

Utilisation of Plastic Waste in Bituminous Road Construction to Achieve Sustainability

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ABSTRACT: Plastic is one of the most integral component of solid waste which is spreading across the world causing so much damage and is been disposed without any treatment causing huge threat to the mother land as well as people all across the world. The increase in plastic is also affecting the world's smallest creature, such as plankton. When these creatures are poisoned by plastic ingestion, this will cause trouble for the larger animals that depend on them for food. Apart from this plastic waste is increasing pollution in many ways. Groundwater pollution, land pollution, air pollution is some of the pollutions that are deteriorating the environment. In order to overcome all this problem's use of plastic as a construction material in the bituminous roads helps us to reduce the plastic waste across the globe with some percentage. This technique will allow the pavements to resist higher temperature through minimizing the formation of cracks. Plastic roads will prove to be a boon for India's hot and humid climate, where temperatures often exceed 50°C and heavy rains can cause serious damage, resulting big potholes. It is said that 33,400km road are been construction by using plastic all across India. This initiative taken up by all the states is helping to reduce the plastic waste in their respective area and state. In the current situation, the increasing traffic volume of business vehicles and the significant difference between daily and cyclical weather temperature put us in an exceedingly critical situation to consider some substitute for the spontaneity of the pavement characteristics and quality by applying some necessary alternatives which shall satisfy both the strength as well as construction cost aspects. In this paper, the main objective is to highlight the different type of processes by which the plastic road can be laid and by considering one of the process a patch of plastic road is been laid in our institute. Apart from that this paper also highlight the impact of using plastic with bitumen and the results that are obtained by performing various test on both the road which is been carried out in the laboratory. The normal bitumen and plastic bitumen sample are compared with each other on the basis of test values.

KEYWORDS: Plastic, Pavement, Bitumen, Environmental crisis, Plastic roads, laboratory study, Processes.

I. INTRODUCTION

The use of plastic is increasing abundantly and causing numerous problem to the people as well as to the environment. Taking into considerations all the parameters of extensive use of plastic the government in the year 2015 and made it compulsory for the road contractors to use some proportion of plastic waste into the bitumen mix in order to overcome the problem that is growing extensively in India [1].

Looking into the past this innovative idea first came into existence when one-day Prof Rajagopalan Vasudevan, Professor of chemistry at Thiagarajar College of Engineering, Madurai, thought of using plastic into the bituminous mix after reading its extensive use and damages causing. He conducted experimental studies in his college laboratory and after results the Plastic bituminous mix was a success and eventually it became obligatory to use plastic during the road construction. It is also proudly said that Prof. Rajagopalan Vasudevan is known as "plastic man of India" [2 -4].

Because of numerous advantages plastic handbags, packaging material, bottles, cups, and various items, it has slowly replaced all items made of other material [5 -7]. Plastic is long lasting, easy to produce, feathery, shatterproof, unscented, and immune to resistant. Because of this advantage the use of plastic is increasing immensely and the plastic waste is seen all around the world causing problems [8]. Plastic waste clogs drains, causing floods. It can suffocate animals that eat polyethylene or polypropylene items. Recycling plastic can only be done 3-4 times and melted plastic will release highly toxic fumes. At the turn of the country, in order to reduce the use of plastic and control the waste generated by them, a lot of noise has been made.

After long into all these Professor conducted Laboratory study and surprisingly coating of aggregates with homogeneous mixture of bitumen and plastic proved to give positive results[4]. He then applied this method to construct a road inside the premises of his college in 2002. In 2006, the Thiagarajar College of Engineering

patented this technology. After that many contractors started to construct plastic road in small proportions [9]. It was then made a huge impact in the field of civil engineering and was taken a big turn when all the governments ordered the contractors in 2015 to laid roads with the use of plastic in it [2].

The laying of the plastic road consists of two field trials that are the dry process and the wet process. Apart from the process of laying of the road there are number of tests to assess the properties of bituminous materials [10]. But Penetration test mainly helps us to determine the hardness of the bitumen. By performing penetration test the Consistency of bituminous material is known. The suitability of bitumen for use under different climatic conditions and various types of construction can also be known as India being in the tropical region having vast climatic condition, the penetration test helps to know in which region the plastic coated bitumen material can be used [11].

