Waste Plastic Usage to Improve Properties of Bitumen in Road Construction

Manoj Kumar Verma[1] Prof. Rajesh Joshi[2]
[1]M. Tech Scholar [2]Head of Department
[1,2]Department of Civil Engineering
[1,2]RGPM College Bhopal, India

Abstract— In the road construction various types of materials and design methods are used, for the reduction of environmental pollution, use of plastic waste in road construction is one of them. Since the plastic waste material is non-biodegradable, the use of plastic waste material in road construction can help us to reduce the plastic waste pollution to some extent. A lot of research is going on all over the country to solve the problems which are related to the road construction. The plastic waste (Low density polymer) in bitumen helps in increasing life of flexible pavement. Generally life of flexible pavement is 4 to 5years, while it is claimed that the plastic waste bitumen roads can last up to 10 years. In this study, I have compare the results of normal bitumen and plastic waste (LDP) mix bitumen, to get the idea of how much percentage of plastic waste can be added in bitumen with respect to the weight of bitumen for the optimum performance of mix. Results shows that as the percentage of plastic waste (LDP) is increased at 1.0%,3.0%,6.0% and 9.0% with respect to the weight of bitumen, the softening point bitumen plastic waste (LDP) mix increases, flash and fire point increases, penetration value decreases and ductility value decreases. Marshall Stability of dense bituminous mix at 1.0%, 3.0%, 6.0% and 9.0% of plastic waste (LDP), the flow value of mix decreases and the stability increases therefore; the optimum percentage of plastic waste (LDP) to get the desirable result is 3%.

Key words: LDP, Marshall Stability, non-biodegradable, flexible pavement

I. INTRODUCTION

In our earth, there is different type of waste materials and plastic waste material is one of them. The municipal solid wastes which also constitute the waste plastic materials are of important concern. Therefore the proper utilization of plastic waste is the present need. And also on the other side, the road traffic is increasing so there is a need to increase the stability of the surface course of roads. The utilization of plastic waste covered aggregate for the flexible pavement permits the reuse of plastic waste. Plastics are used in various types of packing materials and it is also used in day to day products such as milk packets, bags, cups, etc, these all are made up of plastic materials. After usage of these materials, they are thrown into the dust bin and it gets transferred to the municipal solid waste. As these plastics pieces are non-biodegradable in nature, they causes problems to the environment. In India consumption of plastic products are increasing day by day and the plastic waste which gets mixed with the domestic waste makes the disposal of municipal solid waste difficult. There are two methods to dispose municipal solid waste: 1) By burning the municipal solid waste 2) By land filled.

In the burning process of municipal solid waste cause's air pollution and the plastic waste which are burned produces harmful toxic gases like dioxins, nitrogen dioxide, sulfur dioxide, etc.

By utilization of the plastic waste in the flexible pavement, we can have eco-friendly constructions of roads and it can decrease the amount of plastic waste up to certain extent.

II. OBJECTIVES

- The purpose is to study the properties of bitumen sample with varying percentage of plastic waste (low density polythene) added with respect to the weight of bitumen.
- To determine the optimum percentage of the plastic waste (low density polythene) which can be added in the bitumen sample so as to enhance its property and adequate use of plastic waste (low density polythene) can help in sustainable growth and increase the life of flexible pavement.

III. METHODOLOGY

1) Chapter 1: Abstract.
2) Chapter 2: Review to the literature work.
3) Chapter 3: Experimental analysis to determine the various physical and engineering properties of bitumen and to determine the optimum percentage of plastic waste (LDP) which can be added in bitumen with respect to the weight of bitumen.
4) Chapter 4: Results analysis.
5) Chapter 5: conclusion.

IV. LITERATURE REVIEW

According to Sangita, Gupta Reena, KaurVerinder (2011): The main focus of this paper is to review and discuss plastic as packaging material and the feasibility and hurdles of incorporating postconsumer plastic waste in urban and rural areas. Already developed technologies on utilization of waste plastic for construction of roads in four metros (Bangaluru, Delhi, Bombay and Calcutta) are the basis of implementing these technologies in urban and rural areas. The findings elaborated in this paper can also serve as the base for the use of other wastes from the industry in road technology on which the research is already in progress.

According to AmitGawandea, G. Zamarea, V.C. Rengea, SaurabhTaydea, G. Bharsakale (2012): In the present paper developed techniques to use plastic waste for construction purpose of roads and flexible pavements has reviewed. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water.

