International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

CONSTRUCTION OF BITUMINOUS MACADAM USING WASTE RECYCLED EVA

Mehdi Karimi Cheshmehgol[1] *, Dr. Malik Shoeb Ahmad[2]

[1]*Research Scholar, Department of Civil Engineering, AMU Aligarh, (India)*

[2]*Professor, Department of Civil Engineering, AMU Aligarh, (India)*

ABSTRACT

This research paper describes the possibility and determining the optimum percentage of recycled waste of Ethaline Venal Acetate (EVA_W) in the bituminous mix. Initially waste EVA material was mixed with VG30 bitumen with different percentages and conventional tests of modified bitumen binder were carried out to infer the most significant percentages of the waste EVA in virgin VG30 Bitumen, which leads to getting the best combination of bituminous binder and finally bituminous mix. In the second stage of the work Mix Specimens for Marshall and IDT tests were prepared for Bituminous Macadam (BM) and compared with control specimens. The improvement in physical characteristics of modified bitumen have been observed. The tests at the laboratory level proved that the bituminous concrete mixes prepared using modified bitumen binder fulfilled all the specified Marshall and IDT mix design criteria for surface course of road pavement.

KEYWORDS: Bituminous Macadam (BM), EVA_W, IDT, Marshall Stability Tests, Modified bitumen

I.INTRODUCTION

Bituminous Flexible pavements are extensively used in the world for construction of rural and urban roads. Overloading of axles and increased volume of traffic, in excess of permissible limits [1] and higher tire pressure, have caused widespread problems with the performance of these pavements [2]. Plastic materials have become the corner stone of our lives, which results in generation of huge quantity of plastic waste. Using plastic will help reduce non-biodegradable waste. Moreover, under the prevailing heavy traffic, overloading and extreme environmental conditions, conventional bituminous overlay, are not meeting the durability requirement. The statistics of various performance studies indicate that useful life of bituminous surfacing has declined from average value of 6-8 years in past to about 4-6 years in recent years. The accelerated deterioration of bituminous overlay burdens the maintenance budget, which in turn affects the availability of funds for new developments. It is a global view that the quality and longevity of pavements, must, be ensured in order to reduce cost of maintenance. Unmodified bitumen binders [3] perform well in many situations on majority of the roads. However, in a given specific location/situation, performance of these bituminous binders falls below the acceptable level. The higher volume of commercial vehicles (trucks) as well as the overloading of axles, and global climate changes in recent years, causes higher stresses onto the pavement, eventually resulting into the development of pre-mature distress (fracture or deformation). To meet such growing demands and challenges, highway engineers have the option to select and use high performance bituminous binders from a wide range of modified binders, made with different types of modifiers (polymer modification), particularly in use of waste plastic materials, The use of modified bituminous binders offer a good solution for such situations and assists in (i) reducing the frequency of maintenance required at particular locations, and (ii) providing a much longer service life of pavement. Moreover, there is an immediate need to improve the properties of pavement in the present scenario since a steady increase is observed in areas like wheel loads, tire pressure, change in climatic conditions and daily wear and tear which affect the performance of bituminous mix pavement in a huge amount [4]. The amount of plastic waste materials is either mixed with municipal solid waste or dumped in an open area leading to increase in the area covered under waste land. Researchers have been finding ways of incorporating recycled materials into bituminous pavements that have brought about action throughout the world. In recent years, there has been a rapid increase in using additives in bituminous concrete mixtures to improve its properties. Plastic wastes have been used to modify bitumen and to improve the properties of bituminous mixes. This paper deals with the viability of using reclaimed polyethylene derived from Ethaline Venal Acetate (EVA_W) collected from domestic waste as an additive in flexible pavement. Plastic roads mainly use plastic carry-bags, disposable cups and other plastic bottles that are collected from garbage dumps as an important ingredient of the construction material. The durability of the roads laid out with shredded plastic waste is much more as compared with roads of ordinary mix. One of the big challenges to use of plastic wastes in bituminous pavement is the cost of plastic road construction compared to the conventional method. However, this should not deter the adoption of the technology, as the benefits are much higher than the cost. By mixing plastic with bitumen the melting point of binder would increase, which leads to increases the ability of the bitumen to withstand against high temperature at summer season.

