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A Review on Utilization of Waste Plastic in Bituminous Roads

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Abstract: *Everywhere there is a bit of plastic , in our wallets, on our dining tables and kitchens, in our cars and buses and in our phones and offices. It is nearly impossible to imagine a world without plastics. From its beginning in 1950, global plastic production has increased dramatically from 2 million tons to 380 million tons in 2015. Its sheer convenience. lightweight and durable – has made this man-made material ubiquitous in every sphere of human existence. In the last 70 years, 8.3 billion. In plastic production much of the growth is driven by single use or disposable applications. Plastics used are single use products nearly 50 %, such as bottles, plastic bags, packaging, straws, stirrers, spoons and forks. We use up to 5 trillion disposable plastic bags every year. Bottle, containers and packing strips etc. is increasing day by day. As a result amount of waste plastic also increases. This leads to various environmental problems. So in each field it is necessary to utilize waste effectively with technical development. Many by-products are being produced using the plastic wastes. For road construction Plastic waste, consisting of carry bags, cups and other utilized plastic can be used as a coating over aggregate.*

Keywords: *Plastic Waste, Bitumen, Aggregates, Plastic Roads.*

I. Introduction

Plastic is user friendly but not eco-friendly as they are non-biodegradable. Today in India nearly more than 12 million tons of plastics are used. As a serious problem there visibility has been perceived and made plastic a target in the management of solid waste. They also have a very long lifetime and burning of plastics waste under uncontrolled conditions could also lead to generation of much hazardous air pollutant (HAPs) depend upon the type of polymers and additives used. Modified Polymer bitumen is emerging as one of the important construction of flexible pavement. For road construction, it shows better properties and plastic waste can find its use in this process and this can help solving problem of pollution. The better binding property of plastic in its molten state has helped in finding out a method of safe disposal of waste plastic .Roads surface with neat bitumen can cause bleeding in hot climate, may develop cracks in cold climate possess fewer loads bearing capacity and can cause serious damages because of higher axial load in present conditions due to rapid infrastructure development. In terms of length and quality, India has to raise transportation system to a higher level. In hot bituminous the use of waste mixes too enhance pavement performance, protect environment and provide low cost roads.

For road construction the polymer modified bitumen show properties and plastic waste can find its use in this process and this can help solving problem of pollution. The better binding property of waste plastic in its molten state has helped in finding out a method of safe disposal of waste plastic. It is easy manufacturing and impervious to water, plastics and rubbers are used in an excessive and manufacturing wide range of products due to its low cost. Disposal of waste plastic and waste rubber in an eco-friendly way is the substance area of today's research. For the construction of road material, the waste plastic and the crumb rubber which would give a better solidity, durability resistance and strength to the road as compared to the conventional rubber. As filler for bitumen mixes for a long time, fly ash has successfully been used and it has the advantage of increasing the resistance of bitumen mixes to moisture damage. Fly ash was reported to have the ability to work as a bitumen extender in addition to filling voids.

waste Plastic

Shredded plastic used for Asphalt road construction.

Fig.-01 Plastic waste and process to use for the asphalt construction.

II. Heading

Prof.C.E.G. Justo (2008)[1] States that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter ($m^3$of BC mix. The stability or strength, life and other desirable properties of bituminous concrete mix are improved by Modified Bitumen. "The polymer bitumen blend is a better binder compared to plain bitumen" stated by Dr. R. Vasudevan. With a suitable ductility, blend has increased Softening point and decreased Penetration value when it used for road construction it can withstand higher temperature and load. The porosity, absorption of moisture and improves soundness are reduced by plastics coating. As the mix shows higher Marshall Stability value and suitable Marshall Coefficient, the polymer coated aggregate bitumen mix forms better material for flexible pavement construction. Therefore for flexible pavement the use of waste plastics is one of the best methods for easy disposal of waste plastics. In road, use of plastic bags help in many ways like Easy disposal of waste, better road and prevention of pollution and so on. According to V.S. Punith, (2001), to improve the performance of bituminous mixes of road pavements some encouraging results were reported in this study that there is possibility. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Therefore, it can be used as a binder for road construction.

Mohd.Imtiyaz(2002) [2] concluded that the mix prepared with modifiers shows:-Higher resistance to permanent deformation at higher temperature. He studied the comparative performance of properties of bituminous mixes containing plastic/polymer (PP) (8% and 15% by wt of bitumen) with conventional bituminous concrete mix (prepared with 60/70 penetration grade bitumen). Improvement in properties like Marshall Stability, retained stability, indirect tensile strength and rutting was observed in Plastic modified bitumen Coarse aggregate The Coarse aggregate may be of crushed rock, crushed gravel or other hard material retained on 2.36 and passing on 4.75 mm IS sieve. Fine aggregate Fine aggregate consists of crushed or naturally occurring material or their combination passing 2.36 mm IS sieve but retained on 75µm. Fly ash Fly ash as a filler passing 75µm IS sieve. It is one of the residues generated in combustion of coal. Which originate from combustion is one of the major pollutants. Bitumen which is a black or dark colored solid or viscous cementations material having an adhesive properties. And it contain chiefly high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt. And also it is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process. Waste plastic is a plastic material is any of a wide range of synthetic or semisynthetic organic solids that are malleable. And they are usually synthetic. Most commonly derived from petrochemicals. Plastic waste (bags, cups, bottles) made out of PE, PP and PS cut in to a size between 2.36mm and 4.75mm using shredding machine. Waste rubber Crumb rubber is obtained from truck or automobile tires. Whole truck tires contain 18% natural rubber compared to 9 percent in automobile tire. And the scrap tire is

shredded into small pieces by the help of mechanical blades up to sizes of 1mm-75µ road laying and Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests.

