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STUDY ON MODIFIED ASPHALT CONCRETE MIX USING CRUMB RUBBER

V.GUNASEKARAN
Lecturer Senior Grade,
Department of Civil Engineering, Nachimuthu Polytechnic College, Pollachi, India

Abstract- The use of crumb rubber in modifying the asphalt is aimed at increasing the stability of the pavement surface, while reducing the environmental problems posed by the growing number of scrap tires. This thesis reports the procedure for modification of asphalt and various inferences obtained from the experimental investigation. Crumb rubber obtained from the industrial tires is used in the original form as the modifier for the research. Asphalt 80/100 grade is used as binder and crumb rubber modifier to achieve maximum stability and minimum flow within acceptable limits. In the process the research was also carried to find optimum content of crumb rubber, changes in durability characteristics of the asphalt concrete, and charges the rheological characteristics of the binder. The studies showed that the addition of the crumb rubber modifier to the asphalt increased the stability and decreased the flow of the asphalt concrete at 15% by weight of the modifier to the asphalt concrete. The results were analyzed and the influence of crumb rubber modifier on the durability and rheological characteristics such as stability, penetration, ductility value, etc is presented.

Key Words – Recycled Crumb Rubber modified asphalt Roads, Modified Bitumen, Flexible Pavements, etc…

I. INTRODUCTION

1.1 GENERAL

In the past decade, Indian transportation sector has undergone a major transformation as the rail transportation has slowly made way for the road transportation. The steep growth in the vehicular traffic has posed two main problems for the pavement engineers.

- The increase in the demand for a more durable pavement that can sustain longer to reduce the maintenance costs, and
- The management of the growing piles of the scrap tires, resulted from the increased vehicular traffic.

The ideal solution should address the problems to give a viable and cost effective way out of these.

1.2 CRUMB RUBBER MODIFIER

Crumb rubber is obtained from scrap tires that have been reduced in size < 6.3mm (1/4”) by mechanical shearing or grinding and it is used for asphalt pavement. The grinding is done through either mechanical means or cryogenic process, where the properties of the scrap tire rubber are changed at low temperatures. The main contributor to the crumb rubber modifier is the tread of the tire, the component of tire, which comes to in contact with the road. The tread is normally composed of Natural Rubber (NR) or Imprene Rubber (IR) in blends with other synthetic elastomers (eg. SBR, BR)for truck tires and a blend of SBR and BR elastomers for passenger tires. Fine particle size carbon blacks are normally

used as fillers since they have large surface area and high reinforcements. Processing aids, curatives and anti-degradients are essential ingredients.

Table 1.1 Composition of passenger and truck tire treads

Ingredients	Passenger tire treads		Truck tire treads	
	Radial	Bias	Radial	Bias
Styrene-Butadience rubber (SBR)1712	82.5	82.5	100	
Butyl-rubber (BR) 1252	55	55		

1.3 OBJECTIVES OF THE STUDY

Taking the constraints of the available resources and the time into account, the following objectives have been set for the study:

- To find out the optimum asphalt binder content and the asphalt crumb rubber modifier blend proportion to achieve maximum stability and minimum flow condition.
- To investigate the rheological characteristics of the asphalt with and without the application of the crumb rubber modifier, and to assess the changes in the binder properties.

1.4 Important properties of bitumen are

- Viscosity of bitumen should be adequate at the time of mixing and compaction.
- It is achieved by heating prior to mixing and by use of cutbacks and emulsion
- In presence of water bitumen should not strip off from aggregate
- Bitumen should be durable in all seasons. It should not become too soft during summers and develop cracks during winters.

II. EXPERIMENTAL INVESTIGATIONS

The present investigation envisages is a quantitative and qualitative assessment of the improvement in Marshal stability and flow characteristics, for the difference combinations of the bitumen and crumb rubber, crumb rubber modified asphalt concrete.

Asphalt cement taken for study is 80/100 penetration grade. The engineering properties of asphalt used in the study, which has been found out through the laboratory tests.

