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DETERMINATION OF STRENGTH CHARACTERISTICS OF BITUMINOUS CONCRETE BY USING WASTE POLYTHENE

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Abstract:* Many researches have been currently going to modify and improved the bituminous concrete properties by the addition of different types of materials. This paper represents the Optimum use of the waste polythene with the concrete mixture and will also help in achieving the desired results. This paper presents a research conducted to study the behavior of BC mix modified with waste polythene. 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).

***Keywords:* Bituminous Concrete (BC), Marshall stability, Flow value, Optimum Polythene Content**

I. INTRODUCTION

Bituminous concrete is a type of construction material used for paving roads, driveways, and parking lots. It's made from a blend of stone and other forms of aggregate materials joined together by a binding agent. This binding agent is called "bitumen" and is a by-product of petroleum refining. It has a thick, sticky texture like tar when heated, then forms a dense solid surface once it dries. Bituminous concrete is also widely known as asphalt in many parts of the world. Despite its name, this material is quite different than standard concrete, and contains no cement. While most cement-based surfaces are white or gray, bituminous concrete is known for its distinctive black appearance. It is often laid right over a gravel base layer to form new roads and parking lots, but may also be poured over existing concrete to repair or smooth out bumps and voids. Once the bituminous concrete has been poured onto the roadway, installers use large paving machines to smooth and compact the surface. 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 : If the surface course of a pavement is bitumen then it is called "flexible" since the total pavement structure can bend or deflect due to traffic loads.

Rigid Pavement : If the surface course of a pavement is PCC then it is called "rigid" since the total pavement structure can't bend or deflect due to traffic loads. Such pavements are much stiffer than the flexible pavements due to the high modulus of elasticity of the Plain Cement Concrete material. Importantly, we can use reinforcing steel in the rigid pavements, to decrease or eliminate the joints.

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow, is called as 'Plastic'. Plastics are durable and degrade very slowly; the chemical bonds that make plastic so durable make it equally resistant to natural processes of degradation. Asphalt, when blended or mixed with the polymer, forms a multiphase system, containing abundant asphaltenes which are not absorbed by the polymer. This increases the viscosity of the mix by the formation of a more internal complex structure.

II. LITERATURE REVIEW

As we know the properties of concrete gets improved due to the incorporation of Glass fibre. Large no. of papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their opinion.

Bahia and Anderson, [1] studied the visco-elastic nature of binders and found that, the complex modulus & phase angles of the binders, need to measured, at temperatures and loading rates which different resemble climatic and loading condition

Shukla and Jain [2] described that the effect of wax in bitumen can be reduced byadding 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.

Shuler et al. [3] found that the tensile strength of SBS modified binder increased significantly as compared to unmodified asphalt mix at minus 21, 25 and 410C.

Collins and Baker et al.[4] 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.

Denning and Carswell [5] reported that asphalt concrete using polyethylene modified binders were more resistant to permanent deformation at elevated temperature.

Palit et al. [6] found improvement in stripping characteristics of the crumb rubber modified mix as compared to unmodified asphalt mix.

Sibal et al. [7] evaluated flexural fatigue life of asphalt concrete modified by 3% crumb rubber as part of aggregates.

Goodrich [8] reported that fatigue life and creep properties of the polymer modified mixes increased significantly as compared to unmodified asphalt mixes.

Justo et al [9] at the Centre for Transportation Engineering, of Bangalore University used processed plastic bags as an additive in asphalt concrete mixes. The properties of this modified bitumen were compared to that of ordinary bitumen. It was noted that penetration and ductility values, of modified bitumen was decreasing with the increase in proportion of the plastic additive, up to 12 % by weight.

Shankar et al [10] crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures. Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubber content and subsequent tests have been performed to determine the different mix design characteristics and for conventional bitumen (60/70) also. This has resulted in much improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67%).

III. MATERIALS USED

Materials required for making bituminous concrete essentially consist of following materials are described below-

AGGREGATES:- The grades of aggregates and their quantities to be used for preparing Marshall samples were used according to the chart given in the MORTH specification.So the aggregates of different grades were sieved through different IS Sieves and they were kept in different containers with proper marking.