Significance of plastic roads

- The properties of bitumen are modified after the addition of waste plastic.
- The results shown by plastic bitumen are good when compared to standard results.
- The amount of plastic that is to be replaced by the bitumen is considered in the range of 5% to 10%.
- Reduction of problems like pot holes, rutting is reduced.

II. Methodology

The methodology consists of two field trials done for the construction of plastic road. The field trial processes are dry process and wet process. The major difference between both the process is that in the wet process mechanical stirrer machine is needed which is a costly equipment. Because of the increase of cost by adopting wet process generally dry process is used for laying of plastic road which is effective process of laying. Most of the contractors use dry process for laying of plastic road pavements across the country [5]. The experiment of laying plastic road patch in the institute was also done by following the dry process steps. The brief explanation of the procedures of both the processes is explained below.

1) Dry Process

- Aggregates are heated up to 170° C in the hot mix plant usually size mini.
- In the heated Aggregate shredded plastic is added in equal proportion.
- Bitumen is heated and the mixture of plastic coated aggregate is added.
- Laying of the road is done

2) Wet Process

- Heat the asphalt to 160° C and use mechanical agitator to add waste plastic to it.
- Stabilizers are to be added and cooling is required.
- Because the wet process requires lot of investment and large equipment's is not commonly used.

Plastic road construction can be done in two ways by adopting either dry process or wet process. Usually dry process is adopted for its cost efficiency. The materials generally used are aggregates, bitumen and waste shredded plastic. All the components including the process of laying the road is explained below with figures.

Materials Used for plastic road:

1. Aggregates: Aggregate of size 10mm and aggregate chips are taken.
2. Bitumen: 60/70 grade bitumen used.
3. Waste Plastic: The waste plastic was collected from the institute dump yard where the type of plastic selected was polypropylene and polyethylene (chip packets, plastic bags, bottles).

III. Construction of Plastic Roads

Step 1) Collection of waste plastic is done in the initial stage of the process and the plastic waste collected is cut into the small sizes.

Step 2) The HRS specification is followed and the aggregate is heated to 165°C and transferred to mixing chamber. 8% of plastic proportion is added to the bitumen.

Step 3) The process of heating of bitumen is to be carried out and maximum of 160°C (HRS Specification) is to be heated to have good binding and to prevent weak bonding.

Step 4) In the next process the shredded plastic is to be added in the mixing chamber and this shredded plastic gets coated uniformly over the aggregate within 30 to 60 seconds, giving an oily look.

Step 5) The plastics waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction and the laying of road. The roller is used to make it compact and uniform.

This experimental study of laying of plastic road in our institute helped us to identify the different process involved for the construction of normal and bituminous road. After the road was constructed by using shredded plastic into the bituminous mix a laboratory study was performed in order to know different properties that road contains and by performing penetration test in the laboratory the major difference between both the roads was achieved because penetration test gives the values of hardness of the road and hardness is the core factor for the construction of road followed by consistency, softness etc. Below explains the penetration test principle and also the process of penetration test carried out in the laboratory.

IV. Penetration Test

It measures the hardness or softness of asphalt by measuring the depth in tenths of a millimetre that a standard loaded needle will penetrate vertically within 5 seconds. BIS had standardized the equipment and test procedures. The penetrometer gauge consists of a needle assembly with a total weight of 100g and a device for releasing and locking in any position. Soften the asphalt to the consistency of the pour, stir thoroughly and then pour into the container, the depth at least 15 mm beyond the expected penetration depth. The test should be performed at the specified temperature of 25°C.

V. Results and discussions

To ascertain the durability of plastic waste with the bitumen road we have conducted the penetration test in the laboratory to attain the major difference between both the roads for proper understanding and to know which road will perform better. The test was carried out in the laboratory by considering both the sample [IS: 1203 – 1978] i.e., plain bitumen sample and plastic bitumen sample mix. Initially the bitumen is softened and stirred properly to make it a homogeneous mix and then transferred to a container with a minimum depth of 15mm or more. The sample is left to be cooled in room temperature and after attaining the container is placed under the needle that is attached to the penetrometer. The needle is loosened and made it to be dropped and this counts the initial reading. The needle is clamped and now for exactly for 5 seconds the needle is dropped and second reading is obtained. This procedure was performed for 3 times for both the samples and reading where noted according to the standard guidelines. Fig 1 shown below is the sample of plastic bitumen mix where in shredded plastic was added into the bitumen to obtain the value for plastic bituminous mix and the 2nd fig is the penetrometer setup in the laboratory.



