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A Discussion on Additives Used in Asphalt Concrete for The Enhancement of Properties

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Abstract: Around the world, bituminous mixtures are most frequently used to build flexible pavement. It is made up of a mixture of asphalt or bitumen (which serves as a binder) and mineral aggregate that is then spread out in layers and compacted. Ordinarily, conventional bituminous pavements that are properly designed and installed perform quite satisfactorily, but the performance of bituminous mixes is very subpar in a variety of settings. As compared to earlier times, today's asphaltic concrete pavements are expected to perform better due to increased traffic, increased loads, and increased daily or seasonal temperature variations. Additionally, it has been discovered that bituminous pavements perform very poorly in conditions brought on by moisture. Given this, a great deal of work has been done. Thus, a review has been done for the identification of plastic waste utilization in highway industry.
Keywords: Bitumen, Pavement, Plastic Waste , Highway

I. INTRODUCTION

A test manual for determining the tensile strength, elongation, and Young's modulus of organic free films using ASTM D 618, ASTM D 882, ASTM D 1005, and ASTM D 2370 was published in 1995 by the IPC, Institute for Interconnecting and Packaging Electronic Circuits.
Characterized Polymers Using TGA by Sichina et al (thermo gravity analysis). In order to ascertain the thermal and/or oxidative stabilities of materials as well as their compositional characteristics, he claims that TGA measures the amount and rate of change in the mass of a sample as a function of temperature or time in a controlled atmosphere. It is particularly helpful for the study of polymeric materials, such as films, fibres, coatings, paints, thermoplastics, thermo-sets, elastomers, composites, and composites.

II. LITERATURE SURVEY

A. Based on Waste Polyethylene in Pavement

When the mixtures were put through performance tests like Marshall Stability, tensile strength, compressive strength tests, and Tri-axial tests, Bindu and Beena (2010) investigated how Waste plastic acts as a stabilising additive in Stone Mastic Asphalt. The findings showed that using 10% shredded plastic can produce flexible pavement with high performance and durability.
By using the thermoplastic elastomer styrene butadiene styrene (SBS), Fernandes et al. (2008) investigated the rheological evaluation of polymer modified asphalt binders.
To improve their compatibility, they compared the modified binder's properties by adding oil shale and aromatic oil. In a dynamic shear rheometer (DSR), the rheological properties of the SBS PMBs were examined, and fluorescence optical microscopy was used to access the morphology.
The findings showed that the effects of aromatic and shale oils on the microstructure, storage stability, and viscoelastic behaviour of the PMBs were comparable. Shale oil could thus effectively serve as a compatibilizer agent without sacrificing properties or even take the place of aromatic oil.
According to Awwad and Shbeeb's 2007 research, the modified mixture has a higher stability and VMA percentage than the non-modified mixtures, which positively affects the mixtures' ability to resist rutting. They claim that adding HDPE polyethylene to asphalt mixture improves the mixture's properties significantly more than adding LDPE polyethylene does.
Gawande et al. (2012) provided an overview of the use of waste plastic in road paving using both wet and dry methods. According to them, using waste plastics in the production of roads and laminated roofing also helps to consume large amounts of waste plastics. They claimed that using modified bitumen with the addition of processed waste plastic of about 5 to 10 percent by weight of bitumen helps in improving the longevity and pavement performance. As a result, these processes improve infrastructure while being highly relevant to society.

According to Khan and Gundaliya (2012), the process of modifying bitumen with waste polythene improves the overall performance of roads over a long period of time by increasing softening point, hardness, and reducing stripping due to water. This improves resistance to cracking, pothole formation, and rutting. They claim that the used waste polythene coats the mixture's aggregates, reducing porosity, moisture absorption, and improving binding properties.

Prusty (2012) investigated how BC mixes that had been altered with waste polythene behaved. For the preparation of mixes with a chosen aggregate grading as specified in the IRC Code, he used a variety of polythene percentages. Marshall He uses properties like stability, flow value, unit weight, and air voids to calculate the ideal polythene content for the given bitumen grade (80/100). In light of these elements, he concluded that polymer modifications can be used to create a pavement mix that is more stable and long-lasting.

Swami et al. (2012) found that adding plastic to bitumen between the ranges of 5 percent and 10 percent decreased the project's overall material cost by 7.99 percent. They came to the conclusion that bitumen modification can improve the quality and performance of roads by reducing issues like bleeding in hot climates and noise pollution from heavy traffic.

In an experimental study on conventional bitumen and polymer modified binder, Pareek et al. (2012) found that polymer modified bitumen significantly increased the bituminous concrete mix's resilient modulus, indirect tensile strength, and rutting resistance. Additionally, they came to the conclusion that polymer modified bitumen has better age resistance properties (the weight loss during heating in a thin film oven is six times greater than with conventional bitumen of 60/70) and a high elastic recovery (79 percent).