According to SourabhAsange, Sanjeev Kumar Verma, Daya Shankar Pandey and PankajRathore (2012) This paper presents the use of waste Polythene carry bags in flexible pavement. Reclaimed polythene (PE) derived from low density polythene (LDPE) carry bags from kitchen waste and plastic bottles have been used as additive in flexible pavements. The investigation indicated that the use of PE/LDPE in asphalt pavements have shown to be advantageous in terms of improving certain characteristics of the pavement.

V. MATERIALS USED

A. Aggregate

Aggregate is a combined term for the mineral materials such as gravel and sand and crushed stone that are used with a binding medium (examples like water, bitumen, Portland cement, lime, etc.) to form a compound materials (such as bituminous concrete material and Portland cement concrete). By volume, aggregate normally accounts for 92 to 96 percent of Bituminous concrete and about 70 to 80 percent of Portland cement concrete. Coconut fiber ash.

B. Bitumen

Bituminous materials or asphalts are widely used for pavement construction, mainly because of their excellent binding properties and water proofing properties and comparatively low cost. Bituminous materials composed of bitumen which is a black coloured solid or viscous cementitious substances consists mostly high molecular weight hydrocarbons which are derived from distillation of petroleum or natural asphalt, has adhesive characteristics, and is soluble in carbon disulphide.

C. Plastics –

Low density polythene (LDP) Polyethylene is categorized by its density and branching. Its mechanical properties depend considerably on variables such as the range and type of branching, the crystal structure, and the molecular weight. Low-density polyethylene (LDPE/LDP) is a thermoplastic prepared from the monomer ethylene. It was the first grade of polyethylene, manufactured in 1933 by a Imperial Chemical Industries (ICI) using a high pressure procedure through free radical polymerization. Its manufacture works the same technique today. LDP have easily processed by most methods, Good chemical resistance, Moisture resistance, Low cost, low water absorption, very tough, weather-proof

VI. LABORATORY WORK

A. Softening Point Test on Bitumen

1) Bitumen is first heated to a temperature between 75to 100 degrees Celsius which is above the approximate softening point of bitumen until it becomes fluid.
2) Then the shredded plastic waste (LDP) is added to the hot bitumen sample in certain percentage with respect the weight to bitumen used and stirring is done until plastic waste is homogenously mixed with the bitumen sample and then it is poured into the rings which are placed on the metal plate.
3) To avoid the sticking of the bitumen sample to the metal plates, coating of grease are done.
4) After the rings are allowed cooling for 30 minute at room temperature and then excess of bitumen is then trimmed off using hot knife and then the rings are positioned on the supports.
5) The temperature of the distilled water in the glass cylindrical vessel is kept at 5 degree Celsius and temperature is maintained at 5 degree Celsius using cold water and ice cubes and this temperature is maintained at 5 degree Celsius for 15 minute before immersing the rings into the cylindrical vessel.
6) Now the temperature of the distilled water is raised at the rate of 5 degree Celsius per minute and continuous stirring is done to maintained uniform temperature in the glass cylindrical vessel.
7) When the temperature starts raising the bitumen becomes soften and touches the bottom of the plate due to the sinking of the balls and at least two observations should be prepared.

B. Flash and Fire Point Test of Bitumen

All the parts of the cup of Pensky-marten closed tester are cleaned and dried thoroughly before the test is started. The bituminous is heated and the shredded plastic waste (LDP) is added to the bitumen with respect to the weight of bitumen and it is mixed until a homogenous mixture is formed, then the bituminous binder is filled in the cup up to the filling mark. The lid is placed to close the cup and the tester is placed over the stove. All garnishing together with thermometer of the particular range must be suitably fixed. The test flame is checked and adjusted such that the temperature of the test specimen increases at the rate of 5 degree Celsius to 6 degree Celsius per minute. The rousing is done at a rate of around 60 revolutions per minute. When the specimen attains a temperature of about 17 degree Celsius below the expected flash point, the test flames is applied at intervals depending upon the expected flash point. First application is made at

least 17 degree Celsius below the actual flash point and then at every 1 degree Celsius to 3 degree Celsius. The stirring is discontinued for a short time during the application of the test flame.

