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Performance Analysis of Waste Plastic Modified Bitumen for Pavements

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ABSTRACT

Bitumen is widely used in construction of flexible pavements due to its versatile properties like impermeability, Ductile, Binding; Bonding etc. plastic is used in almost all the industries including hospitals. The plastic waste generated from the hospitals has to be safely disposed to conserve environment. The aim of the paper is to study the optimum usage of plastic waste like syringes and glucose bottles in bitumen and its performance evaluation.

Keywords: *Plastic Waste, Hospital waste usage, Environmental Safety*

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1. Introduction

The utilization of plastic wastage like syringes and glucose bottles in the flexible pavement road construction is the main concern in this study because they are hazardous to health and causes pollution to the environment. So the pavements are designed by mixing the plastic waste originated from hospitals at percentages of 0% to 7% by the weight of bitumen [7].

Objectives of Bituminous mix design are

1. To increase the Durability of pavement.
2. Resist deformation for the traffic.
3. Avoid cracking failures due to repeated traffic.
4. Prevent the shrinkage cracks.
5. Skid Resistance.
6. Stable.

Composition of the Mix: Coarse and Fine aggregates, Filler, Fly ash and Binder.

2. Literature Review

Yildirim Y (2007) in this paper, she explains about the usage of waste plastic in bitumen. And the Plastic usage increases the strength of pavement. And also the increasing in the usage of plastic may increasers the properties of aggregate too up to certain limit [5].

Silva et al (2009) the life of a road pavement is divided into 4 parts they are (i) The materials used (ii) construction (iii) The maintenance and (iv) The demolition or recycling of the pavement [4].

Ahmadinia et al (2012) Re-using of waste materials like plastic waste bottles (Polyethylene Terephthalate) in stone mastic asphalt with various percentages of 0% to 10% by weight of bitumen. The experiment result shows that appropriate range is 4% to 6% [1].

Anzar Hamid Mir (2015) the disposal of plastic wastes is difficult and also plastic waste is non bio-degradable in nature [6].

3. Methodology and Experimental Investigation

3.1 Process of Making Plastic Road

The flow chart of making the PMB road was shown in Figure 1 [8].

3.2 Materials Used

- Aggregate- Aggregate of 20mm, 12.5mm, 6.3mm and stone dust
- Bitumen- 80/100 grade
- Waste Plastic- shredded form
- Tests on Bitumen- Penetration Index Test, Ductility Index Test, Softening point test and Flash and Fire point test.
- Optimum Bitumen Content (OBC): Normal mix specimens were prepared; OBC was measured with Marshall Test apparatus [2, 3].

4. Results and Discussions

4.1 Properties of Bitumen

The physical properties of Bitumen are like

1. Stability
2. Voids in Mineral Aggregate (VMA)
3. Air Voids
4. Unit Weight
5. Flow Value
6. Voids Filled with Bitumen (VFB)

The physical properties of bitumen are shown in different graphs grouped under Figure 2.

