Reading 1	Reading 2	Reading 3	Average value
1	0	6.6	7.2	6.2	6.67
2	2	5.9	6.6	5.4	5.97
3	4	5.3	4.9	5.8	5.35
4	6	5.2	4.0	4.1	4.53
5	8	3.4	4.6	3.9	3.95
6	10	3.2	3.8	3.5	3.50
7	12	2.6	2.9	3.2	2.90

3.2 Ductility Test [IS: 1208-1978]

The ductility of a bituminous material is measured by the distance in cm to which it will elongate before breaking when a standard briquette specimen of the material is pulled apart at a specified speed and a specified temperature.

Table 2. Bitumen Ductility Test Results

S. No	%of Plastic	Ductility Reading(cm)		
		Initial	Final	Reading
1	0	0	64	64
2	2	0	56	56
3	4	0	47	47
4	6	0	40	40
5	8	0	34	34
6	10	0	25	25
7	12	0	18	18

3.3 Softening Point Test [IS: 1205-1978]

This test is conducted using Ring and ball apparatus. The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test.

Table 3. Softening Test Results

S. No	% of Plastic	Softening Point(^{o}C)
1	0	53.7
2	2	56.2
3	4	57.8
4	6	59
5	8	61.3
6	10	64.4
7	12	66.7

3.4 Flash & Fire Point Test [IS: 1209 - 1978]

In the interest of safety, legislation has been introduced in most countries fixing minimum flash point limits to prevent the inclusion of highly inflammable volatile fractions in kerosene distillates.

Table 4. Flash and Fire Point Test Results

S. No	% of Plastic	Flash Point(^{o}C)	Fire Point(^{o}C)
1	0	192	213
2	2	201	221
3	4	207	230
4	6	215	239
5	8	221	247
6	10	230	252
7	12	237	260

4. Results and discussion:

Then, the comparison of the test results for standard bitumen and modified bitumen were illustrated below.

4.1.Comparison of Penetration Test Results

It is measured using Penetrometer. The penetration of a bituminous material is the distance in tenths of a millimetre, which a standard needle would penetrate vertically, into a sample of the material under standard conditions of temperature, load and time.

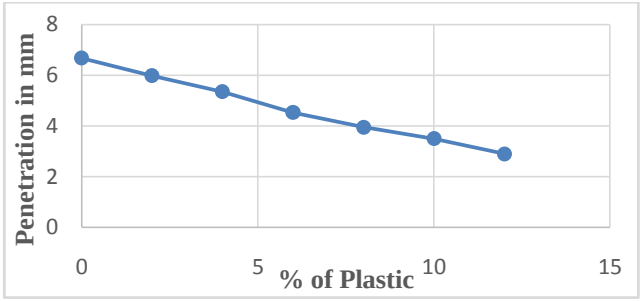

Fig 2. Variation in Penetration with % of Plastic

Penetration values in mm were taken on Y- axis & the percentages of plastic waste added were taken on X-axis. A graph was drawn for these two constraints, then a falling graph indicating the decreasing penetration values was observed.

4.2 Comparison of Ductility Test Results

The ductility of a bituminous material is measured by the distance in cm to which it will elongate before breaking when a standard briquette specimen of the material is pulled apart at a specified speed and a specified temperature.

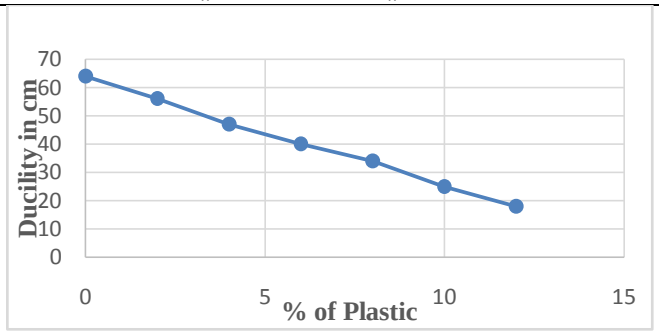

Fig 3. Variation in Ductility with % of Plastic

Ductility values in mm were taken on Y- axis & the percentages of plastic waste added were taken on X-axis. A graph was drawn for these two constraints, and then a falling graph indicating the decreasing ductility values was observed.

