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Pothole Repair by using PET (Polyethylene Terephthalate) and ZycoTherm

Amol Bhosale Siddhesh Katkar Shubham Shinde Suraj Shrivastav Deepika Bhulla Mrunalini Deshmukh Neha Badiger
Dept. of Civil Engineering
Shree L.R. Tiwari College of Engineering
Mumbai , Maharashtra, India

Abstract- **In India, Most of the pavements are of flexible pavement as they are economical compared to rigid pavements but its maintenance causes more trouble and also increase cost of flexible pavement construction. Bitumen and aggregates being an important aspect of the flexible pavement from cracking and deterioration of the pavement. . Bitumen acting as a binding material in the pavement when mixed with the Polyethylene Terephthalate (PET) and ZycoTherm (upgraded version of ZycoSoil) brings more stability to the roads and helps ion resisting the forces from the vehicles. Hence in this study different test is to be done regarding more stable and effective proportions to be used between bitumen and plastic waste comprising of Marshal Stability test, Ductility test, Penetration test and Softening point test for Bituminous mix and Bitumen.**

Key word s- **ZycoTherm, ZycoSoil, Bitumen (VG-30), Polyethylene Terephthalate, Aggregate**

I. INTRODUCTION

India has a road network more than 56, 03,293 kilometers as per 2018, the second largest road network in the world. About 98% of the paved roads in India have Flexible pavements, within are included surfacing of various type and thickness. Flexible pavements works on principle of taking heavy load of vehicles and transferring it to the earth through different layers like base course, sub base, sub grade. Bitumen and aggregates plays an vital role in construction of flexible pavements. Bitumen is hydrocarbon material which obtained by the distillation of petroleum crude.

In flexible pavements one of the setback caused is due to water that infiltrate the pavement structure can cause premature failure. This can happen due to loss in adhesion between bitumen binder and aggregate or loss in cohesion of bitumen binder. To overcome this problem another modified is added with bitumen which is called ZycoTherm (upgraded version of ZycoSoil) and Polyethylene Terephthalate (PET). ZycoTherm nanotechnology can be helpful in preventing the striping of the bitumen course leading to reduction in the maintenance of the pavement.

Plastic products have become an integral part in our daily life as a basic need. It produced on a massive scale worldwide and its production crosses the 150 million tons per year globally. In India approximately 12 Million tone's plastic products are used every year (2014). Its broad range of application in films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. It is a fact that plastics will never been degraded and remains as it is for 1000 years. Although most plastics are recyclable but recycled products becomes more hazardous than the virgin products. In India approximately 15342 tons of plastics waste is generated per day.

II. EXPERIMENTAL

Methodology

1. Material Used

1.1 ZycoTherm- ZycoTherm nanotechnology substantially improves coating of asphalt binder on aggregates. ZycoTherm is Silane Based Technology with No Amines. It is an doorframe, chemical warm-mix additive WMA) and anti-stripping agent. It helps provide better adhesion.

Fig.1 (ZycoTherm)

1.2 PET (Polyethylene Terephthalate): PET is polyester and is made from mono-ethylene glycol (MEG) and purified terephthalic acid (PTA), which is derived from

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crude oil and natural gas. Its use for it strength, thermo-stability, and transparency. It is also reduce both the costs and carbon emissions relating to transportation.

Fig.2 (Polyethylene Terephthalate)

1.3 Bitumen (VG-30)- It is a material which is a by product of petroleum refining process. The primary use of asphalt is in road construction, where it is used as the binder mixed with aggregate particles to create asphalt concrete**.**VG-30 is especially used to construct extra heavy duty bitumen pavements that need to tolerate significant traffic loads.

Fig. 3 (Bitumen (VG-30))

1.4 Aggregates- Aggregate is a mineral materials such as sand, gravel and crushed stone that are used with a bitumen to form asphalt concrete. An aggregate which has good and sufficient strength, hardness, toughness and soundness have to be chosen. Crushed aggregates produce higher stability.

Fig. 4 (Aggregates)

1.5 Lime- Lime is calcium containing inorganic mineral composed primarily of oxides and hydroxide, usually calcium oxide and calcium hydroxide. Lime has an adhesive property with stones, it is often used as binding material in masonry works.