Medical waste collection

Medical waste is segregation

Medical waste cleaned and dried

Medical waste shredded to 2 to 4mm

Aggregate is heated up to 160-170°C

shredded waste plastic is added to heated aggregate for 30 to 40sec with coating

Bitumen (temp 155-163°C) is mixed with Coated aggregate

4 layers of mixture is laid and rolled

A finished layer is made

Figure 1: Flow chart of making the Polymer Modified Bituminous road

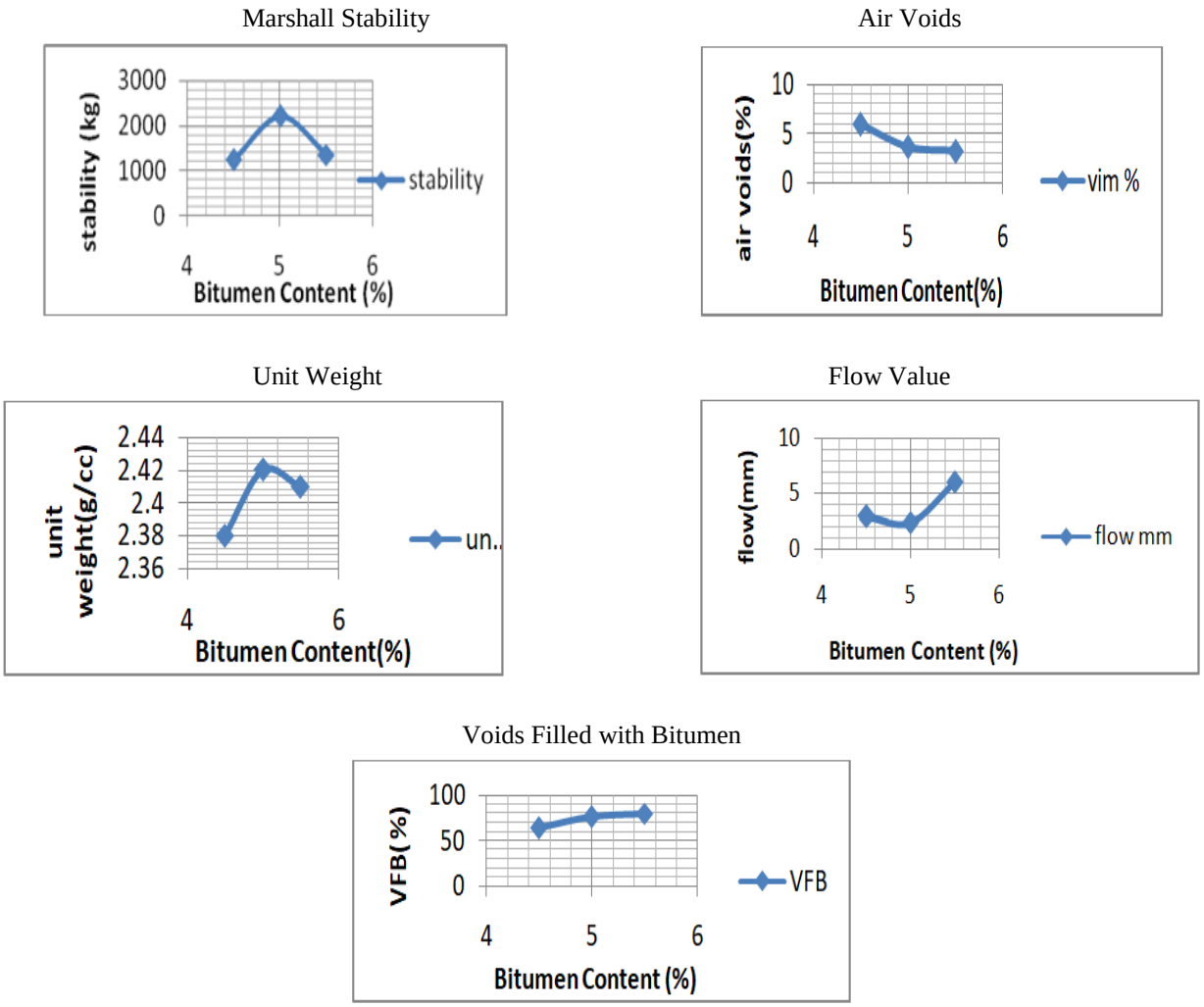


Figure 2: Physical Properties of Bitumen

4.2 Bituminous Mix Properties by Marshall Method with Medical (Syringes) Plastic Waste

Plastic modified mix specimens with plastic waste contents of 2 percent, 3 percent, 5 percent, 7 percent etc. by weight of bitumen were prepared through dry process by adding plastic waste to heated aggregates. Marshall Test was conducted on PMB to find out the Optimum Plastic Content. The aggregates were then coated with this optimum plastic content and aggregate tests were repeated for comparing its properties with normal aggregates.

