International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Waste Plastic in Bitumen Mix for Flexible Pavements

Panga Vandhana

GMR Institute of Technology

A B S T R A C T:

Growth of varies industries and increase in population has become a reason to split out the waste products in a huge volume. The plastic waste is a serious global problem now a days. So, it is reused by certain processing and used in road constructions. The waste formed from urban and semi urban areas can be optimally reutilized as an additive in the construction of bituminous pavements. Plastic wastes have proved to be a source of health hazard as it is toxic in nature. Plastic coated aggregates have proved to offer better resistance to abrasion and wear and tear. Moreover, the bond between these plastic-coated aggregates and the bitumen are also extraordinarily strong due to increase in contact area between plastic (polymer) and bitumen. A cleaned, dried, and grind waste plastic bag is introduced to the bitumen mixture from 6–18% with a 3% increment by the weight of optimum bitumen content for each nominal maximum aggregate size. For knowing the performance of this modified bituminous roads, the tests conducted are Marshall stability and Indirect tensile strength test with inclusion of plastic in different percentages. This process is eco-friendly and economical too and the main aim is to analyze and study how the waste plastic will be effectively utilized in construction of flexible pavement as a binder material for replacing the content of bitumen and in detail process and its successful applications

Keywords: Plastic waste, bitumen, plastic-coated aggregates, optimum bitumen content, Marshall stability, Indirect Tensile test, flexible pavement

1. INTRODUCTION

Bitumen pavements are not performing as expected, especially with permanent deformation (rutting). The causes are expected to be due to elevated temperatures in the summer combined with heavy traffic loads. Disposal of diverse types of waste in different place from various sources has been a matter of concern from a long time. These materials cause several types of pollution to the environment. One of those materials are plastic which have become both a convenience and an inconvenience to society. Plastics have become a major thing to deal with because they are the fourth largest volume of waste generated worldwide where most of its types are not bio-degradable. 1.5 million tonnes of plastics were produced worldwide in 1950 and this figure escalated to 245 million tonnes in 2008. The increasing volumes of plastics over the years create havoc on the environment, especially the non-biodegradable ones which can stay in the environment for up to 1000 years without decomposing. Increasing in population results into more waste generation from the household daily. According to surveys plastic constitutes 5% in municipal waste which is toxic. Plastic bags are the most commonly found sources of plastic waste, we come to see littering of plastics result into the choking of drains etc., this results into stagnation of water and leads to ill hygiene of the locality. The only way to overcome these problems is to reuse the plastic effectively. The use bitumen was reduced to 10% on introduction of plastic waste as filler material. Plastic filling increases the softening point of the bitumen. The plastic waste mixing improves the abrasion and slip resistance of flexible pavements allows to calculate splitting tensile strength when the plastic mixed is beyond 30% of the weight of the mix.

2. RESEARCH METHODOLOGY

2.1 Materials used

The materials used for carrying out the present research are

1. Aggregates
2. Bitumen
3. Plastic waste

Aggregates:

Bituminous minerals or cement are used to bind the aggregates together. In a few instances, the rock dust itself creates a slurry when combined with water, which serves as a binding agent. Aggregates can be divided into two categories: natural and manufactured aggregates. Once more, the natural aggregates are divided into coarse aggregates made up of sand and fine aggregates or gravel made from crushed rock aggregates. The material used most often for road construction is blast furnace slag, a byproduct of blast furnaces. For bituminous surfaces, stone aggregate used for roads needs to be hard,

robust, long-lasting, and hydrophobic. Gravel should have a fineness modulus of at least 5.75 and be properly graded (6.4mm to 38mm). Sand should be clean, crisp, and well-graded.

Fig 1: Aggregates

Bitumen:

Bitumen is a binding agent used in the creation of pavements. The leftovers from the refinement of naturally existing asphalt can be used to make bitumen. The American Society of Testing Materials defines bitumen as "Mixtures of Hydrocarbons of Natural or Pyrogenous Origin, or Combination of Both, Frequently Accompanied by their Non-Metallic Derivates, which may be Gaseous, Liquid, Semi-Solid or Solid, and which are completely soluble in Carbon Disulphide." There are significant amounts of solid mineral stuff present in asphalt, which is bitumen in its native state. They are separated by fractional distillation in the order of decreasing volatility when petroleum crude is refined in a refinery. Straight-run bitumen is produced by distilling the remaining bituminous residue. We call this bitumen penetration petroleum bitumen that has been steam refined. Paving grades are the bitumen grades used to build pavements, and industrial grades are the bitumen grades used to waterproof buildings. The grade of straight run bitumen is selected based on the local climate of the area where the surface dressing will be built. Most of India uses bitumen of grades 80/100 and 180/200. It is also possible to employ heavier grade tars, emulsions with a quick setting time, or cutbacks. Basic bitumen's grade can be changed by carefully refining it or by mixing it with other oils, such as diesel. The amount of bitumen needed for single dressings on WBM base course ranges from 17 to 195 kg per 10 m2 areas.

