Experimental Study on Bitumen Partially Replacing by Plastic Waste & Lane Marking using Phosphorescent Paint in Flexible Pavement

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Abstract— This study is aimed at replacing a portion of bitumen by using plastic fines in laying flexible pavements. The Quantum of Plastic waste in Municipal Solid Waste (MSW) is increasing due to increase in population, urbanization, etc., which leading widespread littering on the landscape. Since plastic is a non-biodegradable material it can be recycled in this way, which is a safe disposal of waste plastics. In flexible pavement construction plastic coated aggregate showed better binding property. They do not absorb much water, have better flexibility which results in less rutting and less need for repair. Road surfaces remain smooth and absorb sound better. Optimum binder content is determined using Marshall mix design. The Phosphorescent highway paint lane markers are intended to increase road visibility in a more energy-efficient way than traditional street lighting. The various proportions of Aqua green blue Phosphorescent pigment, water based Acrylic Polyurethane, White water based Highway paint were studied and the optimum proportion was found. And showing better road visibility, energy efficient.

Key words: Plastic Fines, Flexible Pavement, Bitumen, Marshall Mix Design, Phosphorescent Highway Paint

I. INTRODUCTION

In general there are two types of roads

1) Rigid pavement roads and
2) Flexible pavement roads.

For rigid roads material used is concrete and for flexible roads bitumen is used. In India mostly the flexible pavement roads are available. And for economical road construction new techniques, new material is used. The significant variation in daily and seasonal temperature demand improved road characteristics. Any improvement in the property of the binder is needed. Bitumen is a useful binder for road construction. Different grades of bitumen like 30/40, 60/70 and 80/ 100 are available on the basis of their penetration values. The steady increase in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature demand improved road characteristics. Any improvement in the property of the binder is the needed.

The glow-in-the-dark lane markers are intended to increase road visibility in a more energy-efficient way than traditional street lighting. The photoluminescent paint charges during the day and slowly emits light over the course of 12 hours during the evening.

Luminous paint is widely used in roads and buildings for directions, safety purposes, interior routes, marking and art. Note that a white coat of paint should be applied on the surface as a background coat prior to the application of the luminous paint. This is because dark background absorbs light and would reduce the luminance by more than 80%.

II. OBJECTIVES

The Objective of this study is

1) To study the effect of plastic in Hot Mix Asphalt.
2) To study the effect of different percentage of bitumen content in Hot Mix Asphalt.
3) To check the properties of bituminous mix specimen due to coating & mix of plastic waste
4) To find the optimum percentage of Phosphorescent pigment with acrylic polyurethane and white based highway paint the better visibility of road.
5) To compare the cost & visibility of normal lane marking to Phosphorescent paint Lane marking.

III. NEED FOR STUDY

1) The growth of various types of industries and rapid growth of population has led to enormous increase in plastic waste pollution.
2) Disposal of plastic waste is a serious problem world wide due to its non-biodegradability.
3) The purpose of this study is to utilize this plastic waste as useful binding material and save the bitumen road.
4) This can be helpful in finding the replacement of the conventional material used in flexible pavement.

IV. INFERENCE FROM LITERATURE

1) Professor.C.E.G. Justo States that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter (m3) of BC mix. Modified Bitumen improves the stability or strength, life and other desirable properties of bituminous concrete mix
2) Sundaram & Rojasay (2008) studied the Effective blending technique for the use of plastic waste into bitumen for road laying and Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests.
3) Verma S.S. (2008). Concluded that Plastics will increase the melting point of the bitumen. This technology not only strengthened the road construction but also increased the road life.
4) Dr. R.Vasudevan and S. Rajasekaran, (2007) stated that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased Softening point and decreased Penetration value with a suitable ductility.
5) Sabina et al (2001) studied the comparative performance of properties of bituminous mixes containing plastic/polymer (PP) (8% and 15% by wt of bitumen) with conventional bituminous concrete mix (prepared

with 60/70 penetration grade bitumen). Improvement in properties like Marshall Stability, retained stability, indirect tensile strength and rutting was observed in Plastic modified bituminous concrete mixes.

