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Study On Use Of Polymeric Waste Materials In Concrete For Road Pavements

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Abstract

Bituminous binders are widely used by paving industry. In general pavements are categorized into 2 groups, i.e. flexible and rigid 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.

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.

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. The main objectives of this investigation are to observe Marshall properties of mixes using stone dust as filler and slag as fine aggregate and fly ash as filler.

Introduction

Today availability of plastic waste is enormous. The use of plastic materials such as carry bags, cups, etc is constantly increasing. Nearly 50% to 60% of total plastic are consumed for packing. Once used, plastic packing materials are thrown outside and they remain as waste. Plastic wastes are durable and non-biodegradable. The improper disposal of plastic may cause breast cancer, reproductive problems in humans and animals,

genital abnormalities and much more. These plastic wastes get mixed with water, disintegrate, and take the forms of small pallets which cause the death of fishes and other aquatic life who mistake them as food material. Sometimes they are either land filled or incinerated. Plastic wastes get mixed with the municipal solid waste or thrown over a land area. All the above processes are not ecofriendly as they pollute the land, air and water. Under these circumstances, an alternative use of these plastic wastes is required. So any method that can use this plastic waste for purpose of construction is always welcomed.

Role of Polyethylene

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.

Material Characterization

Bituminous mix consists of a mixture of aggregates continuously graded from maximum size, typically less than 25 mm, through the fine filler that is smaller than 0.075mm. Sufficient bitumen is added to the mix so that the compacted mix is effectively impervious and will have acceptable dissipative and elastic properties. The bituminous mix design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical.

The basic materials used are as follows:

- Aggregates
- Fly Ash
- Slag
- Bituminous Binder
- Polyethylene

Gradation of aggregates for SMA

Sieve size (mm)	Percentage passing
19	100
13.2	94
9.5	62
4.75	28
2.36	24

Sieve size (mm)	Percentage passing
1.18	21
0.6	18
0.3	16
0.075	10

Determination of specific gravity of polyethylene

Specific gravity of polyethylene was found out by following the guidelines of ASTM D792-08. The procedure adopted is given below;

- The weight of the polyethylene in air was measured by a balance. Let it be denoted by "a".
- An immersion vessel full of water was kept below the balance.
- A piece of iron wire was attached to the balance such that it is suspended about 25 mm above the vessel support.
- The polyethylene was then tied with a sink by the iron wire and allowed to submerge in the vessel and the weight was measured. Let it be denoted as "b".
- Then polyethylene was removed and the weight of the wire and the sink was measured by submerging them inside water. Let it be denoted as "w".

Determination of tensile properties of polyethylene

The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials. Tensile strength of polyethylene was calculated by using INSTORN – 1195 CORPORATION with Sample rate = 9.103 pts/sec and Crosshead speed (speed at which sample is stretched) = 50 mm/min. Rectangular Polyethylene samples were prepared according to ASTM D882. Dimension of polyethylene was measured by using digital Vernier calliper (Width = 10mm, Thickness = 0.1mm, Gauge length = 10mm, Grip distance = 40mm). The following results are found out from this test.

Preparation of Marshall Samples

The mixes were prepared according to the Marshall procedure specified in ASTM D1559. For SMA, BC, and DBM mixes the coarse aggregates, fine aggregates and filler were mixed with bitumen and polyethylene according to the adopted gradation as given in Table 3.1, Table 3.2, and Table 3.3 respectively. First a comparative study was done on SMA, BC, and DBM mixes by using stone dust as filler in between with and without polyethylene in mixes. Again a comparative study was done on SMA, BC, and DBM mixes by using slag and fly ash as filler in between with and without polyethylene in mixes. Here Optimum Binder Content (OBC) and optimum polyethylene content (OPC) was found by Marshall Test. The mixing of ingredients was done as per the following procedure;

- Required quantities of coarse aggregate, fine aggregate & mineral fillers were taken in an iron pan and kept in an oven

at temperature 160℃ for 2 hours. Preheating is required because the aggregates and bitumen are to be mixed in heated state.

- The required amount of shredded polythene was weighed and kept in a separate container.
- The aggregates in the pan were heated on a controlled gas stove for a few minutes maintaining the above temperature. Then the polyethylene was added to the aggregate and was mixed for 2 minutes.
- Now bitumen was added to this mix and the whole mix was stirred uniformly and homogenously. This was continued for 15-20 minutes till they were properly mixed which was evident from the uniform colour throughout the mix.
- Then the mix was transferred to a casting mould. 75 no. of blows were given per each side of the sample so subtotal of 150 no. of blows was given per sample. Then each sample was marked and kept separately

Conclusions

In this study, three types of mixes i.e. SMA, DBM and BC are prepared with VG30 grade bitumen used as a binder. The effect of addition of waste polyethylene in form of locally available artificial milk with brand OMFED packets in the bituminous mixes has been studied by varying concentrations of polyethylene from 0% to 2.5% at an increment of 0.5%.

- Using Marshall Method of mix design the optimum bitumen content (OBC) and optimum polyethylene content (OPC) have been determined for different types of mixes. It has been observed that addition of 2% polyethylene for SMA and DBM mixes and 1.5% polyethylene for BC mixes results in optimum Marshall Properties where stone dust is used as filler. But when small fraction of fine aggregates are replaced by granulated blast furnace slag and filler is replaced by fly ash, optimum Marshall Properties for all types of mixes result with only 1.5% polyethylene addition. The OBCs in case of modified SMA, BC and DBM mixes by using stone dust as filler are found 4% and OBCs in case of modified (i) SMA, and (ii) BC, and DBM by using fly ash and slag are found to be 5% and 4% respectively.
- Using the same Marshall specimens prepared at their OPCs and OBCs by using both (i) stone dust as filler and (ii) replacing of stone dust by fly ash and fine aggregate by slag, for test under normal and wet conditions it is observed that the retained stability increases with addition of polyethylene in the mixes, and BC with polyethylene results in highest retained stability followed by DBM with polyethylene and then SMA with polyethylene.
- Addition of polyethylene reduces the drain down effect, though these values are not that significant. It may be noted that the

drain down of SMA is slightly more than BC without polyethylene. However, for all mixes prepared at their OPC there is no drain down.

- In general, it is observed that the Indirect Tensile Strength (ITS) value decreases with increase in temperature and for a particular binder, when polyethylene gets added to the mixes the value further increases in both cases. The BC mixes with polyethylene result in highest indirect tensile strength values compared to SMA, followed by DBM.
- It is observed that by addition of polyethylene to the mixture, the resistance to moisture susceptibility of mix also increases. BC with polyethylene results in highest tensile strength ratio followed by DBM mixes with polyethylene and SMA mixes with polyethylene for both cases.
- It is observed from the static creep test that deformation of mix generally decreases by addition of polyethylene at all test temperatures used. The BC mixes with polyethylene result minimum deformation compared to others.

From the above observations it is concluded that use of waste polyethylene in form of packets used in milk packaging locally results in improved engineering properties of bituminous mixes. Hence, this investigation explores not only in utilizing most beneficially, the waste non-degradable plastics, but also provides an opportunity in resulting in improved pavement material in surface courses thus making it more durable.

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