Fig 2: Bitumen

Plastic waste:

The backbone and side chains of the polymer are used to classify plastics chemically. The categories of acrylics, polyesters, silicones, polyurethanes, and halogenated plastics include some significant subgroups. Plastics can also be divided into groups according to the chemical processes that were employed to create them, such as condensation, polyaddition, and crosslinking. Thermoplastics and thermosetting polymers are the two dissimilar categories of plastics. Thermoplastics are plastics that can be heated without changing their chemical makeup and can be repeatedly moulded. Polytetrafluoroethylene (PTFE), polyethylene, polypropylene, polystyrene, and polyvinyl chloride are some examples. An irreversible chemical reaction takes place during the thermosetting process. Rubber is vulcanized by a thermosetting process. The polyisoprene is a sticky, slightly watery substance before sulphur heating, but after vulcanization the product is rigid and non-tacky.

Fig 3: Waste plastic

Types of Plastics

PET, polyethylene terephthalate HDPE (High density polyethylene), high-density polyethylene PVC, polyvinyl chloride LDPE (Low density polyethylene), low-density polyethylene PP, polypropylene PS, polystyrene.

2.2 Tests conducted

For aggregates

1. Sieve analysis of aggregates
2. Specific gravity and water absorption
3. Aggregate impact value test
4. Aggregate crushing value
5. Flakiness & elongation index test

For bitumen

1. Penetration test
2. Softening point test
3. Ductility test
4. Viscosity test
5. Flash point and fire point

2.3 Methodology

2.3.1 Dry method

In the dry method waste plastic is shredded into small pieces and added to aggregate at 170^0c. Due to heat, plastic forms a thin layer around the aggregate surface. After these coated aggregates are mixed with hot bitumen at 160^0c. Thus, it improves properties such as voids, soundness, water absorption etc.

2.3.2 Wet method

This method helps to produce plastic modified bitumen by directly introducing waste plastic to bitumen after which it is heated to a temperature of about 160^0C to formulate a proper blend with adequate dispersion of waste plastic into bitumen. After mixing this modified bitumen and aggregates, it is laid over the surface and compacted with the help of rollers.

3. LITERATURE REVIEW

Bindhu et al (2010): She investigated the benefits of stabilizing the stone mastic asphalt (SMA) mixture in flexible pavement with shredded waste plastic. Conventional (without plastic) and the stabilized SMA mixtures were subjected to performance tests including Marshall Stability, tensile strength, and compressive strength tests. Triaxial tests were also conducted with varying percentage bitumen by weight of mineral aggregate (6% to 8%) and by varying percentage plastic by weight of mix (6% to 12% with an increment of 1%). Plastic content of 10% by weight of bitumen is recommended for the improvement of the performance of Stone Mastic Asphalt mixtures. Stone Mastic Asphalt is a gap graded bituminous mixture containing a high proportion of coarse aggregate and filler. It has low air voids with high levels of macro texture when laid, resulting in a waterproof layer with good surface drainage.

Bharsakale et al (2012): He says that it is possible to improve the performance of bituminous mixed used in the surfacing course of roads. Studies reported in the used of re-cycled plastic, mainly polyethylene, in the manufacture of blended indicated reduced permanent deformation in the form of rutting and reduced low – temperature cracking of the pavement surfacing. Plastic is a very versatile material. Due to the industrial revolution, and its large-scale production plastic seemed to be a cheaper and effective raw material. Looking forward the scenario of present life style a complete ban on the use of plastic cannot be put, although the waste plastic taking the face of devil for the present and future generation. We cannot ban use of plastic but we can reuse the plastic waste. In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength and life of road pavement. But its resistance towards water is poor. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with synthetic polymers like rubber and plastics. Use of plastic waste in the bitumen is like polymer modified bitumen. The blending of recycled LDPE to asphalt mixtures required no modification to existing plant facilities or technology. Polymer modified bitumen has better resistance to temperature, water etc. the use of recycled plastics composed predominantly of polypropylene and low-density polyethylene in plain bituminous mixtures with increased durability and improved fatigue life. Dense bituminous macadam with recycled plastics, mainly low-density polyethylene (LDPE) replacing 30% of 2.36-5mm aggregates, reduced the mix density by 16% and showed a 250% increase in Marshall Stability; the indirect tensile strength (ITS) was also improved. Resistance to deformation of asphaltic modified with low density polythene was improved in comparison with unmodified mixes. The recycled polyethylene bags may be useful in bituminous pavements resulting in reduced permanent deformation in the form of rutting and reduced low temperature cracking of pavement surfacing.

