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The Study of Marshall Stability and Flow Parameters of Semi Dense Bitumen Concrete mix with Plastic Waste

Varun[1] and Sumesh Jain[2]

[1,2]*Department of Civil Engineering, OITM, Hisar, Haryana, India- 125001*

Abstract: Semi Dense Bituminous Concrete (SDBC) is a composite material for the most part utilized as a part of development activities like street surfacing, airplane terminals, parking areas and so on. It comprises of bitumen (use as a binder) and mineral total which are combined and set down in layers and after that compacted. Presently days, the enduring addition in high movement power regarding business vehicles, and the critical variety in day by day and regular temperature place us in a requesting circumstance to think about a few choices for the asphalt attributes and quality

by applying some essential adjustments which might fulfill both the quality and in addition efficient angles. Likewise considering the ecological approach, because of inordinate utilization of plastic in everyday business, the contamination to the earth is colossal. Since the plastic is non-biodegradable, the need of the present hour is to utilize the waste plastic in some valuable purposes. This theory displays an examination directed to concentrate the conduct of SDBC mix changed with waste plastic. Different percentage of waste plastic are utilized for preparing the mix by following the procedure given in the IRC Code. The part of waste plastic in the mix is to concentrate the different building properties by planning Marshall Test of SDBC mix with and without polymer. Marshall Properties, for example, stability, flow value, unit weight, air voids, voids filled with bitumen are utilized to decide optimum bitumen.

Introduction

During 1900's bitumen pavements was first introduced to rural roads in order to prevent WBM roads from disintegration due to fast growth of motor cars. **Sulyman et al. 2014 [1]** Heavy oils were used to settle the dust. An eye estimation process which is called pat test was used to estimate the required quantities of the heavy oil in the mix. Sand-Bitumen mixture was used to make the first mix design for flexible pavements and known as Habbard field method. There was one limitation in this method that it cannot deal with the mixtures having large sized aggregates.

Hveem, 1942; developed the Hveem stabilometer in 1927. He did not have any idea about the quantity of bitumen required to be used in a mix so, he used the surface area calculation concept (which was used to design PCC mix), to calculate the optimum bitumen required for a mix. Marshall developed the Marshal Testing Machine before the World War II. In 1930 US Army Corps of Engineer adopted it and in 1940 modified it further.

Need of Modification in Bituminous Mixes

The day by day increase in the traffic increases the load on the pavement & changing climatic conditions around leads to its wear and tear and ultimately affects the life and performance of the bituminous mix pavements. Therefore, modification in the bituminous mixes is the demand of today's traffic so; we can improve the strength and increase the life of a bituminous pavement. There are many waste material available which can be use to modify bituminous mix like crumb rubber, waste plastic, fly ash, marble dust etc in order to increase the efficiency and life of the flexible pavements. durable & resistant to normal natural processes of degradation. A study says around 1 billion tons of plastic have been disposed of, and this may continue for many years or even, a great many decades. The plastic gets mixed with water, doesn't break down, and appears as little pallets which cause the death of fishes and numerous other sea-going creatures that eat them as nourishment materials. Today the garbage of the waste plastic is gigantic, as the plastic materials have turned into the vital part, of our everyday life. It is possible that they get blended with the Municipal Solid Waste or tossed over a land territory. On the off chance that they are not reused, their present transfer might be via land filling or it might be by incineration. Both the procedures colossal affect on nature. On the off chance that they are burned, they pollute the air and on the off chance that they are dumped into some place, they cause soil and water contamination. Under these conditions, a substitute use for this plastic waste is required. So, I decide

to modify SDBC with1.1.4 Waste plastic is a concern Plastics are durable & non-biodegradable; the chemical bonds make plastic very waste plastic for my thesis work.

Waste Plastic in SDBC Mix

BC mix modification, with the different polymers can be good a solution to overcome the problems that we are facing now days like rapid increase in wheel loads and change in climatic conditions. It can also help us to improve the fatigue life, reduce the rutting & thermal cracking in the flexible pavement. Bitumen, when mixed with the polymer, forms a complex structure which partly isolates it from bitumen and not absorbed by the polymer. This builds the consistency of the SDBC mix by forming a more internal complex structure. Plastic has good sound absorbing properties so it helps in reducing noise from the roads and plastic also not allow seepage of water which increase the life and save the pavement from disintegration due to rains. **Materials and Methodology**

The materials used are as follows.

i. Aggregates

ii. Mineral Fillers

iii. Bitumen

iv. Waste Plastic

Marshal samples were prepared by using the chart given in MORTH specification of grading and quantities of aggregates for different bituminous mixes. This study is carried out on the SDBC for this two grading is given in the handbook out of which grading 2 was adopted to carry out all samplings and testing.