Table 2.1 The properties of asphalt used

S.No	Property	Value
1	Penetration at 25^0 C , 100gm, 1/10mm	91.5
2	Softening Point in ^{0} C	41
3	Ductility at 25^0 C, cm	66.3
4	Specific gravity	1.03

2.1 MATERIALS USE FOR THE STUDY

2.1.1 Aggregate

Table 2.2 The properties of Aggregate used

S.No	Property	Value obtained
1	Specific Gravity	2.72
2	Impact Value	28.4%
3	Cushing Value	26.7%
4	Los angels abrasion value	31.3%
5	Flakiness index	19.6%
6	Elongation index	16.2%

2.1.2 Bitumen

Bitumen of penetration grade 80/100 was used

2.1.3 Modifier

Crum Rubber (CR)

It has been obtained in raw form from the retreading radial truck tires of MRF Company Chennai. It is rich in Styrene-Butadiene Rubber and ISAF-HM black (N-220).

III. MIXING PROCESS

- First heat the bitumen and remove all air and water particles.
- Then take some amount of bitumen from this heated bitumen and pour the required quantity of CR into that and mix it thoroughly at a temperature of 170^0 C for a period of 45 min.

IV. STANDARD TESTS CONDUCTED ON BINDER

The following experiments have been carried out to study the characteristics of the crumb rubber modifier bituminous mix.

4.1.1 Penetration test:

This is carried out as per procedure given in IS: 1203-1978. The test has been carried out on the modified bituminous mix containing 0, 12.5, 15, 17.5, & 20% of crumb rubber.

4.1.2 Softening point:

The softening point has been carried out as per IS: 1203-1978. The test has been carried out on the modified bituminous mix containing 0, 12.5, 15, 17.5, & 20% of crumb rubber.

4.1.3 Ductility Value:

The Ductility test has been carried out as per IS: 1203-1978. The test has been carried out on the modified bituminous mix containing 0, 12.5, 15, 17.5, & 20% of crumb rubber.

4.1.4 Specific Gravity:

The test has been carried out as per IS: 1203-1978. The test has been carried out on the modified bituminous mix containing 0, 12.5, 15, 17.5, & 20% of crumb rubber.

4.1.5 Marshall Stability Test;

The procedure of the test will be like this.

1. First heat the required quantity of aggregate to a temperature of 190^0 C.
2. Then heat the required quantity of bitumen and remove all air and water particles presented in it.
3. Then pour this heated bitumen into that heated aggregate, and mix this mixture thoroughly.
4. Then pour this mixture in the cylindrical moulds and give 50 blows on each side.
5. Cylindrical moulds should be allowed to cool for 24hrs. Then remove the specimens from the moulds and place in a steam bath maintaining at $60^{\circ}\pm1^{\circ}$C for 30 to 40 minutes.
6. After keeping the specimens in the steam bath for 30 to 40 minutes take out the specimens from the bath and place under the Marshall stability test machine.
7. Now apply the load on the specimen and corresponding dial gauge readings will be taken to find out the corresponding values like Marshall Stability, Flow value and Density etc.

Marshall Stability and the flow values have been used as the assessment of the strength of the pavement.

V. TEST RESULTS AND DISCUSSION

Table No 5.1 Properties of bitumen with different % of CR

S.No	Property tested	% CR added to 80/100 Bitumen				
		0	15	17.5	20	22.5
1	Penetration 25^0 C 100gm, 5sec(1/10mm)	91.5	52	50.5	49	44.5
2	Softening point ^{0} C	41	50.5	54.5	55	56
3	Ductility in cm	66.3	18	14.5	12.5	12
4	Specific Gravity	1.03	1.04	1.042	1.054	1.041

Table No 5.2. Discussion on Binder Tests

Bitumen by weight of aggregate + % of CR		Theoretical Density (gm/cc)	Bulk Density (gm/cc)	Vv %	Vb %	VMA%	VFB %	Marshall Stability (KN)	Flow value (mm)
4%	0% CR	2.460	2.338	4.9	8.50	13.4	63.1	92.09	2.14