II.LITERATURE REVIEW

Mehndiratta and Chandra [5] studied bitumen modified with CR and EVA and reported that properties, like, low temperature ductility, elastic recovery, water and temperature susceptibility, viscosity and Marshall Stability improved by adding modifiers to bitumen. Panda M and Mazumdar M [6] developed and evaluated bituminous paving binder containing reclaimed plastic wastes for modification of bitumen. It was observed that the penetration, ductility and the specific gravity of the modified binder decreases, while the softening point and viscosity are increased. The temperature susceptibility of the modified binder is also improved. Lepeet et al [7] found that mixing of polymers into bitumen has important consequences on engineering properties of bituminous binders. Zoorob and Suparma [8] reported the use of recycled plastics composed predominantly of polypropylene and low-density polyethylene in conventional bituminous concrete mixtures with increased durability and improved fatigue life. D. N. Little [9] has found that resistance to deformation of asphaltic concrete modified with plastics was improved in comparison with unmodified mixes. It was found that the recycled polyethylene bags may be useful in bituminous pavements resulting in reduced permanent deformation in the form of rutting and reduced low temperature cracking of pavement surfacing. Based on Mazumdar [10] research report; "Fatigue in bituminous pavements is the phenomenon of cracking. It consists of crack initiation and crack propagation and is caused by tensile strains generated in the pavements by not only traffic loading but also temperature variation and construction practice". The Indirect Tensile Strength (IDT) testing provides a measure of the tensile strength of the bituminous mixtures. The cracking of the mixture can be estimated through the tensile strength. As the temperature varies the fatigue properties also varies. IDT test was conducted to know the tensile strength of the BM mix as per ASTM D-6931. IDT tests were conducted on Marshall samples prepared with conventional and modified bitumen. S. Bindu and Dr. K. S. Beena [11] investigates the benefits of stabilizing the stone mastic asphalt (SMA) mixture in flexible pavement with shredded waste plastic. They observed that, 10% plastic content gives an increase in the stability, split tensile strength and compressive strength of about 64%, 18% and 75% respectively compared to the conventional SMA mixes.

III.TEST MATERIALS

In this study, the materials used are:

(i) Bitumen

(ii) Plastic waste (EVA)

(iii) Aggregates

1.1 Bitumen

The bitumen used in this study was of VG-30 grade. It was tested in the laboratory for basic conventional tests such as Penetration, Ductility, Softening Point, Specific Gravity, Viscosity and Flash Point. The results obtained from the above tests are tabulated in the Table-I.

Table-I **Properties of Bitumen**

Property	**Values**	**Test Method**
Penetration	69 (1/10th of mm)	IS: 1203-1978
Ductility	76 cm	IS: 1208-1978
Softening Point	44^{o}C	IS: 1205-1978
Specific Gravity	1.011	IS: 1202-1978
Viscosity	2.25 Poise	IS: 1206-1978
Flash Point	223^{0}C	IS: 1209-1978

1.2 Ethylene Vinyl Acetate (EVA)

Ethylene Vinyl Acetate (EVA) is used in several applications thanks to the varied properties it possesses like shoes, sandals and cables. The EVA waste plastics were collected from local dumpsites. Collected waste materials were washed with soap and water and shredded into small pieces of size 1 to 2 mm. The physical properties of recycled EVA used in this study are given in Table-II.

Table-II Properties Of Ethylene Vinyl Acetate (EVA)

Property	**Standard Values** **ASTM D4635**
Melting Temperature	65-95^0 C
Flash Point	> 340^0 C
Elongation at Break	200 - 990 %
Density	0.93 – 0.95 g/cm^3
Softening point	40^0 C

1.3 Stone Aggregates

The physical properties of stone aggregates used in this study are shown in Table-III.

Table-III Properties of Coarse Aggregates

Property	**Test**	**Results**	**MORT&H (2001) Specification**
Cleanliness	Grain Size Analysis (% Finer)	2.50	Max 5 % passing 0.075 mm sieve
Particle Shape	Flakiness and Elongation Index (%)	16.0	Max 30 %
Strength	Los Angeles Abrasion Value (%)	27.0	Max 40 %
	Aggregate Impact Value (%)	23.0	Max 30 %
Durability	Magnesium Sulphate (%)	11.0	Max 18 %
Water Absorption	Water Absorption (%)	0.53	Max 2 %
Specific Gravity	Specific Gravity	2.80	2.5-3.0

1.4 Fillers

Fillers consist of finely divided mineral matter such as rock dust, hydrated lime or cement. Filler has an important effect on the voids content and the stiffness of the bitumen-fines matrix. Five percent filler material of stone dust used in the study. The grading requirements for mineral fillers indicated in Table-IV.