Bilal et al (2016): He says that the earth which is the ultimate home for all organisms, nature, and even nonliving constituents is today aggressive for the survival, the way it gets polluted, reveals that in some coming hundreds of years it will be nearly impossible for organisms to live on it. The rate of waste is increasing repeatedly with time including Common food wastes, plastics, paper, cardboard, wood, leather, glass, tin cans, and textiles, yard wastes etc. World watch Institute estimates that about 100 billion polyethylene bags are thrown away each year after being used (for hauling away trash and garbage, for carrying groceries and for other routine purposes), with less than 1% being recycled. Due to the industrial revolution, Plastic is widely used not only for packaging but also for protecting, serving, and disposing all kinds of consumer's goods. Which is non-biodegradable and can stay unchanged for about 4500 years. And there for it is linked with different problems like breast cancer, reproductive and genital abnormalities' and even can affect human sperm count and quality. Countries of the world are facing problems due to inadequate disposal facilities for the solid wastes and hence commonly one can see can see open dumps of wastes not only in residential areas and road sides but also on the river banks. After disposal, a plastic bag stays for a long time in the environment and take about over 1,000 years to degrade by photo degradation a process in which sun light breaks down the plastic bags into smaller toxic particles and hence pollute air, water, and land by producing toxic substances into the environment. Hundreds of thousands of animals like sheep, goats, crows, fish, turtles etc., ingest plastic bags and get killed. One can see the plastic bags hanging in the trees and bushes, floating in the lakes and rivers, and scattered in the public recreational parks and roads. Plastic waste particularly the plastic shopping bags are responsible for the clogging and blocking of sewerage system and leads to overflow of waste or rain water to the roads and hence affecting the durability of roads infrastructure. Because changes in water content and temperature, especially excess moisture, in pavement layers combined with traffic loads and freezing and thawing can significantly reduce pavement service life. Stopping the production and usage is not going to solve the problem, efforts are needed to get rid of the load already created in our environments. For this purpose, use the plastic waste in such a way which not only reduce the plastic waste load but also improve our roads durability and make it able to cope climate change and supply opportunities to reduce oil usage, carbon dioxide emissions and the quantities of waste requiring disposal. Addition of plastic polymers to the road pavement decrease the cost and reduce pressure on landfills as well increase rate of waste reusing to strengthen road pavement. This not only make the roads resistive against permanent deformation, but also enhance the service life of the road pavement, reduce viscosity, improve stability and stiffness, crack, fatigue, abrasion improved and reduce the thickness of the road pavement.

Agrawal et al (2016): He says, flexible pavements are especially important in present scenario. But Bituminous binders are causing bleeding in hot climate, cracks in cold climate, rutting, pot holes and its water resistance is poor. So, they think for alternative, plastic waste are non-biodegradable thus they can be used as bitumen modifier and aggregates to increase their strength. It is economical as well as the uses of plastic waste improve abrasion and slip resistance of flexible pavement. Here the author followed wet process of mixing of waste plastics in bitumen. Here plastic waste is grounded & converted into powder form; now 3 - 4 % plastic is mixed with bitumen. By this, melting point of bitumen is increased by using plastic, thus during winter season flexibility is preserved. He also said that the ability of bitumen to withstand higher temperatures can be increased by mixing plastic with bitumen. He saw that Blending occurs when temperature reaches 45.5ºC but when plastic is mixed; it remains at 55ºC. The test proves that bitumen concrete mixes made from treated bitumen binder fulfilled every Marshall Mix design criterion for road pavement. Another observation is that it can withstand adverse soaking condition for higher duration. He also explains the dry process. The shredded plastic is to spray over the hot aggregate is melted and spreaded over the aggregate; it gives a thin coating at surface of aggregate. At 140 - 160ºC temperature, the coated plastic stays in the softened state, in the next process; hot bitumen (160ºC) is added