Dr. R.Vasudevan and S. Rajasekaran, (2007) [3] , Stated that the polymer bitumen blend is a better binder compared to plain bitumen. Softening point and decreased Penetration value increased by blend with a suitable ductility. Marshall stability value with 5.31% waste plastic in 2900 kg and the percentage increases in stability value has been found to be 75.76% as compared to the mix without plastic. In bituminous concrete mixture, the consumption of waste polythene thus formed. In the mix, the waste polythene consumed will get coated over aggregates of the mixture and reduces porosity, absorption of moisture and improves binding property.

Santosh(2013) [4] In his study author have conducted various study in this topic and concluded that the shredded waste to bituminous concrete (BC) mix and to evaluate the various mix properties like Marshall Stability number, bulk density, flow, voids in the mix and voids field with bitumen (VFB) and the highest marshal stability yielded by 8% PP coated on aggregates .

Kazami & Govardhana Rao (2015) [5] Author have done test on waste materials of polythene, were he 5 to 11% waste plastic were mixed with bitumen (60⁄70) grade. The studies conclusively showed that the waste plastic materials could be incorporated as a binding agent for the construction of road low density polyethylene (LDPE) to extent of 9% sample was found to be the most effective binder proportion.

Soyal (2015) [6] Author states that addition 1%, 2%, 3%, 4%, 5% by weight of processed plastic for the preparation of modified bitumen. Polythene waste which 4% is showing better performance as compared to other mixes. Marshal stability value increase with 4% polythene waste.

Rokdey (2015) [7] Author concluded in his study that if plastic will increase the melting point of the bitumen also increase. Also this innovative technology not only strengthened the road construction but also increase the road life.The aggregate compressive strength and bending strength is increased by using plastic coating over. For different percentage of bitumen Marshal stability was conducted on ordinary aggregate and plastic coated aggregate. Plastic coated aggregate improved water absorption, stripping value and soundness. it can withstand higher temperature when used for road construction

Rajput (2016) [8] In his study the author mixed shredded plastic waste with the hot aggregate and the plastic modified mix is prepared by using 6,8,10,12 and 14% plastic by weight of bitumen. The addition of plastic waste to bitumen increases softening point its shows by studies of properties of the plastic waste-blended bitumen, decreases penetration value and ductility, increases flash point and fire point, increases Marshall Stability value and improve anti-stripping properties. and increases the flexibility and flexural strength of the carpet layer of mix.

Chhabra(2014) [9] Author stated that the waste Tires can be used as well sized aggregate in the various bituminous mixes if it is cut in the form of aggregate and can be called as rubber aggregate. This not only minimizes the pollution occurred due to waste tires but also minimizes the use of conventional aggregate which is available in exhaustible quantity.

Onyango (2015) [10] The author concluded that if Crumb rubber of sieve fraction 2.36 mm was used to substitute a fraction of the fine mineral aggregates of similar sieve size (2.36 mm) the overall grading was maintained. In the asphalt mix Proportions of 0%, 1% 2%, 3%, 4% and 5% of crumb rubber by weight of the aggregates were used and desired plastic to asphalt ratio was added from 2-10% by weight of bitumen.

Kumar k& Rajakumara (2016) [11] Author concluded that by Adding 0-4% Crumb rubber in bitumen specific gravity, softening point, flash & fire point are increasing and ductility, penetration are decreasing. But the limited value is up to 1% addition of crumb rubber. By replacing 5% aggregate of size passing 19mm & retained on 13.2mm by rubber aggregate obtained Marshall Stability and flow value are within optimum limit.

Kshirsagar& Deshmukh (2017) [12] The author concluded that Penetration value decreased with the increased amount of the rubber waste added. Making a harder grade of asphalt, lower Penetration, giving additional strength to the road and reduces water damage. The road life increases in comparison to the normal bitumen whereas the cost increase on the road is the biggest advantage of using rubberized bitumen.

III. Process

An alternate method was innovated to find an effective way of using higher percentage of plastic waste in the flexible pavement. The aggregate coated with plastic was used as the raw material. The plastic used were the disposed carry bags, films, and cup etc. with a maximum thickness of 60 microns. Plastic waste can be used as a coating over aggregate and this coated stone can be used for road construction. The bitumen was not blended with plastic waste.

3.1 Preparation of Plastic-Waste Coated Aggregate:

When the aggregate was heated to around 170^0C , the plastic waste chopped to the size varying between 2.36mm and 4.75mm. This shredded plastic waste was added over hot aggregate with constant mixing to give a uniform distribution. The plastic got softened and coated over the aggregate. The hot plastic waste which are coated aggregate was mixed with hot bitumen 65/75 or 80/100 grade (165^0C).