C. Penetration Test on Bitumen

Heat the bitumen over the softening point (somewhere around 70 and 100 degree Celsius). Blend it completely to evacuate air bubbles and water.

And then in the next following trials add certain percentage of plastic wastes (LDP) in the heated bitumen and mix them until a homogenous mixture is obtain.

Pour the bitumen sample into a container of 35 mm depth (to a depth at least 15 mm more than the expected penetration).

Cool it at a room temperature of 15 degree Celsius to 30 degree Celsius for 60 minutes to 90 minute after this time is completed put it into transfer dish in the water bath at 25 degree Celsius plus minus 2 degree Celsius again for 60 minutes to 90 minute.

The transfer tray with the sample container and water is removed from the water bath and placed under the needle of the penetrometer. Using the adjusting screw, the needle assembly is lowered and the tip of the needle is made to just touch the top surface of the bitumen sample and the needle assembly is clamped in this position. The contact of the needle tip is verified using the mirror placed on the back of the needle.

The first reading of the penetrometer dial is either adjusted to zero or the reading is taken before releasing the needle. The needle is released exactly for a period of 5 seconds by pressing the knob and the final reading is taken on the dial. The needle assembly is then raised and the penetration needle is removed and replaced by a clean dry needle. The test is repeated on the same sample by conducting the repeat test at a distance of not less than 10mm.

D. Ductility Test of Bitumen

The bitumen sample is melted to a temperature of 75 to 100 degree Celsius above the approximate softening point until it is fluid. Then the shredded low density polythene is added to bitumen and mix until it is homogenously mixed. The molten bitumen is poured in the mould assembly and placed on a brass plate, after a solution of glycerin and dextrin is applied at all surfaces of the mould exposed to bitumen. Bitumen is poured into the moulds and the plate assembly along with the sample is kept for air cooling in room temperature for 30 to 40 minutes. The air cooled specimen is then placed in water bath maintained at 27 degree Celsius for 30 minutes. The sample and mould assembly are removed from the water bath and excess bitumen material is cut off by leveling the surface using the hot knife. After trimming the specimen, the moulds are now removed and the clips are carefully booked on the machine without causing any initial strain. Two or more specimen may be prepared in the moulds and clipped to the machine so as to conduct these tests simultaneously.

E. Marshall Stability Test of Bitumen Sample

1) The bitumen is heated to 140^0C - 1650^0C. The shredded plastic waste (plastic covers, milk covers) is added to the bitumen.
2) The aggregate size 6mm, 10mm, 20mm, stone dust and cement are weighed to all total of 1200 gm. and then heated to 150^0C.
3) The heated aggregate and the plastic waste added bitumen is mixed and transferred to the compaction mould.
4) The specimen is given 75 number of blow on the topside of the
5) Sample mix with standard hammer (450mm, 4.86kg).reverse the specimen and 75 blows is given on the other side.
6) The mould is kept undisturbed for 24hours.The specimen from the mould is gently removed.
7) A sequence of sample is prepared by a similar Method with varying quantities of bitumen content with percentage of plastic wastes.
8) The mould is immersed in hot water bath at 60^0c for30min. The mould is tested for its stability and flow.

VII. RESULT & ANALYSIS

The grade of bitumen on which test are performed is VG-30. Method of test according to IS 1205-1978.

	% of plastic (LDP) with respect to weight of bitumen sample.	Mean Temperature
Temperature at which sample touches the bottom plate	0 %	51 °c
	1 %	52.5°c
	3 %	54.5°c
	6 %	53.5°c
	9 %	56.5°c

Flash and fire point of bitumen of bitumen

% of plastic (LDP) added with respect to the weight of bitumen sample	Flash point	Fire point
0 %	246.66°C	261.66°C
1 %	266.66°C	286.66°C
3 %	283.33°C	316.66°C
6 %	291.66°C	330°C
9 %	303.33°C	336.66°C

Penetration test of bitumen

Method of test is according to IS- 1203-1978. Grade of bitumen used vg-30. % of plastic (LDP) added with respect to the weight of bitumen sample.	Penetration 1/10th mm
0 %	128.33 mm
1 %	129.66 mm
3 %	117.33 mm
6 %	59.66 mm
9 %	52 mm

Ductility test of bitumen

% of plastic (LDP) added with respect to the weight of bitumen mix sample.	Stability in kN	Flow in mm
0%	15.83kN	5.70mm
1 %	16.87 kN	5.63 mm
3 %	16.93 kN	2.83 mm
6 %	17.32 kN	1.1 mm

9 %	20.86 kN	1.23 mm

VIII. CONCLUSION

From this study, the following observations are made:

1) VG-30 bitumen which are generally used in flexible road construction. In the present research work, it was observed that the softening point of plastic waste (LDP) mix bitumen is increased by the increase of percentage of plastic waste (LDP) in bitumen from 1%, 3%, 6% and 9% respectively by 2.84%, 6.86%, 4.90% and 10.78%. For the 3% of plastic waste (LDP) optimum, the softening point is increased by 6.86%
2) In the present research work, it was observed that the flash and fire point of plastic waste (LDP) mix bitumen is increased by the increase of percentage of plastic waste (LDP) in bitumen from 1% ,3%, 6% and 9% respectively by 8.10%, 14.86%, 18.24% 22.97% and fire by 9.55%, 21.02%, 26.11% and 28.63%.
   For the 3% of plastic waste (LDP) optimum, the flash point is increased by 14.86% and fire point is increased by 21.02%.
3) In the present research work, it was observed that the penetration value of plastic waste (LDP) mix bitumen is decreased rapidly by the increase of percentage of plastic waste (LDP) in bitumen from 1%, 3%, 6% and 9% respectively by 1.036%, 8.57%, 53.51% and 59.47%. Since the consistency of bitumen materials are measured by penetration test, the higher value of penetration represents softer consistency. In warmer area, lower penetration grade bitumen is preferred and in colder area, bitumen having high value of penetration is preferred. For the 3% of plastic waste (LDP) optimum, the penetration value is decreased by 8.57%.
4) In the present research work, it was observed that the ductility of plastic waste (LDP) mix bitumen is decreased rapidly by the increase of percentage of plastic waste (LDP) in bitumen from 1%, 3%, 6% and 9% respectively by 4.63%, 49.10%, 75.72% and 83.22%. Tensile properties of bitumen materials are measured by ductility test. Bituminous materials used in road construction should have sufficient ductility; otherwise the road surface would crack due to temperature variations or by the traffic load stresses which may cause the pavement to become pervious that can result in damage of the pavement structure. During day time, the pavement surface expands and during night time, pavement surface contracts. So, if the bitumen does not have sufficient ductility, cracking will occur in the pavement surface
   For the 3% of plastic waste (LDP) optimum, the ductility is decreased by 49.10%. As per 1208-1978, the minimum ductility of VG-30 bitumen at 25 degree Celsius is 40 cm. Therefore at 3% of plastic waste (LDP) it is within the permissible limit.
5) In the present research work, it was observed that the Marshall Flow value of plastic waste (LDP) dense bituminous mix of surface course is reduced and the Marshall Stability value is increased by the increase of percentage of plastic waste (LDP) in bitumen from 1%, 3%, 6% and 9% respectively by 1.23%, 50.35%, 80.70%, 78.42% and stability by 6.57%, 6.95%, 9.41%, 31.77%.
   For the 3% of plastic waste (LDP) optimum, the Marshall Stability value is increased by 6.95% and the flow value is decreased by 50.35%.
6) Since now days as the plastic waste materials are increasing day by day there efficient disposal has become difficult. The recycle of the waste plastic (LDP) material in the road construction has given us a new ray of hope and getting new innovative method so we can go towards the sustainable development of the city and thus by dropping man made dangerous impacts on the environment.
   The following result concluded that for the optimum performance of the surface course of flexible pavement and to give us improved properties of bitumen material we can use plastic waste (LDP) of 3% with respect to weight of bitumen to give the desired results.

IX. ECONOMIC ANALYSIS

Economic analysis of the plastic road was done considering the material necessity for paving 4 inch thick wearing course on standard 12 feet wide lane of one kilometer length roadway section. Using LDP content of 3% by weight of bitumen will save the 3% bitumen. We have surveyed a lot of recycling agencies and municipal waste organization agencies. From which we came to know that the processing cost of waste plastic bottles (including the collection cost, cleaning & shredding cost) was estimated to be Rupees (Rs) 40 per kg. It was found that 8% percent of the required bitumen can be replaced with waste plastic (LDP) thus reducing the cost by approximately Rs.53000.00 per kilometer per lane in assessing the same to conventional (unmodified) asphalt mix in road construction

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