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ORIGINAL RESEARCH PAPER

Engineering

A BITUMINOUS ROAD CONSTRUCTION USING WASTE PLASTIC MATERIALS

KEY WORDS: Bitumen, Modified Bitumen, Sustainable development, Plastic

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ABSTRACT

The current challenges to meet the infrastructure development in transport sector in India is becoming vital. The transportation serve as backbone for the national development. The thousand km of road is need to lay down. The proliferation in population create an immense stress to meet the demand side of consumer. This gigantic population also create lot of polymer waste such as PET bottle, carry bag, garbage bag, and automobile tyres. The concept is to convert this discarded material into raw materials in various construction or in recycling if possible such as MRF technique. This paper focused on the study the used of discarded material into road construction. It reduces the waste and percentage of binder (Bitumen) used in road construction. It help in achieving the engineering parameter by increasing stiffness in summer and ductility in cold weather. The aim is to find the right percentage and composition to meet all desired parameter to withstand all weather.

INTRODUCTION

This research paper focuses on the future construction of a road in Saharsa in Bihar's district with descriptive discussion on sources of polymer, blending process, familiar sources of polymer and its types. The history of polymer modification has helped us a lot but now with bitumen and GIS estimation is new in this field. The GIS will help us find the yearly increase in road area and the rate of construction. It would help in forecast construction rate and inventory management along with a reduction in bitumen consumption. The GIS also calculates the road's renewal rate to estimate maintenance cost with its life span. The Polymer Modified Bitumen (PMB) is now can sharp the constructional material in roads lying. Scientist and researcher of all part of the world finding many polymers; although the waste is a matter of concern, to overcome, they are trying to use scrap tires, pet bottle, waste polythene as a polymer to induce various properties to it.

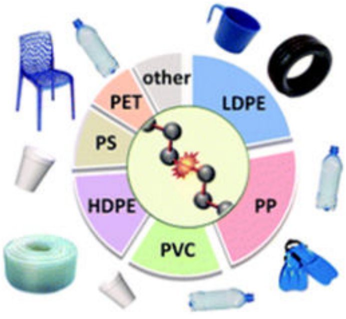

Figure 1: Polymer Waste

Sources:https://chemical-mater ials.elsevier.com/chemical-manufacturing-excellence/polymer-waste-recycling-over-used-catalysts/

LITERATURE

J. Santosh et. al. [1] studied an environmentally perspective, the processes to the conversion of waste plastics into recycled plastic pellets. In general, the results show that recycling plastic as a polymer for bitumen modification and as a synthetic aggregate replacement in asphalt mixes, which has the potential to be environmentally advantageous compared to their virgin polymers and natural quarry aggregate. The question remains in his research about to investigate the overall problem of recycling plastics in roads by performing a multi-attribute analysis that considers cost and mechanical performance (Durability) in addition to environmental factors.

Mohammad Alamri et. al. [2] studied for the designing of long life pavement and pavement recycling with reclaimed asphalt pavement (RAP) has important strategies for improving the sustainability of asphalt pavement. His studies convey to explore the performance of hot mix asphalt (HMA) containing reclaimed epoxy asphalt materials. Samples were prepared and tested for their performance in comparison with mixtures without RAP. At this stage, results from this study do not provide evidence to invalidate the use of epoxy RAP in HMA, at least a coarse aggregate replacement rate of less than 40%. The experiments performed in the study did not cover the full-scale performance evolution of HMA due to the limitation of resources and time.

E.M. Abdel Bary. et. al. [3] studied in this research, environmentally friendly green asphalt was prepared for road construction by mixing with waste polyethylene terephthalate (WPET). The modifier were used in percentage of 4% and 8% (wt/wt) to obtain modified asphalt binder with desirable physical and engineering properties. The result showed an important in asphalt properties which became more thermal stable, resistant to rutting and plastic deformation causing the susceptibility of asphalt to operate in different climates which means obtaining eco-friendly green asphalt with enhanced dynamic mechanical properties.

Muhammad Bilal khurshid et. al. [4] present a comparative analysis of properties & performance of hot mix asphalt (HMA). With mixing of polymer modified bitumen in terms of low density polymer ethylene (LDPE), high density polymer ethylene (HDPE) and crumb rubber (CR). Marshal method was used for the analysis of modified asphalt mixes & dry method have better asphalt mix properties. Polymer modified bitumen (PMB) improved stiffness and susceptibility to high temperature effects. Polymer modifier asphalt mix increase stability, rutting resistance and load bearing capacity in comparison with unmodified asphalt mix. Finally in overall comparison HDPE-modified mix was to the most effective & with CR- modified HMA was found to the most cost effective with RS. 0.166 Million saving per lane km, compared to, LDPE and HDPE-modified HMA. The question remains in his research study based on varied aggregate and binder grades.

Islam Abo El-Naga et. al. [5] studied the polyethylene terephthalate waste plastic materials (PTP) have a negative impact on the environment. Therefore, the main aim of this research is to investigate the effect of using PTP on improving the performance and properties of asphalt pavement. The investigation was performed for asphalt binder and asphalt mixtures. The results of asphalt binder test show that the addition of this modifier, reduced the penetration and increased the softening point of the modified asphalt binder. The optimized percentage of PTP achieving the better performance of the asphalt mixtures is 12%. Finally, the advantages show that addition of 12% of PTP increased the pavement service life 2.81 times and saved about 20% of the asphalt layer thickness. The question remain in his research the contained super pave binder tests to asses key-performance-related properties of asphalt binders.