Fig. 5 (Lime)

III. EXPERIMENTS TO BE PERFORMED

1. Tests on Bitumen

- Penetration test
- Softening point test
- Ductility test
- Marshall stability test

1.1 Penetration Test: The test determine the hardness of bitumen by measuring the depth (one tenth of a mm) to which a standard, and loaded needle will vertically penetrate in 5 seconds, in a sample of bitumen maintained at 25 degree C. The test was carried out in accordance with the procedure laid down in IS1203-1978.

1.2 Ductility Test: The Ductility test is an empirical test which measures the cohesive strength of bitumen and its ability to stretch. The test was conducted as per IS 1208-1978.

1.3 Softening Point Test: The Softening point test is an empirical test and a temperature at which bitumen would behave more like a liquid and less like a solid under standard condition of heating and loading. The test was conducted as per IS 1205-1978.

1.4 Marshall Stability Test: This test is done to determine the Marshall Stability of bituminous mixture as per ASTM D1559. The principle of this test is that Marshall Stability is the resistance of plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface. It is the load carrying capacity of the mixture at 60 degree C and is measured in kg.

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IV. GRADATION OF AGGREGATE FOR BITUMINOUS CONCRETE

Table 1 Aggregate grading of BC mix Individual grading of 10mm metal sample wt=2000.

IS Sieve	Wt. Ret.	Wt.Pass	%Pass
19.00 MM	0	2000	100
13.20 MM	5	1195	99.75
9.50 MM	784	1211	60.55
4.75 MM	1198	13	0.65
2.36 MM	5	8	0.4
1.18 MM	0	8	0.4
0.60 MM	0	8	0.4
0.30 MM	0	8	0.4
0.15 MM	0	8	0.4
0.075 MM	0	8	0.4
PAN	8	8	0

Table 2 Aggregate grading of BC mix Individual grading of C/Sand sample wt. =1000.

IS Sieve	Wt. Ret.	Wt.Pass	%Pass
19.00 MM	0	1000	100
13.20 MM	0	1000	100
9.50 MM	0	1000	100
4.75 MM	39	961	96.1
2.36 MM	221	740	74
1.18 MM	314	426	42.6
0.60 MM	133	293	29.3
0.30 MM	81	212	21.2
0.15 MM	70	142	14.2
0.075 MM	50	92	9.2
PAN	92	0	0

Table 3 Aggregate grading of BC mix Individual grading of lime filler sample wt= 100.

IS Sieve	Wt. Ret.	Wt.Pass	%Pass
19.00 MM	0	100	100
13.20 MM	0	100	100
9.50 MM	0	100	100
4.75 MM	0	100	100
2.36 MM	0	100	100
1.18 MM	0	100	100
0.60 MM	0	100	100
0.30 MM	0	100	100
0.15 MM	0	100	100
0.075 MM	1.5	98.5	98.5
PAN	98.5	0	0

Table 4 % Grading of aggregate grading for BC mix Individual grading of 10 mm metal.

Metal Type	10MM	C/Sand	Filler		
	30%	66%	4%	Total	Limit
IS Sieve					
19.00 MM	30	66	4	100	100
13.20 MM	29.93	66	4	99.93	79-100
9.50 MM	18.165	66	4	88.17	70-88
4.75 MM	0.2	63.43	4	67.62	53-71
2.36 MM	0.12	48.84	4	52.96	42-58
1.18 MM	0.12	28.12	4	32.24	34-48
0.60 MM	0.12	19.34	4	23.46	26-38
0.30 MM	0.12	13.99	4	18.11	18-28
0.15 MM	0.12	9.372	4	13.49	12-20
0.075 MM	0.12	6.072	3.94	10.13	4-10
Pan	0	0	0	0	

Table 5 Grading of Aggregate

IS Sieve	Total	Lower Limit	Upper Limit
19.00 MM	100	100	100
13.20 MM	99.93	79	100
9.50 MM	88.17	70	88
4.75 MM	67.62	53	71
2.36 MM	52.96	42	58
1.18 MM	32.24	34	48
0.60 MM	23.46	26	38
0.30 MM	18.11	18	28
0.15 MM	13.49	12	20
0.075 MM	10.13	4	10