Figure1: Addition of Shredded Plastic



Figure2: Penetration Test in the Laboratory into the Bitumen Mix

The execution of penetration test on both the samples was done and the results obtained for both the samples where noted down in order to obtain the mean values. Mean values of both the samples were calculated and plastic bitumen mix sample obtained lesser penetration value with compared to the normal bitumen mix. As the guidelines says greater the penetration value softer the bitumen, the plastic bitumen mix has shown lesser value in the laboratory study making it more durable and harder than the normal bitumen mix. Below are the values that are obtained by performing the test in the college laboratory (table 1 and 2) and the results are obtained accordingly satisfying the need of the guidelines and proving that plastic bitumen mix is more durable than normal bitumen mix. The results are taken and plotted in graph format for better understanding (Fig 3,4,5).

Table1: Penetration Test Results of Plain Bitumen

Sr.no	Penetration Readings		Difference between A and B	Mean value
	Initial A	Initial B		
1	00	99	99	91.3
2	00	95	95	
3	10	90	80	

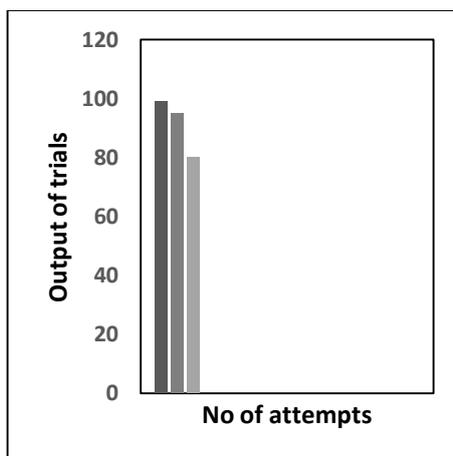


Figure 3: Plain bitumen penetration sample value graph

Table2: Penetration Test Result of Plastic Bitumen Mixture

Sr.no	Penetration Readings		Difference between A and B	Mean value
	Initial A	Initial B		
1	140	210	70	66.0
2	140	208	68	
3	140	204	64	

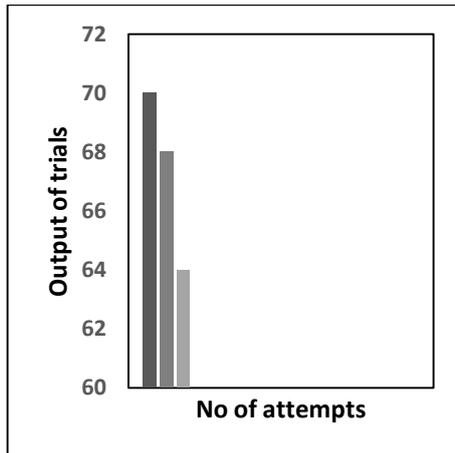


Figure 4: Modified bitumen penetration sample value graph

Table 3: Mean values of both the samples

Sr. No	Mean values
1	Plain Bitumen mix penetration mean value : 91.3
2	Plastic bitumen mix penetration mean value : 66.0

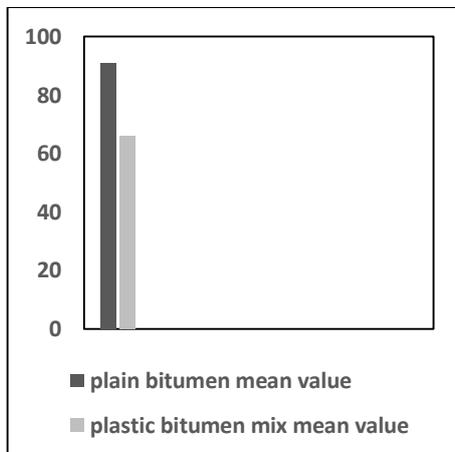


Figure 5: Mean values of Plain bitumen and plastic bitumen

VI. Comparison study

After the laboratory process of penetration test and the construction process of laying of plastic road is known few comparison studies between cost parameter, waste utilisation, durability between both plastic road and normal road was done and the results are incorporated in bar chart below. The rating for 5 was done for both the roads.

- (1) Cost: As we know utilisation of plastic in bituminous road helps to reduce the bitumen by some percentage because plastic is replaced by 5%-10%. By this addition of plastic, the cost of plastic bituminous road reduces and study says that 5140rs is reduced for 100m of road and almost 51400rs for 1Km of road laying. The rating of 5 for both the roads is shown below fig6.