3.2 By Mini Hot Mix Plant Mixing:

Step I: Cut Plastic waste made out of PE, PP and PS into a size between 2.36mm and 4.75mm using shredding machine.

Step II: Similarly to have good binding and to prevent weak bonding, the bitumen is to be heated to a maximum of 1600C.

Step III: Plastic waste is to be added to the hot aggregate at the mixing chamber the shredded. Giving an oily look Plastic coated aggregate It gets coated uniformly over the aggregate within 30 Seconds.

Step IV: Resulting mix is obtained by adding hot aggregate over the plastic coated aggregate and then it is used for road construction. The road laying temperature is between 1100C to 1200C.

3.3 Mixing by Central Mixing Plant (CMP)

The dry process can also be carried out using central mixing plant. Along with the aggregate the shredded plastic is added in the conveyor belt. This is transferred into the hot cylinder. The aggregate is coated with plastic first and then with the bitumen. The mixer so prepared is then loaded in the dipper lorry and transported for road laying.T have better control of temperature and better mixing of this material CMP helps thus helping to have a uniform coating.

IV. Characteristics Of Plastic Coated Aggregate

4.1 Moisture Absorption and Void Measurement: For the flexible pavement, hot stone aggregate (170^0C)is mixed with hot bitumen (160^0C) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity per IS code. On the basis of its binding property, penetration value and viscoelastic property, the bitumen is chosen. The aggregate, when coated with plastics improve its quality with respect to voids, moisture absorption, soundness and other properties. The coating of plastic is responsible to decrease the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.

4.2 Soundness Test: To study the resistance of aggregate to weathering action Soundness test is intended. The weight loss is ascribed to the poor quality of the aggregate. The plastic coated aggregate did not show any weight loss, thus confirming the improvement in the quality of the aggregate.

4.3 Porosity: The porosity of the aggregate should be less than 2%. If pores are present, the air accumulated in the pores oxidizes the bitumen and the bitumen loses its viscoelastic property. The material becomes hard. By plastic coating, the pores are very much reduced. This is a proof by the reduction in the moisture adsorption with the percentage increase in the plastic coated. Moreover, during water stagnation; the pores accelerate the stripping of bitumen resulting in pothole formation. By coating with plastic the pores are reduced. Therefore the quality of the aggregate is improved and there was no catching of bitumen.

4.4 Aggregate Impact Value: It is clearly observed that the coating of plastics improves Aggregate Impact Value, thus improving the quality of the aggregate. Moreover a poor quality of aggregate can be made useful by coating with polymers

4.5 Los Angeles Abrasion Test: The values are less for polymer coated aggregate, when the Los Angeles abrasion value of plain aggregate is compared with the Plastic coated aggregate. The Los Angeles abrasion value will be improved by coating of waste plastics over aggregate.

V. Case Study

More than 200km length plastic tar road has been laid in India at different states from 2002. These roads are functioning well without pothole, reveling and rutting. This technique was first adopted in India in 2002 in Bangalore. A 25 km. plastic road was laid in Bangalore. The plastic road showed superior smoothness, uniformity and less rutting as compared to a plastics - free road laid at the same time, which began developing "crocodile crack" soon after. The process was also approved in 2003 by the CRRI (Central Road Research Institute Delhi) Road life improves through improved tackiness and viscosity of the bituminous mix, there by binding the stones more firmly together and improving the water-resistance of the mix to rain etc.

VI. Conclusion

We can conclude that, using plastic waste in mix will help reduction in need of bitumen by around 10%, increase the strength and performance of road. By incineration and land filling and ultimately develop a technology, which is eco-friendly, avoid use of anti-stripping agent, avoid disposal of plastic waste. Increased traffic conditions will and are reducing the life span of roads. Plastic roads will save millions of Polymer Modified Bitumen is used due to its better performance. But the blend is a more polymer dispersion in bitumen, which get separated on cooling in the case of higher percentage of polymer bitumen blend. But it may affect the quality of the blend, properties and also the road laid using such blend.

In the modified process (dry process) plastics-waste is coated over aggregate. This helps to have better binding of bitumen with the plastic-waste coated aggregate due to increased bonding and increased area of contact between polymer and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in reduced rutting, raveling and there is not pothole formation. The road can withstand heavy traffic and show better durability.

6.1 Advantages & Disadvantages

Advantages:

1-Better binding property, Higher Softening point, withstands high temp.
2-Lower penetration value; withstands higher load. No stripping – Resists the permeation of Water.
3-Higher Marshall Stability–increased strength of road. Cost less compared to bitumen road.
4-Better disposal of waste plastics. Ten lakhs or one ton carry bags in one kilometer road.
5-The polymer coating also reduces the voids. This has resulted in reduced rutting, reveling,
There is no formation of pot hole. The road can withstand heavy traffic & show better durability.

Disadvantages:

1-The burning of plastic waste creates air pollution and also health hazards.

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