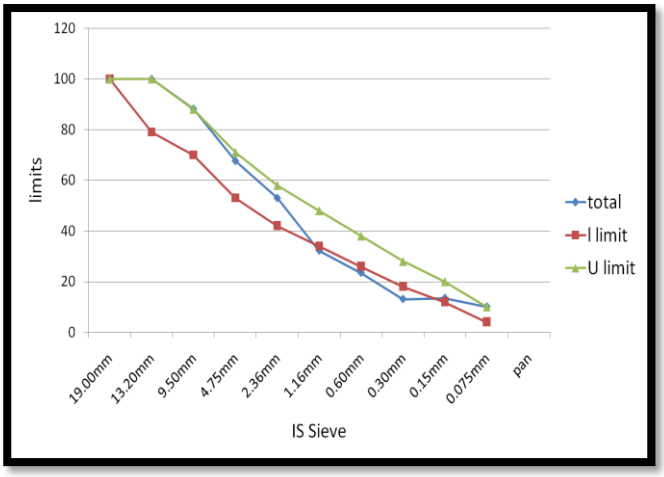

Fig 6 (Gradation of Aggregate).

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V. RESULTS

Table 6 Effect of PET & ZycoTherm on Penetration Values of Bitumen (VG-30)

Zyco Therm %	PET %	Penetration Dial Reading				Mean
		Initial	Final			
			1	2	3	
0	0	0	69	71	68	69.33
0.1	0	0	69	68	70	69
0.1	2	0	67	66	67	66.67
0.1	4	0	65	64	63	64
0.1	6	0	58	60	57	53.67
0.1	8	0	55	53	53	53.67

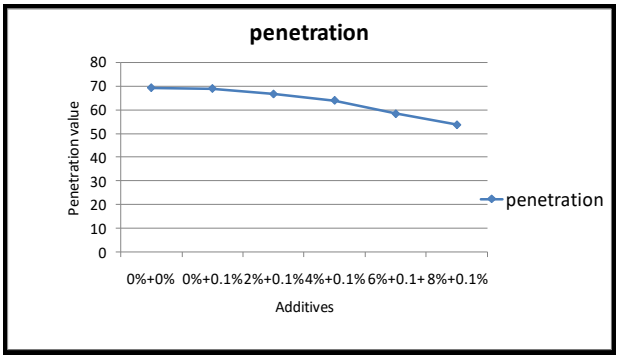

Fig.7 (Penetration)

Table 7 Effect of ZycoTherm & PET on Ductility Values of Bitumen (VG-30).

Zyco Therm %	PET %	Ductility			Mean
		1	2	3	
0	0	80	80	79	79.67
0.1	0	85	85	84	84.67
0.1	2	85.5	86	85.6	85.7
0.1	4	88	88.5	89.2	88.57
0.1	6	93	92.8	94	93.27
0.1	8	96	98	97.6	97.2

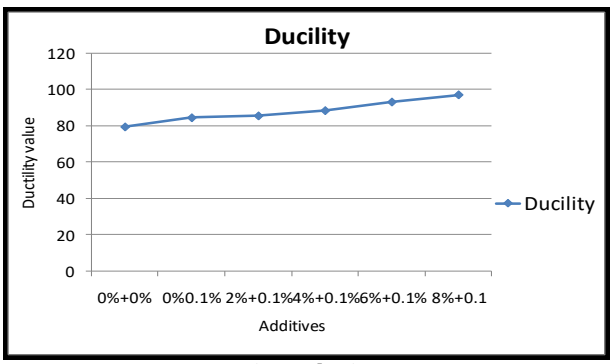

Fig. 8 (Ductility).

Table 8 Effect of ZycoTherm & PET on Softening point values of Bitumen (VG-30)

ZycoTherm %	PET %	Temperature when Mean Ball Touches		Mean
		1	2	
0	0	54	58	56
0.1	0	57	59	58
0.1	2	58	58.5	58.25
0.1	4	62	62	62
0.1	6	63	64	63.5
0.1	8	62	61	61.5

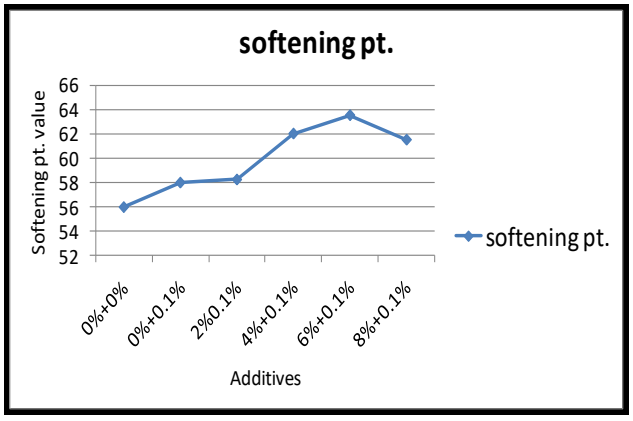

Fig. 9 (Softening point)