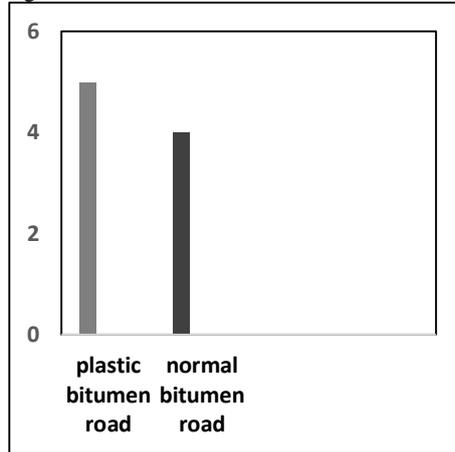


Figure 6: Comparison between normal road and plastic bituminous road

- (2) Waste Utilisation: The plastic waste generated enormously is degrading the mother earth as well as people’s health. By this innovative idea of using waste plastic into the road construction helps to reduce the waste and can save the earth. This parameter is the most important factor as this is the main advantageous aspect of plastic road construction i.e., utilisation of waste plastic into the road construction and fig7 explains the comparison.

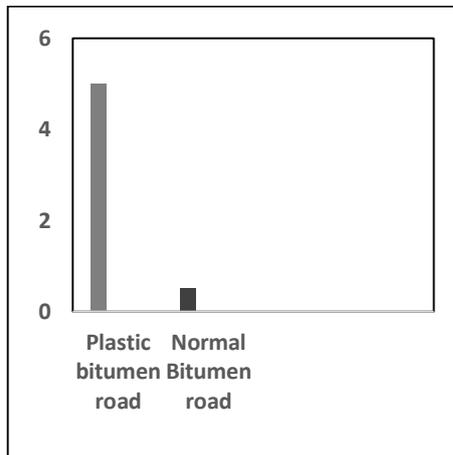


Figure 7: Waste utilisation comparison between both the roads

- (3) Durability: Study says that normal bitumen roads last for 4-5years whereas plastic bitumen mix roads last for 10 years because of the oily coat formation on the road surface helps to reduce the pot hole formation and rutting. This helps the roads to last longer. Fig 8 shows the comparison chart.

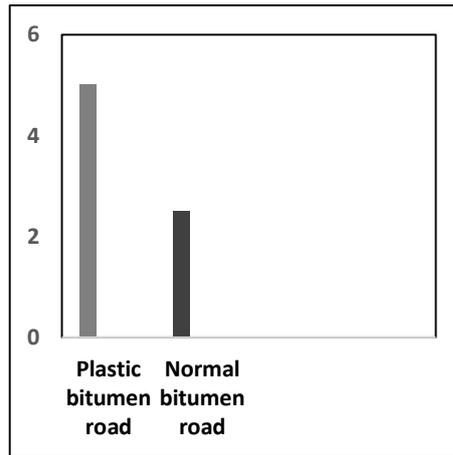


Figure 8: Durability Comparison between both the roads

All the three comparison studies have explained that plastic bitumen roads are most durable and good when compared with normal road. All the parameters satisfy the utilisation of plastic road and the initiative taken by government for the use of plastic in roads can be the new modern form of great innovation as the waste is also reduces by huge percentage all across the globe.

VII. Conclusion

Plastic mixed with asphalt and aggregates exhibit better road performance. The polymer coated on the aggregate reduces the voids and moisture absorption. This can reduce rutting and potholes are not formed. Plastic roads can withstand heavy traffic and are durable than flexible pavement roads. The use of plastic mixture reduces the bitumen content by 10% and improves the strength and performance of the road. This new technology is environmental friendly. The field trails have also been successful in Pune, Bangalore and Jamshedpur. With combined efforts of contractors and Government plastic bitumen roads will be able to curb the biggest waste disposal problem of the country. The plastic roads are also cost efficient and it is said that use of plastic in road constructions would help to resolve the problem in the world up to some extent. The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road. Apart from this by performing the penetration test in the laboratory the results obtained shows that the use of plastic coated bitumen mix is more durable and has more strength because the penetration test results obtained of both sample shows that plastic coated mix has less penetration value than normal bitumen and it is said higher the penetration value softer the bitumen is. The comparison study done between various parameters have also explained that utilisation of waste plastic is the new saviour of mother land.

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