Table-IV Properties of Filler

IS Sieve (mm)	Cumulative Percent Passing by Weight of Total Aggregate
0.6	100
0.3	95
0.075	90
Specific gravity	2.70

IV.EXPERIMENTAL PROGRAM

The present study deals with the preparation and testing of unmodified bitumen, bitumen mixed with plastic waste (EVA) and Bituminous Macadam (BM) mixes. In this study, the most significant tests such as penetration, ductility and viscosity tests were conducted on virgin bitumen as well as plastic waste modified bitumen. The plastic waste was mixed with bitumen in 2%, 4%, 6%, 8% and 10%. The BM mixes were prepared (as per the Marshall mix design procedure vide ASTM designation D 1559-62 T) by adding bitumen to the mix (as per the Job Mix Table-V) by weight of aggregates and the waste EVA were added in different percentages to the mix by weight of bitumen (VG-30). Mixtures were prepared with 0, 2, 4, 6, 8 and 10% by weight of bitumen. The Marshall specimens were kept in water bath at 60 ± 1ºC for 24±1 hours. These are called conditioned specimens. The specimens kept in thermostatically controlled water bath maintained at 60±1℃ for 30 to 40 minutes are called unconditioned specimens. The ratio of Marshall Stability values of conditioned specimens to that of unconditioned specimens is termed as Retained Stability. Marshall Stability tests were conducted on control (unmodified bitumen) and EVA modified bituminous mixes.

Table-V Job Mix for 50 mm BM (Grade 2)

Material Used		Quantity (%)	Specific Gravity
Aggregates	22.4 mm	31	2.68
	11.2 mm	36	2.7
	5.6 mm	24.5	2.74
Fillers	Stone dust	5	2.70
Binder	Bitumen	3.5	1.021

V.TEST RESULTS AND DISCUSSION

The results of penetration, ductility, viscosity, Marshall Stability, indirect tensile strength and stripping value tests are presented and discussed to bring out the effect of plastic waste on various properties of bitumen, bitumen modified with EVA wastes and BM mixes.

5.1Penetration Test Results of Unmodified Bitumen With Waste EVA

Table-VI shows the variation of penetration value of waste EVA modified bitumen with respect to unmodified bitumen (B). It can be observed from the result that the consistency and penetration values of unmodified bitumen decrease on increase of the EVA waste content. The results also show that the addition of modifier makes the modified bitumen became harder and more consistent than unmodified bitumen which indicating the improvement in their temperature susceptibility-resistant characteristics and improvement in the rutting resistance of the mix.

5.2Ductility Test Results of Unmodified Bitumen With Waste EVA

Table-VI shows the variation of ductility value with the various percentages of bitumen modified EVA. The observation data shows that ductility of unmodified bitumen decreases with the addition of EVA. The ductility value decreased with an increase in the percentage of the modifier but the rate of decrease was less when added beyond 8.0%. The ductility value decreased significantly at 10% EVA addition. By adding waste EVA, the purity of the bitumen decreases so that the solubility of modified bitumen decreases and makes modifying binder harder, which makes bitumen stiffer. The samples with ductility value less than 50 cm should not be used in road constructions but may be used as crack and joint filler materials.

5.3Viscosity Test Results of Unmodified Bitumen With Waste EVA

Table-VI shows the variation in viscosity with the addition of waste EVA. It has been observed from the test results that on addition of EVA, the viscosity of unmodified bitumen increases. The increase in the viscosity value is found to be significant when EVA is added up to 10% afterwards, it becomes almost constant. It has also been observed that the increase in the viscosity values after addition of waste EVA in the unmodified bitumen was above 50%, which indicates that the modified binder became neither too soft nor too viscous, as it was observed that if the viscosity of bitumen is too high, the binder may not completely coat the aggregate in the bituminous mixture on the other hand if it is too low, binder drainage is likely to occur during the storage and transportation of the mix. On the basis of the present study it can be observed that the waste EVA modified bitumen may have better workability as compared to unmodified bitumen.

Table-VI Variation of Penetration Values, Ductility Values and Viscosity Values with waste EVA Content

S. No.	Mix	Penetration Value	Ductility Value (cm)	Viscosity Value (cSt)
1.	Unmodified bitumen (B)	70.0	78.0	329
2.	B + 2 % waste EVA	61	72.0	364
3.	B + 4 % waste EVA	59.5	67.5	387
4.	B + 6 % waste EVA	58	68	408
5.	B + 8 % waste EVA	56	62.0	435
6.	B + 10 % waste EVA	54	57.5	478

5.4Stripping Value Test

The test was carried out as per IS: 6241 [15] equivalent to ASTM D-3625 [16]. Retain on 12.5-mm IS sieve 200 g of aggregates passing 20 mm IS sieve. Dry, clean and mix with 5 percent binder by weight of aggregates, binder being heated previously to 160°C. The aggregates were also heated to a temperature of 150°C, and then it was mixed with bitumen. After complete coating the mixture is transferred to a 500-ml beaker and allowed to cool at the room temperature for about two hours. Distilled water is then added to immerse the coated aggregates. The beaker is covered and kept in a water-bath maintained at 40°C, taking care that the level of water in the water-bath comes up to at least half the height of the beaker. After the expiry of 24 hours the beaker is taken out, cooled at room temperature and the extent of stripping is estimated visually while specimen is still under water. The results of stripping tests for different time are shown in Table-XIII. It has been observed from the stripping test results that there is significant improvement in the stripping values of unmodified bitumen when it was mixed with plastic waste. The stripping value of unmodified bitumen after 48 hours has been reduced from 8% to 3% when it was mixed with 6% waste EVA and it is further reducing to 0% at 8 and 10% EVA respectively at 48 hours. This shows that the modified bitumen has better resistance towards water.

Table-VI Stripping Value of Mixes

Time (Hours)	Permissible Value MORT&H (2001)				
	Bitumen (B)	B + 6% EVA	B + 8% EVA	B + 10% EVA	Stripping Value (Average of percentage of area on aggregates surface stripped off from
1.0	0.0	0.0	0.0	0.0	

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

3.0	3.0	2.0	0.0	0.0	bitumen) should not be more than 5%
24.0	5.0	3.0	0.0	0.0	
48.0	8.0	3.0	0.0	0.0	

5.5Optimization of Unmodified Bitumen In The BM Mix

The Marshall Stability tests were conducted on the mixes prepared with unmodified bitumen which was mixed with aggregates in percentages 3.0, 3.5, 4.0, 4.5 and 5.0%. The results of the stability tests are shown in Table-VII. On the basis of stability, flow, bulk density, air voids in the mix and voids in mineral aggregates values the optimum binder content was determined as 3.5%, which is shown in Table-VII. It has been observed from the test result that the mix possessed fair to good strength, however, the bulk density of the mix was on the lower side.

Table-VII Results of BM Mix Using VG-30 Grade Unmodified Bitumen

S. No.	Bitumen Content	Marshall Stability Value	Flow Value	Bulk Density of the mix	Air Voids	VMA	VFB
		S	F	G_m	V_V		
	%	kN	mm	gm/cc	%	%	%
1.	3.0	10.00	4.09	2.14	6.61	12.5	66.5
2.	3.5	10.15	4.11	2.16	5.32	14.2	68.3
3.	4.0	10.01	4.21	2.18	4.86	13.4	66.9
4.	4.5	9.71	4.34	2.16	4.69	12.7	65.4
5.	5.0	9.28	4.35	2.15	4.27	12.0	62.1

Table-VIII Properties Of The BM Mix At Optimum Bitumen Content (3.5%)

S. No.	Design Parameters	Values	Units
1.	Marshall Stability Value (S)	10.15	kN
2.	Marshall Flow Value (F)	4.11	mm
3.	Bulk Density of the mix (G_m)	2.16	gm/cc
4.	Air Voids in the mix (Vv)	5.32	%

5.	Voids in Mineral Aggregates (VMA)	14.2	%
6.	Voids Filled with Bitumen (VFB)	68.3	%

5.6Effect of Waste EVA on Stability of BM Mixes

The plastic waste was mixed with bitumen in 2, 4, 6, 8 and 10% and the Marshall stability test was conducted on the specimens prepared with each percentage. The avarage values of all vital parameters were taken out of the three replicate tests specimens of most significant percentages (6, 8 and 10%) of plastic waste which are shown in Table-IX and Figs. II to VII.The variation of stabilty value of the mix comprises of conventional and modified bitumen shown in Table-IX and Fig. II. It has been observed from Fig. I that the stability values of mixes modified with plastic waste have been increased significantly upto the tune of 42.3% at 8% waste as comapred to mix prepared with unmodified bitumen. This shows the enhancement in strength of the mix due to addition of plastic waste which siginifies that the inclusion of plastic waste increases the density of the mix.

5.7Effect of waste EVA on Flow Value of BM Mixes

The variation of flow value of the mix is shown in Fig. II and Table-IX.It is evident from the test results that flow value of mix was decreasing with increase in the waste content in the mix from 6 to 10%. However, the maximum decrement in flow value is observed at 10% waste content which is about 27.5%.

5.8Effect of waste EVA on Bulk Density of BM Mixes

It is evident from Fig. III and Table-IX that the bulk density of the mix was increasing with increase in the plastic waste content. The most significant percenatge of waste is observed as 8% at which the density is maximium (2.79g/cc). Which about 20% more than the density of the mix prepared with unmodified bitumen.

5.9Effect of waste Air Voids EVA on (Vv) of BM Mixes

Fig. IV and Table-IX shows the variation the Air Voids (Vv) with waste content. It has been observed that the Vv values were significantly changing from 5.32 to 3.28% from 0 to 10% waste content. However, the decrease in Vv values were observed as about 38% at 10% waste content. The decrement in the Vv values show that the stability of the mixes were improving on addition of plastic waste.

5.10Effect of waste EVA on Voids in Mineral Aggregates (VMA) of BM Mixes

The variation of VMA of the mixes are shown in Fig. V and Table-IX. It is evident from the test result that VMA value of mix was increasing with increase in the waste content in the mix from 6 to 8%. However, the maximum increment in the VMA value is observed at 8% waste content which is 32.1%.

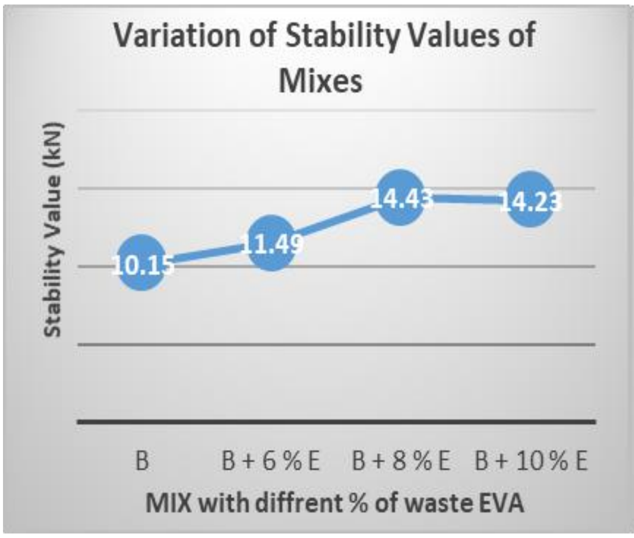
5.11Effect of waste EVA on Voids in Filled with Bitumen (VFB) of BM Mixes

Fig. VI and Table-IXshows the variation in the VFB values with waste content. It has been observed that the variation in the VFB values were most significantly observed at 8 and 10% waste content which are about 12.6 and 3.5% respectively.

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Table-IX Variation of Stability Values, Flow Values, Bulk Density, Air Voids, VMA And VFB With Waste EVA Content

S. No.	Mix	Stability Value (kN)	Flow Value (mm)	Bulk Density (g/cc)	Air Voids (%)	VMA (%)	VFB (%)
1.	Unmodified bitumen (B)	10.15	4.11	2.16	5.32	14.2	68.3
2.	B + 6 % EVA_W	11.49	3.68	2.40	4.64	16.13	74.3
3.	B + 8 % EVA_W	14.43	3.51	2.59	2.98	18.75	76.9
4.	B + 10 % EVA_W	14.23	2.98	2.52	3.28	18.64	70.6



