

Review on Usage of Waste Plastic in Bituminous Roads

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Abstract: *This paper presents the review of the use of the plastic waste material in the road construction. Plastic cannot be easily decomposed by bacteria as it is a non-biodegradable. There is an increase in amount of waste plastic material due to day by day increment of industrialization and population. We can construct roads with the help of the plastic waste material. To withstand the stresses, the field tests demonstrated that the waste plastic material used after proper treatment as an additive would build up the life span of the road and can also deal with the environmental problems. As we change the amount of waste plastic in the bitumen the properties such as ductility, aggregate impact value, penetration value, Los angles values and softening point of bitumen changes with change in the amount of plastic waste. The roads laid out with the addition of the shredded plastic waste are much more durable compared to those roads which are laid out with normal bitumen. With the help of latest technology, the life span of the road is increased and construction cost is reduced. This technology helps to improve the environment also.*

KEYWORDS: Plastic Waste, Environment, Bitumen, Ductility, Penetration Value

INTRODUCTION

Plastics are synthetic, non-biodegradable polymers formed by big chain hydrocarbons with the addition of additives and shaped into finished products. These polymers of plastics are crushed in the presence of appropriate impetus, into monomers, for example, vinyl, propylene, ethylene, styrene, and benzene [1]. In recent studies, it is shown that for almost 4500 years the plastic can remain unchanged on the earth. The demand for food, packing and other essential things increases with the increase of the global population. Also, with the increase of population, there is an addition in the measure of waste being created day by day by each household. In municipal solid waste, we can find almost 5% of waste plastic material, which is harmful to nature. Plastic has biodegradable property due to which water gets stagnated due to hygiene problems generated. To prevent these problems various researches have been done on the waste plastic that we can use to waste plastic again productively or not. Researches by the various institution have been shown that when we add waste plastic to hot aggregates, plastic form a coat over aggregates and such aggregates when mixed with asphalt, give higher strength and resistance to water and superior performance for a long period of time. Plastic waste which comes from disposal cups, laminated pouches such as chips, aluminum foils, and packing materials used for chocolates, milk, or any kind of grocery item can be used for surfacing roads. The smoothness and lifetime of the road can be increased by using waste plastic material with bitumen while construction of the road. When we use waste plastic as a modifier it also makes the road more economically sound and environmentally friendly. The properties of bitumen improve when waste plastic materials are used as a modifier in bitumen. The roads which we construct with the help of plastic waste material are commonly known as “Plastic Roads” and these roads are found more superior than the roads which are constructed by unmodified bitumen [2-6].

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The debate on environmental protection from the impact of waste plastic material can go on; without any result until some practical steps should be taken at the crucial level by everyone who is in a position to do something about this. The firm from the Bangalore and engineers team from R.V. College of Engineering, Bangalore, did some research and find out a way in which we can use plastic waste material in the construction of roads. In 1977, an initial study was conducted to test the durability and strength of the road by the team. The roads which are constructed with the addition of plastic waste are known as Plastic roads. After the various field tests, it was found out that the roads which were constructed by using proper processing of plastic waste as an additive have a longer life span.

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In the process of laying plastic roads, firstly we collect the plastic waste material from different areas like landfills or dump yards. Then this plastic waste material is separated and stored somewhere in an intact place. After that waste plastic material is washed or cleaned with any appropriate method and then dried for some time. Then we use the shredding machine to shred plastic waste into size ranging from 2.36mm to 4.75mm. We don't use PVC in laying plastic roads as they are highly toxic in nature. Then we select the appropriate size of aggregates for road construction.

There are two different types of field process which we can use for the road laying purpose:-

- [1] Dry process for bitumen mix
- [2] Wet processes for bitumen mix

In the dry-process for the bitumen mix, the aggregates are firstly heated to 165°C and then the aggregates are transferred to the mixing chamber. In this process, it is very important to check the temperature. If the temperature is not correctly maintained, then the required properties of the aggregates may not be obtained. In the mixing chamber we add shredded plastic for about 45 seconds to the hot aggregates and shredded plastic is mixed uniformly to the aggregates at the surface. After that within a minute, all the aggregates are coated uniformly with plastic. The mixture is heated up to 165°C for the prevention of its weaker bond with bitumen and also good binding property can be obtained by doing so. After that, the coated aggregates are mixed with hot bitumen with the variation in temperature from 155°C to 165°C in the mixing cell so that the mixture which is obtained is used for the road construction. It should be noted that laying temperature of the road is 110°C-120°C. For the construction of roads which use waste plastic as one of its component, roller of 8-ton capacity is used.

