STUDY ON USAGE OF WASTE PLASTIC IN BITUMEN MIXES IN COLD CLIMATE AREAS

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Abstract *The waste plastic and its disposal is a major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. In addition it will also be a solution to plastic disposal & various defects in pavement viz., pot holes, corrugation, ruts, etc. Plastic was found to be an effective binder for bitumen mixes used in flexible pavements. This efficient method helps the pavements to resist higher temperature by minimizing the formation of cracks and reducing rainwater infiltration which otherwise leads to the development of potholes. These pavements have shown improved crushing and abrasion values and reduced water seepage.*

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 In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made, which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water

Keywords: *Plastic waste, Bitumen, Plastic roads, Flexible pavement, Bitumen mix.*

1. INTRODUCTION

Construction of highway involves huge outlay of investment. A precise engineering design may save considerable investment as well a reliable performance of the in-service highway can be achieved. Two things are of major considerations in mix design considerations. A good design of bituminous mix is expected to result in a mix which is adequately strong, durable, resistive to fatigue, permanent deformation, and environment friendly, economical and so on. A mix designer tries to achieve these requirements through a number of tests on the mix with varied proportions and finalizes with the best one. The present research work tries to identify some of the issues involved in this art of bituminous mix design and the direction of current research. Plastic use in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density polyethylene) pipes to form plastic mats.

The plastic roads include transition mats to ease the passage of tyres up to and down from the crossing. Both options help protect wetland haul roads from rutting by distributing the load across the surface. But the use of plastic-waste has been a concern for scientists and engineers for a quite long time6. Recent studies in this direction have shown some hope in terms of using plastic-waste in road construction i.e., Plastic roads.

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 Waste plastic

Use of polyethylene in road construction is not new. Some aggregates are highly hydrophilic (water loving). Like bitumen polyethylene is hydrophobic (water hating) in nature. So the addition of hydrophobic polymers by dry or wet mixing process to asphalt mix lead to improvement of strength, water repellent property of the mix. Polyethylenes get added to hot bitumen mixture and the mixture is laid on the road surface like a normal tar road.

Plastic roads mainly use plastic carry-bags, disposable cups, polyethylene packets and PET bottles that are collected from garbage as important ingredients of the construction material. Polymer modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting & thermal cracking in the pavement. Creating a modified bituminous mixture by using recycled polymers (e.g., polyethylene) which enhances properties of HMA mixtures would not only produce a more durable pavement, but also provide a beneficial way of disposal of a large amount of recycled plastics.

1.3 Objectives of the study

From this study the following objectives were made

1. A comparative study has been made for bitumen mixes with varying plastic contents (0% - 20%).
2. The effect of polyethylene as admixture on the strength of bituminous mix with different filler.
3. The performance of bituminous mix under water with and without plastic different percentages from 0% to 20%.
4. To study resistance to permanent deformation of mixes with and without plastic content.
5. To test the bitumen and the modified bitumen.
6. To reduce the disposal problem of plastics.

2. LITERATURE REVIEWS

R.Manju1 , Sathya S2 , Sheema K3 , et al.,(2017) The waste plastic and its disposal is a major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. From this study it was concluded that the plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption .

Sunil Jayant Kulkarni1 ,et al., (2016) Solid waste material can be classified as putrescible and nonputrescible. Putrescible solid waste undergoes decay or putrification. The disposal of biodegradable waste can be carried out in open dumping, sanitary landfill or composting methods waste plastic can be converted into ethanol and other products. From this studies we concluded critical problem of solid waste minimization lies with non-biodegradable waste. Use of plastic in construction material is becoming more and more acceptable due to the improved properties of materials.

3. PAVEMENT DESIGN

Pavement design is the major component in the road construction. Nearly one-third or one-half of the total cost of construction, so careful consideration should be taken in design of pavement.

3.1 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.

3.2 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 behaviour, considering external factors such as traffic loading and climate conditions.

3.3 Requirements of Bituminous mixes

Stability

Stability is defined as the resistance of the paving mix to deformation under traffic load. Two examples of failure are (i) shoving - a transverse rigid deformation which occurs at areas subject to severe acceleration and (ii) grooving - longitudinal ridging due to channelization of traffic. Stability depend on the inter-particle friction, primarily of the aggregates and the cohesion offered by the bitumen. Sufficient binder must be available to coat all the particles at the same time should offer enough liquid friction. However, the stability decreases when the binder content is high and when the particles are kept apart.

Durability

Durability is defined as the resistance of the mix against weathering and abrasive actions. Weathering causes hardening due to loss of volatiles in the bitumen. Abrasion is due to wheel loads which causes tensile strains. Typical examples of failure are (i) pot-holes, - deterioration of pavements locally and (ii) stripping, lost of binder from the aggregates and aggregates are exposed. Disintegration is minimized by high binder content since they cause the mix to be air and waterproof and the bitumen film is more resistant to hardening.

