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USE OF WASTE PLASTIC IN DENSE BITUMINOUS MIX

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Abstract: Plastic is a cost-effective material and it is using widely in industrial production and is an efficient raw material for manufacturing of plastic based goods. The huge quantity of waste materials such as plastic, polythene bags, rubber tyres cause environmental hazards when it is disposed. Although waste plastic is currently viewed as a demon for present and future generations due to its non-biodegradability and unsightly appearance. The utilisation of plastic has revolutionised various sectors of the growing economy of the country, such as information technology, automobile, construction and etc. The studies have linked improper disposal of plastic waste to various issues such as skin problems, cancer, genital abnormalities, and negative impacts on animals. This study aimed to develop a modified binder for bitumen concrete mix by utilizing these waste materials as a partial replacement for bitumen and it enhances the desired mechanical properties of the road mixtures. The polymer coated on aggregates can reduce the voids and moisture absorption, results in reducing the formation of ruts and potholes. The road constructed with this modified bituminous mix can withstand heavy traffic load and durable than normal mix roads. The use of this modified mixes can improve the abrasion and the toughness value. To replicate field conditions the study focused on the Marshall test and the Ultimate performance of hot mix asphalt. The plastic and the crumb rubber were substituted for bitumen at different proportions of between 5%-10% and 5%-15%. By substituting bitumen with waste plastic, there may be a increase in strength of up to 16%, and with rubber material up to 50% increase compared to conventional mix. By using these waste materials, it is possible to get a bituminous mix with required strength and density, as an eco-friendly green pavement at lower cost.

Keywords: Waste plastic, Crumb rubber, Disposal, Modified Bituminous mix, Eco-friendly, Low cost.

I. INTRODUCTION

Plastic is a widely using material, it is corrosion resistant, strong, highly flexible synthetic polymer, Due to the increasing number of users globally, there is a fierce competition among industries to produce products that are cheaper, more durable, attractive, and easily transportable. Unfortunately many industries are using plastic without considering their harmful effects on the environment and human health. The quantum of plastic waste in municipal solid waste is increasing due to increase in population, urbanization etc. And disposal of the wide variety of plastic and rubber in an eco-friendly way is a huge challenge. The various types of plastic such as High and Low-density polyethylene, polypropylene and other polymers are widely used in our daily consumables.

This extensive use of plastics results in massive waste worldwide, which is non-biodegradable and posses long lasting threats to human health and environment. researchers are exploring ways to convert this waste into resource. As the highway industry as wide range of material applications, the use of waste plastic in constructing the roads gaining more importance. In the regular way of constructing roads bitumen is used as a binder, apart from that the bitumen is replaced partially with waste plastic, because the plastic has adhesion property as well as it makes the road materials more durable and resistant to water.

II. LITERATURE REVIEW

Dr . S. L. Hake et al.[1] The Marshall stability test conducted on the samples prepared with both neat and plastic modified bitumen mixes. On 101.6 mm dia and 63.5 mm thick compacted cylindrical specimen mix is prepared with varying bitumen content 2.5% increments over a range that gives a well-defined maximum value for specimen density and stability. To the increment to bitumen content, the plastic content of 7.5, 10, 12.5, 15% is added to check the effect of plastic replacement of the Marshall property of the mix. The Marshall stability of net DBM shows 1.6% less than modified DBM and the volume of voids is 8.1% lower when compared with modified mix, optimum bitumen content required for DBM is 10% more when compared with modified mixes.

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R. Manju et al.[2] A comparative study was conducted to test normal aggregates and plastic-coated aggregates, as well as bitumen and modified bitumen with 10% of bitumen replaced by plastic. The results showed that plastic-coated aggregates had 40% more crushing strength and 9% lower aggregate impact value compared to normal aggregates due to their higher toughness. Additionally, the abrasion value of plastic-coated aggregates was 21% lower than that of normal aggregates. The penetration value of bitumen was higher than bitumen mixed with plastic, but the bitumen mixed with plastic softened 10^0C less than the normal mix. The stability of modified bitumen with 10% bitumen replaced by plastic was found to be 10% higher than normal bitumen through Marshall testing. The use of plastic mix could reduce the bitumen content by 10% while increasing the road's strength and performance in an eco-friendly way.