In the wet process, plastic is grounded and made into powder form. In this process, we can only use plastic at max 6% to 8 % of bitumen content by weight. The melting point of the bitumen can also be increased with the help of plastic and plastic also makes the road to keep its flexibility during winters which helps in a longer life span of the road. A strong binding agent for the tar is shredded plastic waste which makes the bitumen last long. With the blending of bitumen and plastic, there is an increment in the capacity of the bitumen to oppose the high temperatures. In this procedure, the plastic waste is dissolved down, and afterwards it is blended with the bitumen in a specific proportion. Normally, at the temperature of 45.5°C we do blending but when we blend plastic in the mix, it stays stable even at 55°C temperature. In laboratory tests, it is verified that the asphalt concrete mixture

satisfies all the described criteria of Marshall Mix design for the road pavement's surface course which are prepared by using the treated bitumen binder.

At the maximum 15% of the plastic waste can be used in dry process but in case of wet process, the use of plastic waste is limited to 10%. Also, the binding of waste plastic material in the dry process is more than that in the wet process. This is because there is more requirement of mechanical energy in the wet process; also the stability in the wet process is average. Thus it can be observed that the dry process is superior to the wet process. Furthermore, it was observed that in dry processes, the Marshall Stability values were found to be higher compared to those evaluated in the wet process [7].

All the papers show that analyzing the utilization of waste plastic with bitumen shows some changes in the ductility, aggregate impact value, penetration value, Los Angeles values, and softening point. This paper aims to solidify such connection and co-relation between above mentioned properties with regards to addition of plastic in bitumen.

Literature review

V. Patel et al. studied the phenomenon of utilizing the waste such as Polypropylene, Low Density Polyethylene and High-Density Polyethylene in the construction of roads. Various tests were performed like Aggregate Impact value, Los Angeles Abrasion, and the Crushing values of the aggregates with composition of one, two and three percentage of plastic waste. On the basis of test performed it was observed that values are increased with the addition of 1% of the plastic. Also, the construction cost of a road made with help of this plastic was analyzed it was found that plastic roads are more economical than other roads. At last it was concluded that the material used for the construction of flexible pavement is made better with the help of coating of bitumen mix with the polymer as it provides us superior Marshall Stability value and suitable Marshall Coefficient.

Farag Khodary et al. did study in which crumb rubber was used as a modifier in the bituminous concrete mix in his research with the inclusion of ten percent of the weight of bitumen. CaCO_3 was also included in the crumb rubber modified bitumen sample with 5 percent, 10 percent, 15 percent, 20 percent and 25 percent modification. Various tests such as Penetration test, Softening Point test, Compression test and Static three-point flexural tests were performed. It was observed that there were improvement in both softening point and penetration value for every modified bitumen samples from the view of fracture resistance and mechanical properties of modified bitumen mix. It was also observed that with 15% crumb rubber/ CaCO_3 nano-compounds were superior to that of the normal mix by almost thirty-four percent. It was concluded in the research that modified mixtures with fifteen percent crumb rubber/ CaCO_3 nano-compounds had twice higher Critical Energy Release Rate than that of unmodified mixtures which means that modified bitumen mixtures are superior in fracture resistance.

Shivraj Sarojero Patil et al. did a study on the modification of bitumen with the help of plastic waste. The main objective of this study was to examine the variation of properties of using rubber as a modifier in bitumen. In this study the gradation of bitumen was done by maintaining the various pieces of rubber with its different ratio content such as 0 percent, 2 percent, 4 percent, 6 percent, 8 percent and 10 percent of the total amount of bitumen used. Various tests were performed such as Penetration test, Softening Point test, Flash and Fire point Test. It was observed that there is an increment in the effectiveness of the mixture with the addition of a different percentage of rubber in the mixture. He concluded that with the usage of waste plastic bags in asphalt mixture has shown that the properties of the matrix can be enhanced by using these waste materials, it also solves disposal problems.

J.K Appiah et al. aimed to solve 2 main issues in country Ghana:

- 1) The used plastic was affecting the major cities and town so there is a need for waste management of municipal solid waste (MSW) regarding this problem;
- 2) Due to excessive heavy traffic load, there is a formation of potholes on the road.

In his study, research was conducted on the effect of mixing of thermoplastic polymers waste, namely Polypropylene (PP) and High-density polyethylene (HDPE) and in the Conventional AC-20 graded

bitumen with different percentage of plastic compositions. Wet procedure was used for performance of test. He performed some experiments for the basic rheological parameters and found out that there was a change in the properties of bitumen such as penetration, viscosity, and ring & ball softening point from the basic bitumen. For the study of chemical functionalities present in bitumen composite FTIR spectroscopy was used. From spectroscopic analysis carried out by FTIR spectrophotometry he observed that spectrophotometry did not show new functionalities distinct from the spectrum of the base binder for all the modified bitumen samples. An observation was made that the polymer-modified bitumen's (PMB) rheological properties were superior to that of unmodified bitumen. Also, the observation was made that with the slight increment of High-density polyethylene (HDPE) modified bitumen showed superior results to polypropylene (PP) polymer on the homogeneity and compatibility in the viscosity, penetration and softening values.