				59	2	61	6		2
	12.5% CR	2.445	2.328	4.785	8.835	13.62	64.86	98.07	2.32
	15% CR	2.448	2.21	5.187	8.918	14.105	63.225	128.47	2.159
	17.5% CR	2.444	2.322	4.991	8.93	13.922	64.143	112.62	1.888
	20% CR	2.442	2.328	4.668	8.945	13.613	65.71	106.67	2.159
4.5 %	0% CR	2.457	2.341	4.720	9.576	14.296	66.983	94.078	2.54
	12.5% CR	2.434	2.334	4.108	9.836	13.944	70.539	106.67	2.472
	15% CR	2.446	2.325	4.278	10.5	14.328	70.142	141.04	2.324
	17.5% CR	2.433	2.323	4.521	10.05	14.571	68.972	137.92	2.122
	20% CR	2.440	2.348	3.77	10.15	13.92	72.92	111.35	2.26
5%	0% CR	2.443	2.346	3.970	10.66	14.63	72.869	146.39	3.175
	12.5% CR	2.43	2.338	3.786	11.091	14.877	74.551	111.35	2.612
	15% CR	2.431	2.342	3.661	11.248	14.909	75.444	163.64	2.709
	17.5% CR	2.429	2.344	3.499	11.269	14.768	76.306	155.68	2.72
	20% CR	2.430	2.346	3.456	11.268	14.724	76.528	147.35	2.54
5.5 %	0% CR	2.429	2.352	3.170	11.760	14.93	78.76	137.90	3.429
	12.5% CR	2.415	2.332	3.456	12.168	15.604	77.98	105.06	2.842
	15% CR	2.416	2.339	3.187	12.357	15.544	79.497	131.73	2.878
	17.5% CR	2.414	2.348	2.734	12.417	15.151	81.954	137.90	23.667
	20% CR	2.412	2.332	3.316	12.32	15.636	78.792	118.75	2.607
6%	0% CR	2.415	2.347	2.815	12.801	15.616	81.970	114.88	3.852
	12.5% CR	2.40	2.335	2.748	13.275	16.023	82.849	100.823	2.931
	15% CR	2.401	2.335	2.748	13.48	16.206	83.043	119.43	3.14