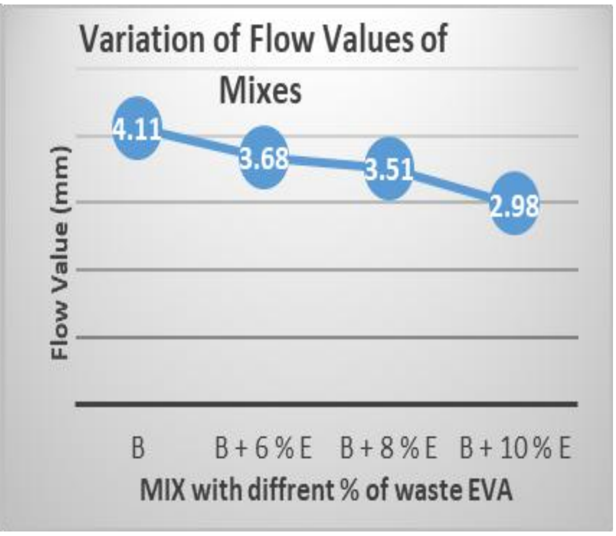
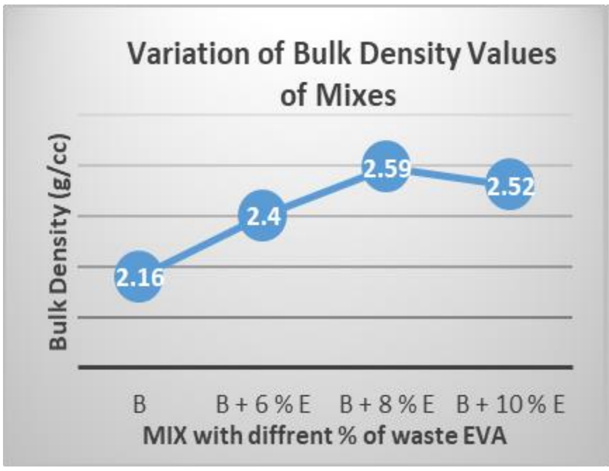


Fig. I variation of stability values of mixes **fig. II variation of flow values of mixes**

IJARSE
ISSN: 2319-8354



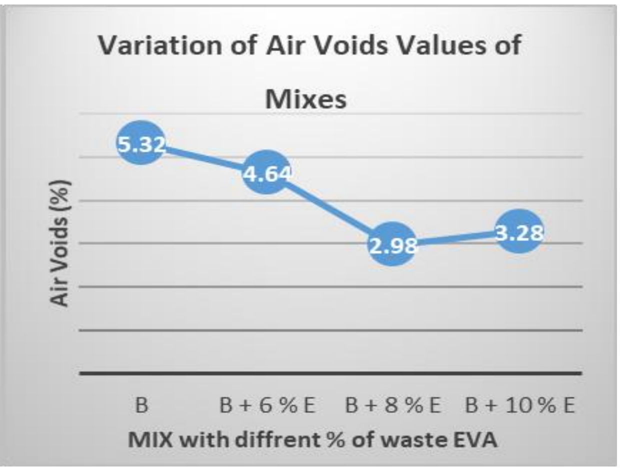
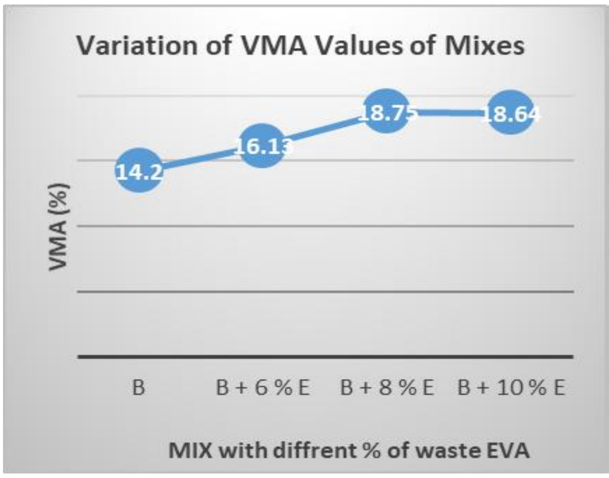


Fig. III Variation of Bulk Densities of Mixes **Fig. IV Variation of Air Voids of Mixes**



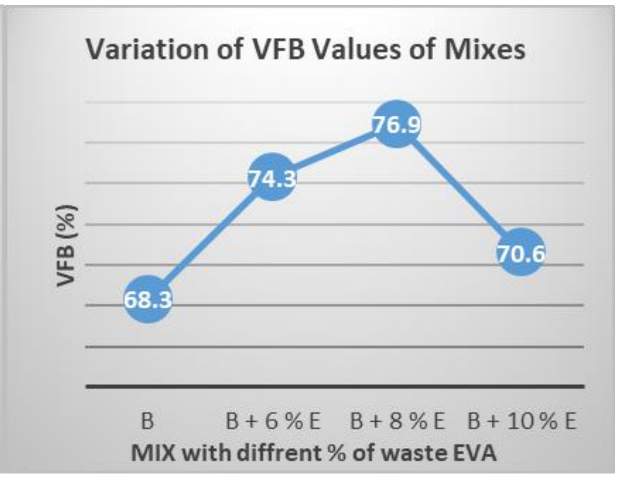


Fig. V Variation of VMA of Mixes **Fig. VI Variation of VFB of Mixes**

The data presented in Tables-X shows that the plastic waste has significant effect on the various properties such as stability, density, VMA, VFB and flow of the BM mix. The values fall well within the limits specified by MORT&H and IRC: SP 98 respectively.