Abdo et al (2017): He says that, the cost of bitumen increased day by day, so we need to think for alternatives. Wate plastics are good alternative and improving properties of aggregates in place of bitumen and the use of recycled waste materials as modifier additives in hot mix asphalt (HMA) could have several economic and environmental benefits. The use of recycled waste materials as modifier additives in hot mix asphalt (HMA) could have several economic and environmental benefit. He says based on recent studies determine asphalt mixes containing plastic waste exhibited improvement in engineering properties (i.e., Marshall stability, resistant to water, and resistant to crack propagation). They include plastic different percentages, the use of plastic waste as an asphalt binder modifier with 4, 6 and 8% by weight of optimum binder content and conduct different tests. Results showed that Plastic Waste Modified Bitumen (WPMB) mix yielded higher Marshall Stability, higher retained stability, and higher indirect tensile strength than a conventional mix with an increase of 10% in Marshall Stability, 7% in Marshall retained stability and 9% in indirect tensile strength. The penetration values and the temperature susceptibility decreased and the softening point increased with the increase of plastic waste content. In addition, modified asphalt mixes performed better than conventional mixes when it came to stability, tensile strength ratios (TSRs), and resilient modulus values at high

temperatures with smaller strain values. Here they investigated that addition of shredded plastic waste bottles to asphalt mixes by evaluating various mix properties; Marshall Stability, flow, bulk density, air voids, and voids filled with binder. They concluded that adding 8% plastic waste to coat aggregates led to the highest Marshall stability. He conducted Dynamic modulus test used to determine the stiffness of the mix at different temperatures. He also uses 3D move analysis software, the software can apply different moving traffic load, traffic velocity, axle configurations, and tire contact area to a pavement structure with different material properties.

Khater et al (2018): He says Asphalt pavements are deteriorating rapidly and pavements life is becoming shorter than what asphalt pavements were designed for. They noticed that asphalt pavements are not performing as expected, especially with permanent deformation (rutting). In addition to that asphalt pavement materials cost increases rapidly, so there is necessity to replace with alternative material which are effective and economical. They decided to use of recycled waste materials as modifier additives in hot mix asphalt (HMA) could have several economic and environmental benefits .Based on certain experiments they concluded that, asphalt mixes containing plastic waste exhibited improvement in their engineering properties (i.e. Marshall stability, flow, resistant to water, and resistant to crack propagation).Based on their findings, the use of plastic in these roads proved to enhance their resistance to monsoons and everyday wear and tear when compared to traditional pavements and it extended the life of asphalt pavements by two more years (Khulla, 2009).He examined the use of plastic waste as an asphalt binder modifier with 4, 6 and 8% by weight of asphalt binder content. Test results showed that mixes with 4% plastic waste were highly resistant to permanent deformation (rutting) and yielded the highest Marshall stabilities and the smallest flows. Results showed that Waste Plastic Modified Bitumen (WPMB) mix resulted in higher Marshall stability, higher retained stability, and higher indirect tensile strength than a traditional mix with an increase of 10% in Marshall stability, 7% in Marshall retained stability and 9% in indirect tensile strength. Plastic waste was obtained by collecting waste mineral water plastic bottles. Plastic bottles were then cut, shredded, then grinded to obtain plastic waste powder with a particle size passing 150 μm and retained on 75 μm sieves. Then the plastic waste powder was added to the tested asphalt binders at 0.2, 0.5, 1.0, and 5.0% by weight. Here, they conducted Rotational Viscosity Test for determining stiffness of the asphalt binder at different temperatures and Binder Dynamic shear modulus determined using the Dynamic Shear Rheometer (AASHTO T315-12 (AASHTO, 2012)). By these tests they concluded that, adding plastic waste to asphalt binder increased its viscosity for all tested asphalt binders. Thus, it is expected that adding plastic waste to asphalt binder would increase it stiffness, which would enhance its rutting resistance at operational temperature.