6) Mohd. Imtiyaz (2002) concluded that the mix prepared with modifiers shows:-Higher resistance to permanent deformation at higher temperature.
7) When comparing different pavement structures in terms of present total cost (which includes construction cost, maintenance cost, and user cost), total service life in years, time to overlays, and thickness of overlays,these pavement structures will be evaluated to find their fatigue and rutting performance in terms of tensile strain at the bottom of asphalt layer and compressive strain on the surface of subgrade
8) V.S. Punith, (2001), Some encouraging results were reported in this 3 study that there is possibility to improve the performance of bituminous mixes of road pavements. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction
9) Shukla and Jain (1984) described that the effect of wax in bitumen can be reduced by adding EVA (Ethyl Vinyl Acetate), aromatic resin and SBS in the waxy bitumen. The addition of 4% EVA or 6% SBS or 8% resin in waxy bitumen effectively reduces the Susceptibility to high temperatures, bleeding at high temperature and brittleness at low temperature of the mixes.
10) Collins et al. (1991) and Baker (1998) observed that SBS modified asphalt mixes have longer lives than unmodified asphalt mixes. The addition of SBS polymer to unmodified bitumen also increases its resistance to low temperature cracking.

V. MATERIAL USED

A. *Binder material*

Different types of bitumen have been used by various researchers to the mixture properties. In this study Bitumen grade of 60/70 is carried out as 5.5%, 6%, and 6.5% of total weight of sample for HMA mixtures. Tests were conducted for the specified grade of Bitumen and the results are as follows,

PROPERTIES	VALUE
PENETRATION VALUE	68mm
SOFTENING POINT	50˚C
FLASH POINT	160˚C
FIRE POINT	175˚C
DUCTILITY VALUE	78cm

Table 1: Physical Characteristics of Bitumen

B. *Aggregate size varying from 20mm-4.75mm*

PROPERTIES	VALUE
SPECIFIC GRAVITY	2.54
WATER ABSO RPTION	0.5%
IMPACT VALUE	16.9%
CRUSHING VALUE	1.78%
ABRASION VALUE	14%

Table 2: Physical Characteristics of C.A

C. *Filler: Plastic fines, Sand.*

PROPERTIES	VALUE
SPECIFIC GRAVITY	2.62
WATER ABSORPTION	0.8%
FINENESS MODULUS	2.65
BULK DENSITY	1.50g/cc
GRADATION	Zone II

Table 3: Physical Characteristics of F.A

PROPERTIES	VALUE
SPECIFIC GRAVITY	0.856
PERCENTAGE OF VOIDS	34.9%
FINENESS MODULUS	4.925
BULK DENSITY	0.608g/cc

Table 4: Physical Characteristics of Plastic fines

VI. DESIGN REQUIREMENTS FOR HMA

The HMA design mix should meet the requirements given in

Mix design parameters	Requirement
Air void content, percent	4.0
Bitumen content, percent	5 min.
Voids in Mineral Aggregate (VMA), percent	17 min.
VCA mix, percent	Less than VCA (dry rodded)
Asphalt drain down	0.3 max.

Table 5: Basic Requirements for HMA Mix

VII. AGGREGATE GRADATION

A. *Coarse and Fine Aggregate*

The higher proportion of the coarse aggregate in the mixture forms a skeleton type structure providing a better stone-on-stone contact between the coarse aggregate particles resulting in good shear strength and high resistance to rutting as compare to BC. The adopted aggregate must possess –

– A highly cubic shape and rough texture to resist rutting and movements,
– A hardness which can resist fracturing under heavy traffic loads,
– A high resistance to polishing, and abrasion

Required and adopted aggregate gradation as per MoRTH specifications are mentioned in Table 6 respectively and the Figure 1 shows graph for aggregate gradations.