B. Based on Plastic Waste Other than Highway Industry

According to Sangita et al. (2011), using plastic waste in road construction is a novel way to improve the quality of the roads. They claim that bitumen modification makes roads last 2-3 times longer, saving us Rs 33,000 crores a year in repairs and reducing vehicle wear and tear. India spends Rs 35,000 crores annually on road construction and repairs, including Rs 100,000 crores just for maintenance.

By using 8 percent and 15 percent (by weight of bitumen) polythene with respect to 60/70 penetration grade of bitumen, Sabina et al. (2009) evaluated the performance of waste plastic/polymer modified bituminous mix and found that the results of marshal stability and retained stability increased 1.21 and 1.18 times higher than that of conventional mix. However, their results for the modified mix with 15% polyethylene showed marginally lower Marshall Stability values than those for the modified mix with 8% modifier.

Reinke and Glidden (2002) used the DSR (dynamic shear rheometer) creep and recovery tests to test the resistance of HMA mixtures to failure, and they found that the results indicated improved resistance in the case of polymer modified binders.

A potential fix for bituminous pavement strength loss under water was provided by Karim et al. They compared the effectiveness of bituminous mixtures under water with and without polyethylene admixture and came to the conclusion that bitumen mixes with polyethylene performed well under water and demonstrated even better Marshall Stability than typical bituminous mixture under normal conditions. Preserving the environment from pollution will be an added benefit.

According to Yousefi (2009), the only thing stopping the modification process was the presence of partitions made from molten bitumen. Polyethylene particles do not typically rip in bitumen medium; instead, they prefer to join together and form larger particles due to interfacial and inter-particle attractive forces. The author claims that the coalescence of polyethylene particles and subsequent polymer phase separation occurred whenever particles had sufficient energy to overcome the remaining thin bitumen film that was separating them.

Vasudevan (2004) used polypropylene/polythene bags for the integrated construction of rural and arterial roads in order to promote socioeconomic development. By adding polymer in relation to the weight of the bitumen used, he studied both the dry and wet mixing processes. According to the author, polymer bitumen blend is a superior binder to plain bitumen, resulting in higher Marshall Stability and fewer opportunities for potholes to form.

According to research by Verma (2008), plastic raises the bitumen's melting point and makes the road flexible during the winter, extending the road's lifespan. According to the author, plastic-bitumen roads can last up to 10 years, whereas a typical "highway quality" road lasts four to five years. This would be beneficial for India's hot and extremely humid climate, where temperatures regularly exceed 50°C and torrential rains cause havoc and leave the majority of the roads with large potholes.

According to Moghaddam and Karim (2012), using waste materials in asphalt pavement could help find an alternative solution to extend the life of asphalt pavement and lower environmental pollution. According to their study, mixtures reinforced with polyethylene terephthalate (PET) have higher stability values, flow rates, and fatigue lives than mixtures without PET.

Wegan and Nielsen (2001) prepared thin sections of the specimen and analysed those thin sections using an infrared fourier transform spectrometer to study the microstructure of polymer modified binders in bituminous mixtures. The bitumen phase is black, the polymer phase is yellow, the fine and coarse aggregates frequently appear green, and air voids or cracks appear with a yellow-green colour when thin sections were illuminated with UV light.

Herndon (2009) used recycled polythene that has been phosphonylated to study the moisture susceptibility of an asphalt mixture. They claimed that the addition of recycled, unaltered polyethylene to asphalt concrete mixtures in both the Wet Process and the Dry Process significantly reduces moisture susceptibility.

By adding the right amount of polyethylene to bituminous mix for road construction, Jain et al. (2011) found that rutting in bituminous roads can be reduced to 3.6 mm from a value of 16.2 mm after applying 20,000 cycles. This improves pavement performance while also easing disposal issues for waste polymeric packaging materials (WPPM) for a clean and safe environment.

Firoozifar et al. (2010) looked into cutting-edge techniques to increase polythene modified bitumen's susceptibility to low temperatures and storage stability.

They used a fluorescent microscope to check the homogeneity of the samples and kerosene, oleic acid, aromatic oil, B-oil, etc. to increase the stability of polythene modified bitumen.

In their 2009 study, Aslam and Rahman compared dry and wet mix construction methods and came to the conclusion that the dry method is more practical and cost-effective for building flexible pavements. Because a higher percentage of polythene in a wet process causes them to separate from bitumen when they cool, additives are required.

According to ScienceTech Entrepreneur (2008), roads constructed with plastic waste that has been shred are much more durable than those that are asphalted with regular mix. According to this paper, plastic-bitumen roads can last up to 10 years, compared to the 4 to 5 years that a typical highway road lasts. According to this paper, the plastic in the tar will prevent rainwater from penetrating. So, less road repair will be necessary as a result of this technology.

When surfacing with modified bitumen as opposed to unmodified bitumen, the time period until the next renewal may be extended by 50%, according to the Indian Roads Congress Specifications Special Publication: 53 (2002).

