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A Study Use Of Waste Plastic Materials In Flexible Pavements

Batthina Sathyanarayana[1], Dr.B. Manoj[2]

[1]M-Tech Scholar, [2]Professor
[1,2] Department of Civil Engineering
QIS COLLEGE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS)
Approved by AICTE | Permanent Affiliation: JNTU-Kakinada | UGC-Recognized
Accredited by NBA | Accredited by NAAC | ISO 9001:2015 Certified
Vengamukkapalem (V), Ongole, Prakasam dist., Andhra Pradesh-523272

Abstract
Plastic trash and its disposal pose a significant environmental problem, resulting in pollution and global warming. The addition of plastic debris to bituminous mixes improves both the characteristics and the strength of the mixture. It will also be a solution for plastic disposal and other pavement faults such as potholes, corrugation, ruts, and so on. Bitumen mixtures used in flexible pavements were found to work well with plastic as a binder. This effective procedure aids in the resistance of pavements to greater temperatures by limiting the creation of cracks and rainfall infiltration, which would otherwise contribute to the formation of potholes. 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

Highway construction necessitates a significant financial expenditure. A accurate engineering design may save a lot of money while also ensuring that the in-service roadway performs effectively. Pavement design and mix design are two significant factors to consider in flexible pavement engineering. The current research is focused on mix design factors.

A well-designed bituminous mix should be sufficiently strong, robust, fatigue-resistant, resistant to permanent deformation, environmentally friendly, cost-effective, and so on. A mix designer attempts a number of different proportions in the mix to meet these parameters before settling on the ideal one. The purpose of this study is to highlight some of the challenges that arise in the art of bituminous mix design, as well as the current research direction.

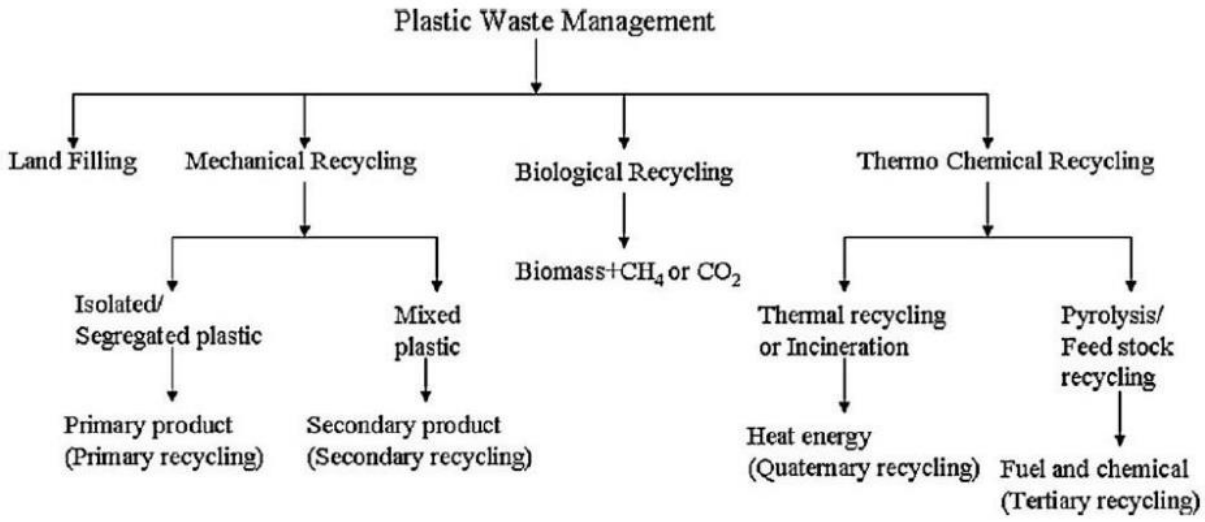
The usage of plastic in road building is not a novel concept. It's already being used as PVC or HDPE pipe mat crossings, which are made by connecting PVC (polyvinyl chloride) or HDPE (high-density polyethylene) pipes to create plastic mats. Transition mats are included on the plastic roadways to make it easier for tyres to get up to and down from the crossing. By dispersing the weight throughout the surface, these techniques help preserve wetland freight routes from rutting. However, scientists and engineers have long been concerned about the usage of plastic trash. Recent research in this area has revealed some promise in terms of employing plastic trash in road building, i.e., plastic roads.