The mix properties of PMB by Marshall Method of syringes plastic was given in Table 1.

Table 1: Properties of Bituminous Mix

% Bitumen by Weight of Mix		4.9	4.85	4.75	4.65
% Plastic Content		2	3	5	7
Weight of specimen in air	A	1180	1190	1188.5	1188
Weight of specimen in water	B	682	688	702	693
Weight of specimen in SSD	C	1189	1201	1203	1196
Volume of specimen	D=C-B	498	502	501	503
Bulk sp.gravity of specimen	G_{mb}=A/D)	2.369	2.37	2.372	2.36
Max sp.gravity of specimen	G_m (max)	2.517	2.519	2.523	2.527
VIM	%	5.88	5.915	5.984	6.608

VMA	%	17.05	16.97	16.81	17.14
VFB	%	65.51	65.14	64.4	61.44
Stability reading	F	480	490	520	400
Marshall stability	F×0.069kg(H)	33.12	33.81	35.88	27.6
Correction	I	1.04	1.04	1.04	1.04
Corrected stability	J=H×I (kg)	34.44	35.16	37.31	28.7
Flow	mm	5.5	5	3	5.5

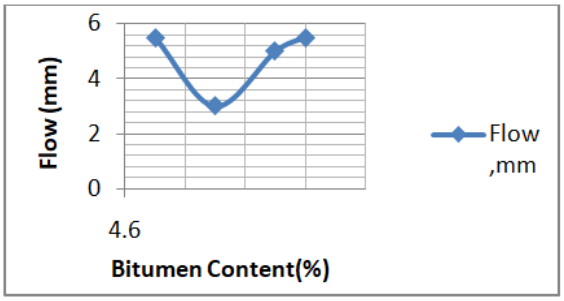
4.3 Calculation of Optimum Plastic Content (Syringes) by Using Graphs

Marshall Parameters for Plastic modified mix specimen as shown in Figure-3 for calculating optimum plastic content by plotting graphs at OBC [9].

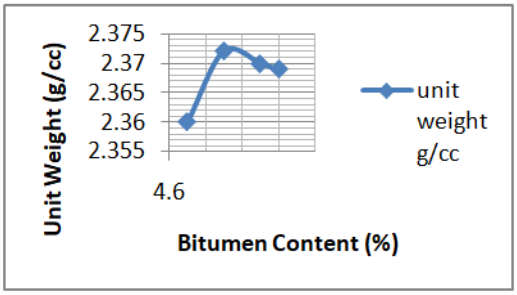
Table 2: Properties of syringes waste mixed Bitumen

Plastic Content (%)	Stability (kg)	Flow (mm)	Unit weight (g/cc)	VIM (%)	VMA (%)	VFB (%)
2	34.44	5.5	2.369	5.88	17.05	65.51
3	35.16	5.0	2.370	5.915	16.97	65.14
5	37.31	3.0	2.372	5.984	16.81	64.40
7	28.70	5.5	2.360	6.608	17.14	61.44

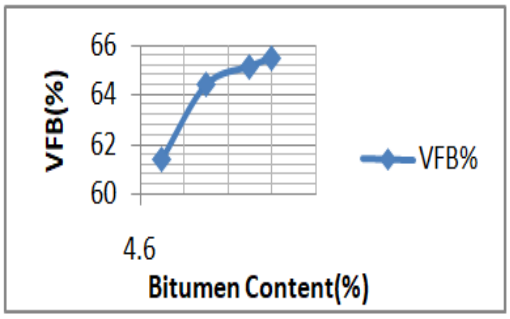
Flow Value



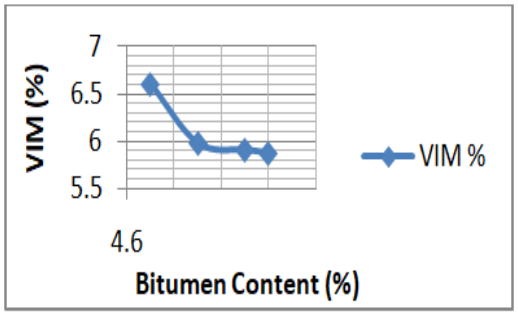
Unit Weight



Voids Filled with Bitumen



Air Void



Voids in Mineral Aggregate (VMA)