Through penetration tests, ring & ball softening point assessments, and viscosity tests, Habib et al. investigated the rheological characteristics of bitumen modified by thermoplastics, specifically linear low density polyethylene (LLDPE), high density polyethylene (HDPE), and polypropylene (PP), as well as their interactions with bitumen with an 80 penetration grade. The thermoplastic copolymer was found to have a significant impact on penetration rather than softening point.

According to the author, PP offers a better blend than HDPE and LLDPE. Visco-elastic behaviour of polymer modified bitumen depends on the polymer concentration, mixing temperature, mixing technique, solvating power of the base bitumen, and molecular structure of the polymer used.

With reclaimed polyethylene as an additive, Punith and Veeraragavan studied the behaviour of asphalt concrete mixtures. They investigated a blend of PE (2.5, 5.0, 7.5, and 10 percent by weight of asphalt) with (80/100) paving grade asphalt and conducted dynamic creep tests (unconfined), indirect tensile tests, resilient modulus tests, and Hamburg wheel track tests. They found that adding PE to the asphalt mixture can lower its temperature susceptibility and rutting potential.

Sui and Chen (2011) investigated polyethylene's use and effectiveness as a modifying additive in asphalt mixtures. The construction process was streamlined and the cost of construction was decreased by adding polyethylene as an additive to hot mineral aggregate for a short period of time. They came to the conclusion that there had been advancements in high temperature stability, low temperature cracking resistance, and water resistance and assessed polyethylene as an additive in the technical, economic, and environmental aspects. Casey et al. (2008) investigated the creation of a modified binder made from recycled polymers for use in stone mastic asphalt. According to their research, adding 4% recycled HDPE to a pen grade binder yielded the most promising results. Wheel track and fatigue tests also revealed that while the binder did not perform as well as a proprietary polymer modified binder—that is, to the same high levels—it did outperform conventional binders used in stone mastic asphalt.

Low density polyethylene (LDPE) was the subject of Al-Hadidy and Yi-2009 qiu's investigation into its potential application as a modifier for asphalt paving materials. According to their study's findings, modified binders exhibit a higher softening point, maintain ductility values within the required range (100+ cm), and lessen the amount of weight loss due to heat and air (i.e. increase durability of original asphalt). Laboratory evaluation of HMA with high density polyethylene as a modifier was done by Attaelmanan et al. in 2011. The analysis of test results reveals that HDPE-modified asphalt mixtures perform better than conventional mixtures because the moisture susceptibility and temperature susceptibility can be decreased by adding 5% by weight of HDPE to the conventional asphalt mixture. Additionally, they conducted the drain down, Marshall, indirect tensile strength, flexural strength, and resilient modulus tests, and in each instance, they received favourable results.

Ahmadinia et al. (2012) conducted experimental research on the use of polyethylene terephthalate (PET) from used plastic bottles as an additive in stone mastic asphalt (SMA). Wheel tracking, moisture susceptibility, resilient modulus, and drain down tests were performed on mixtures in their study that contained different percentages of waste PET, including 0%, 2%, 4%, 6%, 8%, and 10% by weight of bitumen content. Their findings demonstrate that the addition of waste PET to the mixture has a significant positive impact on the properties of SMA, which could increase the mix's stiffness, provide lower binder drain down, and promote the reuse and recycling of waste materials in a more economical and environmentally friendly manner.
The chemically grafted polyethylene used as asphalt modifiers was examined by Vargas et al. (2013). Their findings demonstrate that the penetration level decreased in blends made with grafted polyethylene, while the softening point of asphalt increased. Additionally, phase distributions of micrographs from fluorescence microscopy demonstrate that non-grafted polyethylene polymers were not easily miscible with asphalt. In comparison to reference polyethylene blends, the majority of asphalt blends show improved performance at higher temperatures with grafted polyethylene, including improved rutting resistance, flow activation energy, and superior time-temperature dependent response.
In their investigation, Rahman and Wahab (2013) used recycled PET as a partial replacement for fine aggregate in modified asphalt. In terms of economic value, it demonstrates that recycled PET could lower the cost of road construction because it is easier to obtain and less expensive than bitumen while also enhancing the performance and lifespan of the road. Their research leads to the conclusion that using recycled PET-modified asphalt offers more benefits than using regular asphalt, particularly in terms of permanent deformation.

III. CONCLUSION

According to a review, the polyethylene is added to the mixture during the dry mixing process. Polyethylene can also be used to modify bitumen through wet mixing, and comparisons can be drawn. Utilizing the proper technique, the microstructure of the modified bituminous mixture should be examined to determine the degree of homogeneity. In order to adequately investigate the potential for finding suitable materials for paving mixes in the event of the current demanding situations, a combination of paving mixes formed with other types of plastic wastes that are widely available, wastes to replace conventional fine aggregates and filler, and different types of binders including modified binders, can be tried.

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