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"Effect of Crumb Rubber on Semi-Dense Bituminous Concrete"

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Abstract: This thesis presents a study of laboratory evaluation on the properties of bitumen by adding crumb rubber to the mix. The purpose of this project is to investigate the strength of the pavement when crumb rubber is used as an additive in asphalt pavement and to know the optimum content of crumb rubber percent which improves resistance of the pavement as well as better durability. According to the literature review, many people have researched and studied on use of crumb rubber in road construction purposes. Fortunately with the growing scenario for better performance in road infrastructure and continued technological advancement, a number of solutions were identified. These included to the growth of use of modified binders all over the world and led to the investigation into the use of devulcanised rubber. Due to increasing expectations for everyday comforts of the general population, the utilization of vehicles has expanded over a most recent couple of years, giving ascent in the vehicular thickness on streets. As vehicles are utilized every now and again the wear and tear of their tires is self-evident. Because of wear and tear of tires the life of tire lessens and finally it gets to be pointless. The transfer of these tires has turned into a difficult issue. These tires are generally disposed of by dumping. Transfer by blazing causes air contamination and dumping causes significant area to be squandered for stacking up the tires. So it is required to arrange these tires securely and monetarily. So an endeavour to utilize this waste tire elastic for blending so as to enhance the properties of bitumen has been done. The incorporation of crumb rubber to the pavements has been beneficial in many aspects such as providing resistance to pavements against cracks and failures, Improved durability of the pavements, cost-effectiveness, Improved fatigue resistance and skid resistance ,overall improved performance and the most important part is solving the environmental issue of disposal of waste rubber tyres.

Index Terms: Waste tire rubber, Blended bitumen, Marshall Stability Test.

I. Introduction

Crumb rubber is very suitable to be the additives in pavement because it has the characteristic that can support the weakness of asphalt. Apart from that adding crumb rubber to pavement, it reduces the problem of disposal of waste tyres which is becoming now a serious environmental problem. The use of crumb rubber in asphalt materials became of interest to the paving industry because the crumb rubber has an elastic property which has the potential to improve the skid-resistance and durability of asphalt. The usage of crumb rubber is proving to be good and reliable. Besides that, crumb rubber can reduce the issue of fatigue or cracking occurring on most of the pavement surface. At once, it can solve the issues of damage and defect. Moreover, it can save the cost for the maintenance of roadway pavement because crumb rubber is found to be economical and it also adheres to solve the environmental issues of disposal of waste tyres. A crumb rubber will prevent the pavement to crack in the cold or melt in the heat. It also increases film thickness in the aggregate that can prevent bleeding, flushing and reduce noises. Crumb rubber also has higher durability than asphalt. So, crumb rubber will be used as additives in asphalt pavement. The concentration and size of crumb rubber will be balanced with asphalt. By using this method, the strength of pavement will be increased and the environmental rescue of wastage tyres can be reduced.

II. Methodology

The aggregates are sieved as per the SDBC Gradation. Here coarse aggregates, fine aggregates and filler are taken and VG-30 Bitumen is used. The gradation chart of SDBC mix is presented below

Aggregate gradation for SDBC

Nominal Aggregate Size	**13.2 mm**	
Layer Thickness	30-40 mm	
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
	Specified limit	Adopted value
13.2	100	0
9.5	90-100	95
4.75	35-51	43
2.36	24-39	31.5
1.18	15-30	22.5
0.3	9-19	14
0.0075	3-8	5.5

All the Marshall properties and the definitions and other formulae used in calculations are described below.

Theoretical specific gravity of the mix (Gt)

$$Gt = \frac{W1+W2+W3+Wb}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{Wb}{Gb}}$$

W1= Weight of coarse aggregate in total mix
W2= Weight of fine aggregate in total mix
W3= Weight of filler in total mix
Wb= Weight of bitumen in total mix
G1=Apparent specific gravity of coarse aggregate
G2= Apparent specific gravity of fine aggregate
G3= Apparent specific gravity of dust filler
Gb= Apparent specific gravity of bitumen

Bulk specific gravity of mix (Gm)

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

Wm = Weight of mix in Air
Ww= Weight of mix in water

Air Void Percentage (Vv)

$Vv= \frac{Gt-Gm}{Gt} \times 100$

Gt = Theoretical specific gravity
Gm = Bulk density

Percent Value of bitumen (Vb)

$Vb = \frac{\frac{Wb}{Gb}}{\frac{W1+W2+W3+Wb}{Gm}}$

W1 =Weight of coarse aggregate in total mix
W2 = Weight of fine aggregate in total mix
W3 = Weight of filler in total mix
Wb = Weight of bitumen in total mix
Gb=Apparent specific gravity of bitumen
Gm= Bulk specific gravity