Specific Gravity of Coarse aggregate = 2.7

Specific Gravity of Fine aggregate = 2.6 BITUMEN:- The bitumen used in preparing Marshall samples was of 80/100 penetration grade. Specific Gravity bitumen = 1.02

FILLER:- The filler material used was fly ash

Specific gravity of fly ash = 2.2

POLYTHENE:- The polythene used in OMFED milk packets was used as raw material for preparation of the samples. These polythene packets were collected; they were washed and cleaned by putting them in hot water for 3-4 hours. They were then dried.

Specific Gravity of polythene = 0.905

Shredding:- The dried polythene packets were cut into tiny pieces of size 2 mm maximum. This is because when the polythene is to be added with bitumen and aggregate it is to be ensured that the mixing will be proper. The smaller the size of the polythene, the more is the chance of good mixing.

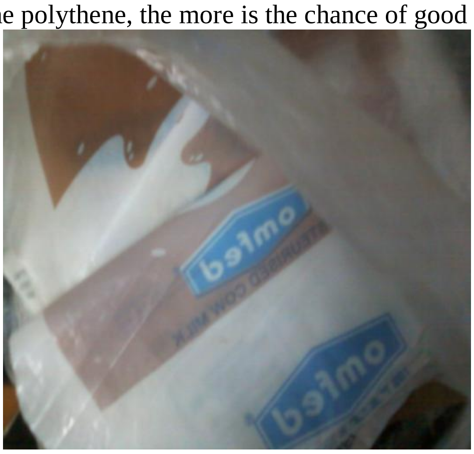

Fig.1: OMFED Polythene Used

Fig.2 Shredded Polythene

IV. EXPERIMENTAL PROGRAMME

It involves mainly three steps i.e

a) Preparation of samples
b) Void analysis
c) Testing

Sample Preparation

Marshall Sampling Mould

The specifications of the Marshall sampling mould and hammer are given in table 1

TABLE – 1: Dimensions of Marshall Sampling mould & hammer

APPARATUS	VALUE	WORKING TOLERANCE
MOULD		
Average internal diameter, mm	101.2	± 0.5
HAMMER		
Mass, kg	4.535	± 0.02
Drop Height, mm	457	± 1.0
Foot diameter, mm	98.5	± 0.5

Fig.3: Marshall Sampling Mould

Fig.4: Marshall Hammer

MIXING PROCEDURE

The mixing of ingredients was done as per the following procedure (STP 204-8).

1) Required quantities of coarse aggregate, fine aggregate & mineral fillers were taken in an iron pan.

2) This was kept in an oven at temperature 160^0C for 2 hours. This is because the aggregate and bitumen are to be mixed in heated state so preheating is required.

3) The bitumen was also heated up to its melting point prior to the mixing.

4) The required amount of shredded polythene was weighed and kept in a separate container.

5) The aggregates in the pan were heated on a controlled gas stove for a few minutes maintaining the above temperature.

6) The polythene was added to the aggregate and was mixed for 2 minutes.

7) Now bitumen (60 gm), i.e. 5% 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.

8) Then the mix was transferred to a casting mould.

9) This mix was then compacted by the Marshall Hammer. The specification of this hammer, the height of release etc. are given in Table – 1.

10) 75 no. Of blows were given per each side of the sample so subtotal of 150 no. of blows was given per sample.

11) Then these samples with moulds were kept separately and marked

Table – 2: Amounts of raw materials

polythene %	wt of polythene	wt of aggregate
	gm	gm
0	0	1140
0	0	1140
0	0	1140
1	11.4	1128.6
1	11.4	1128.6
1	11.4	1128.6
2	22.8	1117.2
2	22.8	1117.2
2	22.8	1117.2
3	34.2	1105.8
3	34.2	1105.8
3	34.2	1105.8
4	45.6	1094.4
4	45.6	1094.4
4	45.6	1094.4
5	57	1083
5	57	1083
5	57	1083

VOID ANALYSIS

For analysis of voids, the samples were weighed in air and also in water so that water replaces the air present in the voids. But by this process some amount of water will be absorbed by the aggregates which give erroneous results. Hence 1st the samples were coated with hot paraffin so that it seals the aggregate-bitumen mix completely and checks the absorption of water into it.

Marshall testing

The Marshall test was done as procedure outlined in ASTM D6927 – 06.

Marshall Stability Value :

It is defined as the maximum load at which the specimen fails under the application of the vertical load. It is the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute (2 inches/minute). Generally, the load was increased until it reached the maximum & then when the load just began to reduce, the loading was stopped and the maximum load was recorded by the proving ring.

Marshall Flow Value :

It is defined as the deformation undergone by the specimen at the maximum load where the failure occurs. During the loading, an attached dial gauge measures the specimen's plastic flow as a result of the loading. The flow value was recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load was recorded.

Two readings were taken from the dial gauge i.e. initial reading (I) & final reading (F)

The Marshall Flow Value (f) is given by

$f = F - I$

The Marshall Stability Values are shown in Table – 3

The Marshall Flow Values are shown in Table – 4

Table – 3: MARSHALL STABILITY VALUE (S)

Sample no.	polythene %	No. of divisions (N)	Marshall Stability Value (S)
			kN
1'	0	460	13.66
2'	0	500	14.85
3'	0	490	14.56
1	1	490	14.56
2	1	470	13.96
3	1	480	14.26
4	2	490	14.56
5	2	480	14.26
6	2	500	14.85
7	3	520	15.44
8	3	530	15.74
9	3	520	15.44
10	4	570	16.93
11	4	600	17.82
12	4	620	18.41
13	5	540	16.04

14	5	520	15.44
15	5	550	16.34

Table – 4: MARSHALL FLOW VALUE

Sample no.	polythene %	Initial Reading (I)	Final Reading (F)	Marshall Flow Value (F)
				mm
1'	0	3.1	7.3	4.2
2'	0	3.3	7.4	4.1
3'	0	3.3	7.4	4.1
1	1	3.5	7.0	3.5
2	1	3.2	7.9	3.7
3	1	4.1	7.3	3.2
4	2	3.9	7.0	3.1
5	2	3.7	6.7	3
6	2	3.2	6.3	3.1
7	3	3.9	7.1	3.2
8	3	3.0	5.8	2.8
9	3	3.1	6.0	2.9
10	4	2.8	5.3	2.5
11	4	2.6	5.5	3.3
12	4	3.3	6.1	2.8
13	5	2.9	5.5	2.6
14	5	3.2	5.9	2.7
15	5	3.3	6.2	2.9

V. TEST RESULTS

For each % of polythene, 3 samples have been tested. So the average value of the 3 were taken. The mean values are shown in Table – 5.1

Table – 5: Data For Plotting Curves

Polythene	Unit weight	Mean	Mean	Mean	Mean S (kN)	Mean
0	2.668241	16.24080719	4.896817	69.86649	14.35667	2.314174
1	2.628602	15.08037044	3.793693	74.86333	14.26	2.302482
2	2.584494	14.21351566	3.020358	78.88036	14.55667	2.283404
3	2.56012	13.87345386	2.837953	79.56232	15.54	2.251242
4	2.52277	13.61238478	2.738914	79.9287	17.72	2.218188
5	2.457956	13.21231979	2.478064	81.2728	15.94	2.189788