Plastic waste

Polyethylene is one of a kind of polymers which was investigated for the potential to enhance asphalt mixture properties. Two types of polyethylene were added to coat the aggregate High-Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE). The results indicated that ground HDPE polyethylene modifier provides better

engineering properties. The recommended proportion of the modifier is 12% by the weight of bitumen content. It was found to increase the stability, reduce the density and slightly increase the air voids and the voids of mineral aggregate.

Researchers have estimated eight million tons of plastic being dumped into the oceans by 192 coastal countries in 2010.It may appear staggeringly high, in reality, the quantity would be many times more than that amount. Besides estimating the total quantity, a paper published recently in the journal of Science has identified the top 20 countries that have dumped the most plastic waste into the oceans. At the twelfth position, India is one of the worst performers. It has dumped up to 0.24 million tons of plastic into the ocean every year; the amount of mismanaged plastic waste per year is 0.6 million tons.



Different routes for plastic waste management

2. Pavement

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.

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.

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.

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 surfacetexture 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.

Materials Used

Bitumen(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).

A20 Grade bitumen

Waste 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.

Preparing waste plastic

Coarse aggregates

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

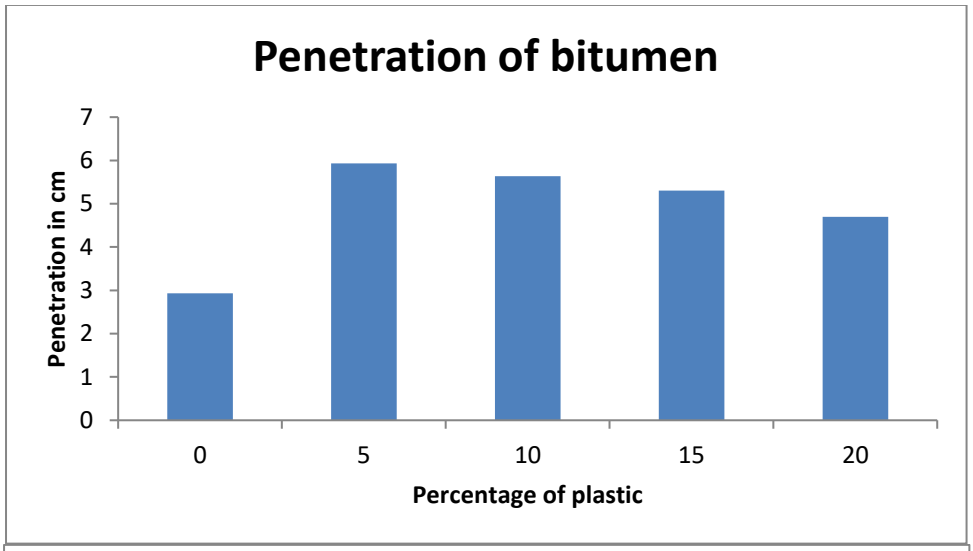
Mixing of Bitumen and waste plastic

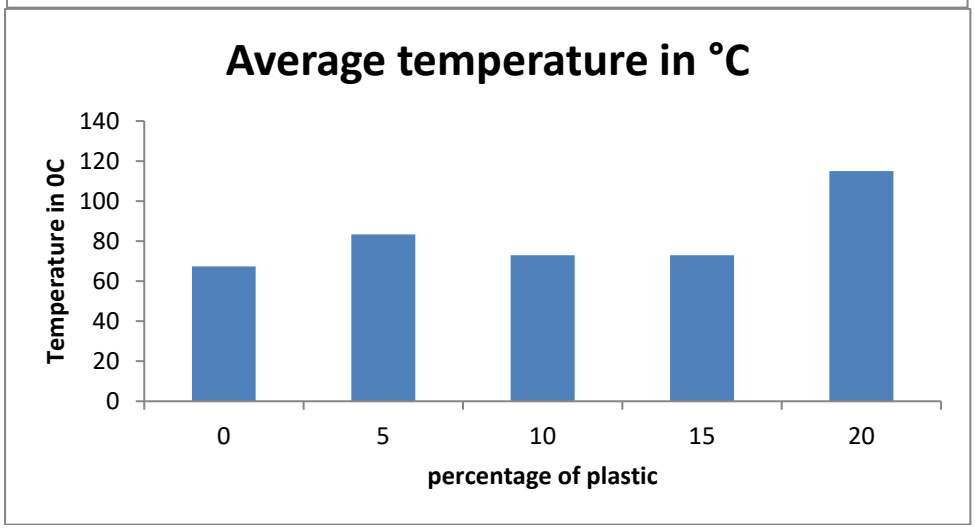
Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp. Pieces were added slowly to the hot bitumen of 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.