Void Minerals in Aggregate (VMA)

VMA = Vv + V b
Vv = % of void in air
Vb= % of void in bitumen

Void Filled with bitumen (VFB)

$VFB = \frac{Vb \times 100}{VMA}$

MARSHALL METHOD OF BITUMINOUS MIX DESIGN:

The Semi Dense Bituminous Concrete (SDBC) mix was prepared using Marshall Method of bituminous mix design. The SDBC was prepared with conventional 60/70 grade bitumen, 60/70 grade bitumen added with varying percentages of Crumb Rubber. The details of the experimental programme are as follows:

Sample preparation:

In this experimental work bitumen VG-30 was taken in percentage 4 %,4.5 % ,5 % ,5.5 % ,6 % and 2 specimens were prepared for each bitumen content and percentage of crumb rubber.The % of crumb rubber was taken in 0 % ,4 % ,8% ,12 %,16 %,20 %.Total number of samples=2×5×2×6=120. So 60 Samples were prepaired through Dry Process.And 60 Samples were prepaired through Wet Process. Total 120 samples were prepaired in this experimental work.

Required quantity of coarse aggregate, fine aggregate and mineral fillers were taken in an pan. This was kept in an oven at temperature 160 deg c for 2 hr. This is because the aggregate and bitumen are to be mixed in heated state so preheating is required.The bitumen was also heated up to its melting point prior to the mix.The required amount of crumb rubber was weighed and kept in a separate container.The aggregate in the pan were heated on a controlled heater for few minutes maintaining the above temperature. The crumb rubber was added to the aggregate in the dry process and was mixed for 2 minutes. But in wet process the crumb rubber was added in bitumen and then mixed for 2 minute.Now bitumen was added by the percentange to this mix and the whole mix was stirred uniformly .This was continued for 15-20 minute till they were properly mixed.Then the mix was transferred to a casting mould. Then 75 blows are applied on either sides of the mould manually. Then the specimen is extracted after 24 hours.The aggregates were washed properly and oven dried at 150deg celcius.

Attached below are some pictures taken during marshall test:-

Aggregates and bitumen are mixed together in a pan.

Preparation of marshall moulds

Demoulded marshall samples

Then marshall stability tests are performed and the detailed results are presented in CHAPTER III.

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III. Results and Discussion

This chapter deals with the test results and analysis of Marshall Test carried out in the previous chapter. In this chapter Stability-flow analysis and Density-void analysis are discussed in depth and tabulation of Marshall Test data has been drawn for different percentages of bitumen and crumb rubber content with their graphs. VA%, VMA%, VFB% and optimum binder content has been found out for each bitumen content.

Preparation of graphical plots

The value of the above properties is determined for each mix with different bitumen content and the following graphical plots are prepared:

1. Binder content versus Marshall Stability
2. Binder content versus Marshall Flow
3. Binder content versus percentage of voids in the total mix (VA)
4. Binder content versus voids filled with bitumen (VFB)
5. Binder content versus unit weight or bulk specific gravity (Gm)

Optimum Binder Content

We calculate optimum binder content from following 3 graph.

1.Marshal stability graph (B1) .
2. Bulk Density graph (B2) .
3.Air void graph (B3) .

Optimum binder content (dry process)