Shubham Bansal et al.[3] The study utilized shredded plastic waste with a particle size of approximately 650mm and specific gravity of 1.18 in the binder mix . The binders were divided into three series: A, B, and C, where A and B represented binary mixes, i.e., Bitumen (B) + Plastic (P) and Bitumen (B) + Rubber (R), respectively, and C represented the tertiary mix with varying proportions of plastic and rubber in bitumen. The mixes with varying percentages of binder constituents were referred to as Bitumen Mix (BM). The Marshall Stability value of the controlled mix (6% by weight of aggregate) was 9.06 KN, satisfying the minimum stability requirement of BC. The results demonstrated that the modified binder mix containing rubber and/or plastic waste provides better stability compared to conventional bituminous mix. The bulk density value of the modified mix was found to be higher than normal or non-modified BC.

A.I. Al-Hadidy et al.[4] The current study employed a mechanistic-empirical design approach to assess the advantages of modifying SMA mixtures for reducing pavement layer thickness and extending service life. Initially, LDPE underwent a pyrolysis process to thermally degrade it. The optimal asphalt content for the control SMA mixture was determined to be 5.82% at 4.2% air voids. The softening point of virgin asphalt increased by 26% at 6% LDPE, indicating improved resistance to deformation. The chemical reaction between asphalt molecules and the larger number of activated groups in the thermally degraded LDPE was found to be easy. The stability increased and the flow decreased up to 6% LDPE due to the lower specific gravity of LDPE than that of virgin asphalt, which served to penetrate between particles and enhanced interlocking of aggregates.

Md T. Awwad et al.[5] The study aimed to explore the potential benefits of using polyethylene, a type of polymer, to improve the properties of asphalt mixture. The research also aimed to determine the optimal type of polyethylene and its quantity to be used. The findings showed that using ground HDPE modifiers improved the engineering properties of the mixture. The recommended proportion of the modifier is 12% by the weight of bitumen content. This increased the stability and decreased the density, while slightly increasing the air voids and voids of mineral aggregates. The modified mixture had higher stability and VMA percentage compared to non-modified mixtures, which could enhance their resistance to rutting. The study concluded that the addition of the modifier could improve the properties of asphalt mixture.

R. Vasudevan et al.[6] Stone aggregate is coated with plastic waste such as PE, PP, and PS. This coated aggregate is then mixed with bitumen to create a flexible pavement construction material called PCA. It is possible to use a higher percentage of plastic waste (10-15%) without the need for separation. In addition, the quality of the aggregate is enhanced. Polymeric materials such as PE, PP, and PS undergo a softening process without any gas evolution at temperatures between 130-140°C. However, they decompose at around 270°C, releasing gases such as methane and ethane. At temperatures above 700°C they undergo combustion, As a result, it is recommended to utilize molten waste plastics at temperatures below 100-150°C to ensure safety.

Osman Gulseven et al.[7] By comparing with the test material with no plastic mix, and the bitumen mixtures with various proportions, the mix with 8% plastic showed the highest stability value. The mixture containing plastic has superior performance when compared to the base mixture. It can withstand 36% more stress in wet conditions and 22% more stress in dry conditions. Additionally, it shows an 18% increase in correlation stability and a 7% increase in flow.

Abhishek garg et al.[8] Mixing waste plastic with bitumen in pavement can reduce the demand for bitumen by around 6% and improve the pavement's serviceability. The use of plastic waste in pavement can reduce the cost of binder, especially in high-temperature zones, as plastic modified bitumen has a higher melting value than conventional bitumen. The waste plastic also reduces penetration and ductility, resulting in a higher softening point and a reduction in rutting and cold cracking in flexible pavement. Marshall Stability values show that stability increases until 6% of replacement, after which it decreases. Deformation increases with an increase in plastic, but the flow value remains within an allowable range. The requirement for binder content is also reduced with the percent of replacement, which ultimately reduces construction costs.