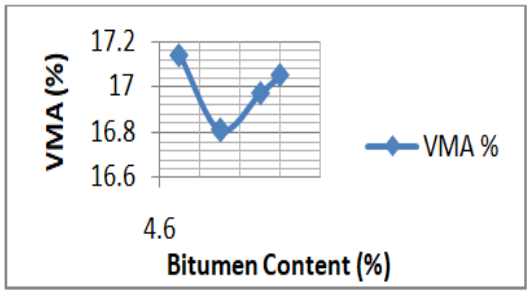


Figure 3: Graphs showing the properties of syringes mixed Bitumen

4.4 Calculations for the Mix of Glucose Plastic Waste

Calculation of maximum theoretical specific gravity of passing mixture and specimen casting at OBC is same as Syringe plastic waste.

4.5 Bituminous Mix Properties by Marshall Method with Medical (Glucose) Plastic Waste

Bituminous mix properties of modified plastic waste mix specimen are shown in the Table with various volumetric properties of modified medical Glucose plastic waste.

Table 3: Properties of glucose waste mixed Bitumen

% bitumen by weight of mix		4.9	4.85	4.75	4.65
% plastic content		2	3	5	7
Weight of specimen in air	A	1208.5	1177.5	1197.5	1170.5
Weight of specimen in water	B	720	701	703	696
Weight of specimen in SSD	C	1219	1187	1197	1182
Volume of specimen	D=C-B	499	486	494	482
Bulk sp.gravity of specimen	G_m b=A/D	2.421	2.422	2.424	2.41
Max sp.gravity of specimen	G_m max	2.517	2.519	2.523	2.527
VIM	%	3.81	3.85	3.92	4.629
VMA	%	15.229	15.149	14.99	15.39
VFB	%	74.98	74.58	73.84	69.92
Stability reading	F	266	326	440	380
Marshall stability	F×0.069 kg(H)	18.354	22.494	30.36	26.22
Correction	I	1.04	1.09	1.09	1.09
Corrected stability	J=H×I kg	19.08	24.518	33.09	28.58
Flow	mm	3.6	3.4	3.2	6

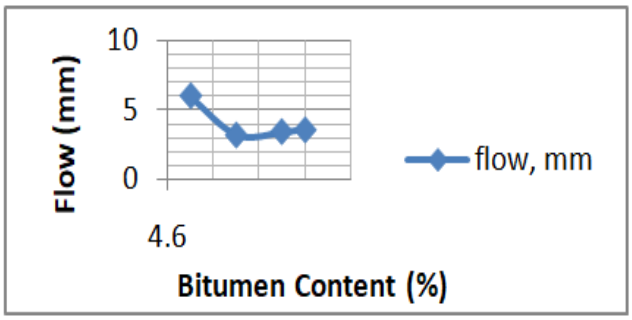
4.6Calculation of Optimum Plastic Content (Glucose Plastic Waste) by Using Graphs

Plastic modified mix specimen values are as shown in table 4 for calculating optimum plastic content by plotting graphs at OBC were shown in Figure 4.