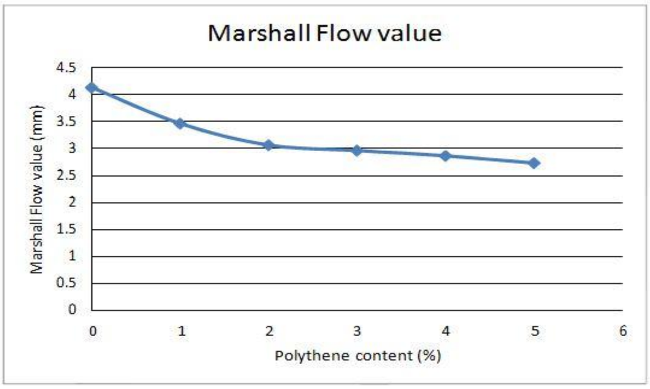

Fig. 5.: Marshall Flow Value vs. Polythene Content

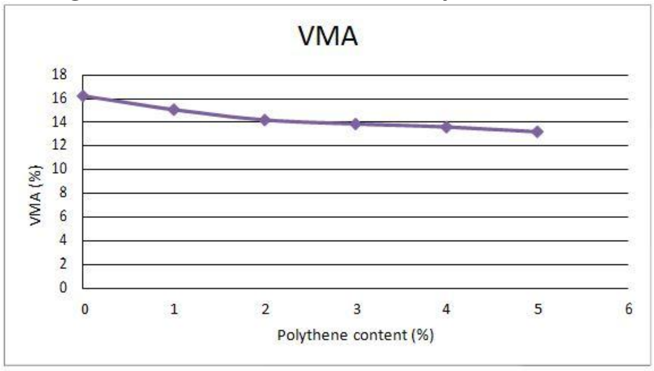

Fig.6: VMA vs. Polythene Content

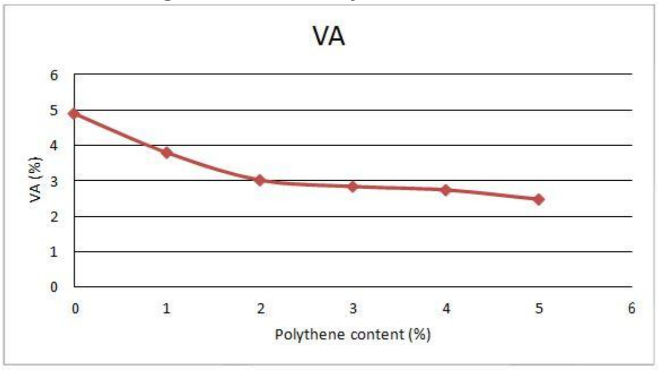

Fig.7: VA vs. Polythene Content

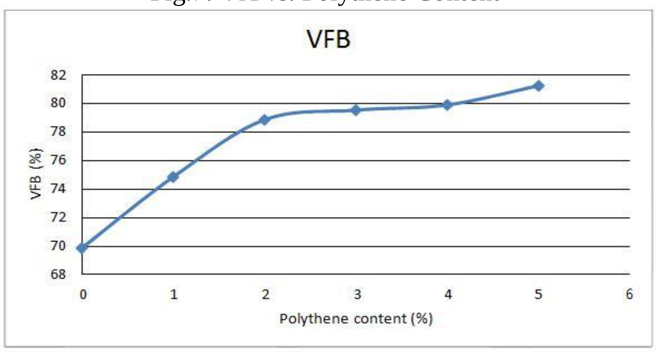

Fig.8: VFB vs. Polythene Content

VI. CONCLUSION

From the study of the behaviour of polythene modified BC it was found that the modified mix possesses improved Marshall Characteristics as mentioned below. 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. Considering these factors we can assure that we can obtain a more stable and durable mix for the pavements by polymer modifications. This small investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period. Polymer modified pavements would be a boon for India's hot and extremely humid climate, where temperatures frequently rises past 50°C and torrential rains create havoc, leaving most of the roads with heavy distresses. This adversely affects the life of the pavements. The polymer modified bitumen show improved properties for pavement constructions. This also can reduce the amount of plastics waste which otherwise are considered to be a threat to the hygiene of the environment. In this modification process plastics-waste is coated over aggregate. This increases the surface area of contact at the interface and ensures better bonding between aggregate and bitumen. The polymer coating also reduces the void spaces present in the mix. This prevents the moisture absorption and oxidation of bitumen by entrapped air. The road can withstand heavy traffic and show better service life. This study will have a positive impact on the environment as it will reduce the volume of plastic waste to be disposed off by incineration and land filling. It will not only add value to plastic waste but will develop a technology, which is eco-friendly. However, it is recommended that more research regarding the topic should be done and more trial sections should be laid and their performance should be studied.

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