Table 1: The gradation used in the sample preparation

GRADING	1	2	**GRADATION Used**
Nominal Aggregate size	**13 mm**	**10 mm**	**10 mm**
Layer thickness	**35-40 mm**	**25-30 mm**	**25-30 mm**
Is sieve (mm)	**Cumulative % by weight of total aggregate passing**		
19	100	-	-
13.2	90-100	100	100
9.5	70-90	90-100	95
4.75	35-51	35-51	45
2.36	24-39	24-39	30
1.18	15-30	15-30	15
0.6	-	-	-
0.3	9-19	9-19	10
0.15	-	-	-
0.075	3-8	3-8	5

Specific Gravity of Coarse aggregate = 2.60

Specific Gravity of Fine aggregate = 2.02

Specific gravity of filler = 1.78

Experimental Procedure

Experimental program has following processes:

- Sample Preparation
- Bulk density determination
- Stability and Flow Test
- Density and Void Analysis

Sampling Procedure

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

1) First of all coarse aggregates, fine aggregate & fillers were taken in a pan.

2) The pan is than kept in an oven at 160 °C for 2 hours. The aggregates & bitumen are needed to be mixed in heated state so preheating is required.

3) The bitumen is also heated up-to melting point before mixing.

4) The aggregates also than heated in the pan over a stove for few minutes in order to maintain the above temperature.

5) The plastic waste is than mix in the bitumen by weight of bitumen according to the sample prepared and stir them well for two minutes.

6) Now, the aggregates and modified bitumen are put together and mixed. Mix them well for around 10-15 minutes until they mix up well to get a uniform color & texture.

7) The mix was then transferred to a casting mould.

8) The mix then compacted by the Marshall Hammer.

9) Total 150 blows were given to sample; 75 blows each side of the mould per sample.

10) Then these samples with moulds were kept separately and marked.

Table 2: Varied percentages of raw materials used

S. No.	Bitumen content		Plastic waste	
	%	Grams	%	Grams
1	4.0	48	0	0
2	4.0	48	0	0
3	4.0	48	0	0
4	5.0	60	0	0
5	5.0	60	0	0
6	5.0	60	0	0
7	6.0	72	0	0
8	6.0	72	0	0
9	6.0	72	0	0
10	4.0	48	5	3.0
11	4.0	48	5	3.0
12	4.0	48	5	3.0
13	5.0	60	5	3.3
14	5.0	60	5	3.3

15	5.0	60	5	3.3
16	6.0	72	5	3.6
17	6.0	72	5	3.6
18	6.0	72	5	3.6
19	4.0	48	10	6.0
20	4.0	48	10	6.0
21	4.0	48	10	6.0
22	5.0	60	10	6.6
23	5.0	60	10	6.6
24	5.0	60	10	6.6
25	6.0	72	10	7.2
26	6.0	72	10	7.2
27	6.0	72	10	7.2
28	4.0	48	15	9.0
29	4.0	48	15	9.0
30	4.0	48	15	9.0
31	5.0	60	15	9.9
32	5.0	60	15	9.9
33	5.0	60	15	9.9
34	6.0	72	15	10.8
35	6.0	72	15	10.8
36	6.0	72	15	10.8

Results and Discussion

Test carried out with different proportion of waste plastic in SDBC mix prepared with these aggregates & bitumen and the plotted graphs of Marshall Parameters. From the graphs above we conclude that when 15 % of waste plastic was added the best results of stability values were at 5 % bitumen content i.e. 1989 kg & all other parameters like Vv, VFB & Unit Weight were within MORTH specification except the flow values, therefore we cannot use waste plastic at 15 % because it will cause disintegration and settlement of roads which is not acceptable.

