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UTILISATION OF MODIFIED BITUMEN IN ROAD CONSTRUCTION

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Abstract:- *In flexible pavement construction, Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together & laid down in layers then compacted.*

Now a days, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects.

Plastics are everywhere in today's lifestyle and are growing rapidly throughout particularly in a developing country like India. As these are non-biodegradable there is a major problem posed to the society with regard to the management of these solid wastes. Low density polyethylene (LDPE) has been found to be a good modifier of bitumen.

Various percentages of polythene are used for preparation of mixes with a selected aggregate grading as given in the IRC Code. The role of polythene in the mix is studied for various engineering properties by preparing Marshall samples of BC mixtures with and without polymer. Marshall properties such as stability, flow value, unit weight, air voids are used to determine optimum polythene content for the given grade of bitumen (80/100).

Key Words: ***Bituminous Concrete (BC), Plastic waste, Aggregate, Marshall stability, Flow value, Optimum Polythene Content.***

INTRODUCTION

Bituminous binders are widely used by paving industry. A pavement has different layers. The main constituents of bituminous concrete (BC) are aggregate and bitumen. Generally, all the hard surfaced pavement types are categorized into 2 groups, i.e. flexible and rigid.

Flexible Pavement: The road pavement which can change their shape to some extent without rupture are known as flexible pavement. e.g., bituminous pavements, gravel pavements, water bound macadam pavement, etc.

Rigid Pavement: The road pavement which cannot change their shape without rupture are known as rigid pavement.e.g. Cement concrete pavement.

Polymer modification of BC

Need of the hour

The steady increase of wheel loads, tyre pressure, change in climatic conditions & daily wear and tear severely affect the performance of bituminous mix pavements. Hence any improvement in the property of the pavement is highly essential considering the present scenario.

Waste plastic is a concern

Plastics are durable & non-biodegradable; the chemical bonds make plastic very durable & resistant to normal natural processes of degradation. Since 1950s, around 1billion tons of plastic have been discarded, and they may persist for hundreds or even, thousands of years. The plastic gets mixed with water, doesn't disintegrate, and takes the form of small pallets which causes the death of fishes and many other aquatic animals who mistake them as food materials.

Today the availability of the plastic wastes is enormous, as the plastic materials have become the part and parcel, of our daily life. Either they get mixed with the Municipal Solid Waste or thrown over a land area. If they are not recycled, their present disposal may be by land filling or it may be by incineration. Both the processes have significant impacts on the environment. If they are incinerated, they pollute the air and if they are dumped into some place, they cause soil & water pollution. Under these circumstances, an alternate use for these plastic wastes is required.

Role of plastic or polymer in pavement

Modification of BC, with the synthetic polymer binder can be considered as a solution to overcome the problems, arising because of the rapid increase in wheel loads and change in climatic conditions. Polymer modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting & thermal cracking in the pavement.

Asphalt, when blended or mixed with the polymer, forms a multiphase system, containing abundant asphalteness which are not absorbed by the polymer. This increases the viscosity of the mix by the formation of a more internal complex structure.

Advantages:

1. Reduce the need of bitumen by around 10% .

2. Develop a technology which is ecofriendly.

3. Improvements in fatigue life of roads.

4. Use higher percentage of plastic waste.

5. The gases released during traffic conditions are absorbed by smoke absorbent.

Disadvantages:

1. Toxic present in the co-mingled wastes would start leaching.

2. But the presence of chlorine will definitely release HCl gas.

Objectives: Objective Study has been carried out to satisfied following objectives:

1. To improve the volumetric properties of BC mix design.

2. To utilize waste plastic in bituminous mixes.

3. To utilize fly ash as filler material in bituminous mixes.

4. To evaluate laboratory performance of BC mix design.

5. To provide an ecofriendly roadway.

MATERIALS USED IN PRESENT STUDY

Aggregates: Aggregate constitutes the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement.

Aggregates are of 2 types. i.e.

a) Coarse Aggregate (CA)

b) Fine Aggregate (FA)

Coarse Aggregate (CA)

The aggregates retained on 4.75 mm IS Sieve is called as coarse aggregates. Coarse aggregate should be screened crushed rock, angular in shape, free from dust particles, clay, vegetation and organic matters.

Fine Aggregate (FA)

Fine aggregate should be clean screened quarry dusts. It should be free from clay, loam, vegetation or organic matter. Fine aggregates, consisting of stone crusher dusts were collected from a local crusher with fractions passing 4.75 mm and retained on 0.075 mm IS sieve. It fills the voids in the coarse aggregate and stiffens the binder.

Bitumen: Asphalt binder 80/100 are used in this research. Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminous mixtures. Bitumen must be treated as a visco-elastic material as it exhibits both viscous as well as elastic properties at the normal pavement temperature. At low temperature it behaves like an elastic material and at high temperatures its behavior is like a viscous fluid. Asphalt binder VG10 is used in this research work. Grade of bitumen used in the pavements should be selected on the basis of climatic conditions and their performance in past. It fills the voids, cause particle adhesion and offers impermeability.

Filler:

The fillers may be stone dust or fly ash.

Aggregate passing through 0.075 mm IS sieve is called as filler. It fills the voids, stiffens the binder and offers permeability. The filler material used was fly ash & stone dust. Specific gravity = **2.13.**

Waste Polythene: Stabilizing additives are used in the mixture to provide better binding property. Now-a days polypropylene, polyester, mineral and cellulose are commonly used as fibers. In this present study polyethylene is used as stabilizing additive to improve performance characteristics of pavement.

Table 1: Properties of polythene used in present study

S.no.	Properties	Result obtained
1	Specific gravity	0.68
2	Melting point (^{0}c)	250-260
3	Size	30mm×3mm

METHODOLOGY:

Segregation.

Cleaning Process.

Shredding and mixing of bituminous

Laying of bituminous mix

Segregation:

Plastic waste collected from various source (roads, garbage trucks, dumpsites etc.) must be separated from other waste.

Cleaning Process: Waste plastic are sorted, de-dusted and washed if necessary.

Shredding and Mixing of Bituminous: Different types of plastic wastes are mixed together cut into small pieces and shredded using shredded machine. The aggregate is heated upto160 ^{0}C in central mixing plant. Similarly, bituminous is also heated up to 160 ^{0}C.

Laying of Bituminous Mix: The plastic waste coated aggregate mixed with hot bitumen and the result mix is used for road construction. The road laying temperature is between1100 ^{0}C to1200 ^{0}C. The roller used is 8-tons capacity.

EXPERIMENTAL PROGRAMME:

The experimental work does not involve Marshall Test only but other tests on aggregate and bitumen should also be performed. The main reason of performing tests on bitumen and aggregate is just to check whether their test values lies within the limit as prescribed in the codes IRC III-2009.

Table -2: Properties of aggregates used in present study

S.no.	Properties tested	Test result	MORTH Specifications
1	Aggregate Impact Value Test	10.65	Max.27%
2	Los Angeles Abrasion Value test	24.06	Max.30%
3	Aggregate crushing Value test	14.63	Max.30%
4	Specific gravity Coarse aggregate Fine aggregate	 2.70 2.62	 2.5-3.0 2.5-3.0

Table 3: Properties of bitumen used in present study

S.no.	Properties tested	Test Result	Range
1	Penetration 100gm,5sec,25^{0}c	92	80-100mm
2	Softening point test, ^{0}c (Ring & Ball Apparatus)	52	40^{0}c min.
3	Ductility test at 27 ^{0}c (5cm /minute pull)cm	81	75min.
4	Specific gravity test 27^{0}c	1.01	0.99min.

Marshall Test

• For preparing bituminous mix required quantities of coarse aggregate, fine aggregate and filler were taken in a pan. The pan was kept in the oven for preheating at a room temperature of 175 ^{0}c for 2 hours. This is because the aggregate and bitumen are to be mixed in heated state.

• Side by side the bitumen was also heated up to its melting point before mixing. The compaction mould assembly is cleaned and kept in the oven for pre heating to a temperature of 100 to 145°C.

• The required amount of shredded plastic was weighed and kept in a pan separately.

• The plastic was added to the aggregate and was mixed thoroughly for 2 minutes.

• Now the bitumen in required percentage is added to the mix and the whole mix was stirred for 15 to 20 minutes until it forms uniform color throughout the mix.

• After mixing whole mix is transferred to casting mould.

• The mould is placed in the Marshall Compaction pedestal. The mix is compacted with 75 no. of blows of blows of the hammer and the sample is inverted and compacted in the other face with same no. of blows.

• After compaction, the sample with mould is kept for few hours to cool. The sample is extracted out from the mould and kept at room temp. for 24 hours.

• Before testing, the sample is kept in the water bath having a temperature of 60 ^{0}C for 20-30 minutes. The mass of sample in air and submerged weight is used to measure the density of the specimen, so as to allow, calculation of the void properties.

Mix Volumetrics

The volumetric parameters are to be checked from the Marshall samples, prior to Marshall test. The following are equations which would be used to determine volumetric parameters such as VMA, VA, VFB etc. and absorbed bitumen content (P_{ab}). The absorbed bitumen is an important parameter, which is ignored in bituminous mix design in many cases (Chakraborty & Das, 2005).

The properties that are of interest include the theoretical specific gravity Gt, the bulk specific gravity of the mix Gm, percent air voids Vv, percent volume of bitumen Vb, percent void in mixed aggregate VMA and percent voids filled with bitumen VFB.

Theoretical specific gravity of the mix Gt

Theoretical specific gravity Gt is the specific gravity without considering air voids, and is given by:

$$Gt = \frac{w1 + w2 + w3 + wb}{\frac{w1}{G1} + \frac{W2}{G2} + \frac{W3}{G3} + \frac{Wb}{Gb}}$$

where,

W1 is the weight of coarse aggregate in the total mix,

W2 is the weight of fine aggregate in the total mix,

W3 is the weight of filler in the total mix,

Wb is the weight of bitumen in the total mix,

G1 is the apparent specific gravity of coarse aggregate,

G2 is the apparent specific gravity of fine aggregate,

G3 is the apparent specific gravity of filler and Gb is the apparent specific gravity of bitumen.

Bulk specific gravity of mix (Gm)

The bulk specific gravity or the actual specific gravity of the mix Gm is the specific gravity considering air voids and is found out by:

$$Gm = \frac{Wm}{Wm - Ww}$$

where,

Wm is the weight of mix in air,

Ww is the weight of mix in water.

Air voids percent (Vv)

Air voids Vv is the percent of air voids by volume in the specimen and is given by:

$$\mathbf{Vv} = \frac{Gt - Gm}{Gt} \mathbf{X\ 100}$$

Percent volume of bitumen V_b

The volume of bitumen V_b is the percent of volume of bitumen to the total volume and given by:

$$V\text{b} = \frac{\boldsymbol{Wb/Gb}}{(\boldsymbol{w1 + w2 + w3 + wb})/\boldsymbol{GM}}$$

where,

W1 is the weight of coarse aggregate in the total mix,

W2 is the weight of fine aggregate in the total mix,

W3 is the weight of filler in the total mix, Wb is the weight of bitumen in the total mix, Gb is the apparent specific gravity of bitumen, and Gm is the bulk specific gravity of mix.

Voids in Mineral Aggregate

It is the volume of inter granular void space between the uncoated aggregate particles of a compacted paving mixture that includes the air voids and effective bitumen content. VMA is expressed as percentage of the total volume of the compacted paving mixture.

$VMA = V_v + V_b$

Where,

V_v= Air voids (%)

V_b= Volume of bitumen

Voids Filled with Bitumen

It is the percentage of VMA that is occupied by the effective bitumen.

$$\textbf{VFB} = \frac{\boldsymbol{Vb}}{\boldsymbol{VMA}} \times \mathbf{100}$$

Where,

Vb= Volume of bitumen

VMA= Voids in mineral aggregate.

ANALYSIS OF RESULTS:

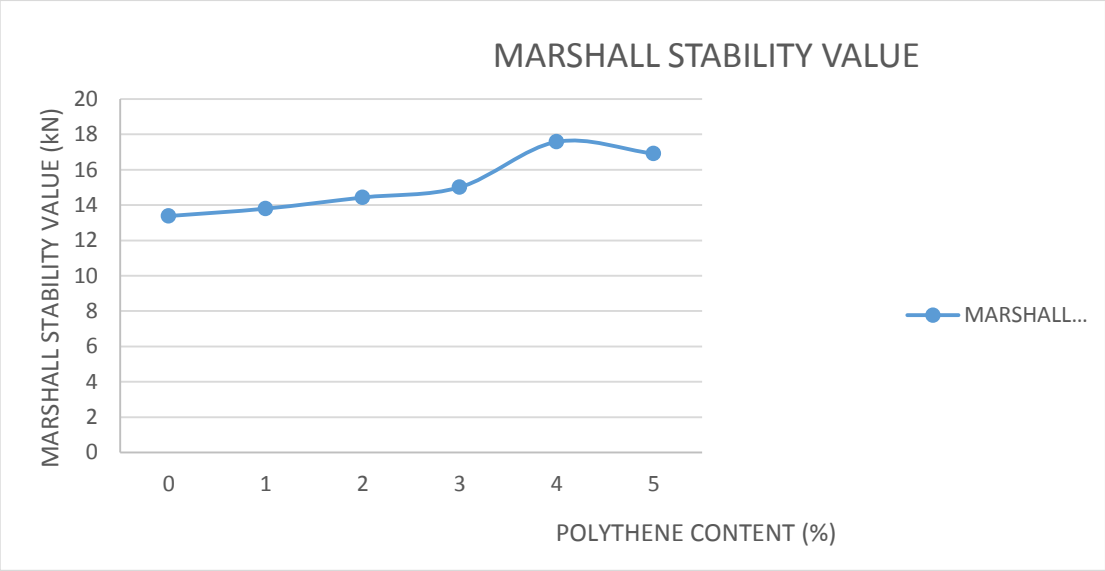
Plotting Curves

5 curves were plotted. i.e.

Table 4: data for plotting curves.

Polythene content %	Mean VMA %	Mean VA %	Mean VFB %	Mean S (kN)	Mean F (mm)
0	23.58	12.13	48.21	13.38	3.36
1	21.17	9.76	40.37	13.80	3.08
2	25.95	14.57	12.54	14.43	2.70
3	16.18	4.90	68.91	15.01	2.31
4	15.04	4.23	69.37	17.58	2.50
5	9.90	1.68	82.59	16.91	2.51