Table 9 Effect of ZycoTherm & PET on Marshall Stability value of Bitumen (VG-30)

4.1 (0.1% ZycoTherm+2% PET)

Additive Used%	0.1% Zycotherm+ 2% PET	Location	ME Infra Asphalt Plant	
% Bitumen		6	6	6
Specimen air wt. (gm)		1123	1146	1144
Specimen water wt (gm)		668	680	675
Specimen SSD wt (gm)		1127	1150	1149
Specimen volume (cc)		459	470	474
Bulk density (gm/cc)		2.447	2.438	2.41
Specific gravity of bitumen (gm/cc)		1.02	1.02	1.02
Specific gravity of aggregate (gm/cc)		2.74	2.74	2.74
Theo. Specific gravity of mix(gm/cc)		2.488	2.488	2.488
VIM %		1.648	2.01	3.13
VMA %		16.042	16.351	17.309
VFB %		89.727	87.707	81.9
Dial gauge reading		460	465	470
Stability (kn)		9.2	9.3	9.4
Corrected stability (kn)		10.948	11.067	10.716
Flow Value		3.3	3.4	3.3
Marshall Quotient		3.318	3.255	3.247

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Table 10 (0.1% ZycoTherm+4% PET).

Additive Used%	0.1% Zycotherm+ 4% PET	Location	ME Infra Asphalt Plant	
% Bitumen		6	6	6
Specimen air wt. (gm)		1090	1075	1096
Specimen water wt. (gm)		636	628	640
Specimen SSD wt. (gm)		1094	1078	1100
Specimen volume (cc)		458	450	460
Bulk density (gm/cc)		2.38	2.3889	2.383
Specific gravity of bitumen (gm/cc)		1.02	1.02	1.02
Specific gravity of aggregate (gm/cc)		2.74	2.74	2.74
Theo. Specific gravity of mix(gm/cc)		2.488	2.488	2.488
VIM %		4.341	3.98	4.22
VMA %		18.341	18.305	18.238
VFB %		76.332	79.344	76.861
Dial gauge reading		615	620	600
Stability (kn)		12.3	12.4	12
Corrected stability (kn)		14.637	14.756	14.28
Flow Value		3.4	3.65	3.5
Marshall Quotient		4.305	4.043	4.08

Table 11 (0.1% ZycoTherm+6% PET).

Additive Used%	0.1% Zycotherm+ 6% PET	Location	ME Infra Asphalt Plant	
% Bitumen		6	6	6
Specimen air wt. (gm)		1130	1157	1150
Specimen water wt. (gm)		665	685	680
Specimen SSD wt. (gm)		1133	1162	1155
Specimen volume (cc)		468	477	475
Bulk density (gm/cc)		2.41	2.426	2.421
Specific gravity of bitumen (gm/cc)		1.02	1.02	1.02
Specific gravity of aggregate (gm/cc)		2.74	2.74	2.74
Theo. Specific gravity of mix (gm/cc)		2.488	2.488	2.488
VIM %		3.315	2.492	2.693
VMA %		17.3115	16.762	16.934
VFB %		81.89	85.139	84.097
Dial gauge reading		560	550	545
Stability (kn)		11.2	11	10.9
Corrected stability (kn)		13.328	12.54	12.426
Flow Value		3.2	3.1	3.4
Marshall Quotient		4.165	4.045	3.655

Table 12 (0.1% ZycoTherm+8% PET).

Additive Used%	0.1% Zycotherm+ 8% PET	Location	ME Infra Asphalt Plant	
% Bitumen		6	6	6
Specimen air wt. (gm)		1130	1071	1141
Specimen water wt. (gm)		670	630	674
Specimen SSD wt. (gm)		1134	1076	1145
Specimen volume (cc)		464	446	471
Bulk density (gm/cc)		2.435	2.401	2.423
Specific gravity of bitumen (gm/cc)		1.02	1.02	1.02
Specific gravity of aggregate (gm/cc)		2.74	2.74	2.74
Theo. Specific gravity of mix(gm/cc)		2.488	2.488	2.488
VIM %		2.13	3.497	2.613
VMA %		16.434	17.621	16.863
VFB %		87.161	80.154	84.522
Dial gauge reading		490	455	465
Stability (kn)		9.8	9.1	9.3
Corrected stability (kn)		11.662	10.829	10.602
Flow Value		4.1	4.3	3.9
Marshall Quotient		2.84	2.578	2.719

Table 13 (Avg. value of Marshall Stability)

% Bitumen content/(%PET+%Zyco Therm) content	Avg. Bulk Density(gm/cc)	Avg. Void in Mix %	Avg. Corrected Stability (KN)	Avg. Flow	Avg. Marshall Quotient
6/(2+0.1)	2.432	2.263	10.92	3.333	3.273
6/(4+0.1)	2.384	4.18	14.558	3.517	4.143
6/(6+0.1)	2.419	2.773	12.765	3.23	3.955
6/(8+0.1)	2.42	2.747	11.031	4.1	2.713

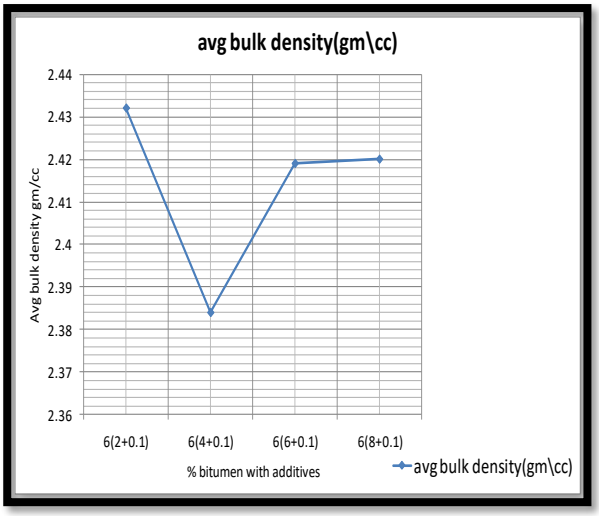

Fig. 10 (Avg. Bulk Density).

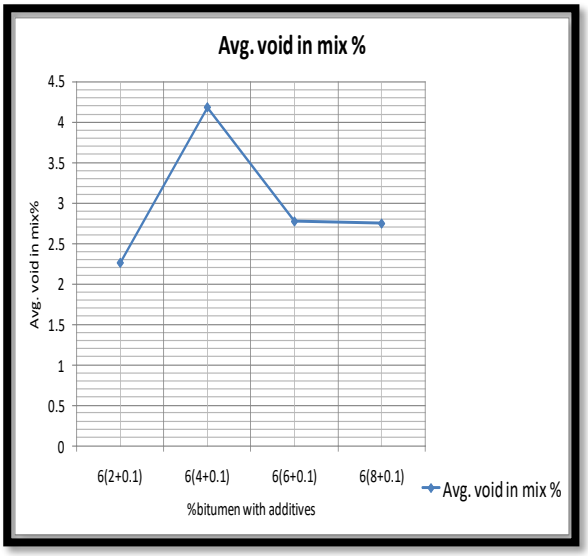

Fig. 11 (Avg. Void in Mix %)

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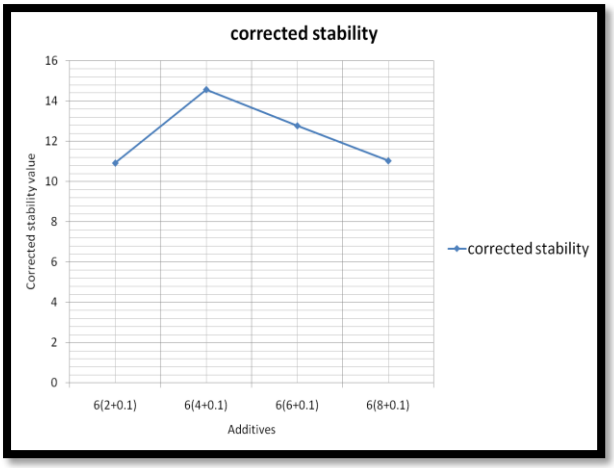

Fig. 12 (Corrected Stability)

