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IMPROVEMENT OF BITUMEN PERFORMANCE USING CRUMB RUBBER AND RECYCLED GLASS POWDER

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Abstract - This study investigates that the use of crumb rubber and recycled glass powder in the flexible pavement since the crumb rubber and recycled glass powder are seen everywhere for small functions to large ones. It remains unseen after the day it serves its purpose. It is decided to use this commonly wasted crumb rubber and recycled glass powder in our project provided to improve the strength of the pavement. The properties such as tenacity, elongation and melting point has been tested both the crumb rubber. Some replacement percentages have been carried out based on trial and error method. Six different mixes were proposed and the properties of those bituminous mixes were compared with conventional bituminous mixes. The various bitumen tests are to be carried out to define the properties of the proposed Bitumen. Marshall stability and flow value test also be carried out. From all these tests it is found out that the proposed bituminous mix can be used in hotter regions and here in the cost can be reduced based on the option exercised by the designer for reducing the thickness of an individual layer and it contributes to recirculation of plastic wastes as well as to protection of the environment.

Keywords- Crumb Rubber, Recycle, Pavement, Bitumnous, Glass Powder.

1. INTRODUCTION

One of the major factors which determine the progress of a nation is the development in the transportation facility. India has the third largest road network in the world with the length of 4.32 million kilometers as per the census of 2011. The quantitative density of the road network in India is 0.66 km of road per square kilometers of land. The pavements can be broadly classified into two types i.e., Flexible pavement and rigid pavement. Flexible pavements are those which reflect the deformation of subgrade and the subsequent layers to the surface. The rigid characteristic of the pavement are associated with rigidity or flexural strength or slab action so the load is distributed over a wide area of subgrade soil. Rigid pavement is laid in slabs with reinforcement. The mostly adopted in India is flexible pavement.

Even in this modern scenario, the conventional method of laying flexible pavement is adopted. Coarse aggregates of various sizes, fine aggregate, bitumen are the traditionally used materials. The requirement for the natural material for the purpose of road construction increases as the day progresses. The natural materials are also in the verge of extinction. So it would be better if some alternate materials were chosen and used for the required purpose. With the increasing production of cars in recentdecades, a huge amount of scrap tires is being generatedworldwide. The scrap tires cannot be processedeasily and burning of those plastic materials produces more amount of emission of toxic gases and it is also a non-biodegradable waste.thereforethey are considered as one of the mostdangerous substances to the environment.

In this project, it is planned to use the rubber as partial replacement material in the flexible bituminous layer. The rubber tend to have Low Density Polyethylene in a considerable amount in their composition. Along with the rubber ,glass are added to improve the strength of the bituminous layer. It is proposed to obtain an optimum mix and replacement percentage of the rubber and glass for the bitumen. The mixes are to be subjected to different temperatures and the properties to be compared with the conventional bituminous mix. This project mainly concentrates on the minimization of the waste and also usage of the rubber and glass material in a useful manner.

2. Test on Bitumin

2.1 Specific Gravity of Bitumen

Specific gravity of a material is defined as the ratio of the density of a substance to the density of a standard, usually water for a liquid or solid, and air for a gas.

Fig. 1: Specific gravity test apparatus

2.2 Penetration Test

Penetration is a measurement of hardness or consistency of bituminous material. It is the vertical distance travelled or penetrated by the point of a standard needle in to the bituminous material under specific condition of load, time and temperature. This distance is measured in one tenth of a millimeter. This test is used for evaluating consistency of bituminous materials. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials and the fact that they contain relatively large amount of free carbon.

Fig. 2: Penetration testing apparatus

2.3 Softening point test

The softening point of bitumen or tar is the temperature at which the substance attains a particular degree of softening. As per IS:334-1982, it is the temperature (in ^{0} C) at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm, when heated under water of glycerin at specified conditions of test.