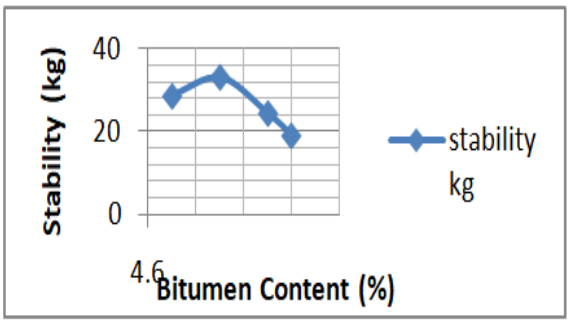
Table 4: Modified mix specimen values

Plastic Content (%)	Stability (kg)	Flow (mm)	Unit weight (g/cc)	VIM (%)	VMA (%)	VFB (%)
2	19.08	3.6	2.421	3.81	15.229	74.98
3	24.518	3.4	2.422	3.85	15.149	74.58
5	33.09	3.2	2.424	3.92	14.99	73.84
7	28.58	6.0	2.410	4.62	15.39	69.92

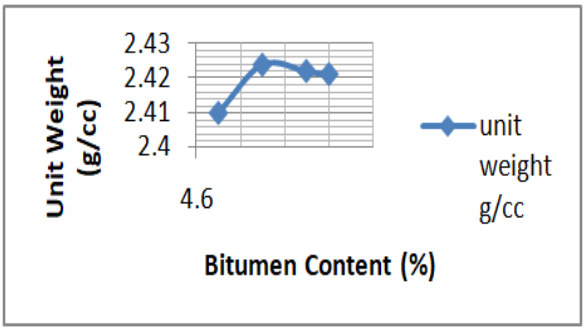
Flow Value



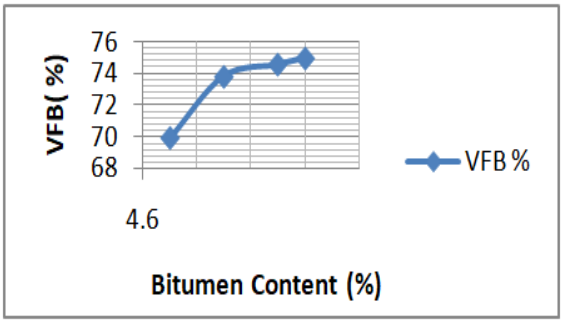
Stability



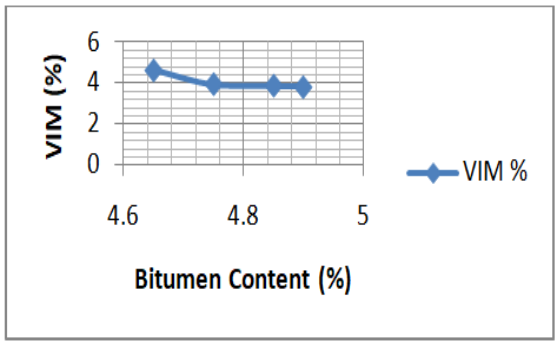
Unit Weight Voids



Filled with Bitumen



Air Voids



Voids in Mineral Aggregate (VMA)

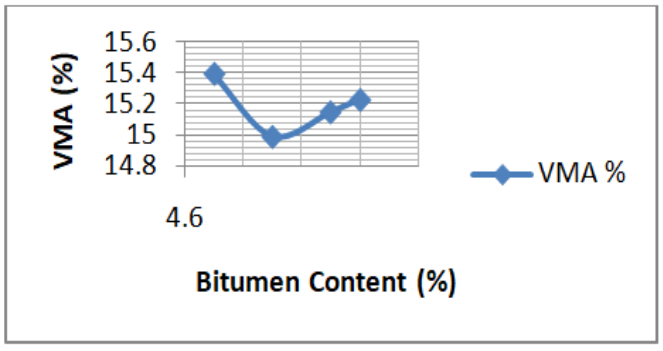


Figure 4: Graphs showing the properties of modified Bitumen

Table 5: Physical Properties of Aggregates

Property	Without plastic	With Syringe plastic waste	With Glucose plastic waste	IRC specification
Aggregate crushing value (%)	29.9	21.248	21.29	<30
Aggregate impact value (%)	29.62	24.22	24.70	<30
Los angles abrasion value (%)	32.1	29.22	28.48	<35
Specific gravity of 20mm aggregate	2.69	2.69	2.69	2.5-3.0
Specific gravity of 12.5mm aggregate	2.77	2.77	2.77	2.5-3.0
Specific gravity of 6.3mm aggregate	2.85	2.85	2.85	2.5-3.0
Water absorption of 20mm aggregate	0.15	0	0	<2
Water absorption of 20mm aggregate	0.1	0	0	<2
Water absorption of 20mm aggregate	0.1	0	0	<2

4.7 Properties of Modified Bitumen

The Penetration, Softening, Ductility Test values were given in Table 6 for Syringe plastic waste and Medical plastic wastes.