Swamy et al (2019): He said that, use of modified asphalt binder in pavement construction is gaining popularity. These modified binders exhibits improved resistance against various distress mechanisms occurring in pavement like fatigue (Khattak and Baladi 1998; King et al. 1993; Terrel and Walter 1986), rutting (Terrel and Walter 1986; Valkering et al. 1990), temperature cracking (King et al. 1992), moisture damage (Aksoy et al. 2005; Collins et al. 1991), binder hardening (Lu and Isacsson 1998; Ruan, Davison, and Glover 2003; Yildirim 2007) and stripping (Gorkem and Sengoz 2009; Kanitpong and Bahia 2005).He says, Waste plastic contains low-density polymer which can be easily blended with asphalt binder. Polyethylene has very good adhesive property, which in turn can improve binding between aggregates as well as with binder. In this study, the four different mixtures were designed by varying percentage of plastics i.e., 0, 2, 4 and 6% (by weight of binder). Here they prepare specimens for conducting Marshell stability test to determine the Marshell properties. This data is use full for determining the OBC (optimum bitumen content). The binder content corresponding to 4% of air void was chosen as the OBC.

Asare et al (2019): He stated that, indiscriminate disposal of plastics by the roadside, riverside and public places have resulted in the choking of gutters as well as cattle consume plastic wastes that is exposed to them mostly at refuse dump sites leads to suffocating of castles. He says plastic waste is usually handled using the three R's, namely re-use, recycle and recovery (or disposal). He can determine the optimum percentage of asphaltic materials that could be incorporated with plastic wastes for road construction. The consequences of not properly managing plastic wastes are far reaching from health-related issues to increasing future financial burdens. Plastic roads or roads made from plastic have been tried and proven to be the best way by which plastic wastes can be managed. This is because such roads are more durable, leaves no potholes, can withstand extreme climate changes even with temperatures above 50°C and can last up to 10 years compared with conventional roads that can last up to 5 years Verma (2008). According to Vasudevan et al. (2012), a tonne of plastic waste is used for every 1 km of road laid. This is supposed to reduce carbon dioxide emission by 3 tonnes. The number of roads built with plastic wastes in India is over 2500 km and this led to a reduction of about 7500 tonnes of carbon dioxide from the environment. He said that, there are two main methods that are needed for the process. They are Dry process and Wet process. He explained, in Dry process after the separation of plastic wastes from non-plastics, the plastics are washed and shredded to smaller sizes. After the shredding is done, the aggregates are heated up to 170°C and the plastic wastes are added which softens and melts (but does not burn) to form a coating around the aggregates. The bitumen is also heated to 160°C. The plastic-coated aggregates are mixed with the bitumen and used for road construction. The road properties were improved with this practice. In wet process, After the washing, the plastics are ground into powder. 6–8% of this is directly mixed with the bitumen before adding to the aggregates. The used low-density polyethylene (LDPE) plastic was used for the dry process and crumb rubber was used for the wet process. Different percentages of these were used for the experiment where the Marshall method was employed. Five per cent of the bitumen content of the 60/70 grade was used whereas 3%, 6% and 9% of LDPE and 8%, 10% and 12% of the crumb rubber were used in the experiment. The results for the LDPE mix showed that increasing the percentage of the plastic also increased the Marshall Stability and bulk density. On the other hand, values for the Marshall stability increased with that of the crumb rubber up to 10% and then decreased but the bulk density increased up to 12%. He the author conducts different tests in waste plastic coated aggregate to assess their behavior. He conducted 1. Apparent density and bulk specific gravity: (ASTM C127) 2. Water absorption and bulk specific gravity: (ASTM C127-04 and C29). In first test they decided that, by coating plastic will results in decrease the pores present in the aggregates, it will result less amount of aggregates. By doing second test they determine the percentage of water and density when water present, he concluded that Aggregates used for road pavements must have low water absorption capacity (<2%). He also conducted Los Angles Abrasion test and Impact test. They knew that the impact and abrasion values are changed when comparing with aggregates and plastic-coated aggregates. The values decreased when comparing with previous.

Bheempal et al (2019): He says that the overuse of plastic leads to create a problem like disposal of waste plastic and management of disposal waste. Waste plastic can be used as the additives in the construction of flexible pavement, by this waste can be used and the problems can be solved like control

of pollution by burning the waste plastic. The utilization of polypropylene waste in the flexible pavement eventually enhances the quality and execution of road. The fine aggregate used in the bituminous mix can be saved to certain quantity by incorporating polypropylene waste. Higher fatigue life of bituminous mix. Longer age durability properties. Use of polypropylene waste in bitumen mix has shown higher deformation and rutting of pavement. Prevent cracking and reflective cracking of the pavement. Polypropylene waste improves the water proofing property. The utilization of polymers in bituminous mix helps accomplish better execution of wearing courses, lower temperature susceptibility, higher resistance to deformation, better age resistance properties, higher fatigue life, better adhesion between aggregate and bitumen.

Bhardwaj et al (2020): He says that there are certain properties of plastic which are like that bitumen such as melting point, setting time and ductility; they both can be used as a binder. The water repellent property of plastic can also be utilized to make more durable road in regions receiving higher annual average rainfall. Till now, only 8% of partial replacement of bitumen has been achieved via wet mix process, and15% partial replacement of aggregates has been seen via dry mix process. Bitumen is a by-product which is obtained during the distillation of crude oil and owns favorable properties. So that it can be used in road construction such as having a melting point of around 110–120 °C. Bitumen is nontoxic and has high molecular density, so it acts as a strong adhesive; hence, it can bind the aggregate all together even in loading conditions of vehicles. Opting Marshall mix design method for design of wearing course of flexible pavement. This test helps to figure out the optimum bitumen and plastic content that can be mixed. Thermal behavior of bitumen is quite suitable for working with bitumen; when plastic heated at 165 °C, there is no evolution of toxic gases. When heated above 270 °C, they start to decompose and around 750 °C they get burnt and evolve harmful gases. Recycle plastic is generally of low-density polyethylene, and their use has increased the durability and fatigue life of flexible pavement. Polymer bitumen bland helps in better binding of plastic-coated aggregate and bitumen. The effective ways to reutilize the rigid plastic into road construction; where plastic is used as a bitumen modifier, the plastic content can be increased 5–10% by weight of bitumen. Fatigue life and abrasion value are found to be increased due to introduction of modified bitumen. The optimum quantity of the waste plastic is 10% in most of the investigations. Investigation shows that PVC up to 10% can be used for bitumen pavement in warm regions so that bleeding can be cured. Plastic bottles, cups, mugs, etc. can be reused by powdering and blending.

Alave at al (2020): He said that, Researches have showed that plastic can be used for the construction of bituminous roads as well, in fact plastic imparts more strength to the aggregates in comparison to the natural aggregates. The Marshall method of mix design will be used for the determination of optimum bitumen content using VG-30 grade of bitumen which will be further used for the design of flexible bituminous pavement. The Use of plastic waste in flexible pavements would open up a solution for the disposal issues regarding plastic wastes. He says Waste plastics, mainly used for packing are made up of Polyethylene Polypropylene polystyrene and Their softening varies between 110ºC – 140ºC and they do not produce any toxic gases during heating but the softened plastics have tendency to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 160ºC.He observed that the sample showed higher Marshall Stability value in the range of 18-20KN and the load bearing capacity of the road is increased by 100%.Roads shows that the constructed with PCA –Bitumen mix are performing well. This process is ecofriendly and economical too (S. Rajasekaran, 2013). Apurva J Chavan had found that Plastic coating on aggregates is used for the better performance of roads. This helps to have a better binding of bitumen with plastic wasted coated aggregate due to increased bonding and increased area of contact between polymers 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 reducing rutting, raveling and there is no pothole formation. The roads can withstand heavy traffic and show better durability (Chavan, APRIL 2013). He observes the variation between pure aggregates and plastic-coated aggregates like the Marshall parameters obtained summarized the variation of stability, flow value, bulk density, air voids and voids fill bitumen (VFB%). Imran Ali, Rupesh Kumar, et al, (2018) investigated by adding plastic waste to road construction. It increases the marshal stability test value. It normally saves the 10% bitumen in comparison to the ordinary road. The coating of aggregates with waste plastic reduces the absorption of moisture. He said one can understand that both Plastic Coated Aggregate and Stone dust waste were acted as have a better binding with Bitumen. More importantly Plastic-Coated Aggregate can reduce the Voids. Hence the roads can withstand heavy traffic and shows better durability. According to Brajesh Mishra, the results showed that waste plastic can be conveniently used as a modifier for bituminous concrete mix as it gets coated over the aggregates of the mixture and reduces porosity, absorption of moisture and improves binding property of the mix. The Optimum Bitumen Content (OBC) was found to be 5.17% by weight of aggregates and the Optimum Plastic Content (OPC) to be added as a modifier of bituminous concrete mix was found to be 9 % weight of Optimum Bitumen Content (OBC) of bituminous concrete mix. Bituminous concrete mix modified with waste plastic coated aggregates showed higher (approximately 31%) Marshall Stability and higher flow value as compared to conventional bituminous concrete mix. Marshall Stability value increases with plastic content up to 11% and thereafter decreases. According to M Chandu, low density polythene type of plastic shows better performance values than polypropylene. He did different tests on aggregates like Impact test, Crushing test, Flakiness and Elongation test and Los Angles Abrasion test. He observed that comparing with old aggregates the values decreased with plastic coated aggregates. They also conduct different tests on Bitumen, these are Ductility test, Penetration test and Softening test.

Arora et al (2021): He says that the bitumen roads are not performing well. Maintaince cost of the road increases and it causes economic burden to the tax payers. It is also not safe to travel on the deformed (rutting) roads. Plastic waste helps to increase the melting point of bituminous pavement. Waste plastic added over hot aggregate with bitumen to give higher strength and resistance to water. On these roads the main cause factor is heavily loaded trucks and continuous moving vehicles and after that heavy rainfall. Study investigated that the coating of plastic layer reduces the porosity, cavity of aggregates, absorption of moisture and improves soundness. Use of bio-medical plastic waste in bituminous road construction, in this study that the Marshall stability value of waste plastic to change bituminous mix that found to be 51% more than normal mix then it gives and found it increases the load carrying capacity of pavement. The rutting performance of asphalt mixtures that percentages (0%,0.25%,0.5%,0.75%,1%) and PET sizes 10 × 2.5, 20 × 2.5, and 30 × 2.5 mm were evaluated through dynamic creep test and Hamburg wheel tracking device. Results got that the rutting resistance of mixtures increases by addition of PET contents with increase in PET sizes. Using rice husk ash (RHA), as a waste byproduct of rice milling addition of 20% RHA with bitumen penetration grade, ductility, softening point, rotational viscosity and dynamic shear rheometer were conducted result got 20% RHA sample was the better mix about rutting resistance.

4. CONCLUSION

Usage of waste plastic in bituminous road is found to be sustainable practice by incorporating a waste material into bituminous roads and making the roads to sustain for a longer life. From the past studies it has been observed that waste plastic incorporated into bituminous road either by dry process or wet process. The dry process includes coating of aggregates with waste plastic and wet process includes direct mixing of waste plastic into bitumen.

The literature review reveled that the plastic incorporated bituminous mix are observed to have a better performance in terms of Marshall stability, moisture sensitivity, fatigue, and rutting performance. The bitumen obtained from the wet process is blended with waste plastic therefore the bitumen thus obtained is a modified bitumen. The modified bitumen can have the properties like viscosity and fatigue resistance quite difference from virgin bitumen. Several studies were done on types of plastic to be incorporated into bituminous mix.

Types of plastic used in bituminous mix are Low density polyethylene (LDPE), High density polyethylene (HDPE), Polyethylene terephthalate (PET), Polyurethane. LDPE is mostly used for bags (grocery, dry cleaning, bread, frozen food bags, newspapers, garbage), plastic wraps; coatings for paper milk cartons and hot & cold beverage cups; some squeezable bottles (honey, mustard), food storage containers, container lids. HDPE is used for Shampoo Bottles, Toys, Chemical Containers, Pipe Systems, Milk Jugs, Recycling Bin, Cereal Box Liners, Flower-Pots. Products commonly made from recycled PET include new PET bottles and jars, carpet, clothing, industrial strapping, rope, automotive parts, fiberfill for winter jackets and sleeping bags, construction materials, and protective packaging. Polyurethanes can be a found in mattresses, couches, insulation, liquid coatings and paints, tough elastomers such as roller blade wheels, soft flexible foam toys, some elastic fibers.

References

1. Ahmad M. Abu Abdo & Mohammed E. Khater | (2018) Enhancing rutting resistance of asphalt binder by adding plastic waste, Cogent Engineering, 5:1, 1452472, DOI: 10.1080/23311916.2018.1452472.
2. Patricia Nana Ama Asare, Francis Atta Kuranchie & Eric Antwi Ofosu | (2019) Evaluation of incorporating plastic wastes into asphalt materials for road construction in Ghana, Cogent Environmental Science, 5:1, 1576373, DOI: 10.1080/23311843.2019.1576373.
3. Adebayo Olatunbosun Sojobi , Stephen Emeka Nwobodo & Oluwasegun James Aladegboye | (2016) Recycling of polyethylene terephthalate (PET) plastic bottle wastes in bituminous asphaltic concrete, Cogent Engineering, 3:1, 1133480, DOI: 10.1080/23311916.2015.1133480.
4. Priyansh Singh & Aravind Krishna Swamy (2019) Effect of aging level on viscoelastic properties of asphalt binder containing waste polyethylene, International Journal of Sustainable Engineering, 12:2, 141-148, DOI: 10.1080/19397038.2018.1474398.
5. Ahmed Trimbakwala, ―Plastic Roads Use of Waste Plastic in Road Construction‖, International Journal of Scientific and Research Publications, Volume 7, Issue 4, April 2017.
6. Rajasekaran S., Vasudevan R. and Paulraj S., Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite for Road Application—Green Method. American Journal of Engineering and Research,2013.
7. Huda Shafiq, Anzar Hamid, ―Plastic Roads: A Recent Advancement in Waste Management‖, International Journal of Engineering Research & Technology, Vol. 5 Issue 09, September-2016.
8. Vatsal Patel, Snehal Popli, Drashti Bhatt, ―Utilization of Plastic Waste in Construction of Roads‖, International Journal of Scientific Research, Volume: 3, Issue: 4, April 2014.
9. Afroz Sultana. SK, K.S.B. Prasad, ―Utilization of Waste Plastic as a Strength Modifier in Surface Course of Flexible and Rigid Pavements‖, International journal of engineering research and application, Volume 2, Issue: 4,2012.
10. T.B. Vishnu, L. Kh. Singh, P. Thomas, N. P. Rumjit, Investigating the suitability of used heavy, medium, and light automobile tyres for bituminous mix pavement applications, Environment, Develop. Sustain. 22 (2) (2020) 1505-1527.
11. Pooja Lamba, Dilraj Preet Kaur, Seema Raj, Jyoti Sorout- Recycling/reuse of plastic waste as construction material for sustainable development: a review Received: 31 May 2021 Accepted: 6 October 2021.
12. Chada Jithendra Sai Raja, N. Sai Sampath, Ch. Suresh, A. Phani Bhaskar A Review on Use of Plastic in Construction of Roads Received: April 04, 2020, accepted: May 01, 2020, Published: May 01, 2020.
13. Abd Kader, S. A., Putra Jaya, R., Yaacob, H., Hainin, M. R., Abdul Hassa. n, N., Wan Ibrahim, M. H., & Ali Mohamed, A. (2017). Stability and volumetric properties of asphalt mixture containing waste plastic. MATEC Web of Conferences, 103, 09002. https://doi.org/10.1051/matec conf/201710309002.
14. Badejo, A. A., Adekunle, A. A., Adekoya, O. O., Ndambuki, J. M., Kupolati, K. W., Bada, B. S., & Omole, D. O. (2017). Plastic waste as strength modifiers in asphalt for a sustainable environment. African Journal of Science, Technology, Innovation and Development, 9(2), 173–177. https://doi.org/10.1080/20421338.2017.1302681.
15. Nakachew Assefa | (2021) Evaluation of the effect of recycled waste plastic bags on mechanical properties of hot mix asphalt mixtures for road construction, Sustainable Environment, 7:1, 1957649, DOI: 10.1080/27658511.2021.1957649.

16. Praveen Kumar & Garg, Rashi. (2011). Rheology of waste plastic fibre-modified bitumen. International Journal of Pavement Engineering. 12. 449-459. 10.1080/10298430903255296.

17. G. R. Bharsakale, V. C. Renge, G. S. Zamre, Amit Gawande (2012) Utilization of waste plastic in asphalting of roads Sci. Revs. Chem. Commun.: 2(2), 2012, 147-157 ISSN 2277-2669.

18. R. Vasudevan, A. Ramalinga Chandra Sekar, B. Sundarakannan, R. Velkennedy (2012) A technique to dispose waste plastics in an ecofriendly way – Application in construction of flexible pavements construction and Building Materials 28 (2012) 311–320.

19. Amit Tyagi, Apoorv Agarwal (2016). Use of plastic waste in construction of flexible pavement: A creative waste management idea. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Published by, www.ijert.org NCACE - 2016 Conference.

20. Yogita Bhiva Alave, Sanika Shekhar Mahimkar, Ketki Sanjay Patil, Jayprakash Jiyalal Gupta, Arbaz Kazi (2021). Experimental investigation of plastic-coated aggregates. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Published by, NTASU - 2020 Conference.