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WASTE POLYETHYLENE USE IN BITUMINOUS PAVING MIXES: A REVIEW

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ABSTRACT

In flexible pavement construction, bituminous mixes are most commonly used all over the world. It consists of asphalt or bitumen and mineral aggregate which are mixed together, laid down in layers and then compacted. In addition, the performance of bituminous pavements is found to be very poor in moisture induced situations. Considering this a lot of work has been done on use of additives in bituminous mixtures and as well as on modification of bitumen. Research has indicated that the addition of polymers to asphalt binders helps to increase the interfacial cohesiveness of the bond between the aggregate and the binder which can enhance many properties of the asphalt pavements to help meet these increased demands. However, the additive that is to be used for modification of mix or binder should satisfy both the strength requirements as well as economic aspects. Plastics are everywhere in today's lifestyle and are growing rapidly throughout particularly in a developing country like India. As these are non-biodegradable there is a major problem posed to the society with regard to the management of these solid wastes. Low density polyethylene (LDPE) has been found to be a good modifier of bitumen.Various percentages of polythene are used for preparation of mixes with a selectedaggregate grading as given in the IRC Code. The role of polythene in the mix is studied for various engineering properties by preparing Marshall Samples of BC mixtures with and without polymer. Marshall Properties such as stability, flow value, unit weight, air voids are used to determine optimum polythene content for the given grade of bitumen (80/100).

Key Words: Bituminous concrete (BC), Plastic waste, low density polyethylene, Aggregate, Bitumen, Marshall Stability, Flow value, Optimum Polythene Content,Low density polyethylene (LDPE)

I INTRODUCTION

Bituminous binders are widely used by paving industry. A pavement has different layers. The main constituents of bituminous concrete (BC) are aggregate and bitumen. Most of the Highways in India constructed with flexible pavement having wearing course/surfacing course with bituminous concrete. In general pavements are categorized into 2 groups, i.e. flexible and rigid pavement.

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1.1 Flexible Pavement

Flexible pavements are those, which on the whole have low flexural strength and are rather flexible in their structural action under loads. These types of pavement layers reflect the deformation of lower layers on-to the surface of the layer.

1.2 Rigid Pavement

If the surface course of a pavement is of Plain Cement Concrete then it is called as rigid pavement since the total pavement structure can't bend or deflect due to traffic loads. Pavement design and the mix design are two major considerations in case of pavement engineering. The present study is only related to the mix design of flexible pavement considerations. The design of asphalt paving mixtures is a multi-step process of selecting binders and aggregate materials and proportioning them to provide an appropriate compromise among several variables that affect mixture behavior, considering external factors such as traffic loading and climate conditions.

1.3 Role of polythene in pavement

Plastic/Polythene used in bituminous concrete mix because of various properties which make a significance contribution to construction needs:

- To improvise the fatigue life
- It is economical and longer life
- Sufficient strength to resist shear deformation under traffic at higher temperature.
- Sufficient flexibility to avoid cracking due to repeated traffic load.
- Corrosion resistant and durable
- Reduce the rutting & thermal cracking in the pavement
- Good insulation for cold heat

III OBJECTIVES

It has been carried out to satisfied following objectives:

- To utilize waste plastic in bimanous mixes.
- To improve the volumetric properties of BC mix design.
- To evaluate laboratory performance of BC mix design.

IV MATERIAL USED

4.1 Polythene

Stabilizing additives are used in the mixture to provide better binding property. Now-a dayspolypropylene, polyester, mineral and cellulose are commonly used as fibers. In this present study polyethylene is used as

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stabilizing additive to improve performance characteristics of pavement.The polythene used in milk packets was used as raw material for preparation of the samples. These polythene packets were collected; they were washed and cleaned by putting them in hot water for 3-4 hours. They were then dried. Waste plastic in the shredded form is used.

4.2 Bitumen

Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminousmixtures. Bitumen must be treated as a visco-elastic material as it exhibits both viscous as well as elastic properties at the normal pavement temperature. At low temperature it behaves like an elastic material and at high temperatures its behavior is like a viscous fluid. Asphalt binder VG30 is used in this research work. Grade of bitumen used in the pavements should be selected on the basis of climatic conditions and their performance in past. It fills the voids, cause particle adhesion and offers impermeability.60/70 grade bitumen Waste plastic in the shredded form 6mm,stone dust and cement as filler

4.3 Aggregates

Aggregate constitutes the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement.

4.4 Filler

Aggregate passing through 0.075 mm IS sieve is called as filler. It fills the voids, stiffens the binder and offers permeability. In this study sand can be used as filler whose specific gravity has been found to be 2.7 and 2.3.

V LITERATURE REVIEW

1. Bindu and Beena (2010) studied how Waste plastic acts as a stabilizing additive in Stone Mastic Asphalt when the mixtures were subjected to performance tests including Marshall Stability, tensile strength, compressive strength tests and Tri-axial tests. There results indicated that flexible pavement with high performance and durability can be obtained with 10% shredded plastic.

2. Fernandes et al. (2008) studied Rheological evaluation of polymer modified asphalt binders by using thermoplastic elastomer styrene butadiene styrene (SBS) and they compared the properties of Modified binder by addition of both oil shale and aromatic 9 oil to improve their compatibly. The rheological characteristics of the SBS PMBs were analyzed in a dynamic shear rheometer (DSR) and the morphology accessed by fluorescence optical microscopy. The results indicated that the aromatic and shale oils have similar effects on the microstructure, storage stability and viscoelastic behaviour of the PMBs. Thus, shale oil could be successfully used as a compatibilizer agent without loss of properties or could even replace the aromatic oil.