Table 6: Properties of Modified Bitumen

Property	Penetration Test		Softening Point Test		Ductility Test	
Standard Specification	**60-70**		**45-60**		**15-100**	
% of Modified Bitumen	**Syringe plastic waste**	**Glucose plastic waste**	**Syringe plastic waste**	**Glucose plastic waste**	**Syringe plastic waste**	**Glucose plastic waste**
0	70	70	45	45	95	95
2	35	38	48	49	84	85
3	12	15	52	51	80	80
5	0	5	56	55	76	77

4.8 Properties of Modifier Bitumen with Medical Plastic Waste

Figure 5 shows penetration value of varying % of modified bitumen with varying medical plastic waste.

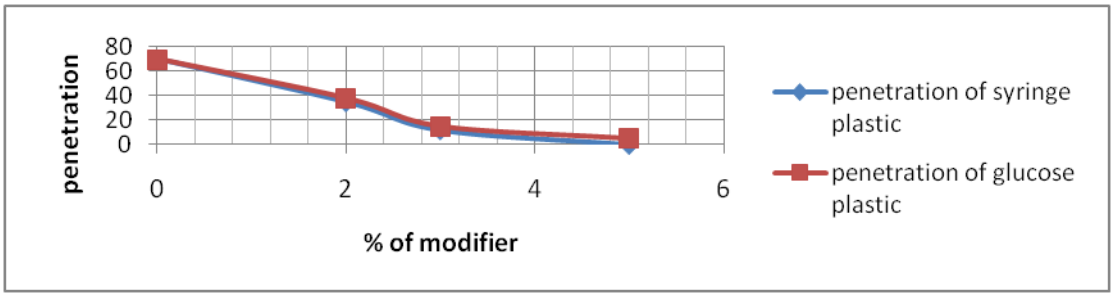


Figure 5: Penetration value versus varying % of modifier

Figure 6 shows ductility value of varying % of modified bitumen with varying medical plastic waste.

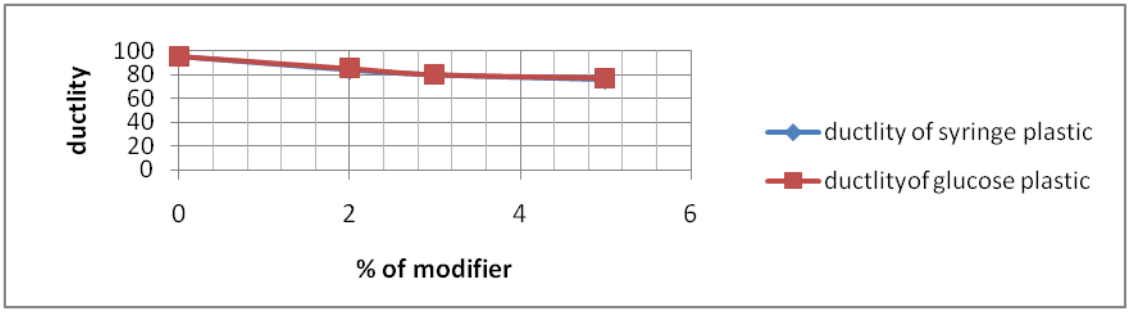


Figure 6: Ductility value versus varying % of modifier

Figure 7 shows softening point of varying % of modified bitumen with varying medical plastic waste.