4.3 Comparison of Softening Point Test Results

This test is conducted using Ring and ball apparatus. The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test.

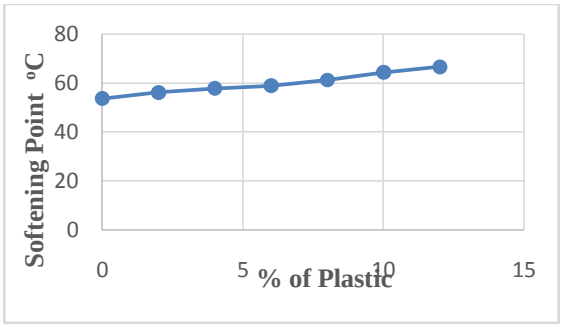

Fig 4. Variation in Softening point with % of Plastic

Softening Point values in mm were taken on Y- axis & the percentages of plastic waste added were taken on X-axis. A graph was drawn for these two constraints, and then a rising graph indicating the increasing softening point values was observed.

4.4 Comparison of Flash & Fire Point Test Results

In the interest of safety, legislation has been introduced in most countries fixing minimum flash point limits to prevent the inclusion of highly inflammable volatile fractions in kerosene.

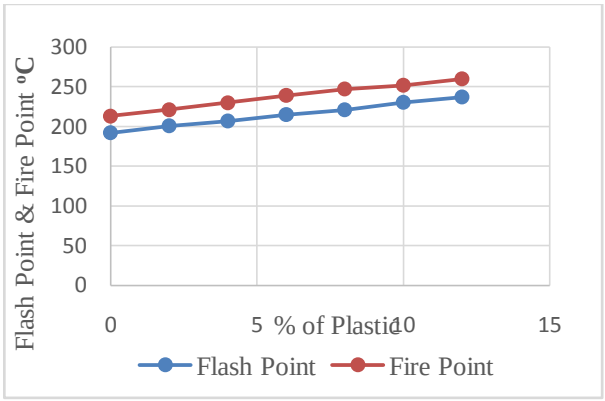

Fig 5. Variation in Flash Point & Fire Point with % of Plastic

Flash Point and Fire point values in ^{0}C were taken on Y- axis and the percentages of plastic waste added were taken on X-axis. A graph was drawn for these two constraints, and then a rising graph indicating the increasing Flash point values was observed distillates.

The investigation on the properties of the modified bitumen with that of conventional bitumen was evaluated above. Several tests were conducted like Penetration Test, Ductility Test, Softening Point Test and Flash & Fire Point Tests. The detailed summary of the work is illustrated with Figures given below.

Summary

The results indicate that waste plastic is effective in improving the properties of asphalt cement. It can be seen that there is an increase in softening point and decrease in penetration and ductility values. Though using polystyrene is for the first time, the results we obtained are in same pattern with the results given when using PP, LDPE, HDPE and PVC. So there is scope for further study in this aspect.

5. Conclusions

On conducting the above tests on bitumen, we can conclude the following points:

- There is a considerable downfall in Penetration values and also bitumen Ductility values. The values conveying that the modified bitumen becomes harder when we increase the content of the plastic, conveying that the modified bitumen becomes harder when we increase the content of the plastic.
- In Softening Point test, there is an increase in the temperature with increasing percentage of plastic. The values indicate that the heat resistance of the bitumen is improved.
- As bitumen is visco-elastic material, the increase in temperature resistance of bitumen is an added advantage which is very much useful in dry weather climatic nation like India.
- The roads built of conventional bitumen may have their life time of four to five years.
- But the roads laid using Modified bitumen would have the life time of nearly ten years.

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