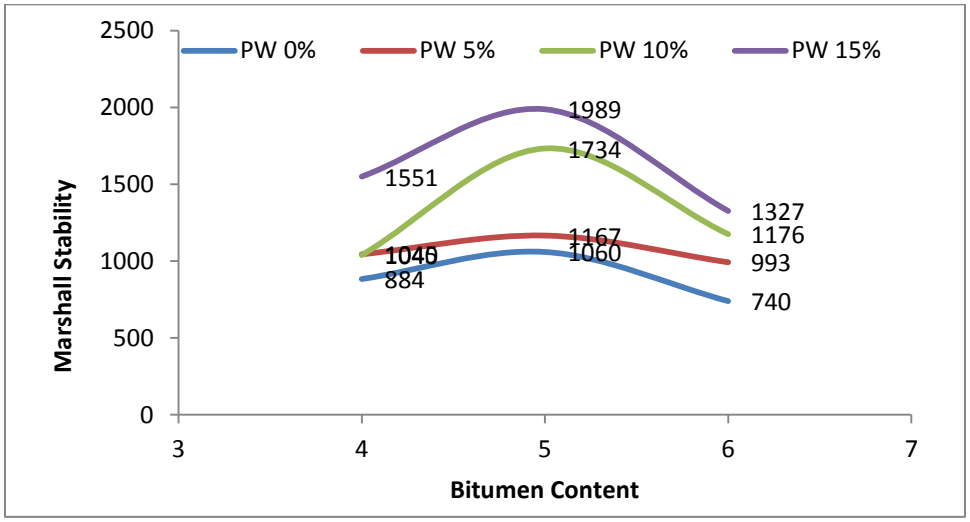

Figure 1: Comparative study of Marshall Stability with different PW

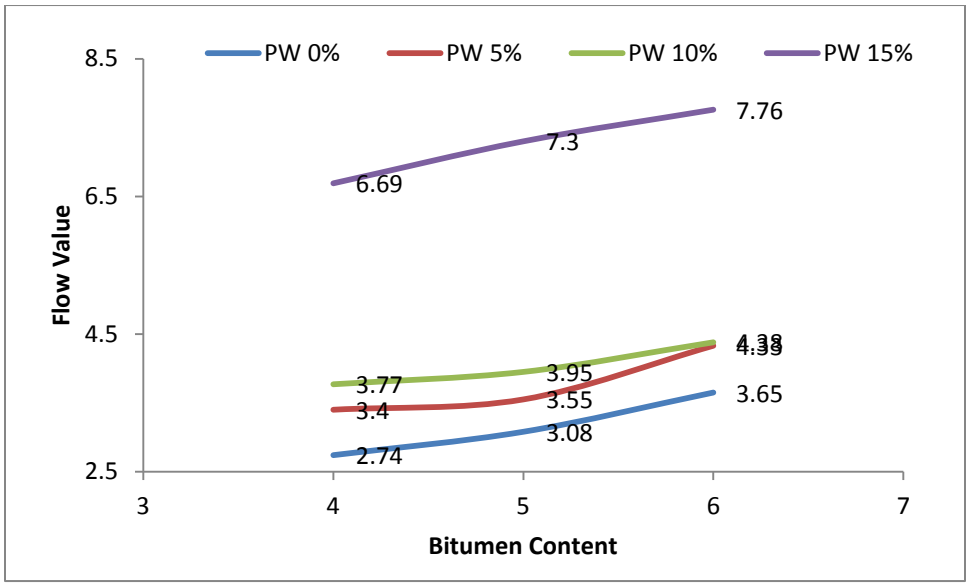

Figure 2: Comparison of flow values at different PW

From the above comparison graphs we can see that the stability values keep on increasing after adding waste plastic at 15 % but the flow values start increasing beyond the specified limits i.e. (2-4 mm) which is not acceptable so the bitumen content to be used for SDBC mix was found to be 5 % and PW to be used in between 5-10 %. The other parameters were within the MoRTH specified limits.

Conclusions

This research studies the use of waste plastic to create modified Semi-Dense Bituminous Concrete for paving high strength pavements for heavy traffic. For this waste plastic in different proportions was added in bitumen & samples were prepared and from the calculated results following conclusions were drawn:

- It was observed that modified SDBC mix gives improved results of Marshall Characteristics than conventional SDBC mix.
- It is observed that the Marshall Stability values increases with the increase in waste plastic for the aggregates and bitumen used.
- The OBC of the bitumen used was found to be 5 % at which samples get the high stability values.
- At 5 % of bitumen content and 0, 5, 10 & 15 % of waste plastic stability values were 1056 kg, 1166 kg, 1735 kg & 1988 kg respectively, but the flow values were found to be within permissible limits as specified by MoRTH up to 10 % addition of plastic waste.
- The other parameters of Marshall Test like Vv, VFB & Unit weight were under specified limits of MORTH for SDBC.
- The stability value was kept on increasing even after the addition of 15 % of waste plastic and the flow value too which shows waste plastic increase the melting point of bitumen and will results in rutting, potholes & disintegration of roads.
- The optimum waste plastic content to be used in modified SDBC mixes should be 5 % to 10 %.
- This study has an affirmative impact on the environment as it not only helps in reducing plastic waste but also gives us high strength roads with long life.

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