Flexibility

Flexibility is a measure of the level of bending strength needed to counteract traffic load and prevent cracking of surface. Fracture is the cracks formed on the surface (hairline-cracks, alligator cracks), main reasons are shrinkage and brittleness of the binder. Shrinkage cracks are due to volume change in the binder due to aging. Brittleness is due to repeated bending of the surface due to traffic loads. Higher bitumen content will give better exibility and less fracture.

Skid resistance

It is the resistance of the finished pavement against skidding which depends on the surface texture and bitumen content. It is an important factor in high speed traffic. Normally, an opengraded coarse surface texture is desirable.

Workability

Workability is the ease with which the mix can be laid and compacted, and formed to the required condition and shape. This depends on the gradation of aggregates, their shape and texture, bitumen content and its type. Angular, flaky, and elongated aggregates workability. On the other hand, rounded aggregates improve workability.

3.4 Materials Used

3.4.1Bitumen (grade A-20)

Bitumen is a sticky, black and highly viscous liquid or semi-solid, in some natural deposits. It is also the residue or by-product of fractional distillation of crude petroleum. Bitumen composed primarily of highly condensed polycyclic aromatic hydrocarbons, containing 95% carbon and hydrogen (± 87% carbon and ± 8% hydrogen), up to 5% sulfur, 1% nitrogen, 1% oxygen and 2000 ppm metals. Also bitumen is Mixture of about 300 - 2000 chemical components, with an average of around 500 - 700. It is the heaviest fraction of crude oil, the one with highest boiling point (525°C).

Fig 1: A20 Grade bitumen

3.4.2Waste Plastic

Plastic such as polypropylene (PP), low density polyethylene (LDPE), and high density polyethylene

(HDPE) with paving grade asphalt [13]. They conducted rheological tests for the unmodified and modified asphalt binders. Better performance was observed for asphalt concrete as indicated by Marshall Stability test and loss of stability test. They concluded that waste plastic can be effectively utilized as binder material with excellent results.

Fig 2: Preparing waste plastic

3.4.3Coarse aggregates

The coarse aggregates used were a mixture of two locally available crushed stone of 20mm and 10mm size in 70:30 proportions. The aggregates were washed to remove drit, dust and then dried to surface dry condition.

4. MIXING OF BITUMEN AND WASTE PLASTIC

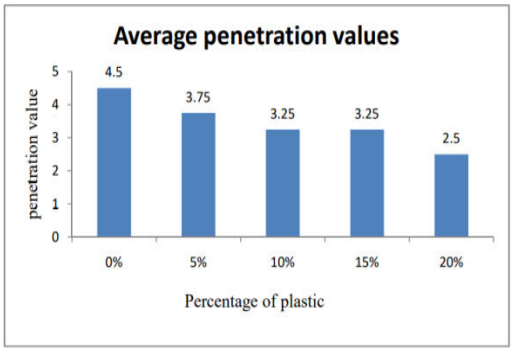
Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp. Pieces were added slowly to the hot bitumen of temperature around 160-170°c.The mixture was stirred manually for about 20-30 minutes. In that time period temperature was kept constant about 160-170°c. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out tests i.e. Penetration test, Ductility test.

4.1 Experimental Tests conducted

1. Softening point test
2. Penetration test
3. Ductility
4. Flash and fire point test
5. Aggregates impact
6. Aggregates crushing
7. Aggregate Attrition value

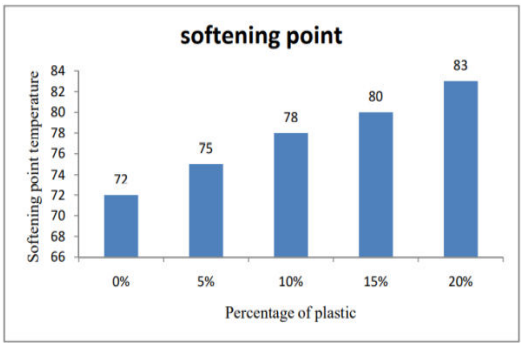
5 RESULTS AND ANALYSIS

5.1 Penetration test of bitumen values



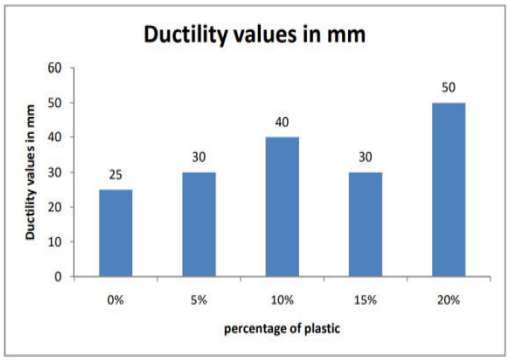
Graph 1: Comparison of Penetration test of bitumen values