Zhen Leng et. al. [6] studied that the addition of waste plastic materials such as Polyethylene Terephthalate (PET) or their functionalized additives into asphalt pavement may improve the durability of pavement and also help decrease the environmental problems caused by plastic. The main objective of this study is to investigate the feasibility of using the additives, derived from waste PET through an aminolysis process, to improve the performance of bituminous mixtures containing RAP, by characterising the binder properties. The results indicated that the samples containing RAP and PET derived additives provided better overall performance compared to the conventional binder, increasing the rutting resistance by at least 15% and fatigue cracking resistance by up to 60%. Usage of such waste PET based additives as an additive for RAP mixtures represents an approach to deal with a relevant recycling problem while simultaneously recovering two value-added materials. Overall, this study has successfully demonstrated an innovative approach to deal with two waste difficulties: waste plastic and RAP and initiates a competitive technology to meet this recycling challenge. It is anticipated that the combined use of such materials could open a new outlet for the efficient disposal of products currently land filled and help alleviate the pressure of disposal.

METHODOLOGY

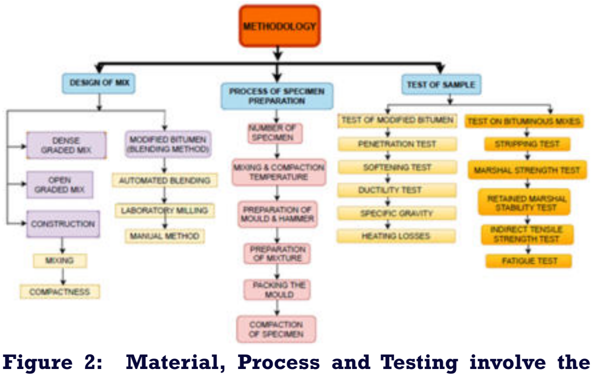

Figure 2: Material, Process and Testing involve the methodology for bitumen and polymer base road construction.

CALCULATION:

A. Volumetric Analysis of Compacted Mixes:

The volumetric properties mix after the compactness such as specific gravity, density, mineral aggregate and air void are needed to be regulated as its impact on the performance of a designing condition.

1 Density

To determine the density, the dry weight and immersed displacement of sample and at 25 ± 1°, C is measured. And the other way is to multiply by a factor of 62.4 to a specific gravity of the specimen.

2 Specific Gravity

The Bulk Specific Gravity (BSG) of each type of material must be measured so that volumes can be computed from the weights as desired. "The BSGs of the individual coarse aggregate fractions, the fine aggregate and mineral filler fractions are used to calculate the Bulk Specific Gravity (G_{sb}) of the total aggregate" using the following formula:

$$G_{sb} = \frac{P_1 + P_2 + \cdots P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \cdots \frac{P_n}{G_n}} \quad (6)$$

Where,
G_{sb} = Bulk specific gravity for the total aggregate
P_1, P_2, ...Pn = Individual % weight of aggregate
G_1, G_2, ...G_n = Individual BSG of

3 Effective Specific Gravity

The "Effective Specific Gravity of the aggregate" (G_{se}) considers all voids of the aggregate sample mixture. The equation gives this:-

$$G_{se} = \frac{100 - P_b}{\frac{P_s}{G_t} - \frac{P_b}{G_b}} \quad (7)$$

Where,
G_{se} = Effective specific gravity of aggregate

G_t = Maximum specific gravity of mixed materials (no air voids) and

$$G_t = \frac{100}{\frac{P_s}{G_{se}} - \frac{P_n}{G_n}} \quad (8)$$

Where,
P_s = Aggregate % of the total weight of a mixture
P_b = Bitumen % of the total weight of the mixture
G_b = Specific gravity of Bitumen

4 Effective Bitumen Content of the Mixes

$$P_{be} = P_b - \frac{P_{ba} P_s}{100} \quad (9)$$

Where,
P_{be} = Effective bitumen % of total eight of mixture
P_{ba} = Absorbed bitumen % of the total weight of aggregate

5 Air Void

The air spaces bitumen the coated aggregate of the paving mixture is known as an air void. It is an essential factor in pavement performance. Too much air voids in the paving mixture may cause stripping allowing water to stay in it. Air void of compacted mixes is determined using the following formula.

$$V_a = 100 \times (G_t - G_{mb})/G_t \quad (10)$$

Where,
V_a = Air void in compacted mixture % of the total volume

6 Void in the Mineral Aggregate

The gap between the intermolecular space of aggregate and modified bitumen is known as Void in the Mineral Aggregate. This is calculated by:-

$$VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}} \quad (11)$$

7 Void Filled with Bitumen

"The percentage of the intermolecular void spaces between the aggregate particles that are filled with asphalt". It is calculated as follows:

$$VFA = \frac{100 \times (VMA - V_a)}{VMA} \quad (12)$$

Where,
VFA = Voids filled with asphalt percent of VMA
VMA = Voids in mineral aggregate, percent of bulk volume
V_a = Air voids in a compacted mixture, percent of the total volume

CONCLUSIONS

The research presents a comparative analysis of properties & performance of hot mix asphalt (HMA). With mixing of polymer modified bitumen (PMB) in terms of LDPE, HDPE & CR. Polymer modified bitumen improved stiffness and susceptibility to high temperature effects. With CR modified HMA was found to the most cost effective with 0.166 million saving per lane km, compared to LDPE & HDPE modified HMA. The main objective of this study in to investigate the feasibility of using the additives containing from waste PET by the aminolysis process, to improve the performance of bituminous mixture. The environmentally friendly green asphalt was prepared for road construction by mixing with waste polyethylene terephthalate (WPET). The modifier were used in percentage of 4%% and 8% (wt/wt) to obtain modified asphalt binder with desirable physical and engineering properties.

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