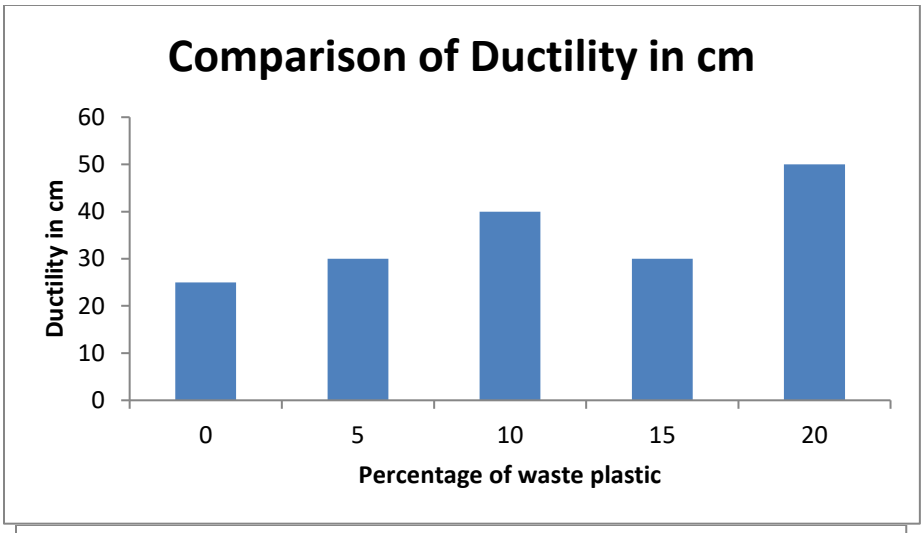
Experimental Tests conducted

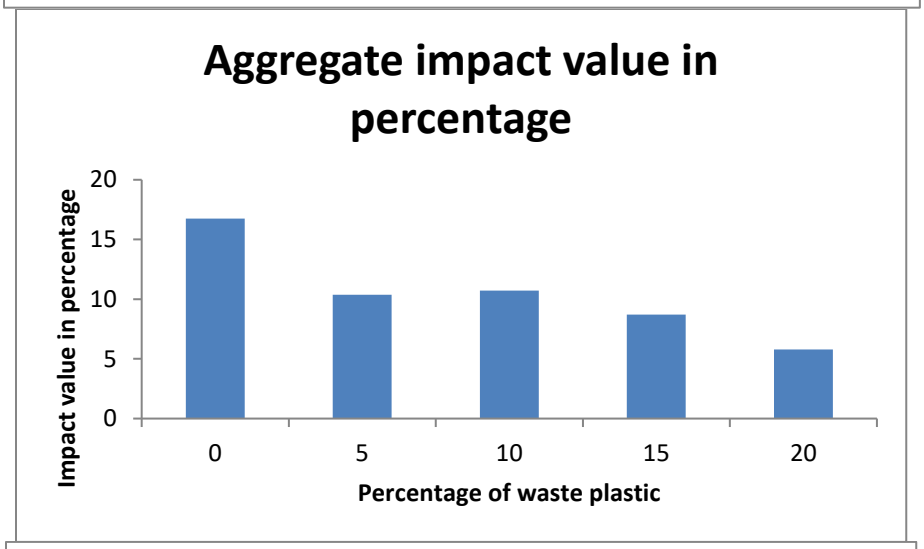
1. Softening point test
2. Penetration test
3. Ductility
4. Aggregates impact
5. Aggregates crushing
6. Abrasion test