	17.5% CR	2.40	2.338	2.623	13.488	16.11	83.719	128.47	2.75
	20% CR	2.40	2.323	3.208	13.389	16.60	80.656	105.08	2.794

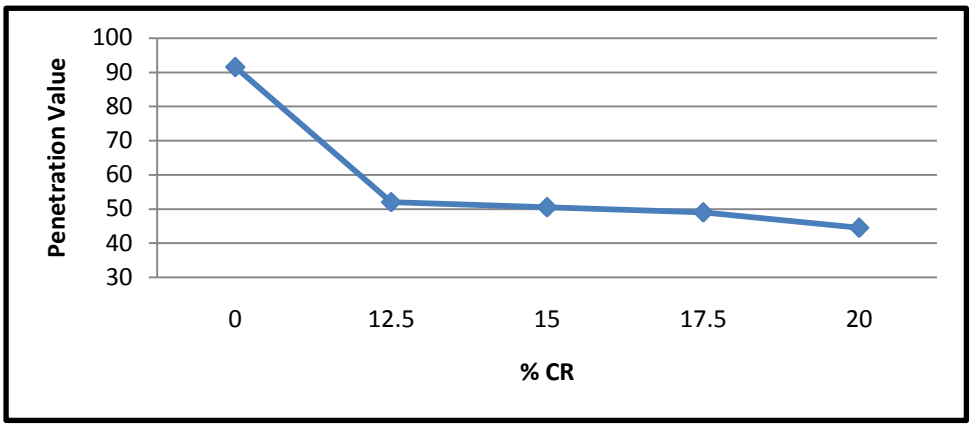

Figure 1. Penetration value of Bitumen for % of CR

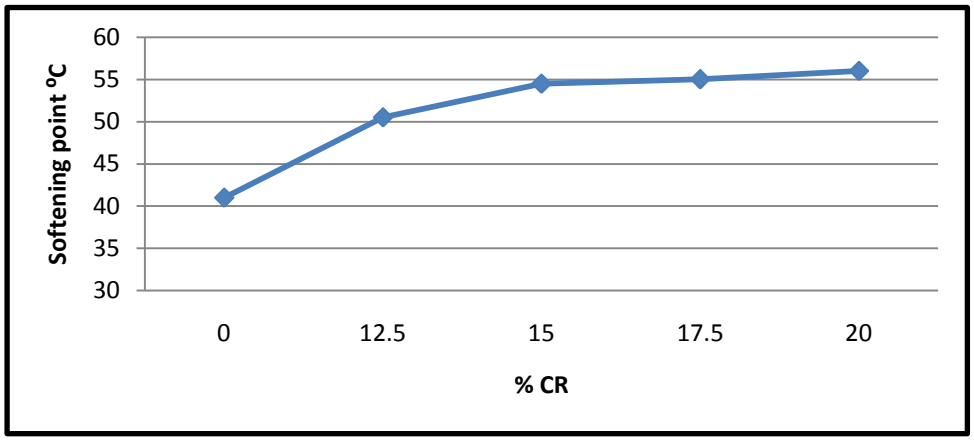

Figure 2. Softening point of Bitumen for % of CR

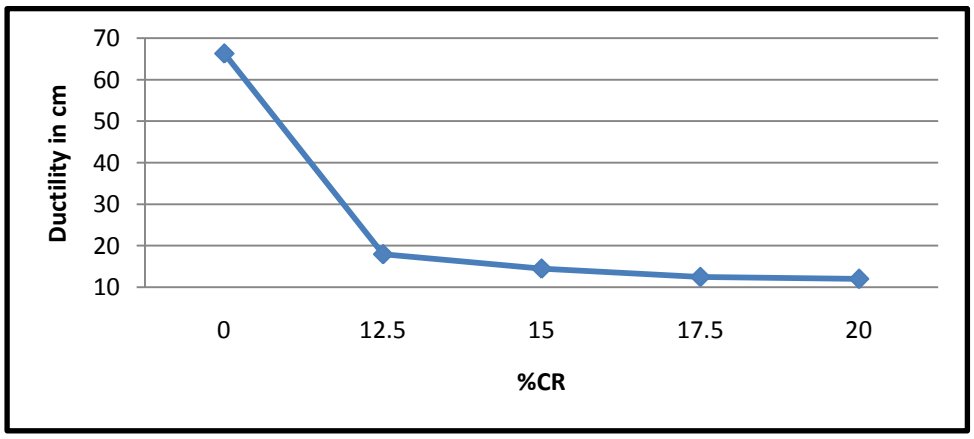

Figure3. Ductility of Bitumen for % of CR

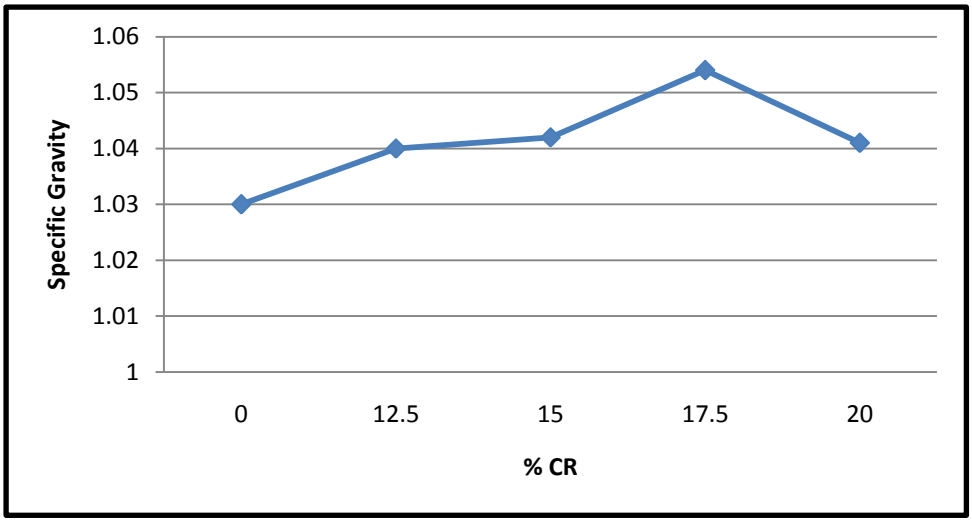

Figure4. Specific gravity of Bitumen for % of CR

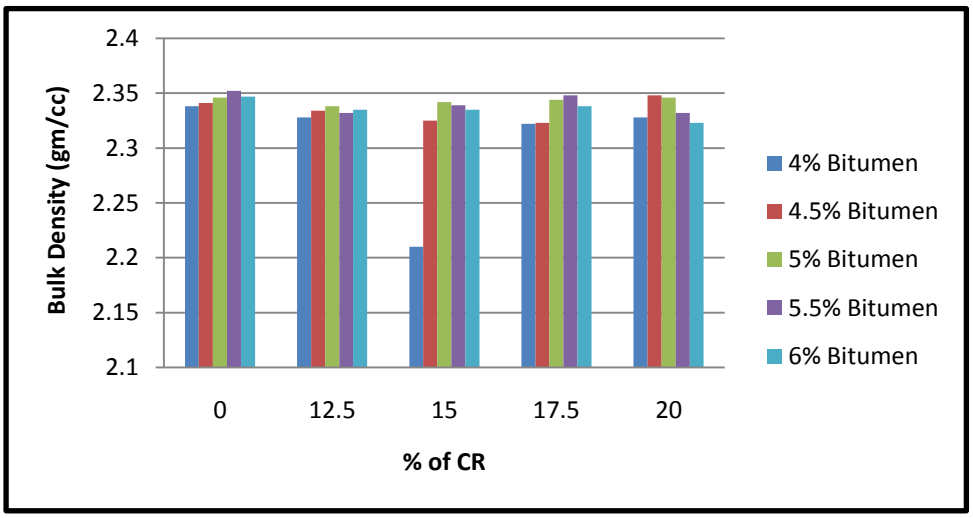

Figure 5. Bulk Density of Bitumen for % of CR

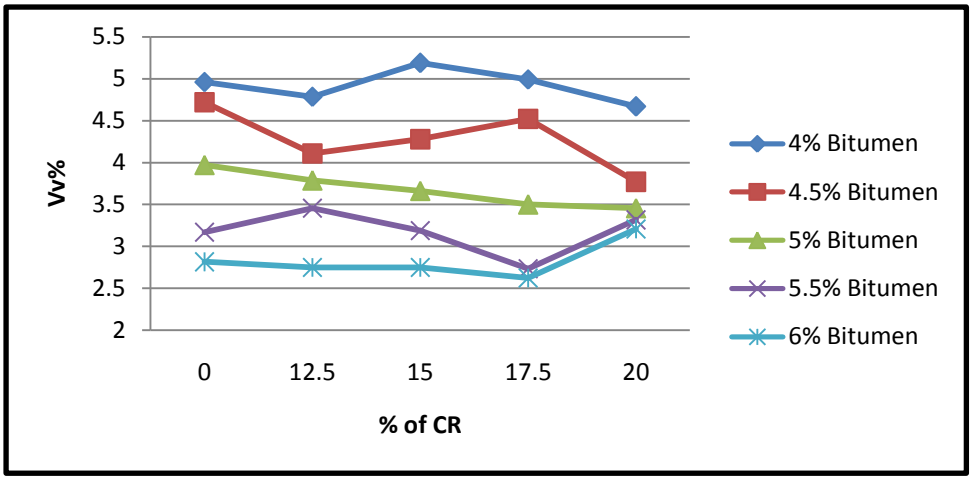

Figure 6. Variations in Vv% for different % of Bitumen with CR

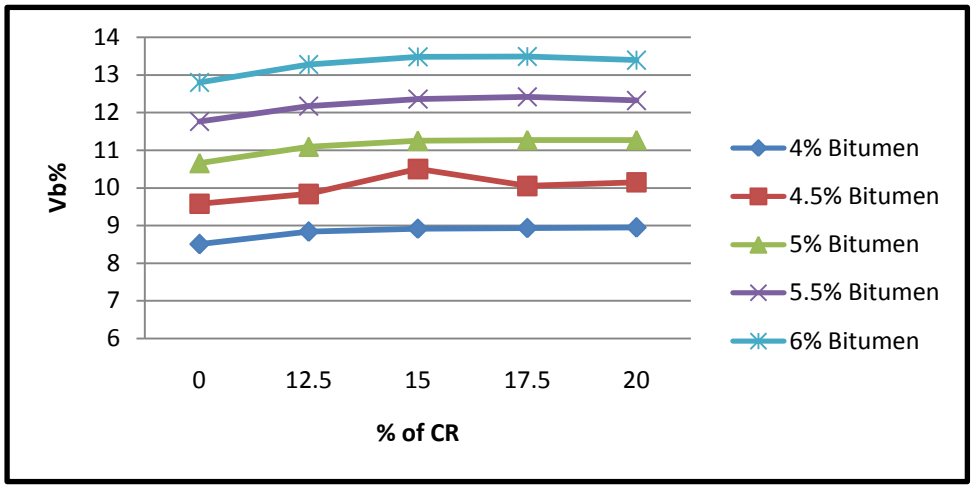

Figure 7. Variations in Vb% for different % of Bitumen with CR

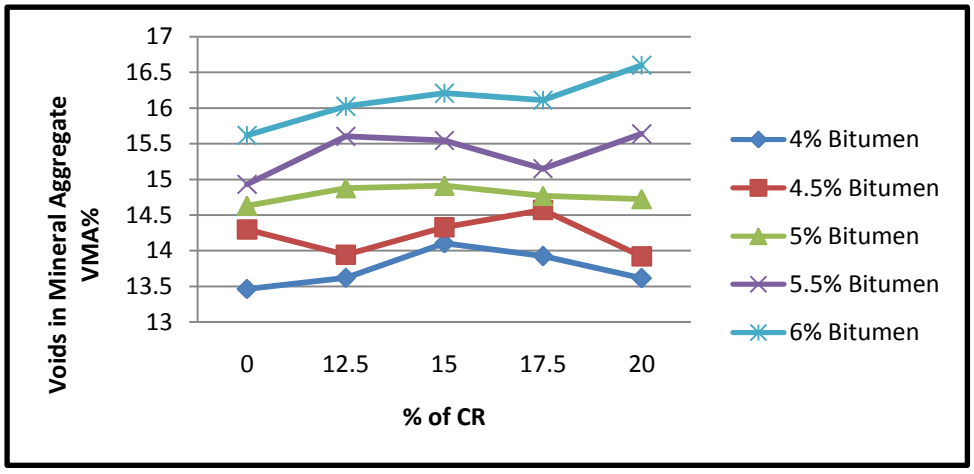