Table-X Comparison of Volumetric Properties of BM Mixes With and Without Waste EVA Plastics

Properties	With Plastic Waste	Without Waste Plastics	Requirement Of Bituminous Mixes	Requirement Waste Plastic Modified Mixes

		(at OBC)	(MORT&H)[12]	(IRC:SP 98)[13]
Marshall Stability Value (S), kN	14.43	10.15	9.0 (Min)	12.0 (Min)
Bulk Density of the mix (G_m), g/cc	2.59	2.16	-	-
Air Voids in the mix (Vv), %	2.98	5.32	3 to 6	3 to 6
Voids Filled with Bitumen (VFB), %	76.9	68.3	65 to 75	65 to 75
Voids in Mineral Aggregates (VMA), %	18.75	14.2	14 (Min)	16 (Min)
Flow Value (F), mm	3.51	2.16	2 to 4	2 to 4

5.11Indirect Tensile Strength Test

The Indirect Tensile (IDT) Strength Tests were also conducted as per ASTM D-6931[14] on mixes prepared with conventional as well as waste EVA modified bitumen. In this test, a compressive load is applied on a cylindrical specimen (Marshall sample) along a vertical diametrical plane through two curved strips the radius of curvature of which is same as that of the specimen. A uniform tensile stress is developed perpendicular to the direction of applied load and along the same vertical plane causing the specimen to fail by splitting. The tensile strength of the specimen was calculated by using the formula given in ASTM D-6931.

$$\sigma x = \frac{2P}{\pi Dt} \qquad \text{(I)}$$

Where,

σx= Indirect tensile strength in MPa(N/mm2)

P = Applied load in Newton

D = diameter of the specimen in mm

t = thickness of the specimen in mm

The tensile strength ratio (TSR) is calculated as follows:

$$TSR = \frac{T2}{T1} \qquad \text{(II)}$$

Where

T1= Average Tensile strength of unconditioned specimen

T2= Average Tensile strength of conditioned specimen

The variation of indirect tensile strength values of the mix prepared with conventional and modified bitumen shown in Tables-XI and XII. It has been observed from the test results that the IDT values of unconditioned and conditioned mixes prepared with 3.5% unmodified bitumen were 0.85 and 0.75 MPa respectivey. The mixes prepared with optimum bitumen content (3.5%) and plastic waste yield better IDT strength vlaues (0.93 and 0.89 MPa) of unconditioned and conditioned specimens respectively. This shows the enhancement in strength of the mix due to addition of plastic waste which siginifies that the inclusion of plastic waste increases the indirect tensile strength of BM mixes. The Tensile Strength Ratio (TSR) values of BM mix with 3.5% bitumen content were observed as 88%, whereas its TSR value increases with EVA percentage. The TSR value of BM mix with 8% EVA was observed as 96%, which is substantially higher than (88%) BM mix prepared with unmodified bitumen.

Table-XI Indirect Tensile Strength of BM Mixes Without EVA

S. No.	Bitumen Content (%)	Indirect Tensile Strength (MPa)		Tensile Strength Ratio (TSR) (%)
		Unconditioned	Conditioned	
1.	3.0	0.73	0.63	86
2.	3.5	0.85	0.75	88
3.	4.0	0.77	0.73	95
4.	4.5	0.71	0.68	96
5.	5.0	0.68	0.63	93

Table-XII Indirect Tensile Strength Of BM Mixes At Optimum Bitumen Content Using EVA

S. No.	Mix	Indirect Tensile Strength (MPa)		Tensile Strength Ratio (%)
		Unconditioned	Conditioned	
1.	Unmodified bitumen (B)	0.85	0.75	88
2.	B + 6 % LDPE	0.90	0.80	89
3.	B + 8 % LDPE	0.93	0.89	96
4.	B + 10 % LDPE	0.92	0.87	94

