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Experimental Study on Modified Bituminous Mix Using Waste High Density Polyethylene And Crumb Rubber

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ABSTRACT: This paper represents an effort taken to produce modified bituminous mix and coated aggregates. Aggregates were coated with 6%, 8%, 10% of high density polyethylene and 8%, 10%, 12% of crumb rubber were mixed in bitumen. Different moulds were prepared with different combinations and compared with conventional bitumen mixes by conducting marshall stability test to check its strength, flow value, stability value. Optimum percentage of crumb rubber was found to be 8%. Then crumb rubber percentage is kept constant and HDPE percentage is varied as 6%, 8%, 10%. Highest stability is achieved for all mix with 8% CRMB combination with 10% of HDPE giving more satisfied results comparing to conventional bitumen.

KEYWORDS: Bitumen, CRMB, Crumb rubber, HDPE.

I. INTRODUCTION

This paper represents an effort taken to produce modified bituminous mix and coated aggregates. Aggregates were coated with 6%, 8%, 10% of high density polyethylene and 8%, 10%, 12% of crumb rubber were mixed in bitumen. Different moulds were prepared with different combinations and compared with conventional bitumen mixes by conducting marshall; stability test to check its strength, flow value, stability value. Optimum percentage of crumb rubber was found to be 8%. Then crumb rubber percentage is kept constant and HDPE percentage is varied as 6%, 8%, 10%. Highest stability is achieved for all mix with 8% CRMB combination with 10% of HDPE giving more satisfied results comparing to conventional bitumen.

II. RELATED WORK

This section discusses the related work done on use of different types of polymers in bitumen. In the paper "Use of waste plastic in construction of bituminous road" by Mrs Vidula Swami has stated the bitumen as binder also helps to improve strength and life of road pavement but its resistance towards water is poor where as polymer modified bitumen has better resistance to temperature and water.^[1] Rokade S in his paper "Use of waste plastic and waste rubber tyre in flexible highway pavement" used HDPE and LDPE to coat the aggregates and the result indicated that the grinded

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Vol. 7, Issue 5, May 2018

HDPE polyethylene modified provides better engineering properties.^[2] In the paper “Utilisation of waste plastic as a strength modifier in surface course of flexible and rigid pavements” by Afroz sultana , SK and Ks Prasad used waste plastic as a strength modifier and found that there is increase in softening point and decrease in penetration and ductility value indicate hardness of bitumen.^[3]

III. OBJECTIVES OF PROJECT

- 1.) To investigate properties of Rubber/ Aggregate.
- 2.) Experimental assessment on strength of flexible pavement & modified bitumen pavement.
- 3.) Comparison between test results of conventional & modified bitumen pavement.
- 4.) To identify the best mechanism of adding the polyethylene (dry or wet process) in aggregate.
- 5.) Environment-There is huge problem of disposal waste tyre by using this waste tyre we protect the environment.
- 6.) Strength- By replacing rubber in bitumen it increasing its strength which gives better strength as compare to normal road.
- 7.) Economy- As compare to waste rubber bitumen is costlier by replacing this waste tyre in bitumen we can reduces the cost, hence economy can be achieved.

IV. EXPERIMENTAL MATERIALS USED

A. Bitumen

The grade of bitumen used for this research work VG30. It was sourced from hot mix plant from Yerawada in Pune.

B. Crumb Rubber

For this research work crumb rubber of 1 to 2 mm size is obtained by shredding waste tyres of automobile from Prabhat Tyres, Kothrud.

C. Course Aggregate

The coarse aggregate used for this research work was 6mm, 10mm, 12mm size. It was sourced from stone crusher from Hot Mix Plant Yerawada in Pune.

D. Fine Aggregate

The fine aggregates used for this work was from Hot Mix Plant Yerwada in Pune.

E. High Density Polyethylene

High density polyethylene used in this project is obtained from waste Tupperware bottles, HDPE sheets etc.

V. DENSE BITUMINIOUS MIX PROPORTIONS

The aggregate and bitumen required for the study was provided by Pune Municipal Corporation Hot Mix plant, Yerawada. The following mix formula was used for DBM mix preparation.

The DBM mix was designed for Marshall Stability test using VG30 grade bitumen, 20mm aggregate, 10mm aggregate, 6mm aggregate, crushed sand and filler.

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Vol. 7, Issue 5, May 2018

Bitumen VG-30 grade	4.3% by weight	52 gm
	4.5% by weight	54 gm
	4.7% by weight	57 gm
20 mm aggregate	42% by weight	504 gm
10 mm aggregate	0.8% by weight	96 gm
06 mm aggregate	0.8% by weight	96 gm
Crush Sand	40% by weight	480 gm
Filler (Stone Dust)	2.0% by weight	24 gm

Table 1: Dense Bitumen Macadam mix Formula

Table 1 shows dense bitumen macadam mix proportions which are used for preparation of specimens. 20mm aggregate, 10mm aggregate, 06mm aggregate, crush sand, filler materials are used in mix proportions.