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3. Awwad and Shbeeb (2007) indicated that the modified mixture has a higher stability and VMA percentage compared to the non-modified mixtures and thus positively influence the rutting resistance of these mixtures. According to them modifying asphalt mixture with HDPE polyethylene enhances its properties far more than the improvements realized by utilizing LDPE polyethylene.

4. Gawande et al. (2012) gave an overview on waste plastic utilization in asphalting road by using both wet and dry method. They said that use of modified bitumen with the addition of processed waste plastic of about 5-10% by weight of bitumen helps in improving the longevity and pavement performance with marginal saving in bitumen usage and according to them use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure.

5. Khan and Gundaliya (2012) stated that the process of modification of bitumen with waste polythene enhances resistance to cracking, pothole formation and rutting by increasing softening point, hardness and reducing stripping due to water, thereby improving the general performance of roads over a long period of time. According to them the waste polythene utilized in the mix forms coating over aggregates of the mixture which reduces porosity, absorption of moisture and improves binding property.

6. Prusty (2012) studied the behaviour of BC mixes modified with waste polythene. He used various percentages of polythene for preparation of mixes with a selected aggregate grading as given in the IRC Code. Marshall Properties such as stability, flow value, unit weight, air voids are used to determine optimum polythene content for the given grade of bitumen (80/100) in his study. Considering these factors he observed that a more stable and durable mix for the pavements can be obtained by polymer modifications.

7. Swami et al. (2012) investigated that the total material cost of the project is reduced by 7.99% with addition of plastic to bitumen between the ranges of 5% to 10%. They concluded that by modification of bitumen the problems like bleeding in hot temperature regions and sound pollution due to heavy traffic are reduced and it ultimately improves the quality and performance of road.

8. Pareek et al. (2012) carried out experimental study on conventional bitumen and polymer modified binder and observed a significant improvement in case of rutting resistance, indirect tensile strength and resilient modulus of the bituminous concrete mix with polymer modified bitumen. They also concluded that Polymer modified bitumen results a high elastic recovery (79%) and better age resistance properties (The loss in weight on heating in thin film oven is 6 times higher as compared to conventional bitumen of 60/70).

9. Sangita et al. (2011) suggested a novel approach to improve road quality by utilizing plastic waste in road construction. According to them India spends Rs 35,000 crores a year on road construction and repairs, including Rs 100,000 crores a year just on maintenance and roads by bitumen modification lasts 2-3 times longer, which will save us Rs 33,000 crores a year in repairs, plus reduced vehicle wear and tear.

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10. Sabina et al. (2009) evaluated the performance of waste plastic/polymer modified bituminous mix and observed that the results of marshal stability and retained stability of polythene modified bituminous concrete mix increases 1.21 and 1.18 times higher than that of conventional mix by using 8% and 15% (by weight of bitumen) polythene with respect to 60/70 penetration grade of bitumen. But modified mix with 15% polyethylene showed slightly decreased values for Marshall Stability than that of the mix with 8% modifier in their results.

11. Reinke and Glidden (2002) tested the resistance of HMA mixtures to failure by using the DSR (dynamic shear rheometer) creep and recovery tests and reported that result shows improved resistance in case of polymer modified binders.

12. Karim et al. gave a potential solution to strength loss of bituminous pavement under water. They compared performance of bituminous mix under water with and without polyethylene admixture and conclude that bitumen mixes with polyethylene performed well under water and showed even better Marshall Stability than normal bituminous mix under normal condition Keeping the environment safe from pollution will be an added bonus.

13. Yousefi (2009) stated that the polyethylene particles do not tend to rip in bitumen medium and these particles prefer to join together and form larger particles due to interfacial and inter-particle attractive forces and the only obstacle in the modification process was the existence of partitions made from molten bitumen. According to the author whenever, particles had enough energy to come close together and overcome the thin remained bitumen film which was separating particles, the coalescence of polyethylene particles occurred and lead to polymer phase separation.

14. Vasudevan (2004) utilized polythene/polypropylene Bags for integrated development of Rural and Arterial road network for socio-economic Growth. He studied both dry 12 and wet mixing process by adding polymer with respect to the weight of bitumen used. Author reported that polymer bitumen blend is a better binder compared to plain bitumen resulting higher Marshall Stability and decreasing the possibilities of potholes formation.

15. Verma (2008) studied that plastic increases the melting point of the bitumen and makes the road flexible during winters resulting in its long life. According to author while a normal “highway quality” road lasts four to five years, plastic-bitumen roads can last up to 10 years and it 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.

VI ADVANTAGES OF POLYTHENE

- Lower penetration value; withstands higher load. No stripping – Resists the permeation of water.
- Better disposal of waste plastics. Ten lakhs or one ton carry bags in one kilometer road.
- Better binding property, Higher Softening point; withstands high temp.

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- The polymer coating also reduces the voids. This has resulted in reduced rutting , reveling, there is no formation of pot hole
- The road can withstand heavy traffic & show better durability.

VII CONCLUSIONS

- Waste Plastic can be used as coating material in bituminous concrete mixture for road construction.
- Use of waste plastic 0.76% by weight of aggregate and3% filler significantly improve the volumetric properties of bituminous mixes resulting better performance of BC with plastic waste than control mix(
- It is observed that Marshall Stability value increases with polyethylene content up to 4% and thereafter decreases.
- we observe that the Marshall flow value decreases upon addition of polythene i.e the resistance to deformations under heavy wheel loads increases.
- Plastic road would be a boon for India's hot and extremely humid climate where durable and eco-friendly roads which will relive the earth from all type of plastic waste.

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