VI.CONCLUSION

On the basis of the analysis of results obtained in the present investigations, the following conclusions were drawn: The optimum bitumen content (OBC) for conventional BM Grade 2 mixes was found to be 3.5%. For BM mixture with Grade 2 the most significant percentage of EVA was obtained 10 to 12%. The addition of plastic waste reduces the air voids which prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in enhancement of Marshall Stability value. The flow value of mix was decreasing with increase in the waste content in the mix from 6 to 10%. The bulk density of the mix was also increasing with increase in the EVA content. The most significant percentage of waste is observed as 8% at which the density is maximum (2.59g/cc). Which about 20% more than the density of the mix prepared with unmodified bitumen. The decrement in the Vv values show that the stability of the mixes were improving on addition of EVA. The VMA value of mix was increasing with increase in the waste content in the mix from 6% to 8%. However, the maximum increment in the VMA value is observed at 8% waste content which is about 32%. The volumetric and Marshall properties of BM mixtures were satisfying both MORT&H specifications. The plastic waste modified mixes were also satisfying the IRC: SP 98 guidelines for plastic waste modified bituminous mixtures. Marshall Quotient was also within the range of tolerance, thus showing that the plastic waste blended bitumen mix is better and more suitable for flexible pavement construction. The indirect tensile strength values for unconditioned samples were increased by 10.1% for BM mixes at OPC. Similarly, for conditioned sample the value was increased by 19%. The TSR at OBC was found to be 88%, This was increased to 96% at OPC, which proved that plastic modification makes the mixtures more moisture resistant.

REFERENCES

[1.] Kandhal, P.S. and Dhir, M.P., Use of Modified Bituminous Binders in India-Current Imperatives, Journal of the Indian Roads Congress, (2011) Vol. 72-3, 175-189.

[2.] Jain, P.K., Kumar, Shanta, Sengupta, J.B., Mitigation of Rutting in Bituminous Roads by Useof Waste Polymeric Packaging Materials, Indian Journal of Engineering & Material Science, (2011) 6, Vol. 18.

[3.] IS: 73, Specification-Paving Bitumen (1992).

[4.] Vasudevan, R., Utilization of waste plastics for flexible pavement, Indian Highways Indian Road Congress, (2006) Vol. 34, No.7.

[5.] Mehndiratta H.C. and Chandra S., Investigation on Bituminous Mixes with Blended Modifiers, Journal of Institution of Engineers, India, (2000)Vol. 81, 115-119.

[6.] Panda M. and Mazumdar M., Development and Evaluation of a Bituminous Paving Binder Containing Reclaimed Polyethylene, Indian Highways, IRC, (1997)Vol. 25, 11-21.

[7.] Lepe A.P., Boza F.J.M., Gallegos C., Gonzalez O., Muzoz M.E., Santamari A., Influence of the Processing Conditions on the Rheological Behaviour of Polymer Modified Bitumen, Fuel 82, (2003)1339-1348.

[8.] S. E. Zoorob and L. B. Suparma, Laboratory design and investigation of the properties of continuously graded asphaltic concrete containing recycled plastics aggregates replacement (Plastiphalt), Cement Concrete Composites, (2000) 22, 233–42.

[9.] N. Little, Enhancement of asphalt concrete mixtures to meet structural requirements through the addition of recycled polythene, use of waste materials in hot mix asphalt, ASTM Special Tech. Publication, 1193 (1993).

[10.] C. S. Bindu and Dr. K. S. Beena, Waste Plastic as a Stabilizing Additive in Stone Mastic Asphalt, Int. J. Engg. Tech.,(2010) 2(6), 379-387.

[11.] Mazumdar, M. P., Utilization of reclaimed polyethylene in bituminous, Journal of Materials in Civil Engineering, (2002)527-530.

[12.] Ministry of Road Transport and Highways-MORT&H, Specifications for road and bridge works, Fourth Revision, Published by Indian Road Congress on behalf of the Government of India (2001).

[13.] IRC: SP-98, Guidelines for the use of waste plastic bituminous construction Published by Indian Road Congress on behalf of the Government of India (2013).

[14.] ASTM D 6931, Standard Test Method for Indirect Tensile (IDT) Strength of Bituminous Mixtures (2007).

[15.] IS: 6241, Method of Test for determination of stripping value of road aggregates. Indian Standard Institution, New Delhi (1971).

[16.] ASTM D-3625, Standard Practice for Effect of Water on Bituminous-Coated Aggregate Using Boiling Water, (2012).