VI. METHODOLOGY

1. Selection of Materials.
2. Basic Tests performed on bitumen and aggregate.
3. Prepare DBM mix design for VG30 grade of bitumen.
4. Prepare conventional bitumen sample.
5. Testing of conventional concrete specimen.
6. Result of conventional bitumen.
7. Preparation of modified bitumen using 8%,10%,12% CRMB & 6%,8%,&10% of HDPE
8. These modified bituminous mix moulds are tested by conducting Marshall stability
9. Result for modified bituminous mix.
10. Comparison between conventional bitumen and modified bitumen

VII. EXPERIMENTAL INVESTIGATION

- A. Penetration Test: - Penetration Test apparatus was used to determine penetration value of bitumen. Penetration value is distance penetrated by standard needle in bitumen in specified time under specified load and temperature. Penetration value is measured in tenth of millimetre.
- B. Softening Test:- This test is done to determine the softening point of asphaltic bitumen and fluxed native asphalt, road tar, coal tar pitch and blown type bitumen as per IS: 1205 – 1978. The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test.
- C. Marshall Stability test: - The Marshall Stability and flow test gives the performance prediction measure for the Marshall Mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute.
- D. Preparation of sample: - 1200 gm of aggregate with design proportion is taken and heated in oven to the mixing temperature. Then bitumen is added at various percentages. The materials are mixed in heated pan with heated

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 5, May 2018

mixing tools. Then mixture is placed in heated Marshall Mould with a collar and base. A filter paper is placed under the sample and on top of the sample. Then mould is placed in Marshall Compactor.



Fig 1: Mixing of Coated Aggregate and CRMB

For obtaining required temperature aggregates were heated in pan. And heated modified bitumen with crumb rubber was mixed after obtaining desired temperature. Then mixture is placed in heated Marshall Mould with collar and base.

E. Compaction of samples-

After preparing batch of the DBM mix sample, it requires to be compacted before testing. Compaction is done with Automatic Marshall Compactor machine present at the lab at Pune Municipal Corporation, Hot Mix Plant, Yerawada. Sample prepared in the mould were compacted in the compaction machine for 75 blows each side. Filter papers were added to the both sides of the mould. The moulds were kept for 24 hours before testing. After compaction of sample, After 24 hour's moulds are kept in temperature controlled water bath at 60°C for 30 minutes. These moulds are loaded in Marshall Stability test apparatus.

Marshall Stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain (5 cm per minute). While the stability test is in progress dial gauge is used to measure the vertical deformation of the specimen. The deformation at the failure point expressed in units of 0.25 mm is called the Marshall Flow value of the specimen.

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Vol. 7, Issue 5, May 2018



Fig 2 Automatic Marshall Compactor

Automatic Marshall Compactor is used for compaction of moulds. Sample prepared in the mould were compacted in the compaction machine for 75 blows on each side.



Fig 3 Marshall Stability test setup

Fig 3 shows Marshall Stability test setup. The specimens are removed from water bath and are completely assembly is placed in testing machine. Then load is applied at 50 mm per minute. Maximum load reading is observed in Newton and the flow value is observed in flow meter.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 5, May 2018

VIII. RESULT

Sr no	Test	Result on Conventional Bitumen	Result on 10% CRMB	References
1	Softening Point (°C)	49.40	59.7	IS:1205-1978
2	Penetration at 25°C 100 gm	53	41.72	IS:1205-1978
3	Specific Gravity	1.01	-	IS:1205-1978
4	Flash Point (°C)	262	-	IS:1205-1978
5	Ductility (Cm)	100	-	IS:1205-1978

Table 2 Test Results On Conventional Bitumen and CRMB-

Table 2 clearly shows that softening point is increased from 49.40 °C to 59.7 °C and penetration value is decreased from 53 °C to 41.76 °C.

Bitumen content	Division	Stability (Kg)	Average Value	Flow (mm)
4.3	270	1179	1055.6	4.5
	245	1070		4
	210	917.49		3.5
4.5	285	1245	1077.63	4
	220	961.18		4.5
	235	1026.72		4
4.7	195	851.96	830.02	4.5
	230	1004.57		5
	145	633.504		5

Table 3 Marshall Stability test result on conventional mixes

Table 3 Shows Marshal stability result on conventional bituminous mix-

- 1) Maximum stability (kg) = 1077.63kg, at binder content = 4.5%
- 2) Minimum flow value (mm) = 4mm, at binder content = 4.3%