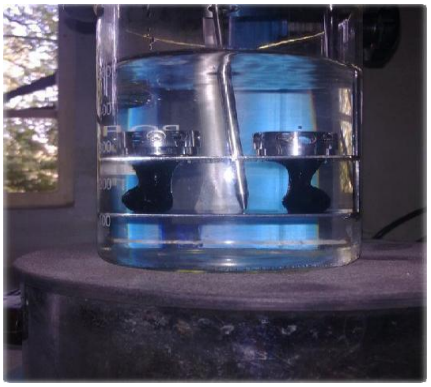

Fig. 3: Softening point test apparatus

2.4 Viscosity test

Viscosity is defined as the increase of fluidity. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate in to void and also coat the aggregates and hence affects the strength characteristics of the resulting paving mixes. There is an optimum value of fluidity or viscosity for mixing and compacting for each aggregate gradation of the mix and bitumen grade. At high fluidity or low viscosity, the bitumen binder simply "Lubricates" the aggregate particles instead of providing a uniform film thickness for binding action. Similarly, low fluidity or high viscosity does not enable the bitumen to coat the entire surface of aggregates.

Fig. 4: Viscometer

RESULTS AND DISCUSSIONS

3. TEST RESULTS OF CONVENTIONAL BITUMEN

3.1 Specific Gravity of Bitumen

Weight of pycnometer (W1) = 0.467 kg
Weight of Pycnometer +Bitumen(W2) = 0.671 kg

Weight of Pycnometer Bitumen + Remaining space completely filled with
Desired kerosene without any air bubbles. (W3)
= 1.231 kg
Weight of pycnometer + full of kerosene (W4)
= 1.247 kg
Weight of Bitumen = $W_2 - W_1$
Weight of kerosene filling the pycnometer
= $W_4 - W_1$
Weight of kerosene in pycnometer over And above bitumen
= $W_3 - W_2$
Weight of kerosene having the same
= $(W_4 - W_1) - (W_3 - W_2)$
Specific gravity of the bitumen = 1.08

3.2 Penetration test for bitumen

The penetration test is carried out on the collected conventional bitumen sample. The results are as follows

Table 1: Penetration value of conventional bitumen

S. No.	Sample No.	Initial Penetrometer Reading	Final Penetrometer Reading
1.	S1	0	87
2.	S2	0	84
3.	S3	0	88
4.	S4	0	85
Average Penetration Value			86

The IS classification of bitumen based on penetration values are as follows

Table 2: IS Penetration values of bitumen

Bitumen Grade	Penetration Value
A25	20 to 30
A35& S35	30 to 40
A45& S45	40 to 50
A65& S65	60 to 70
A90& S90	80 to 100
A200& S200	175 to 225

3.3 Softening point of bitumen

The softening point test is carried out on the collected conventional bitumen sample. The results are as follows:

Table 3: Softening point of conventional bitumen

S. No.	Sample No.	Softening Point(°C)
1.	S1	37.6
2.	S2	37.3
3.	S3	38.1
4.	S4	37.4
Average Softening point of bitumen		**37.6**

The Indian standard classification of bitumen based on their softening point values areas follows:

Table 4: IS Softening point of conventional bitumen

Bitumen Grade	Penetration Value
A25 & A35	55 to 70
S35	50 to 65
A45 A65 & S45	45 to 60
S65	40 to 55
A90& S90	35 to 50
A200& S200	30 to 40

3.4 Viscosity test on bitumen

The viscosity test is carried out on the collected conventional bitumen sample. The results are as follows:

Table 5: Viscosity of conventional bitumen

Sample No.	Orifice Size (mm)	Test Temperature (C)	Viscosity (sec)
1.	10	40	62
2.	10	40	67
3.	10	40	69
4.	10	40	66
Average viscosity value of bitumen			66

The Indian standard classification of bitumen based on their softening point values areas follows:

Table 6: IS Viscosity range of bitumen

Bitumen Grade	RT-1	RT-2	RT-3	RT-4	RT-5
Orifice size (mm)	4	4	10	10	10
Test temperature	25	25	25	40	40
Viscosity range	25-75	50-150	10-20	14-45	60-140

From the above three test, it is evident that the bitumen belongs to A90 and S90 grade bitumen. Generally the bitumen can be said as 80/100 bitumen, which means the penetration value is between 80 and 100.