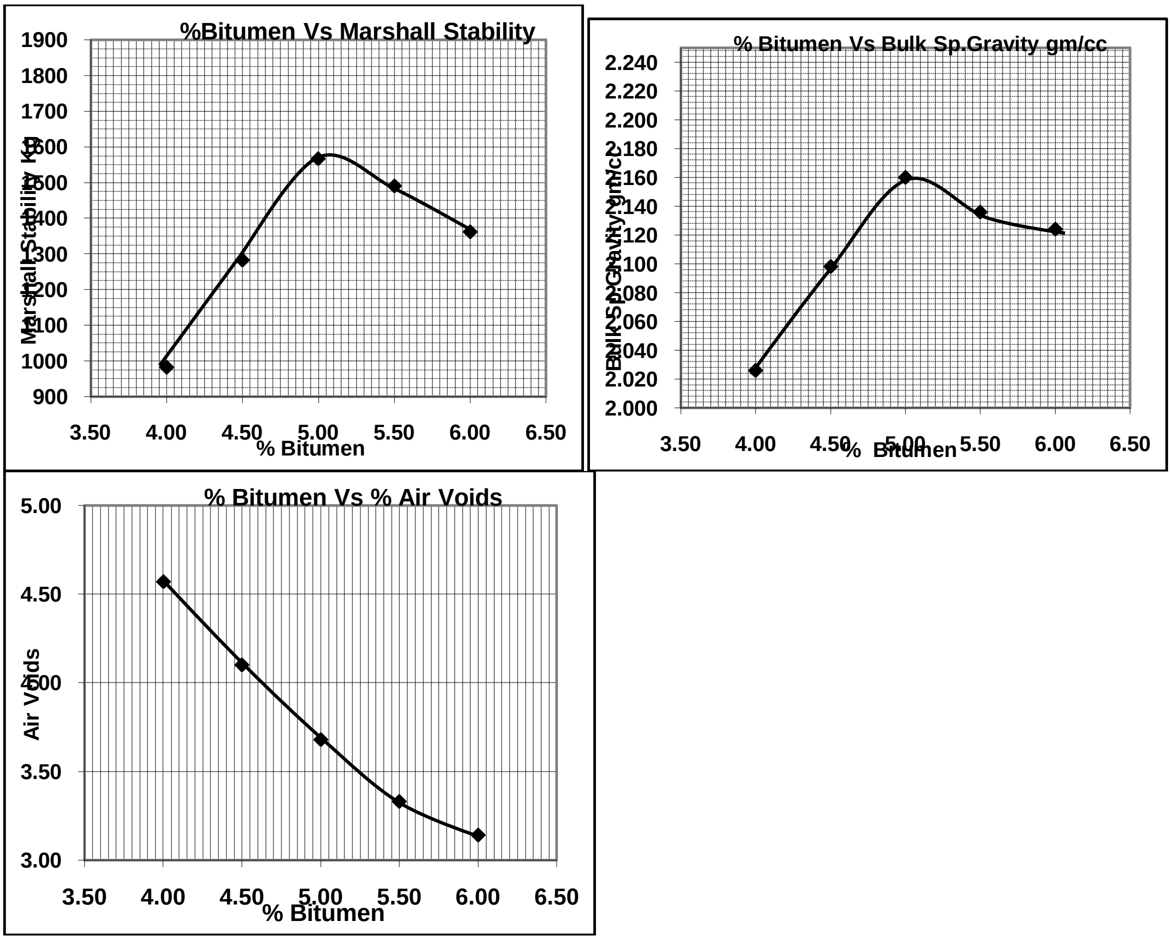
Sl.no	properties	Bituminous mix with crumb rubber % of bitumen							
		0%	4%	8%	12%	16%	20%	Requirements asper MORT&H 2013	
1.	Marshall stability	1636	1342	1426	1566	1462	1284	9-12	AASHTO T245
2.	Flow(mm)	3.8	3.2	3.3	3.5	3.1	3.0	2-5	AASHTO T245
3.	Bulk density	2.192	2.120	2.160	2.160	2.142	2.140		AASHTO T245
4.	VA(%)	3.48	3.52	3.52	3.68	4.10	3.81	3-5	MS-2 and ASTM D2041

5.	VMA(%)	15.10	14.78	14.32	14.66	14.38	14.48	14-16	AASHTO T245
6.	VFB	76.95	76.18	75.41	74.89	72.10	73.31	60-70	AASHTO T245

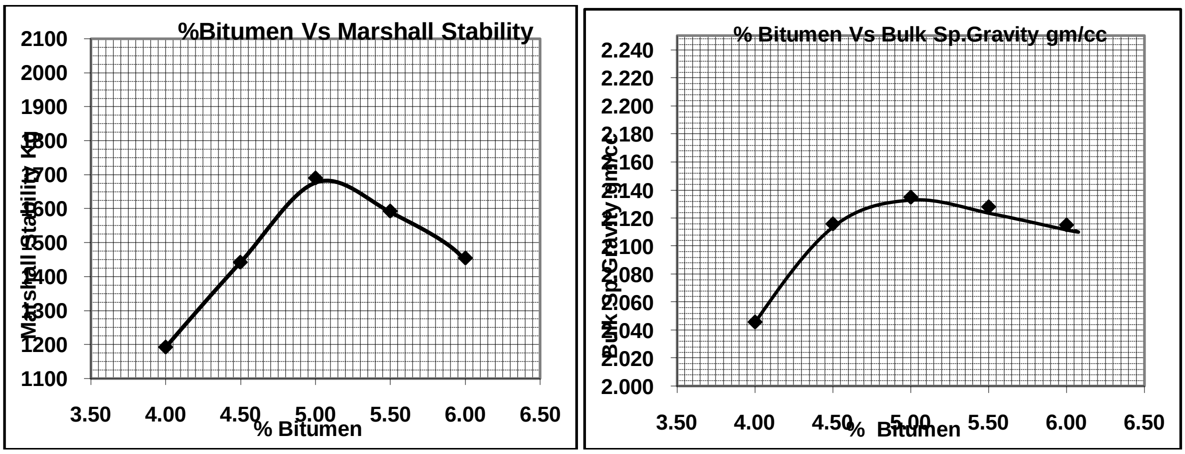
(b) Optimum binder content (wet process)