5.2 Softening point of bitumen values



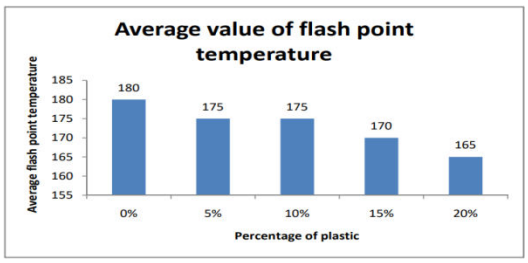
Graph 2: Comparison of softening point of bitumen values

5.3 Ductility of bitumen values



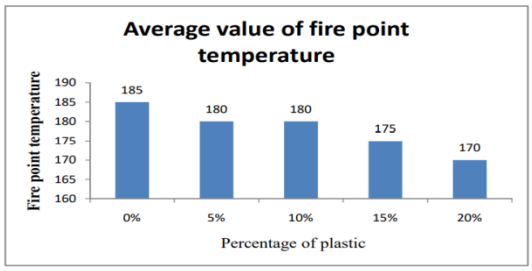
Graph 3: Comparison of Ductility of bitumen values

5.4 Flash point of bitumen values



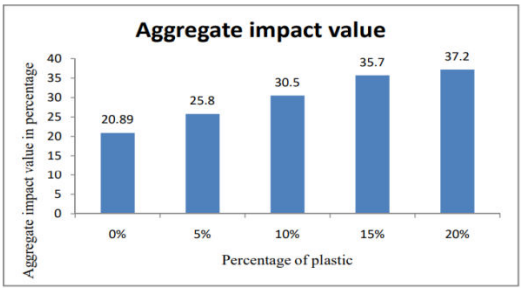
Graph 4: Comparison of Flash point of bitumen values

5.5 Fire point of bitumen



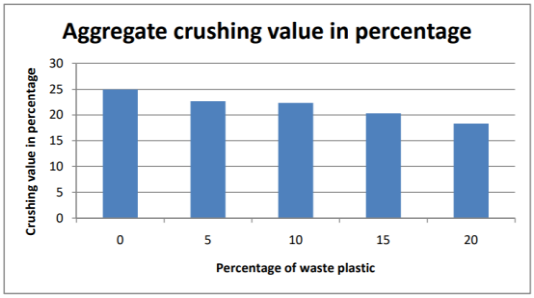
Graph 5: Comparison of Fire point of bitumen values

5.6 Aggregate Impact values



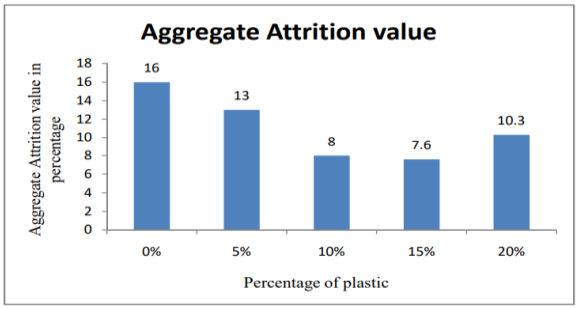
Graph 6: Comparison of Aggregate Impact values

5.7 Aggregates crushing test values



Graph 7: Comparison of Aggregates crushing test values

5.8 Aggregate Attrition value



Graph 8: Comparison of Aggregate Attrition values

6. CONCLUSIONS

From this study the following conclusions were made

1. Construction of highway involves huge outlay of investment. A precise engineering design may save considerable investment as well a reliable performance of the in-service highway can be achieved.
2. A good design of bituminous mix is expected to result in a mix which is adequately strong, durable, resistive to fatigue, permanent deformation, environment friendly, economical and so on.
3. The maximum value of penetration was observed at 0% plastic waste and minimum value of penetration was observed at 20% plastic waste. So the 0% plastic waste bitumen has more strength than remaining cases.
4. The maximum value of softening point was observed at 20% and 0% plastic waste and minimum value of softening point was observed at 0% plastic waste. So from this point it was concluded that by using plastic waste temperature effect on the bitumen reduces for the Flexible pavements.
5. At 0% plastic waste and minimum value of ductility was observed at 20% plastic waste maximum value of ductility was obtained.
6. The value of aggregates impact test in percentage decreases with increasing the percentage of waste plastic from 0% to 20%.
7. The value of aggregates crushing test in percentage decreases with increasing the percentage of waste plastic from 0% to 20% 8. The value of abrasion test in percentage

decreases with increasing the percentage of waste plastic from 0% to 20%.

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