3.5 TRIAL MIXES FOR PROPOSED BITUMEN

Trial and error methods were followed to find out the optimum mix for proposed bitumen. 6 mixes were tried based upon the literature review. The proportions of the crumb rubber and recycled glass fibres added to the bitumen (% by total weight) are as follows:

Table 7: Mix Details

MIX	Crumb rubber (% by total weight)	Recycled glass Powder (% by total weight)
1	5	5
2	5	6
3	5	7
4	6	5
5	6	6
6	6	7

3.6 RESULTS OF PROPOSED BITUMEN

MIX I

Table 8: Properties of bituminous mix 1

Parameters	Values
Specific Gravity	1.130
Penetration Value	34
Softening point (°C)	40.5
Viscosity(sec)	74

MIX II

Table 9: Properties of bituminous mix 2

Parameters	Values
Specific Gravity	1.104
Penetration Value	29
Softening point (°C)	42
Viscosity(sec)	79

MIX III

Table 10: Properties of bituminous mix 3

Parameters	Values
Specific Gravity	1.096
Penetration Value	27
Softening point (°C)	42.6
Viscosity(sec)	85

MIX IV

Table 11: Properties of bituminous mix 4

Parameters	Values
Specific Gravity	1.092
Penetration Value	24
Softening point (°C)	45.5
Viscosity(sec)	97

MIX V

Table 12: Properties of bituminous mix

Parameters	Values
Specific Gravity	1.085
Penetration Value	20
Softening point (°C)	47.5
Viscosity(sec)	112

MIX VI

Table 13: Properties of bituminous mix 6

Parameters	Values
Specific Gravity	1.22
Penetration Value	44
Softening point (°C)	37.5
Viscosity(sec)	74

4. GRAPHICAL REPRESENTATION

4.1 VARIATION OF SPECIFIC GRAVITY

As per Indian standards, the specific gravity of bitumen should be between 0.8 and 1.2. The Fig. 5 shows the mixes I to V seem to satisfy standards, while the specific gravity of Mix VI goes beyond the standard value. Mix V tends to have a specific gravity nearly equal the value of conventional bitumen.

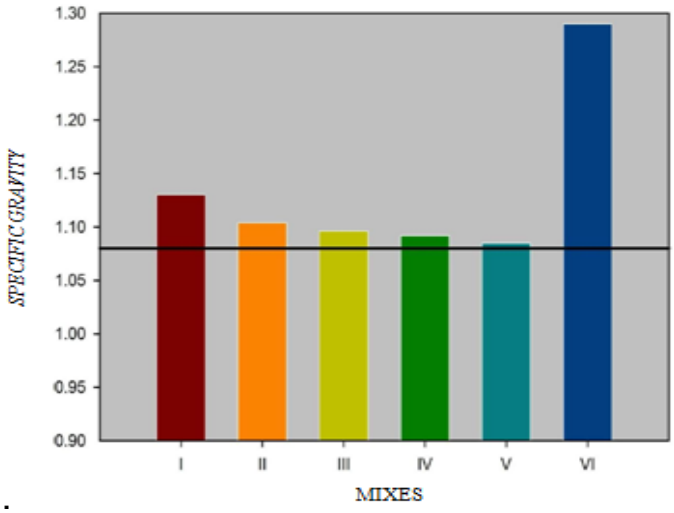

Fig. 5: Variation of specific gravity

4.2 VARIATION OF PENETRATION VALUE

All the mixes of proposed bitumen show good penetration values and it is evident from the Fig. 6. The Mix V has the least and better penetration value than the other bituminous mixes. There is also a great change in the value for Mix V and VI.