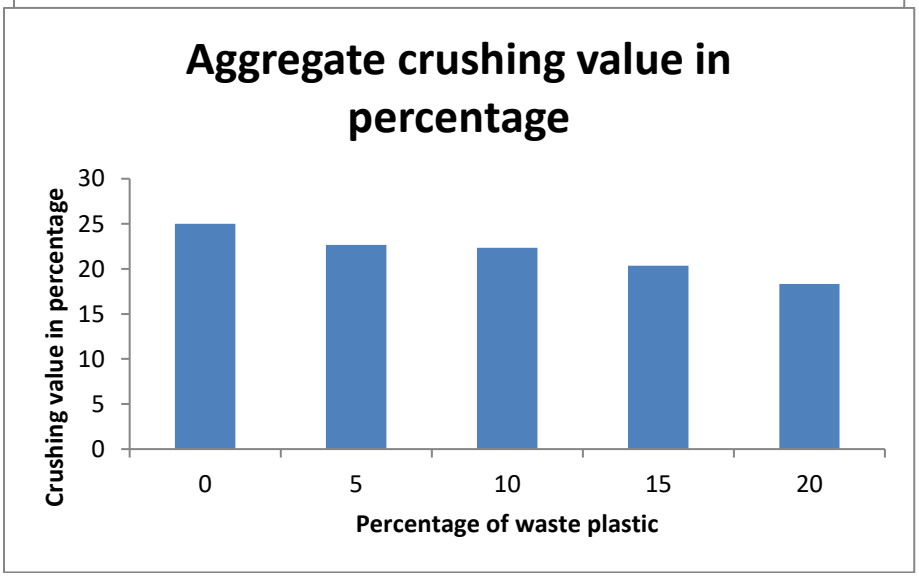
RESULTS AND ANALYSIS

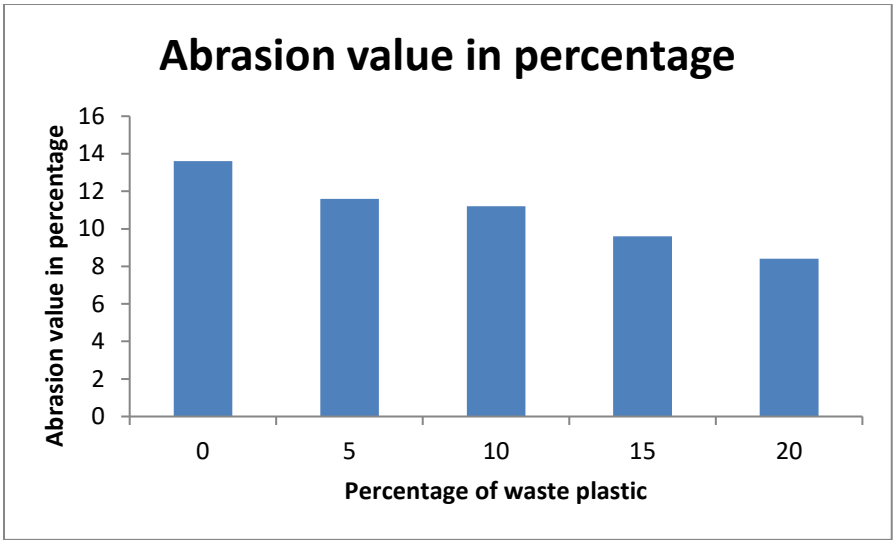





Comparison of Ductility in cm
Ductility in cm
60
50
40
30
20
10
0
0
5
10
15
20
Percentage of waste plastic


Aggregate impact value in percentage
Impact value in percentage
20
15
10
5
0
0
5
10
15
20
Percentage of waste plastic


Aggregate crushing value in percentage
Crushing value in percentage
30
25
20
15
10
5
0
0
5
10
15
20
Percentage of waste plastic



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 5% plastic waste and minimum value of penetration was observed at 0% plastic waste. So the 5% plastic waste 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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