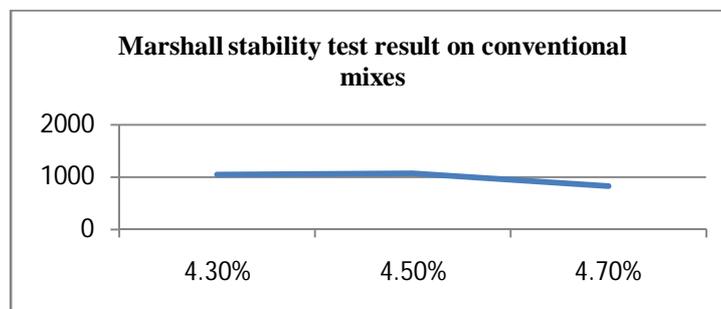


Fig 4 Marshall Stability test results on conventional mixes

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Vol. 7, Issue 5, May 2018

Crump Rubber %	Division	Stability(Kg)	Average	Flow(mm)
8%	275	1201.47	1043.22	3.5
	240	1048.56		4
	270	1179.63		4
10%	280	1223.3	1194.13	3.5
	265	1157.7		4.5
	275	1201.4		4
12%	265	1157.7	1048	4.5
	250	1092.2		4
	230	1004.8		7

Table 4: Marshall Stability Test Results on CRMB Mixes

Table 4 Shows crumb rubber percentage is varied as 8%, 10% and 12%. at binder content of 4.5%. Maximum results are obtained at 10% crumb rubber modified bituminous mix and flow values are also in specified limit

CRMB+HDPE	Division	Stability (kg)	Average (kg)	Flow (mm)
10%CRMB+ 6%HDPE Coated Aggregate	260	1135.94	1128.66	3
	245	1070.40		3.5
	270	1179.63		4
10%CRMB+ 8%HDPE Coated Aggregate	280	1223.32	1209.76	4.5
	265	1157.785		4
	285	1248.16		3.5
10%CRMB+ 10%HDPE Coated Aggregate	270	1179.63	1172.35	4
	260	1135.94		3.5
	275	1201.47		4

Table 5: Test results on CRMB & High Density Polyethylene

From above table Marshal Stability results are on Crumb Rubber + HDPE Coated Aggregate (Optimum binder content is 4.5%)

- 1) Maximum stability (kg) = 1209.76kg, at 8% HDPE and 10% CRMB.
- 2) Minimum flow value (mm) = 3mm, at 6%HDPE and 10% CRMB

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Vol. 7, Issue 5, May 2018

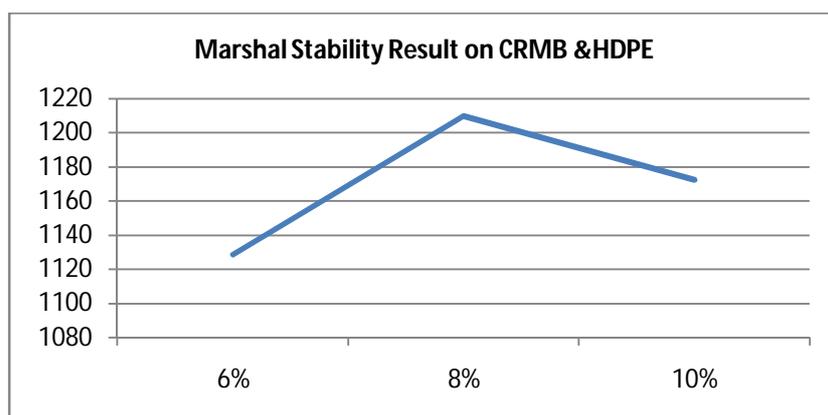


Fig 5- Marshall Stability Test Result on CRMB and HDPE coated aggregate

Summary of Results-

1. Marshal stability result on conventional bituminous mix-
 - 1) Maximum stability (kg) = 1077.63kg, at binder content = 4.5%
 - 2) Minimum flow value (mm) = 4mm, at binder content = 4.3%
2. Marshal stability results on Crumb Rubber + HDPE Coated Aggregate (Optimum binder content is 4.5%)
 - 1) Maximum stability (kg) = 1209.76kg, at 8% HDPE and 10% CRMB.
 - 2) Minimum flow value (mm) = 3mm, at 6% HDPE and 10% CRMB
3. Marshal stability results on CRMB mix –
 - 1) Maximum stability (kg) = 1194.13kg, at binder content 4.5% and crumb rubber 10% of binder
 - 2) Minimum flow value (mm) = 3mm, at 4.5% binder content and crumb rubber 10% of binder

VIII. CONCLUSION

Penetration values and softening points of plain bitumen can be improved by modifying it with addition of crump rubber. Optimum binder content for conventional bitumen was found to be 4.5%. Optimum value of crumb rubber in CRMB was found to be 10%. Dry Process (polymer coating of aggregates) is more useful as compared to Wet Process (adding polymer in the binder) for manufacturing modified mixtures, as it can accommodate higher amount of waste plastic as modifier and results more stable mixtures. In addition with 10% crumb rubber optimum content of HDPE was found to be 8%. Using waste rubber and plastic reduces threat to environment and also improve the road quality.

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Vol. 7, Issue 5, May 2018

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