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Laboratory Testing of Crumb Rubber addition in Bituminous Mix Design: A Comparative study

Vikram Patel[1], Priyanka Patil[2], Shweta Shah[3], Hitesh Ahirrao[4], Vedashree Shinde[5], Rajendra Patil[6]

[1]*Assistant Professor, Department of Civil Engineering, R.C.Patel Institute of Technology, Shirpur(M.S.), India*
[2,3,4,5,6] *UG Student, Department of Civil Engineering, R.C.Patel Institute of Technology, Shirpur(M.S.), India*

Abstract: Nowadays Waste products proves to be the better option in construction. Many materials are being used to increase the use of Recycled materials to large extent. Crumb material falls under the same category, a rubber made of Tyres and is widely found to be Industrial waste product. But this waste product proved to be the better option in Bituminous Pavements. This not only gives the strength but also make the Roads economical as it is replacing some amount of Bitumen by itself. This research summarizes the comparative study of 10% and 15% crumb rubber addition in bitumen whose results are varying as the quantity increases. It can be used as a cheap and environmentally friendly modification process to minimize the damage of pavement due to increase in service traffic density, axle loading and low maintenance services which has deteriorated and subjected road structures to failure more rapidly. Use of crumb rubber leads to excellent pavement life, driving comfort and low maintenance.

Keywords: Aggregates, Bitumen, Crumb Rubber, Pavement, Waste etc.

I. INTRODUCTION

India being a very vast country has widely varying climates, terrains, construction materials and mixed traffic conditions both in terms of loads and volumes. Increased traffic factors such as heavier loads, higher traffic volume and higher tyre pressure demand higher performance pavements. So to minimize the damage of pavement surface and increase durability of flexible pavement, the conventional bitumen needs to be improved.
Crumb rubber is the term usually applied to recycled rubber from automotive and truck scrap tires. During the recycling process steel and fluff is removed leaving tire rubber with a granular consistency. Continued processing with a granulator and/or cracker mill, possibly with the aid of cryogenics or mechanical means, reduces the size of the particles.

Fig.1: Preparation of Mix

Purpose:
Following are the objectives of research,

- To utilize waste materials as a pavement (in surface course) ingredients.
- To check the sustainability of waste materials in asphalt mixture.
- To Optimize of pavement design with waste materials.
- To study & compare the effect of modified bitumen in the bituminous concrete mix design with conventional bitumen.

II. MIX DESIGN PROCESS

1. Mixture of 1200 gm aggregates are then placed in oven maintaining the temp. of 170^0 – 190^0 C for 2 hours.
2. Bitumen is heated at 150^0 C. Also heat all the mixing tools so that mixing becomes easy. While mixing heated aggregates & bitumen together, maintain the temp. of 150^0 C.
3. The mixture is returned to the oven & reheated to the compacting temp. for 20-30 minutes. The mixture is then placed in a heated Marshall mould with a collar & base. A filter paper is placed under the sample.
4. The material is compacted for 50 blows on each & both faces. (35- light traffic, 50- medium traffic, 75- heavy traffic). Allow the sample to cool at room temp. for 1 hour after compaction.
5. The mass of sample in air is then taken & after weighing it is then submerged in hot water maintaining temp. 60^0 C of water bath for 30-40 minutes.
6. After 30 minutes immediately sample is placed in the lower segment of breaking head & place the complete assembly in position on the testing machine. Adjust both dial guage to zero. Upper guage measures stability (strength) in Newton & Lower guage measures flow in units or mm (0.25 mm = 1 unit).

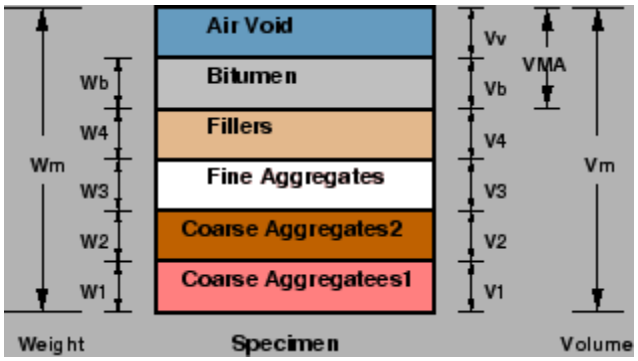

Fig. 2 : Phase diagram of a Bituminous Mix

III. EXPERIMENTAL WORK AND RESULTS

Table.1: Calculation for 10% Crumb Rubber in Bitumen are tabulated below:

	4.50%	**5.00%**	**5.50%**	**6.00%**	**6.50%**
Weight of sample in air (W_A)	1250	1258	1266	1270	1277
Weight of sample in water (W_w)	670	667.8	669	669.7	668
Weight of coarse aggregate (W_1)	468	468	468	468	468
Weight of fine aggregate (W_2)	204	204	204	204	204
Weight of filler material (W_3)	480	480	480	480	480
Weight of bitumen (W_b)	54	60	66	72	78
Weight of crumb rubber (W)	5.4	6.0	6.6	7.2	7.8
Specific gravity of coarse aggregate (G_1)	2.6	2.6	2.6	2.6	2.6
Specific gravity of fine aggregate (G_2)	2.03	2.03	2.03	2.03	2.03
Specific gravity of filler material (G_3)	1.78	1.78	1.78	1.78	1.78
Specific gravity of bitumen (G_b)	0.99	0.99	0.99	0.99	0.99

Bulk specific gravity (Gm)	2.15	2.132	2.12	2.11	2.09
Specific Gravity without considering Air Voids (G_t)	2.00	1.97	1.985	1.97	1.96
Air voids (V_v)	7.50	8.22	6.80	7.10	6.63
% Volume of bitumen (V_b)	9.68	10.61	11.54	12.46	13.30
Voids in mineral aggregate (V_{MA})	17.18	18.83	18.34	19.56	19.93
Voids filled with bitumen (V_{FB})	56.34	56.34	62.92	63.70	66.73
Stability Value	406 kg	472 kg	594 kg	556 kg	685 kg
Flow Value	2.45	3.55	3.13	3.2	3.66

Graphs:

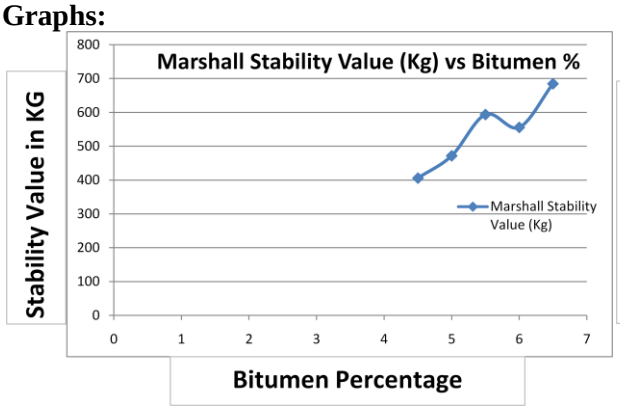

Fig. 3 : Graph showing stability value in KG v/s Bitumen Percentage

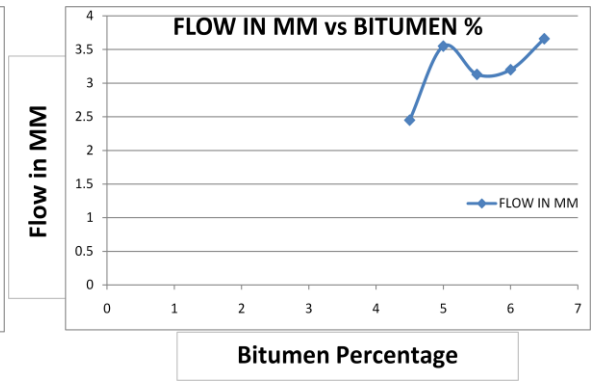

Fig. 4 : Graph showing Flow in mm v/s Bitumen Percentage

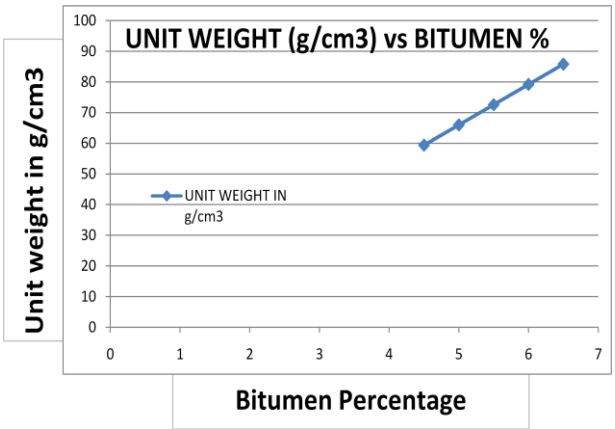

Fig. 5 : Graph showing Unit weight in g/cm^3 v/s Bitumen Percentage

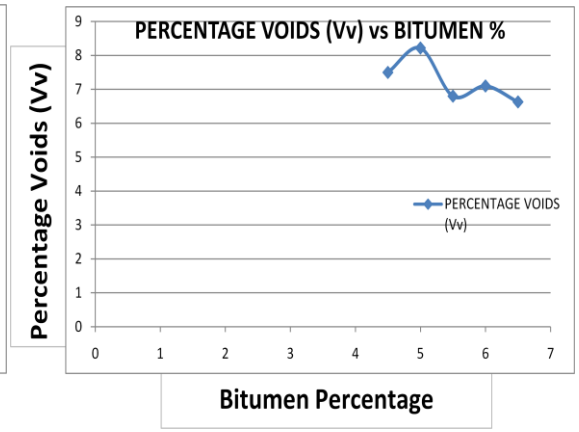

Fig. 6 : Graph showing Percentage Voids (V_v) v/s Bitumen Percentage

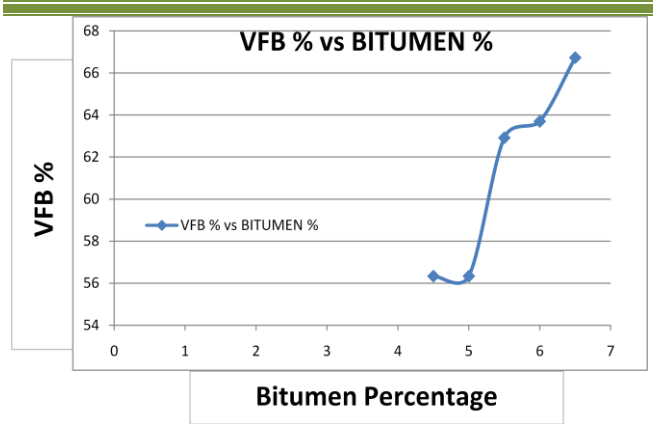

Fig. 7 : Graph showing VFB % v/s Bitumen Percentage

Table.2: Calculation for 15 % Crumb Rubber in Bitumen are tabulated below:

	4.50%	**5.00%**	**5.50%**	**6.00%**	**6.50%**
Weight of sample in air (W_A)	1250	1258	1266	1270	1277
Weight of sample in water (W_w)	680.5	678.8	677	675	676.4
Weight of coarse aggregate (W_1)	468	468	468	468	468
Weight of fine aggregate (W_2)	204	204	204	204	204
Weight of filler material (W_3)	480	480	480	480	480
Weight of bitumen (W_b)	54	60	66	72	78
Weight of crumb rubber (W)	8.1	9.0	9.9	10.80	11.70
Specific gravity of coarse aggregate (G_1)	2.6	2.6	2.6	2.6	2.6
Specific gravity of fine aggregate (G_2)	2.03	2.03	2.03	2.03	2.03
Specific gravity of filler material (G_3)	1.78	1.78	1.78	1.78	1.78
Specific gravity of bitumen (G_b)	0.99	0.99	0.99	0.99	0.99
Bulk specific gravity (Gm)	2.19	2.171	2.149	2.13	2.126
Specific Gravity without considering Air Voids (G_t)	2.00	1.99	1.99	1.98	1.97
Air voids (V_v)	9.50	9.41	7.98	7.57	7.918
% Volume of bitumen (V_b)	9.83	10.77	11.66	12.54	13.49
Voids in mineral aggregate (V_{MA})	19.33	20.18	19.64	20.11	21.41
Voids filled with bitumen (V_{FB})	50.85	53.37	59.37	62.35	63.00
Stability Value	346kg	547 kg	650 kg	613 kg	698 kg

Flow Value	2.7	3.57	3.73	3.12	3.8

Graphs:

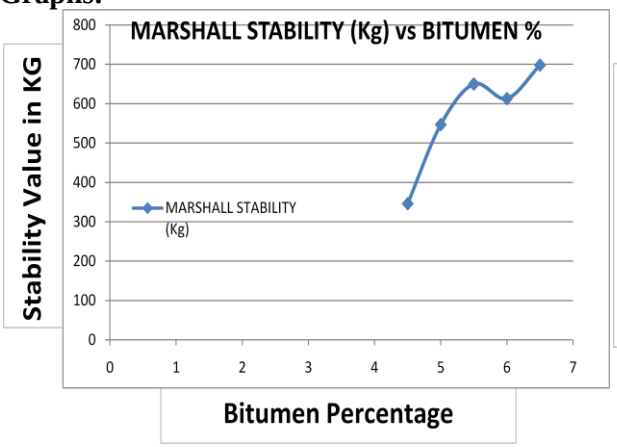

Fig. 8 : Graph showing stability value in KG v/s Bitumen Percentage

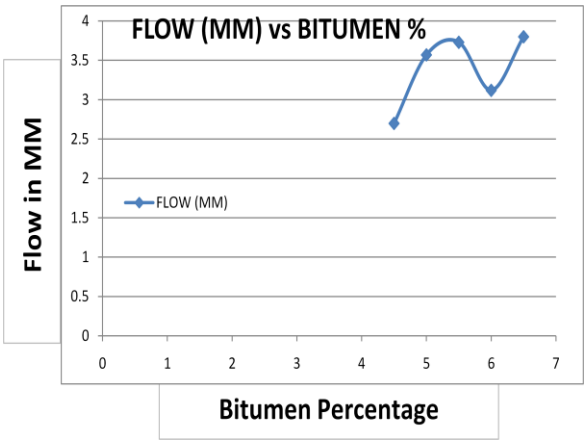

Fig. 9 : Graph showing Flow in mm v/s Bitumen Percentage

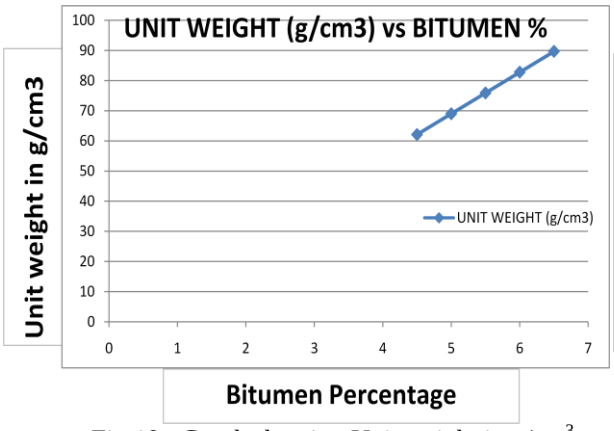

Fig.10 : Graph showing Unit weight in g/cm^3 v/s Bitumen Percentage

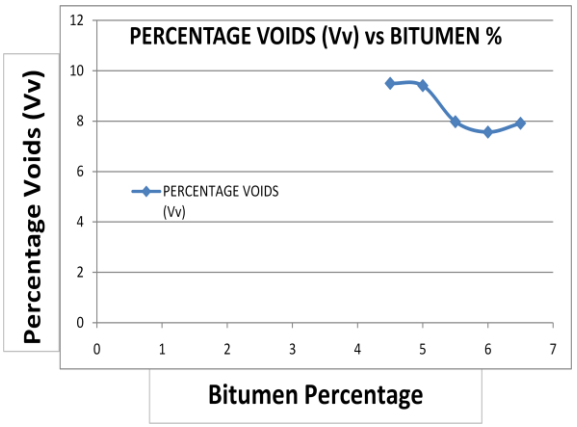

Fig.11 : Graph showing Percentage Voids (V_v) v/s Bitumen Percentage

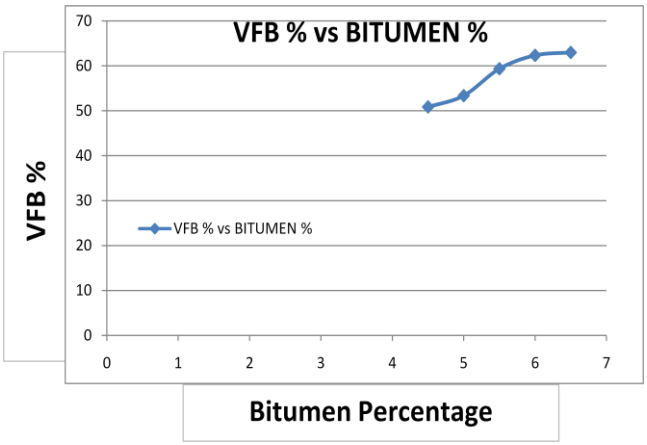

Fig.12 : Graph showing VFB % v/s Bitumen Percentage

IV. CONCLUSION

The Present study shows that there is a lot variation in the results when crumb rubber is added in 10 % and 15%. The results obtained in Bituminous Mix Design process is satisfactory in 10% addition but failed as per IS in 15% . Upto 10%, it proved to be the best innovative idea to use in Roads to make economical & to make use of waste material. It saves environment too, because rubber is that material which is not decay in soil & when the rubber is going to be burn then it create poisonous gases and by that it affect environment. It causes health problems too.

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