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Paravita Sri Wulandari et al.[9] Asphalt with penetration grade 60/70 was selected. The crumb rubber use with sizes 0.42mm and 0.177mm. By this study they recommended crumb rubber is a good additive with asphalt mixture, as all the tests results are occurred with in the standard needs. The mixing of crumb rubber to asphalt can increases the strength and quality of mixture. The result shows decrease in flow as well as increase in stability. The use of crumb rubber in asphalt mixtures allows for a reduction in asphalt content. However, this reduction can result in increased air voids and greater permeability in the mixture. Greater permeability can compromise the durability of the asphalt mixture, which is a concern that needs to be addressed especially when using lower asphalt content in crumb rubber modified asphalt mixtures.

Kamakashi jamwal et al.[10] In this test, the specimen is prepared to pouring consistency at the temperature of less than 60°C for tar and 90°C for bitumen. The penetration values of sample occurred between 60 and 70. Fir this grade 60/70 the softening point got at 69.6° C. The marshall stability value occurred as 8.9 and 13.10 respectively for plain and modifies bitumen. The polymer coated on aggregates will reduces the voids and absorbing of moisture content.

III. CONCLUSION

The studies reviewed in this text provide evidence for the potential of plastic waste as a modifier for bitumen mixtures. The addition of plastic waste can improve the engineering properties of the mixture, increase stability, reduce density and voids, and enhance resistance to rutting. The use of plastic waste can also reduce the bitumen content while increasing the road's strength and performance in an eco-friendly way. The results of the studies show that modified binder mix containing rubber and/or plastic waste provides better stability compared to conventional bituminous mix. Overall, these findings suggest that the use of plastic waste in bitumen mixtures can have significant benefits for the construction and maintenance of roads.

REFERENCES

[1]. S.L. Hake, R.M. Damgir, P.R. Awsarmal. (2020). Utilization of Plastic waste in Bitumen Mixes for Flexible Pavement, Transportation Research Procedia, Volume 48.
[2]. R.Manju Anand & Sathya.S, (2017). Use of Plastic Waste in Bituminous Pavement. International Journal of ChemTech Research. 10. 804-811.
[3]. Shubham Bansal, Anil Misra & Purnima Bajpai. (2017). Evaluation of modified bituminous concrete mix developed using rubber and plastic waste materials. International Journal of Sustainable Built Environment. 6. 10.1016/j.ijsbe.2017.07.009.
[4]. Al-Hadidy, Abdul-Rahim & Tan Yi-qiu, (2009). Effect of polyethylene on life of flexible pavements. Construction and Building Materials. 23. 1456-1464. 10.1016/j.conbuildmat.2008.07.004.
[5]. Mohammad T. Awwad, (2007). The Use of Polyethylene in Hot Asphalt Mixtures. American Journal of Applied Sciences. 4. 390-396. 10.3844/ajassp.2007.390.396.
[6]. R. Vasudevan, & Ramalinga Chandra Sekar, & B.SundaravKannan, & R.Velkennedy. (2012). A technique to dispose waste plastics in an ecofriendly way – Application in construction of flexible pavements. Construction and Building Materials. 28. 311–320. 10.1016/j.conbuildmat.2011.08.031.
[7]. Gulseven, Osman & Ashkanani, Shaimaa & Abdullah, Sarah & Ismaeil, Hawraa & Alkandari, Haneen & Baroun, Mariam. (2019). A sustainable model for enhancing road quality with recycled plastic bags. Kuwait Journal of Science. 46. 112-119.
[8]. Abhishek Garg, Prakash Somani, Arun Gaur & B L Swami. (2020). Gainful utilization of plastic waste in dense bituminous macadam. IOP Conf. Ser.: Mater. Sci. Eng. 872 012129.
[9]. Paravita Wulandari, & Daniel Tjandra, (2017). Use of Crumb Rubber as an Additive in Asphalt Concrete Mixture. Procedia Engineering. 171. 1384-1389. 10.1016/j.proeng.2017.01.451.
[10]. Kamakashi Jamwal, Er. Avtar Singh, Er.Sunil Priyadarshi. (2020). Use of Plastic in Road Construction. DOI 10.17148/IARJSET.2020.7621