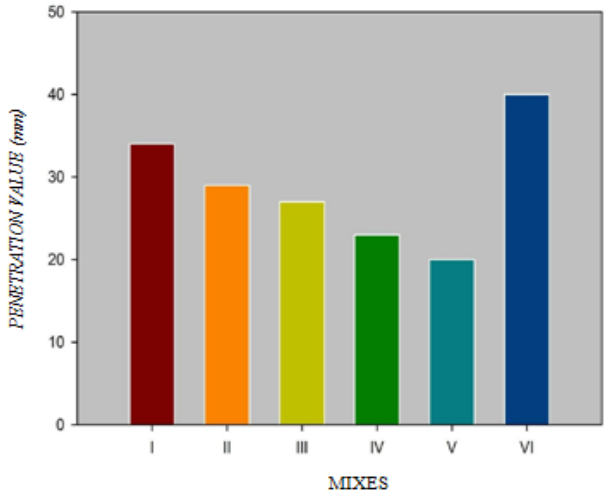

Fig. 6: Variation of penetration values

4.3 VARIATION OF SOFTENING POINT

The Fig. 7 shows the variation of the softening point of the bituminous mixes. All the proposed bituminous mixes have a good softening point except the Mix VI, which denotes the more addition of the foreign materials resulted in reduction of softening point. Mix V shows better softening point.

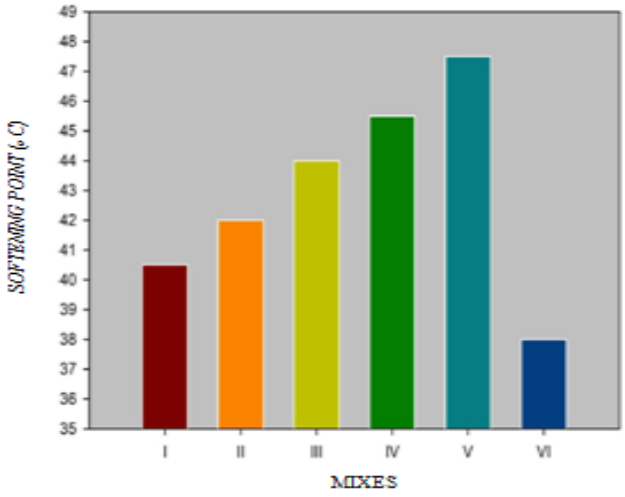

Fig. 7: Variation of softening point

4.4 VARIATION OF VISCOSITY

This Fig. 8 shows the variation of viscosity values for the proposed bituminous mixes. Viscosity is defined as the resistance offered against the flow of a liquid. The Mix V shows a greater viscosity value than the other mixes.

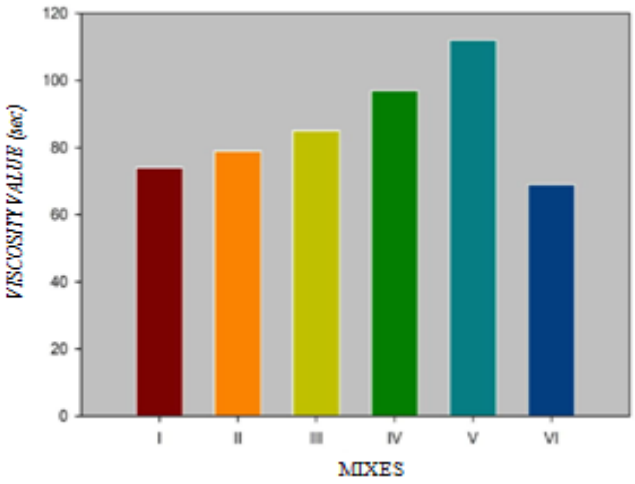

Fig. 8: Variation of viscosity

5. TEST ON BITUMINOUS PAVEMENT

MARSHALL STABILITY TEST:

It is the standard test used in designing and evaluating the bituminous paving mixes. In this method, the resistance to plastic deformation of cylindrical specimen of bituminous mixture is measured when the same is loaded at the periphery at 5 cm per minute.

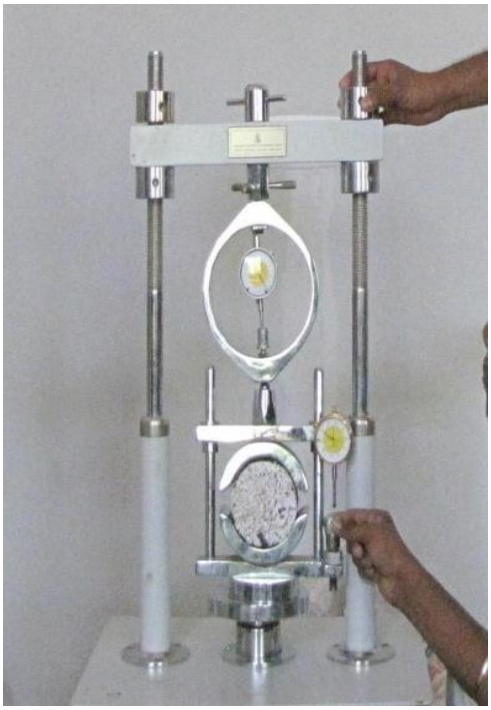

Fig. 9: Marshall stability setup

There are two major features of Marshall Method of designing mixes namely (i) density-voids analysis and (ii) stability flow tests.

5.1 Marshall Stability for Conventional Mix:

Table 14: Marshall stability of conventional bituminous layer

Bitumen Content (%)	Sample Number	Weight of the sample (g)	Stability value (kg)	Flow value (mm)	Mean Stability value (kg)	Mean flow value (mm)
5	1	1176	418	8.75	421.0	8.83
	2	1182	429	9.25		
	3	1179	416	8.5		
5.5	1	1185	432	10.5	439.7	10.83
	2	1179	440	11.25		
	3	1184	447	10.75		
6	1	1180	460	12.5	461.7	12.33
	2	1175	458	12.75		
	3	1183	467	11.75		
6.5	1	1173	434	14.0	432.3	13.75
	2	1181	428	13.5		
	3	1179	435	13.75		

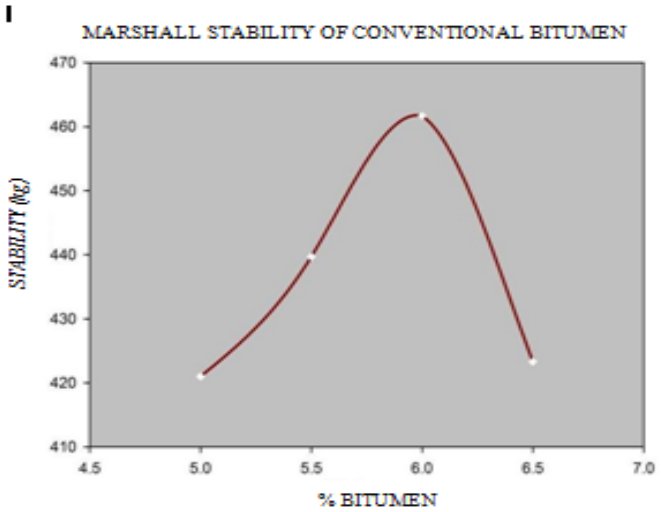

Fig. 9: variation of marshall stability for conventional bitumen mixes

The above Fig. 6.6 shows the Marshall Stability value for four types of bitumen addition percentages. A higher value of Marshall stability has been obtained for the bitumen mix of 6 % by total weight, while the mean flow values increases as the addition of bitumen by weight increases.

5.2 Marshall Stability for Proposed Bituminous Mix:

Table 15: Marshall Stability of Proposed Bituminous layer

Bitumen Content (%)	Sample Number	Weight of the sample (g)	Stability value (kg)	Flow value (mm)	Mean Stability value (kg)	Mean flow value (mm)
5.5	1	1178	622	13.75	611.0	8.83
	2	1187	598	13.55		
	3	1172	613	13.25		
6	1	1189	632	14.50	637.6	10.83
	2	1182	637	14.25		
	3	1189	644	14.75		
6.5	1	1185	692	15.50	687.6	12.33
	2	1184	687	15.75		
	3	1188	684	15.85		
7	1	1178	629	16.00	631.3	13.75
	2	1183	631	16.50		
	3	1177	634	16.75		