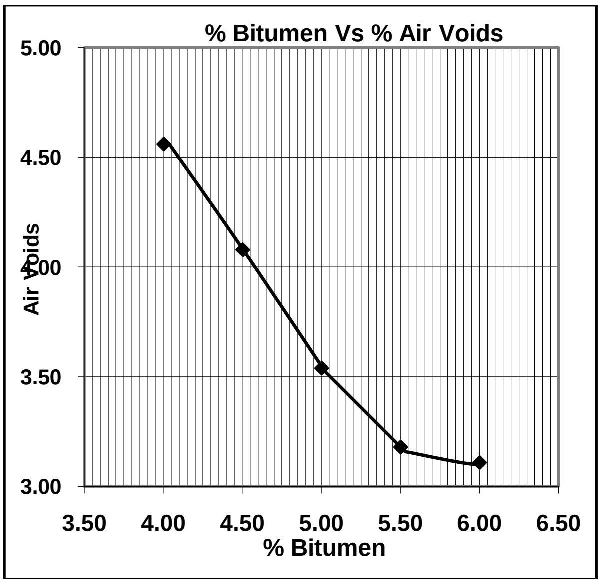
Sl.no	properties	Bituminous mix with crumb rubber % of bitumen							
		0%	4%	8%	12%	16%	20%	Requirements asper MORT&H 2013	
1.	Marshall stability	1543	1498	1528	1690	1560	1676	9-12	AASHTO T245
2.	Flow(mm)	3.6	3.4	3.6	3.7	3.5	3.3	2-5	AASHTO T245
3.	Bulk density	2.188	2.142	2.168	2.135	2.158	2.146		AASHTO T245
4.	VA(%)	3.45	3.65	3.78	3.54	3.76	3.98	3-5	MS-2 and ASTM D2041
5.	VMA(%)	15.02	14.70	14.56	14.60	14.52	14.65	14-16	AASHTO T245
6.	VFB	75.43	75.17	74.03	75.75	74.10	72.83	60-70	AASHTO T245

The optimum binder content is satisfied at 5% bitumen content and 12% addition of crumb rubber. The graph of 12% crumb rubber dry process is presented below



Graphs of bitumen content 5% with crumb rubber 12% (wet process)





IV. Conclusion

Here I came to a conclusion that 12% addition of crumb rubber to 5% bitumen content gives satisfactory results and can be used for construction of road pavements .All test values are consistent with the specification limits. The results of the study are applicable to only the type of rubber used i.e. the rubber passing through 75micron sieve. Other sources of rubber may produce different results.

References

[1]. Mahrez.A,1999,‘Properties of rubberised bitumen binder and its effect on the bituminous mix, M.S. thesis, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia.

[2]. Mahrez and Rehan, 2003 “Rheological evaluation of aging properties of crumb rubber-modified bitumen,” Journal of the Eastern Asia Society for Transportation Studied, vol. 5, pp. 820–833, 2003.

[3]. Lee.S.J., Akisetty.C.K, and Amirkhanian.S.N “The effect of crumb rubber modifier (CRM) on the performance properties of rubberized binders in HMA pavements,” Construction and Building Materials, vol. 22, no. 7, pp. 1368–1376, 2008.

[4]. Becker.Y, Méndez.M.P, and Rodríguez.Y, “Polymer modified asphalt,” Vision Technological, vol. 9, no. 1, pp. 39–50, 2001.

[5]. Shen.J, Amirkhanian.S, Xiao.F, and Tang.B, “Influence of surface area and size of crumb rubber on high temperature properties of crumb rubber modified binders,” Construction and Building Materials, vol. 23, no. 1, pp. 304–310, 2009.

[6]. HU Bahia, R.Davies (1994). Effect of crumb rubber modifiers (CRM) on performance related properties of asphalt binders. J. Assoc. Asphalt Paving Technol., 63: 414-449.

[7]. Airey.G.D, Rahman.M.M. And Collop.A.C, “Absorption of bitumen into crumb rubber using the basket drainage method,” International Journal of Pavement Engineering, vol. 4, no. 2, pp. 105–119, 2003.

[8]. MA.Abdelrahman, SH Carpenter, 1999. “Mechanism of interaction of asphalt cement with crumb rubber modifier”, Transport Res Rec: J Transport Res Board.1661 (1):106–13.

[9]. Patrick, JE and Logan TC, (1996) Use of tyre rubber in bituminous pavements in New Zealand, Transit New Zealand research report 62- 65pp.

[10]. Niraj D. Baraiya: Use of Waste Rubber Tyres in Construction of Bituminous Road – An Overview: Volume 2, Issue 7, July 2013.