Fig.1 : Marshall Stability Value vs. Polythene content



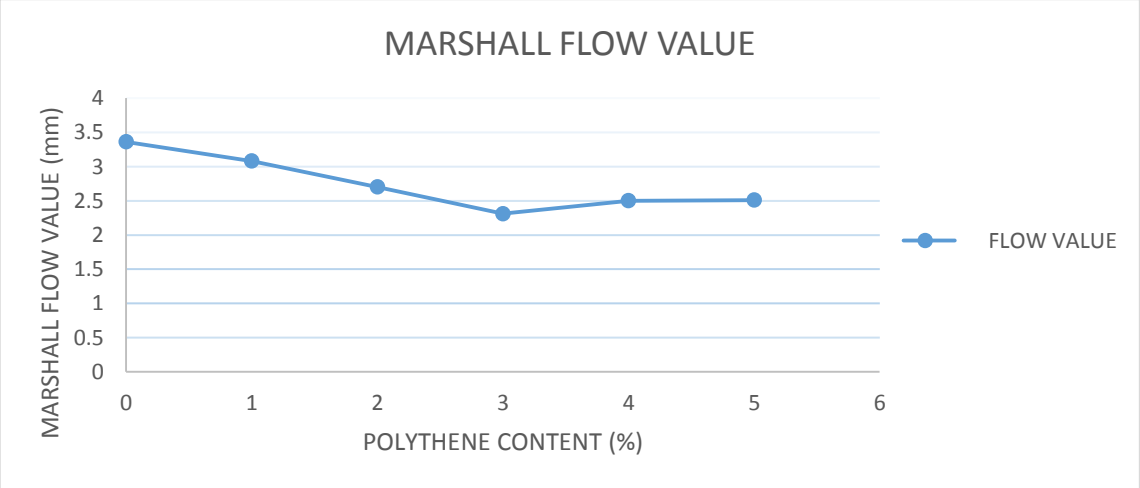


Fig.2: Flow Value vs. Polythene Content

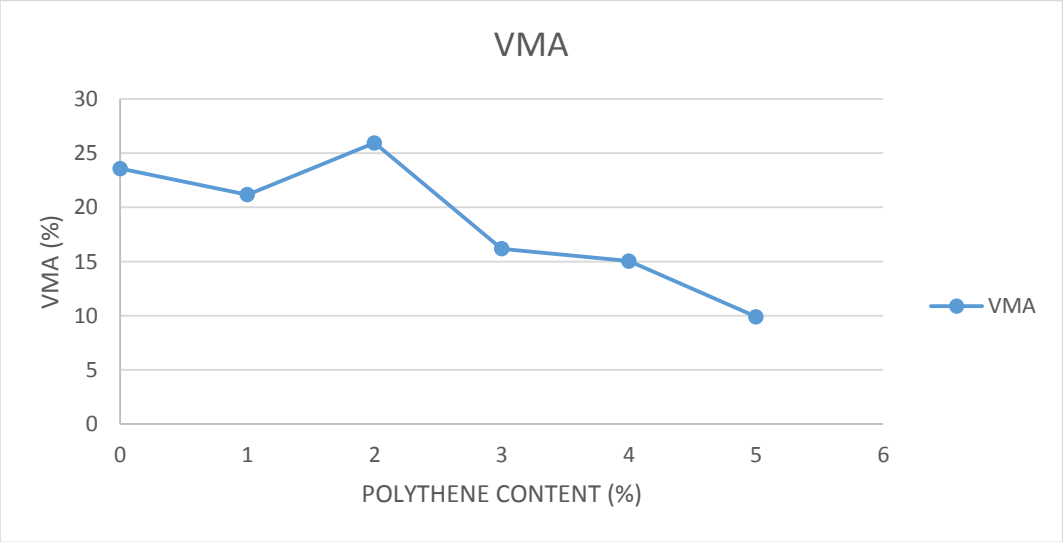


Fig.3: VMA vs. polythene content

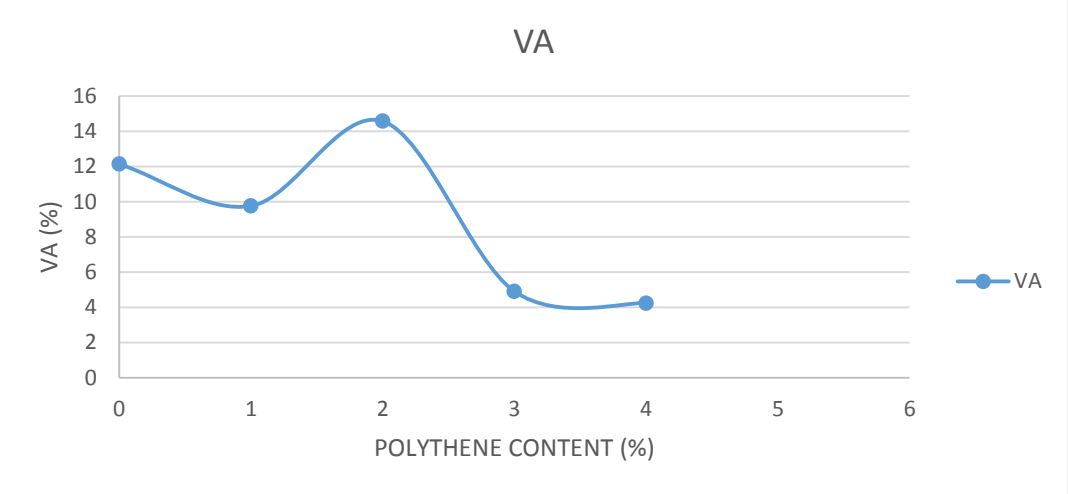


Fig.4: VA vs. polythene content

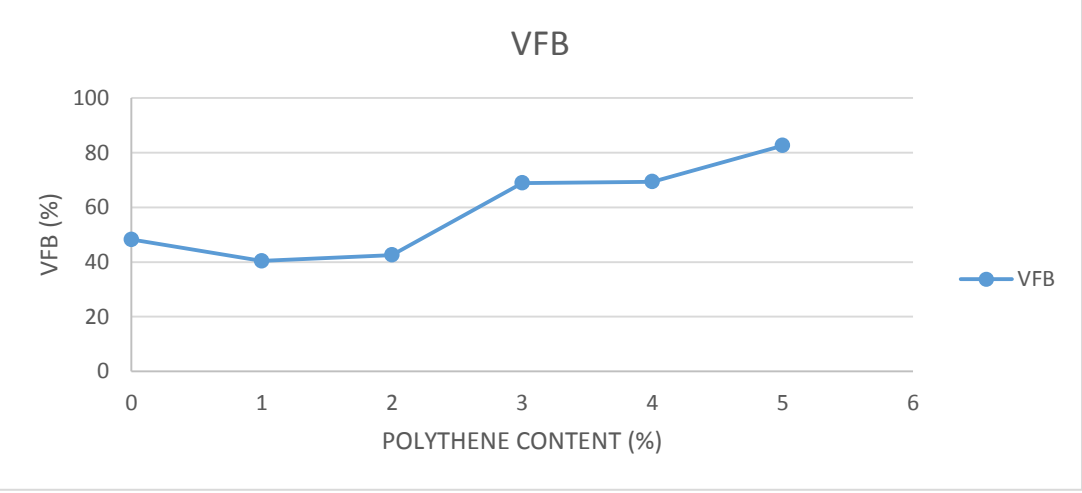


Fig.5: VFB vs. polythene content

ANALYSIS

Finding optimum polythene content

The value of polythene content at which the sample has maximum Marshall Stability Value and minimum Marshall Flow Value is called as Optimum Polythene Content.

From the Figure – 1& 2 we get the Optimum Polythene Content as 4%.

Also from Figures – 3,4 & 5 we conclude that upon addition of polythene the voids present in the mix decreases

CONCLUSIONS:

Plastics increase the melting point of the bitumen. The use of this plastics in road construction is an innovative technology which not only strengthens the road but also increases the road life. It is hoped that in near future we will have strong, durable and ecofriendly roads which will relieve the earth from all type of plastic waste. It is observed that Marshall stability value increases with polyethylene content upto 4% and thereafter decreases. We observe that the marshall flow value decreases upon addition of polythene i.e. the resistance to deformations under heavy wheel loads increases. Also the values of the parameters like VMA, VA, VFB are within the required specifications.

FUTURE SCOPE:

The main scope of plastic roads is:

As the population increases, the solid waste also increases proportionality. The best alternative is the usage of waste as construction material assuring a good disposal. As this method is economic, the practice would be on satisfactory extent aiding the future generations for a good solid waste management.

(i**) Economic in terms of bitumen**: The shredded plastic in form of polymer covers the aggregates and thus occupies a larger portion of the road reducing the quantity of bitumen needed.

(ii) **Efficient management of non-biodegradable waste**: Plastic is a harmful and non-biodegradable waste responsible mainly for land pollution. Utilizing it for road construction will result in its efficient management.

(iii**) Easy process without any new machinery**: It is a simple and easy technique which does not involve any complex or new machinery.

(iv) **Enhanced durability**: The addition of plastic to bitumen will help in improving the strength and durability of the pavement.

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