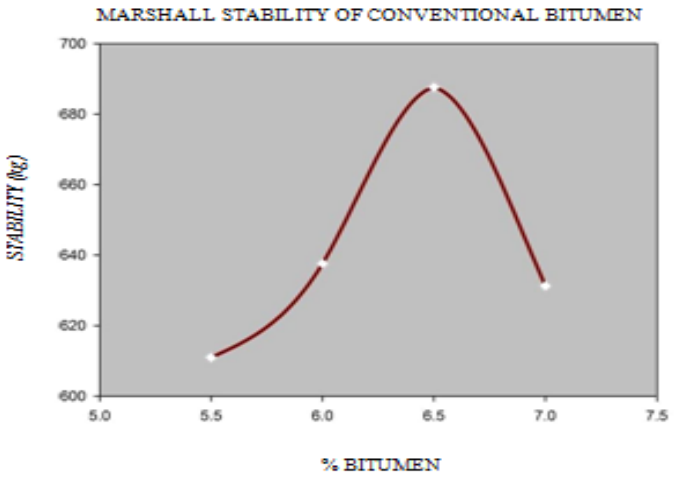

Fig. 10: variation of marshall stability for proposed bituminous mixes

From the above Fig..6.7 it is evident that there is a drastic change in the strength of bitumen mix for 6.5% of addition of bitumen. While comparing the Fig. 6.6 and Fig. 6.7 it may be concluded that there is an increase in the strength of the proposed bitumen mix compared to the conventional mix.

6. CONCLUSION

Better results are obtained for an optimum replacement of 6% of crumb rubber by total weight and 6% of recycled glass fibre by total weight. Crumb rubber and recycled glass fibre has modified many properties of the bitumen and those parameters are as follows:

(i) Specific gravity of the proposed bituminous mix equals the specific gravity of the normal conventional bitumen.

(ii) Penetration value has been reduced to 20 which means, the bitumen has been upgraded to A20 & S20 grade from A90 & S90 grade. It could resist greater impact and could offer more resistance against wearing.

(iii) From the softening point value it is evident that the bitumen has been upgraded from A90 & S90 grade to A35 & S35 grade. The softening point value has been drastically increased and this type of bitumen can be preferred in hotter regions where the temperature would be more than 45^{o}C.

(iv) The value of viscosity has also been increased when compared with the conventional bitumen.

(v) In case of Marshall Stability test, the values of the proposed bitumen for 6% of modified bitumen mixture increased 40% of strength when compared to the normal conventional mix.

Thus the modified bitumen binders provide better resistance due to their high stability and high Marshall Quotient and it contributes to recirculation of waste rubber materials. It also helps to maintain an eco-friendly environment.

REFERENCES

[1.] A.I.AI Hadidy, Tan Yi-qui, (2009) “Effects of polyethylene on life of flexible pavements” 1456-1464, Construction and Building materials 23.

[2.] Casey, Donnchadh; McNally, Ciaran; Eibney; Amanda; Elchrist M.D, (2008) „Development of a recycled polymer modified binder for use in stone matrix

asphalt" 1167 – 1174, Resources conservation & Recycling 52 (10).

[3.] Mohammad T.Acowad, LinaShberb, (2007)" Use of polyethylene in hot Asphalt" 4(6): 390–396 .

[4.] Material & Desing (2009) "Mechanistic approach for polypropylene – modified flexible pavements" 1133 – 1140.

[5.] O.Gonzaliz, M.E.Munoz, A.Santamaria, (2006)

[6.] "Bitumen/polyethylene blendo : using m-LLDPEs to improve stability & viscoelastic properties", 45: 603 – 610.

[7.] SerkanTapkin ,AbdulkadirCevik, Un Usar, (2012) " Prediction of Marshall test results for polypropylene modified dense bituminous mixtures using neutral networks", 4660 – 4670 Expect systems with Applications 37.

[8.] Sangita, TahrezAlam Khan, Sabina, D.K.Sharma, (2011) 3841

[9.] 3848 "Effect of waste polymer modified on the properties of bituminous concrete mixes", Construction and Builing materials 25.

[10.] Sayyed Mahdi Abtahi, Mohammed Sheikhzadeh, Sayyed Mahdizi, (2010) 871 – 877 " Fibre reinforced asphalt concrete – A review", CbM 24.

[11.] SerkanTapkin," (2008) 1065 – 1071 "The effects of polypropylene fibre on aspalt performance", Building & Environment 43.