Figure 8. Variation in (VMA %) for different % of Bitumen with CR

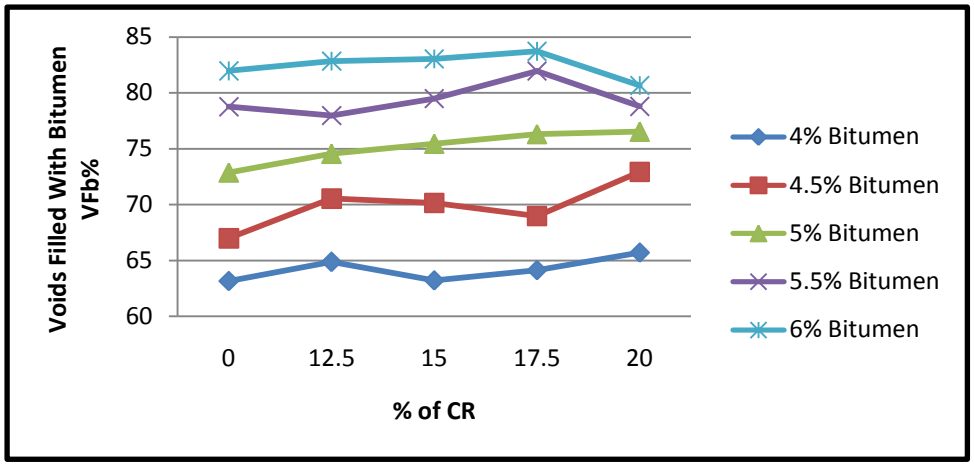

Figure 9. Variations in VFb% for different % of Bitumen with CR

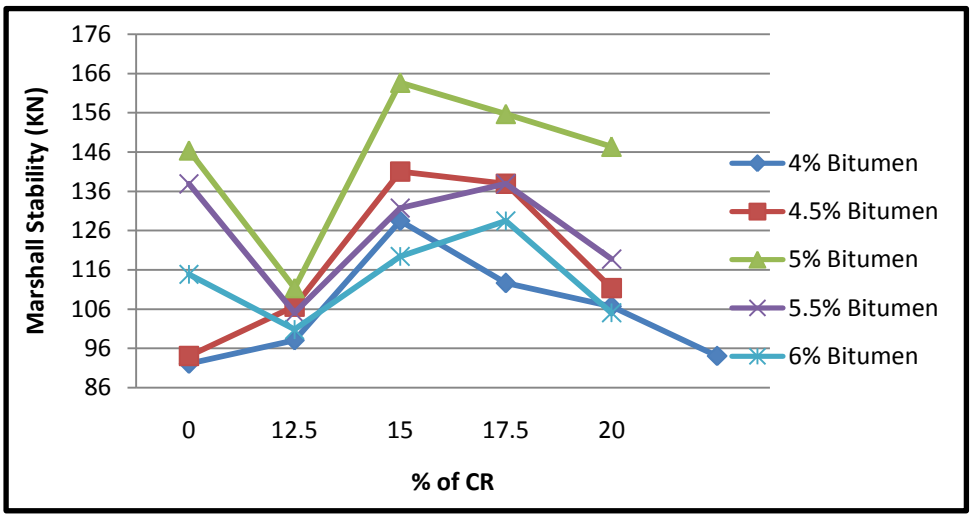

Figure 10. Variations in Marshall Stability for different % of Bitumen with CR

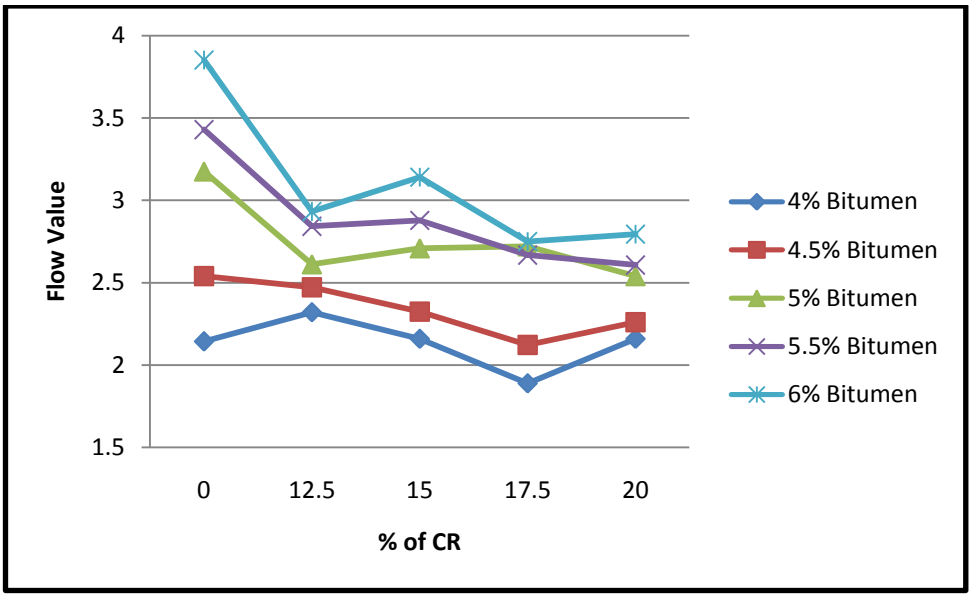

Figure 11. Variations in Flow value for different % of Bitumen with CR

Penetration Test:

The results have shown a decrease in the penetration value with the increase in the percentage of crumb rubber modifier. The result indicate that the increase in the velocity of the bitumen is due to the addition of crumb rubber. Figure 1 shows the relation between penetration and percentage of the crumb rubber modifier.

Softening Point:

Fig 2. Shows the relation between softening point and the percentage of crumb rubber modifier. By seeing figures we can understand that the softening point has increased with the increase in the percentage of crumb rubber modifier. It indicates that the addition of CRR to bitumen will increase the temperature of the bitumen at which it can flow.

Ductility Test:

Ductility values are hardened for all percentages of crumb rubber added. From figure 3. We can see that there is a continuous decrease in their ductility values.

Marshall Stability:

Based on the results maximum value of Marshall Stability is 163.64 KN (Fig 10). It can be seen that the optimum content is 5% of bitumen with 15% CR. It helps in substantial improvement in the stability or strength, fatigue life and other desirable properties of the bituminous mix.

The flow value was found to be decrease with addition of crumb rubber modifier as compare to the plain Bituminous mixes. From the fig 11: The average flow value of pavement mix is 5% of bitumen with CR.

CONCLUSIONS

After observing the results obtained from laboratory, we can draw the following conclusions.

- The crumb rubber modifier obtained from the Scrap Tires of the trucks improves the resistance of the asphalt concrete to plastic flow.
- The penetration and ductility value decreases with increasing percentage of crumb rubber content.
- The Softening point value increases with increasing percentage of CR content
- Marshall Stability value as high as 163.64 KN was obtained as a result of modification with 15% CR proportion by weight of bitumen in 5% binder content.
- The Marshal Stability value of modified binder increases when compare with the plain bitumen.

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