Sieve Size	Lower Limit (L.L)	Upper Limit (U.L)	Adopted Gradations	
19	100	100	100	100
13.2	90	100	94	98
9.5	50	75	60	70
4.75	20	28	22	24
2.36	16	24	18	20
1.18	13	21	16	18
0.6	12	18	15	16
0.3	10	20	14	15

Table 6: Adopted Gradation of Aggregate as per MoRTH

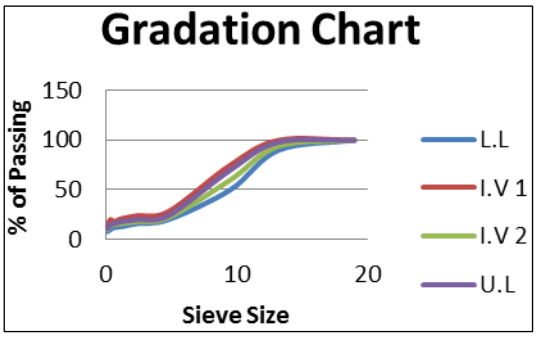

Fig. 1: Gradation of aggregates

VIII. Specimen Preparation

Approximately 1200gm of aggregates and filler is heated to a temperature of 175℃ -190° C. Bitumen is heated to a temperature of 121℃ -125℃ with the first trial percentage of bitumen (4.5% by weight of the mineral aggregates). The heated aggregates and bitumen are thoroughly mixed at a temperature of 121℃-125℃. The mix is placed in a preheated mould and compacted by a rammer with 75 blows on either side at temperature of to +0.5 %. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. The bitumen content is varied to 5% and 5.5% by weight of mineral aggregates in the next trials and the above procedure is repeated. The mix design determines the optimum bitumen content. The prepared specimen is loaded in the Marshall test setup as shown in the figure 1.

IX. Marshall Mix Design

The mix design determines the optimum bitumen content. The Marshall stability and flow test provides the performance prediction measure for the Marshall mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute. Load is applied to the specimen till failure, and the maximum load is designated as stability. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.

X. Test on Specimen

The tests carried out whether it meets basic recommendations. Table 7 indicates that the HMA Mix meets the Basic recommendations with optimum dosage of plastic as 7% by weight of fine aggregate

Properties	Requirements*	HMA
Bitumen content, %	5. min	5.5
Opt dosage of plastic, %	Min 6%,	7%
Air void content, %	4	>4
Void in mineral aggregate, %	17min	>17
Compactive effort, No of blows	75	75
Drain down, %	<0.3%	0.12
Voids in Coarse aggregate, %	Less than VCA (Dry rodded)	29.5
VCA by dry rodded method, %	Min 45%	44.6
VCA Ratio	<1	0.
Tensile Strength, Ratio	85% min	86.5

Table 7: HMA meets the Basic Recommendations

XI. Results

1) In this study it is observed that when bitumen percent is increased stability and flow value is also increased at certain point after increment of bitumen percent it again decreases.
2) This study observed that when the percent of bitumen is increasing then the value to V.F.B. is increasing for all gradation. V.F.B
3) The HMA mixes designed with available aggregates showed good stone on stone contact. The 17% Voids in Mineral aggregate and 4% air voids in the mix were fulfilled as HMA Mix design criteria. The Drain Down values was in the range of 0.12-0.22% by weight of mix.
4) The Tensile Strength Ratio is more so, it indicating improving the adhesion property of binder to hold the aggregate in mix and it exhibit superior water resistance property of mix and it is used in heavy rain fall area.
5) Based on the above performance, plastic fines can be used as a fine aggregate without affecting the design criteria of HMA Mixtures.
6) The Optimum dosage of Binder content is found to be 5.5% by total weight of mix for 60/70 grade of Bitumen.
7) The Optimum dosage of plastic fines is found to be 7% by weight of the fine aggregate.

XII. Conclusion

As the unit rate for bitumen is getting accelerated, an alternative for bitumen is important. So, the replacement of bitumen using plastic fines is practically proven to meet the requirement and the strength of pavement can also be increased by using it. It is recommended that the design mix may be taken as 5.5% penetration grade 60/70 bitumen with 7% plastic fines fulfilled the design criteria as per IRC SP 79:2008.

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