Mr. Dinesh M. Sutra et al. did research which was focused on the cost of construction bitumen road and its performance. This study was about the increase of reuse of waste plastic as the bitumen modifier. In this plastic waste bag are used as replacement of some amount of bitumen. Various testes like Penetration test, Ductility test, Viscosity test and Softening Point test with the addition of 2 percent, 4 percent, 6 percent, 8 percent, 10 percent and 12 percent of plastic waste in bitumen were performed. It was observed in the study that there was increase in the penetration value and viscosity but decrease in the ductility and softening point with the increase of percentage of plastic waste. It was also seen that with the use of waste plastic the construction cost can be saved approximately 3 to 4 percent. In the study it was concluded that plastic waste help to increase durability and shining of road.

R. Manju et al. did research in which the main focus was to minimize the global warming, pollution, and greenhouse gases, to increase the lifespan of the roads and to minimize the potholes. In the research various test on normal aggregates and plastic-coated aggregates which were prepared with the help of dry process were performed. About 10 percentage of bitumen was replaced for the modification with plastic. It was observed that there is about 40 percent decrease in aggregate crushing value of modified bitumen, also the los abrasion value of plastic-coated aggregates were 21 percent less and there is about 10°C decrease in softening point. It was also observed that the polymer-coated aggregates reduced the voids and moisture absorption. Due to this, there is no potholes formation and reduction in ruts. The plastic pavement can tolerate heavy traffic and are durable than those of flexible pavement. In this study researcher concluded that the use of plastic mix will reduce the bitumen content up to 10% and increases the strength and performance of the road. Also, this new technique is eco-friendly. The use of material which is smog absorbent such as titanium dioxide by ten percentage of polymer content can reduce vehicular pollution.

Gagandeep et al. studied the effect of utilization of plastic waste in aggregates and bitumen for roads. The major objectives of this work were to perform various tests on aggregates and bitumen and then analyze and discuss results obtained from tests. This study was also to find suitability for using plastic modified aggregates and bitumen. He performed Aggregate Impact test, Los Angeles Abrasion test, Penetration test and Ductility test. All these tests are performed with unmodified bitumen and modified bitumen with 0.5 percent and 1 percent addition of the plastic waste. After performing these tests, he found out that that the Aggregate impact value and Los Angeles Abrasion values are least in modified bitumen which contained 1 percent of waste plastic. Ductility test and Penetration tests were performed with the addition of 5 percent and 10 percent of waste plastic. It was observed that the samples which contained 10 percent of plastic showed least values of ductility and penetration. It was concluded that the use of waste plastic in the construction of road would enhance the performance of the road. It was also concluded that the involvement of the rubber aggregates even after mixing in the bituminous mix declines the amount of the stone aggregates by volume, forms it further flexibly, and also raises the flexural strength in the topmost layer of the highway. It reduced the pollution that occurred due to excess tyres and also condensed the use of predictable aggregate present inexhaustible quantity.

C.N. Rudram et al. did various experiments with the addition of various ratios of plastic waste materials in the Bitumen to check out the consequences of using the plastic on the properties of bitumen such as Penetration test, Ductility test, Softening Point test and Flash and Fire Point test. He used Polypropylene (PP), Polyethylene (PE) and Polystyrene (PS) with the different compositions of 5 percent, 8 percent, 10 percent and 12 percent. It was observed that blend which had plastic of 12 percent has least Penetration Index and maximum Softening Point, Flash Point and Fire Point among the other samples. It was seen in the research that blend which contained plastics were more resistible to water. Researcher concluded that the total construction cost decreases in plastic modified bitumen as waste plastic replaced bitumen by some amount, which is cheaper in comparison to unmodified bitumen. In his study, he also concluded that the dry process gives us much more superior Marshall Stability values compare to those which we get in the wet process.

Conclusion

This paper discussed the change of properties ductility, aggregate impact value, penetration value, Los angles values, and softening point of bitumen to be used in the construction of roads by adding different percentages of plastic in it. It was observed that the addition of waste plastic material in bitumen showed an intense effect on the uniformity and affinity with the minute consecutivesurge in viscosity, penetration, softening point, flashand fire point. Also, the bitumen mix which is coated with the polymer aggregates forms superior material for asphalt road structure as we can observe Marshall Stability values are superior and also have suitable Marshall Coefficient. The adoption of a mix that contains plastic will reduce the bitumen content up to 10% and raise the stability and performance of the road.

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