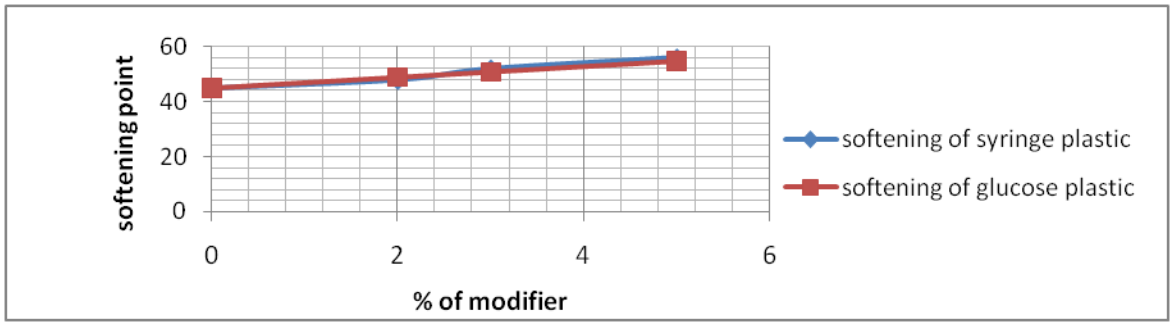


Figure 7: Softening point versus varying % of modifier

5. Conclusion

With increase in plastic content in bitumen after 7%, penetration and ductility values were decreases and resulting in increase the hardness and brittleness of bitumen and Optimum plastic content was found to be 5% in weight of bitumen content. Also the load carrying capacity was increased with increasing in plastic waste up to 7 percent by weight of bitumen. Strong, durable and eco-friendly roads shall be prepared from all types of plastic-waste in the mere future.

References

1. Ahmadinia E., Zargar M., Karim M.R., Abdelaziz M., and Ahmadinia E., (2012): "Performance evaluation of utilization of waste Polyethylene Terephthalate (PET) in stone mastic asphalt", Construction and Building Materials, vol. 36, pp. 984-989.
2. Vidula Swami J, Abhijeet and P. Karan, (2012): "Use of waste plastic in the construction of bituminous road", International Journal of Engg Science and Tech., vol. 4, Issue 5, pp. 1-5.
3. S. K. Sultana and K. S. B. Prasad, (2012): "Utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements", International Journal of Engineering Research and Applications, vol.2, Issue 4, pp. 1185-1191.
4. Silva M.R.D., Oliveira J.R.M., Peralta E.J., and Ferreira C.I.G., (2009): "Evaluation of the rheological behavior of Warm Mix Asphalt (WMA) modified binders", Advanced Testing and Characterization of Bituminous Materials, vol. 1 and 2, pp. 661-673.
5. Yildirim Y., (2007): "Polymer modified asphalt binders, Construction and Building Materials", Sri Ram Institute for Industrial Research, Plastics Processing and Environmental Aspects, vol.3 Issue 6, pp. 66-72.
6. Anzar Hamid Mir, (2015): "Use of Plastic Waste in Pavement Construction: An Example of Creative Waste management."
7. Vasudeva R., (July2006): "Utilization of waste plastics for flexible pavement", Indian High Ways (Indian Road Congress), vol. 34, No.7.
8. Ministry of Road Transport and High Ways Manual for construction and super vision of bituminous works, New Delhi, (2001): International Journal of Engineering and Advanced Technology (IJEAT).
9. AmjadKhan, Gangadhar, Murali Mohan and Vinay Raykar, (1999): "Effective Utilization of Waste Plastics in Asphalting of Roads". Project Report prepared under the guidance of R. Suresh and H.Kumar, Dept. of Chemical Eng., R.V. College of Engineering, Bangalore.
10. IS: 2386, (1963): "Methods of Test for Aggregates for Concrete (P - I): Particle Size and Shape", Bureau of Indian Standards, New Delhi.
11. IS: 2386, (1963): "Methods of Test for Aggregates for Concrete (P-III): Specific Gravity, Density, Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi.