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Low Density Poly Ethylene – A Relevant Choice as Bitumen Modifier

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Abstract

Rapid growth in plastic consumption and its improper disposal have led to severe environmental challenges. The disposal of waste plastic poses significant environmental threat, contributing to both pollution and climate change. Recycling and reusing plastic waste have emerged as viable solutions, and the application of LDPE (Low-Density Polyethylene) and HDPE (High-Density Polyethylene) waste in bituminous road construction has gained significant attention. Bituminous mixes gain strength and improved properties when plastic waste is used for paving roads. Poly-ethylene, polystyrene, and polypropylene are the types of waste plastic utilized. The shredded waste plastic is coated with aggregate, mixed with hot bitumen, and used to construct pavement. The pavement's durability increases and reduces flaws, such as, ruts, corrugations, potholes etc. This paper reviews published literature and comprehensively analyses existing research on the compatibility and effectiveness of incorporating LDPE waste plastic on Indian roads. The paper brings out literature on various methods of utilization, performance enhancements, environmental benefits and identifies a research gap in sustainable road infrastructure development which can create a very big shift in clearing or even completely avoiding LDPE in landfills and waste dumps.

Index Terms Circular Economy, Waste plastic use, LDPE, Asphalt/Bitumen Modifier, Road Pavement

Plastic in Circular Economy

Plastic is long lasting and degrades very slowly in just 450 years!! Plastic debasement of just 0.5% will happen in 100 years! There exists no procedure for removal of used plastic from the environment. Plastic is a waste that contributes to global warming and the greenhouse effect. According to the Environmental Performance Index (EPI), India is among the 12 countries, along with China, Brazil, Indonesia, Thailand, Russia, Mexico, the United States, Saudia Arabia, the Democratic Republic of Congo, Iran and Kazakhstan, which are responsible for 52 per cent of the world's mismanaged plastic waste. India produces 3.4 million tonnes of plastic waste in a year, only 30 per cent of it is recycled," 11-Jan-2023. India ranks fourth in the Mismanaged Waste Index (MWI), with 98.55 per cent of generated waste being mismanaged and fares poorly in the management of plastics waste, according to the EA report.31-Jul-2023.

In India any road gets used greater number of times in comparison to roads in most other countries due to population. Countries which have roads that get over used ought to pay attention to the road surface and make it stronger so that they withstand all weather and last a little longer and therefore reduce the economic burden of relaying the road very often. Longevity and water resistance are two basics for any road. Mixing different kinds of materials with Asphalt provide it a good binding strength making the roads withstand all weather and last longer.

Plastic is a material that can be shaped by its flow and contains one or more organic polymers with a high molecular weight. Thermoplastics solidify irreversibly when heated, they have high durability and strength, making them ideal for binder mix. Plastic asphalt will be the best way to put use to the plastic while it is trying to degrade. Plastic waste has a bad impact on the environment, because it is difficult to be decomposed by the soil naturally. Trials on the use of plastic waste for road construction have been carried out by Public Works Department (PWD). Construction of a kilometre-long highway is estimated to require 2–5 tons of plastic waste. This study is trying to figure out the various studies and experiments that have already been conducted to understand the use of plastic as a modifier along with Asphalt Mix in order to lay better roads which can withstand all weather and wear and tear.

Asphalt Mix on the Road

Asphalt concrete, asphalt or blacktop consists of stone, sand/gravel bound by asphalt cement. It is mixed at a high temperature, laid, and compacted, in order to provide a driving surface for the traveling public. Paved roads are surfaced with asphalt. Hot Mix Asphalt (HMA) is a combination of approximately 95% stone, sand, or gravel bound together by asphalt cement, a product of crude oil. Asphalt cement is heated aggregate, combined, and mixed with the aggregate at an HMA facility. Bitumen is a complex mixture of organic compounds that is used as a binder in asphalt concrete. It is a sticky, black, viscous material that is extracted from crude oil. Bitumen is a binder mixed with an aggregate creating asphalt cement that binds the stone, sand, and gravel, resulting in the pavement for our roads and highways.

Public agencies in recent times prefer longevity of the road less maintenance. Lower stiffness (or viscosity) at the high temperatures associated with construction. This facilitates pumping of the liquid asphalt binder as well as mixing and compacting of HMA. Higher stiffness at high service temperatures. This will reduce rutting, shoving and thermal cracking. Increased adhesion between the asphalt binder and the aggregate is necessary when moisture or water is present. It will reduce the road from stripping.

Polymer Modified Bitumen

The modification of bitumen enhances materials properties and extends life of road before relaying. The durability of the road reduces maintenance cost. There is an increased demand for hot mix asphalt due to increase in Traffic volume, loads and tire pressures in recent years.

The roads are more often rutting and cracking. Many modifiers can improve the asphalt binder's stiffness at normal service temperatures to increase rut resistance, while decreasing its stiffness at low temperatures to improve its resistance to thermal cracking.

Fig 1 Asphalt Mix Road in Rain and Sun

Figure 1 shows two aggregate samples from the same source after they have been coated with asphalt binder. The asphalt binder used with the sample on the left contain no anti-stripping modifier, which resulted in almost no aggregate-asphalt binder adhesion. The asphalt binder used with the sample on the right contains 0.5% (by weight of asphalt binder) of an anti-stripping modifier, which results in good aggregate-asphalt binder adhesion.

Types of Modifiers Used with Asphalt

There are numerous binder additives available on the market today. The benefits of modified asphalt cement can only be realized by a judicious selection of the modifier(s); not all modifiers are appropriate for all applications. In general, asphalt cement should be modified to achieve the following types of improvements (Roberts et al., 1996) Table1.

Table 1. Asphalt Cement and HMA Modifiers (from Roberts et al., 1996)

Type	General Purpose or Use	Generic Examples
Filler	Fill voids and reduce optimum asphalt content Meet aggregate gradations, increase stability Improve the asphalt cement-aggregate bond	Mineral filler, Crusher fines Lime. Portland Cement, Fly Ash, Carbon black
Extender	Substituted for a portion of asphalt cement (typically between 20 – 35 % by weight of total asphalt binder) to decrease the amount of asphalt cement required	Sulphur Lignin
Rubber	Increase Hot Mix Asphalt (HMA) stiffness at high service temperatures Increase HMA elasticity at medium temperatures to resist fatigue cracking Decrease HMA stiffness at low temperatures to resist thermal cracking	Natural latex, Synthetic latex (e.g., Polychloroprene latex) Block copolymer, (e.g., Styrene-butadiene-styrene (SBS)) Reclaimed rubber (e.g., old tire crumbs)
Plastic		Polyethylene/polypropylene Ethylene acrylate copolymer Ethyl-vinyl-acetate (EVA) Polyvinyl chloride (PVC) Ethylene propylene or EPDM Polyolefins
Rubber-Plastic Combo		Blends of rubber and plastic
Fiber		Natural: Asbestos, Rock wool Manufactured: Polypropylene, Polyester, Fiberglass, Mineral, Cellulose
Oxidant	Increase HMA stiffness after the HMA is placed.	Manganese salts
Antioxidant	Increase the durability of HMA mixtures by retarding their oxidation	Lead compounds Carbon, Calcium salts
Hydrocarbon	Restore aged asphalt cements to current specifications. Increase HMA stiffness in general	Recycling and rejuvenating oils Hard and natural asphalts
Antistripping Agent	Minimize stripping of asphalt cement	Amines Lime
Waste Materials	Replace aggregate or asphalt volume with a cheaper waste product	Roofing shingles Recycled tires, Glass

Types of Plastics

The polymers can be elastomers, thermoplastics, or a combination of both. Waste plastic softens on heating and has a binding property. When it is mixed with bitumen, it can improve the following properties of bitumen: Rutting resistance, Fatigue resistance, Water resistance, Low-temperature performance. In addition to these properties, waste plastic can also help to reduce the cost of road construction and improve the environmental sustainability of bitumen.

- PET Poly Ethylene Terephthalate
- HDPE High Density Poly Ethylene
- PVC Poly Vinyl Chloride
- LDPE Low Density Poly Ethylene
- PP Poly Propylene
- PS Poly Styrene

Low Density Polyethylene (LDPE) as Bitumen Modifier

Waste plastic disposal has led to different circular economy ideas one such being an additive in Hot mix asphalt. There exist many a type of plastic waste. Low Density Polyethylene (LDPE) is available easily and plenty. It degrades the slowest around 450 years only. Hence to reduce its damage to land and sea is to burn and bind it into asphalt and lay it as road. LDPE is made from petroleum. It has low density of 0.91–0.94 g/cm3, and a melting point of 105–115 °C. LDPE-type plastic waste as a bitumen modifier for asphalt concrete-binder course (AC-BC) mixtures have been tried and tested many a times and there exist numerable literature on the same.

Literary Voices in the Public Domain on LDPE as Asphalt Modifier

These literatures reviewed below discuss the latest advances in polymer-modified bitumen (PmB).

Prof. S. S. Barmade, Mustafa Jarman, (2022) **Utilization of Waste Plastic in Flexible Pavement.** A study was done to investigate if plastic coated aggregates combined with bitumen and gravel could possibly improve the road's performance. The usage of plastic mix lowers the bitumen concentration by 10% while increasing the road's strength and performance. The melting point of bitumen raises as principal polymers, such as polyethylene, polypropylene, and polystyrene, display adhesion properties in their molten states. The waste plastic bitumen mix has a greater Marshall Stability value and a sufficient Marshall Coefficient and it is a better material for road building.

Prof. Harsh Gupta, Gaurav Singh (2022) From this study of behaviour of polythene modified BC it was found that the modified mix possesses improved Marshall Characteristics. It is observed that Marshall stability value increases with polyethylene content up to 4% and thereafter decreases. We observe that the marshal flow value decreases upon addition of polythene i.e., the resistance to deformations under heavy wheel loads increases. Also, the values of the parameters like VMA, VA, VFB are within the required specifications. Polymer modified pavements would be a boon for India's hot and extremely humid climate, where temperatures frequently rise past 50°C and torrential rains create havoc, leaving most of the roads with heavy distresses. This adversely affects the life of the pavements. The polymer modified bitumen show improved properties for pavement constructions. This also can reduce the amount of plastics waste which otherwise are a threat to the hygiene of the environment.

Pradeep E More, Dr Ravi W Tapre (2022) Addition of plastic waste with small particle size, thin thickness, and at 15% by weight of the total aggregate resulted in improved Marshall stability and resistance to water damage. Reusing waste materials such as plastic trash bottles (Polyethylene Terephthalate) as a mix with asphalt at varied ratios ranging from 0% to 10% by weight of bitumen was tried. The experiment results reveal that the ideal range is 4% to 6%. By boosting the strength and performance of roads, the plastic waste mix reduces the requirement for bitumen by roughly 10%.

Shakir Al-Busaltan, Rand Al-Yasari, Ola Al-Jawad & Behrooz Saghafi. (2021) **Durability assessment of open-graded friction course using a sustainable polymer** Their study aimed at minimizing the costs and maximizing the lifespan while considering sustainability. The effect of using a stabilizing material Recycled Low-Density Polyethylene (R-LDP) as an asphalt modifier on the performance of Open-graded friction course (OGFC) asphalt mixture was studied. The study concluded that incorporating R-LDP as an asphalt modifier in OGFC asphalt mixtures increased mixture air void, porosity, and permeability while reducing rut depth, moisture damage, and abrasion loss. It also almost eliminated the drain down problem. The use of R-LDP with OGFC increases road life span and decreases costs.

Melkamu Birlie Genet, Zenamarkos, Addis Lemessa Jembere (2021) **- Investigation and optimization of waste LDPE plastic as a modifier of asphalt mix for highway asphalt: Case of Ethiopian roads** This study found that a mixing temperature of 170°C and a mixing time of 1.5 hours resulted in a homogeneous mix between the bitumen and waste LDPE plastic materials. The optimum bitumen content for the modified asphalt mix was found to be 6.5% by weight of the optimum bitumen content (OBC). The modified asphalt mix with 6.5% waste LDPE plastic content exhibited 33.67% higher stability compared to the non-modified asphalt mix. These findings suggest that using waste LDPE plastic as a modifier can enhance the stability of asphalt mix and reduce the amount of bitumen used, contributing to sustainability and improved pavement performance on Ethiopian roads.

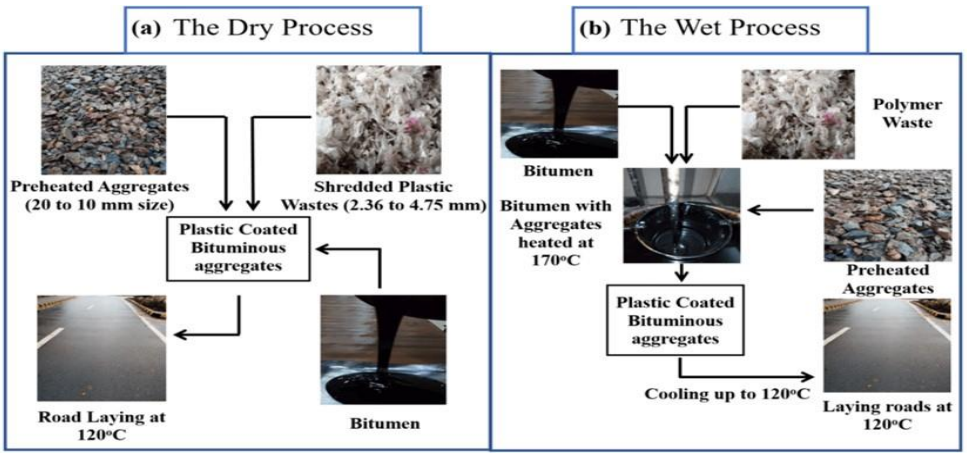
Sabyasachi Biswas (2021) **Book: Advances in Sustainable Construction Materials** Low-density polyethylene (LDPE) as a modifier of bitumen in road construction resulted in improved performance and service life exhibiting higher strength and viscosity, indicating enhanced durability and resistance to heavy traffic loads.

Yuetan Ma (2021) In general, the incorporation of waste plastics into asphalt mixtures presented improvements in rutting resistance, fatigue resistance, and moisture resistance.

✓ The wet process is suitable for plastics with low melting points, improving the rutting resistance, moisture resistance, and fatigue resistance of the binder blends. Plastics with higher melting point tend to increase viscosity and reduce ductility of the binder blends. Wet process may encounter two potential concerns: 1. the phase separation and 2. low-temperature performance. Plastics with high melting points tend to exaggerate such concerns.

✓ The dry process is applicable for all plastic types to enhance the rutting and moisture resistance of asphalt pavements. Plastics with high melting points are usually applied as aggregates substitution, whereas the plastics with low melting points form a thin film & help increase adhesion among asphalt, plastics, and aggregates.

Figure 2 Wet & Dry Process



Sabzoi Nizamuddin1, Muhammad Jamal1, Rebecca J. Gravina (2020) **- The role of recycled linear low-density polyethylene in the modification of physical, chemical, and rheological properties of bitumen** Based on this study, the addition of R- LLDPE enhances the overall performance of bitumen without significant drawbacks. The study suggests that 3% R-LLDPE is suitable for most environmental conditions, while 6% R-LLDPE is ideal for tropical climates. However, higher dosage is not recommended

Abhishek Kumar, Prashant S, Sushant S, Rajeev Rajput (2020) **Plastic Waste in Flexible Pavement-Green Highway** This is a study to observe improvement in performance of bitumen on addition of waste plastic. It showed good result when compared with conventional flexible pavements. The polymer coated on aggregates reduced the voids and moisture absorption. Also, this plastic pavement withstood heavy traffic and lasted longer. It also reduced the bitumen content by 10% and increased performance and strength of the road. Increase of plastic waste in bitumen increases the properties of both aggregate and bitumen.

Carlos Fernando Rodrigues, Silvino Capitão, Luís Picado-Santos (2020) **- Full Recycling of Asphalt Concrete with Waste Cooking Oil as Rejuvenator and LDPE from Urban Waste as Binder Modifier** This paper deciphers adding waste cooking oil (WCO) as rejuvenator into asphalt concrete (AC) with low density polyethylene (LDPE) from urban wase as binder modifier with potential as a long-lasting pavement material. The score obtained was higher than that of a conventional AC used for comparison. The paper suggests it could be used in real pavements, particularly for low and intermediate traffic levels.

Panda, S., Mishra, S.P., Mohanty, M. (2020)**- Effect of Blended Waste LDPE/LLDPE on Properties of Bitumen for Rural Roads.** This study used Odisha State Cooperative Milk Producers' Federation's (OMFED) polythene Milk pouches as an additive to bitumen for rural road construction. The study found the optimum was achieved at 10% replacement of asphalt mixture with shredded OMFED pouches. The use of blended waste LDPE/LLDPE as an additive to bitumen can be a cost-effective and sustainable solution for rural road construction.

Eduardi Prahara, Fennysia Aswita, (2020) During the comparative experimental study on the effect of High-Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE) on characteristics of asphalt concrete with dry and wet mixing process the following inferences were obtained. LDPE is a better choice technically, commercially, and also environmentally.

Seyed Sattar Emamian, Timothy O. Adekunle, Utaberta Nangkula, Mokhtar Awang (2019) **- Use of Waste LDPE as Bitumen Modifier in Asphalt Concrete-Binder Course (AC-BC) Mix** The study examined the influence of LDPE mixing temperatures and content on the Marshall properties of road pavement. The study suggests that the use of LDPE plastic waste as a bitumen modifier can be a sustainable solution for managing plastic waste while improving the performance of road pavement.

Ravi Kumar, Professor Mr. Shivam Singh Pate, (2019) **Use of Plastic Waste in Road Construction.** In the review it was inferred that plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. The study shows that if the roads are plastic coated then they have stronger surface with increased stability. The Obtained strength of plastic-coated aggregate is more than conventional aggregates. There is no effect of rain water and other weather condition mostly of water attacks. Also, there is reduction in stripping and potholes.

S Naveen Bheempa, B Vinayaka (2019) **Use of Waste Plastic in Flexible Pavement Construction.** A Study was done by mixing the polypropylene with the bitumen mix by % of weight of total mix (4%,6%,8%,10%) heating at a temperature of 1600 c to 180o c, (60/70 grade bitumen is used in the study). This study evaluates the results of the use of polypropylene which has been used as a modifier by the amount of 8% by the weight of bitumen. From that obtained OBC the ITS specimens were prepared for each OBC and tests conducted in laboratory. The maximum ITS (Indirect Tensile Strength) values and TSR (Tensile Strength Ratio) also determined. Optimum Binder Content (OBC) for conventional mix (0%) polypropylene was 5.25% which is within the specified range of Minimum 5.4% for bituminous concrete.

Dr. S. L. Hake: Dr. R. M. Damgir (2019) Have conducted an experiment where in the Marshall Stability test with plastic content of 7.5%, 10%, 12.5%, and 15 % replacement of bitumen was tried. Marshall Stability test results showed the plastic percentage increases up to 10 % plastic replacement then it goes down. The optimum bitumen content of the neat semi dense bituminous concrete mixes showed 10% higher when compared with modified semi dense bituminous concrete mixes with waste plastic. The Marshall Stability of neat semi dense bituminous concrete mixes at optimum bitumen content showed 1.6% lower when compared with modified semi dense bituminous concrete mixes with waste plastic. Voids filled with bitumen for neat and plastic modified semi dense bituminous mixes were within the limits specified by MORTH and Voids in mineral aggregates for both neat and modified mixes were within the limits

K. I. Vishnu Vandana, M. Rajyalakshmi (2018) **Plastic Waste for Road Construction- A Survey** The cost of plastic road construction may be slightly higher compared to the conventional method. However, this should not deter the adoption of the technology as the benefits are much higher than the Cost. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes.

Singh Brijesh Kumar Shivshankar (2018) By using OBC as 5.5% various samples of varying HDPE percentages (2%, 4% and 6%) were prepared and subsequent test performed to find properties of modified dense bitumen mix. The results show that increase in % of HDPE in mix increases marshal stability value, bulk density and voids filled with bitumen (VFB) but decreases air voids. It has been observed that modified mix shows better properties at 4% HDPE. Marshall's mix design conducted on DBM using HDPE results as per MORTH commendations, indicate the acceptability of the HDPE in Bituminous Concrete mix, since in acceptable range.

Aditya Raut, Prof. Sagar W. Dhengare, Prof. Ajay L. Dandge, Prof. Harshal R.Nikhade (2017) **Utilization of Waste Plastic Materials in Road Construction** A study was conducted and by using waste plastics as modifier, It was observed that the stability of bituminous concrete mixture increased by 20%. Increase in indirect tensile strength was by about 30%. Addition of 5 to 10% recycled plastics and about 0.5% resin to binder showed significant reductions in rutting characteristics of bituminous concrete mixes. Fatigue and ITS (Indirect tensile strength) study showed improved properties over conventional mixes. Significant reduction in the fatigue life of mixes containing more than 5% of plastic waste was observed. At 8% of plastics in the bituminous concrete mixes, stability increased by about 1.65 times. This gives better resistance towards rain water and water stagnation so no stripping and no potholes. It also increases binding and better bonding of the mix thus having reduction in pores in aggregate and hence less rutting a ravelling.

Palli Praveen Kumar (2017) **Use of Waste Plastic In Road Construction** The major polymers namely polyethylene, polypropylene, polystyrene show adhesion property in their molten state. The plastic-coated aggregate bitumen mix and plastic modified bitumen showed higher flexible pavement with higher Marshall Stability value and suitable Marshall Coefficient. The use of polymer coated aggregate is better than the use of polymer modified bitumen in many aspects. For example, if all the Roads in India (3.3 million km) are converted into plastic tarmac road, all the waste plastic available will be used on the road and the disposal of waste plastics will no longer be a problem.

Huda Shafiq, Anzar Hamid (2016) **Plastic Roads- A Recent Advancement in Waste Management** Plastics show adhesion property in their molten state. Plastics increase the melting point of the bitumen. Plastic use in road construction will help in disposal of these wastes in an eco-friendly manner. Plastic roads will be most feasible for a country like India, where temperature is around 50°C and the heavy monsoons too create havoc, leaving the roads with potholes and ruts.

Vasudevan et. al (2014) have made an investigation on the readiness of plastics squander – bitumen mix and its properties to discover the appropriateness of the mix for street development. A changed procedure was produced and the stone total was covered with liquid plastics and the plastics squander covered total (Portland Cement Association) was utilized as the crude material for adaptable development. PCA demonstrated better restricting property, less wetting property, voids were substantially less, higher Marshall Solidness. The overall result shows roads laid utilizing PCA are performing better.

Apurva J Chavan (2013) **Use of Plastic waste in Flexible pavements** 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, ravelling and there is no pothole formation. The roads can withstand heavy traffic and show better durability.

Kim Byeong Chae 2011 **Asphalt modifier with recycling LDPE** The effects of different proportions of the functional components, SBS, hydrogenated modifying oil, petroleum resin, antioxidants, and film-forming agents, were investigated to optimize the performance of the asphalt modifier with LDPE. It was found a very viable and low costing mix.

Dr. S. L. Hake1, Dr. R. M. Damgir1, (2011) **Plastic waste in Bitumen Mixes for Flexible Pavement** The optimum bitumen content of the neat semi dense bituminous concrete mixes showed 10% higher when compared with modified semi dense bituminous concrete mixes with waste plastic. Marshall Stability test was conducted by adding waste plastic to bitumen mix. It was observed that the bulk density of neat semi dense bituminous concrete mixes at optimum bitumen content showed 0.43% higher when compared with modified semi dense bituminous concrete mixes with waste plastic. The volume of Air Voids of neat semi dense bituminous concrete mixes at optimum bitumen content showed 8.1% lower when compared with modified semi dense bituminous concrete mixes with waste plastic. Voids filled with bitumen for neat and plastic modified semi dense bituminous mixes were within the limits specified by MORTH and Voids in mineral aggregates for both neat and modified mixes were within the limits.

Sheikna Lebbai et. al. (2011) Performed reusing of plastic waste by blending it through bitumen to set streets. Blending plastic up to 8% with bitumen 92% for street surfaces. They have tried with 2%, 4%, 6% and 8% of the total content. They have investigated using penetration test, softening point test, ductility test and specific gravity test. The 6% of LDPE was preferred as a bitumen modifier

Mohammad T. Awwad et al. (2007) In order to enhance asphalt mixture properties polyethylene was studied. Their objective was identifying best quality of polyethylene to be used and its proportion. Two types of polyethylene High Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE) were used to coat the aggregate. The results indicated that in order to attain better engineering property grinded HDPE polyethylene modifier provides should be used. The recommended amount of the modifier is 12% by the weight of bitumen content. After going through number of researches it was concluded that waste polythene of different types of waste plastics ought to be collected and used in bituminous mix. This technique is very eco-friendly as it uses the waste plastic which is being disposed in oceans, landfills etc.

MoisésGarcía-Morales1, Pedro Partal1, Francisco J. Navarro (2004) The rheology of recycled EVA / LDPE modified bitumen

The addition of recycled EVA/LDPE to bitumen improves its mechanical properties at optimum temperature range when used as a surface coating. The study also found that pure bitumen has shear-thinning characteristics and a drop in viscosity occurs at very high shear rates. The study found that the addition of recycled EVA/LDPE to bitumen improves its mechanical properties and it is a suitable and interesting alternative from both environmental & economical point of view.

Findings

This paper runs an investigation of the possibility of using low-density polyethylene (LDPE) plastic waste as a bitumen modifier for asphalt concrete-binder course (AC-BC) mixtures. They have tried to study how to harness the power of waste plastic by using it while paving the roads. On devouring up the various existing literature we found, LDPE is a type of polymer which has been tried as bitumen modifier since early 90s till date all over the world. LDPE is a low-density polyethylene that is made from ethylene gas. It is a flexible and elastic material that is relatively inexpensive. Plastics with high melting points are usually applied as aggregates substitution, whereas the plastics with low melting points could form a thin film to increase the adhesion among asphalt, plastics, and aggregates.

LDPE modified bitumen has several advantages, including:

- ✓ Improved permanent deformation resistance
- ✓ Thermal and aging stability
- ✓ Low cost

However, LDPE modified bitumen also has some disadvantages, including:

- ✓ Poor compatibility with bitumen
- ✓ Low elasticity at low temperatures
- ✓ Difficulty in dispersing evenly in the bitumen matrix

- ➢ One challenge is that the type of waste plastic used can affect the properties of the bitumen. Some types of waste plastic can make the bitumen more brittle, while others can make it more viscous.
- ➢ Another challenge is that the waste plastic must be properly processed before it can be mixed with bitumen. This is because the waste plastic must be free of contaminants, such as dirt and moisture.

In essence, use of waste plastic in bitumen is a promising technology that has the potential to improve the performance of bituminous pavements and reduce the environmental impact of road construction. There exist thermoplastic elastomer copolymers which are more compatible with bitumen than LDPE. They are more elastic and have better low-temperature properties. However, they are more expensive than LDPE.

Way Forward

Despite the thermal and aging stability of plastomer-modified bitumen due to the absence of double bonds, the main problem resides in the stability of the blend (polymer + bitumen) during storage and difficulties to disperse them homogenously in the bitumen matrix. Thermoplastic elastomer copolymers, owing to their elastic component, are usually more effective than plastomers for bitumen modification in pavement applications. The modification ranges from low-modified containing 3% polymer to a high level with polymer content of 7%. Polymer chemical structure and reactivity are also of paramount importance in bitumen/polymer system compatibility.

Considering the variety of the conclusions, especially regarding bitumen's chemical characteristics and its engineering properties, further studies may be done to integrate the aspects related to bitumen functionality compatibility, low elasticity, dispersion and obtain conclusions concerning challenges on this topic.

Further studies, may also be done on wet process, innovations to improve the compatibility between asphalt and plastics, especially the plastics with high melting points. Effective compatibilizers should be developed to stabilize the nanomaterials, plastics, and other polymer additives to improve the low-temperature properties of the binder blends. The aging effects of plastic-modified asphalt mixtures require more tests and validation to evaluate the long-term performance of plastic-modified asphalt. Regarding the dry process, the mechanisms of using plastics and the interactions among asphalt, aggregates, and plastics are worthy of investigation. The homogeneity problem of coating between plastics and aggregates needs to be solved to improve the workability during construction.

There are a lot of good servants and bad masters the FIRE, WATER, WIND and ***PLASTIC***. Plastic waste type - LDPE (Low density polyethylene) is one such bad master but if we grind it into the asphalt binder mix and lay the road Voila!! It becomes the most promising submissive and helpful slave and a good servant.

Conclusion

Incorporation of plastics in asphalt pavement could improve the moisture resistance, enhance binding properties, and facilitate the high temperature performances without increasing construction costs and releasing the toxic gases. Considering the foregoing, LDPE is a great choice for low-cost modifiers. Other inexpensive modifiers can be used to further improve the technical qualities of bitumen. This concept could be applied to areas where the traffic intensity is not very high, such as on Gram Panchayat Roads or Village roads, where LDPE's inherent properties provide for improved rutting resistance and moisture susceptibility. The usage of LDPE in village and gram panchayat roads will contribute to lower maintenance costs and a longer lifespan for these roads. We can therefore conclude from the above that LDPE is an effective low-cost modifier

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