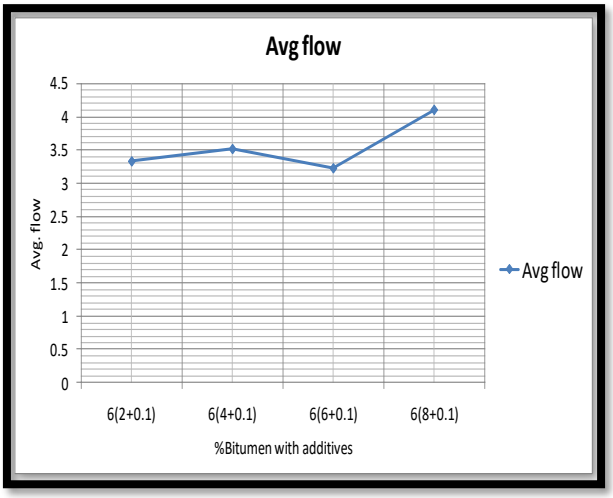

Fig. 13 (Avg. Flow)

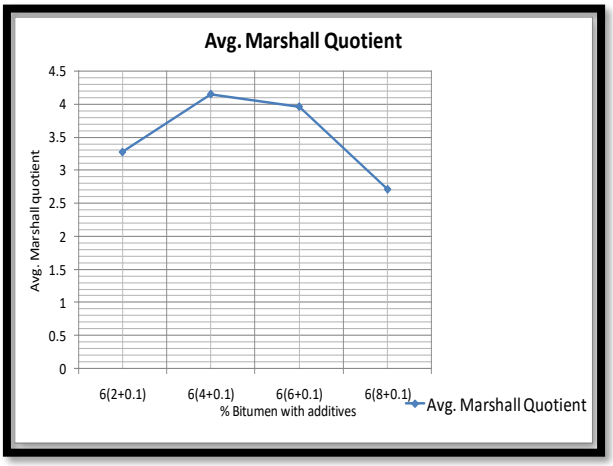

Fig. 14 (Avg. Marshall Quotient)

V. CONCLUSION

- It is observed that the penetration values of plain bitumen decrease on increase of the PET and ZycoTherm content. The results also show that the addition of PET and ZycoTherm makes the modified bitumen harder and more consistent than plain bitumen which results in improvement in the rutting resistance of the mix
- The results of the study indicated that the modified mixture have a better result compared to the non-modified mixture. By adding Polyethylene Terephthalate (PET) and ZycoTherm to the bitumen a better binding between binder and aggregates was obtained.
- It is observe that ductility value of plain bitumen increases with addition of ZycoTherm and PET.
- It is observe that softening point value of plain bitumen is increase with addition of ZycoTherm and PET. The increase in value observed as 58, 58.25, 62, 63.5 degree Celsius on addition of ZycoTherm and PET, whereas softening point value is decline at 0.1% ZycoTherm and 8% PET.
- Marshall Stability value is maximum at mixture of 0.1% of ZycoTherm and 4% of PET.

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REFERENCES

1. R. Vasudevan et al, “Reuse of waste plastic coated aggregates-bitumen mix composite for road application”.
2. E-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-02, Issue-11, pp-01-13.
3. R. Teppala et al, “Performance of zycosoil- A nano material as an additive with bituminous concrete mix”.
4. e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 11
5. Verma S.S, 2008, roads from plastic waste, science tech entrepreneur, The Indian concrete journal, p no 43-44.
6. Kumar and V. Kumar (2014) Fatigue behaviour of chemically treated bituminous concrete mix international journal of research (IJR) Vol-1, Issue-6, July 2014.
7. Ministry of Road transportation and highway (MoRTH) appendix 5 Anti-Stripping agents used for bituminous materials and mixes.

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8. M. Sulyman, J. Haponiuk, and K. Formela, Utilization of Recycled Polyethylene Terephthalate (PET) in Engineering Materials, pp. 1-2, Feb 2016.
9. A. F. Ahmad, A. R. Razali, I. S. M. Razelan, Utilization of polyethylene terephthalate (PET) in asphalt pavement, pp. 2-5, Jan 2004.
10. IS: 1203 (1978) "Method for testing tar and bituminous materials: determination of penetration value." BIS, New Delhi.
11. IS: 1205 (1978) "Method for testing tar and bituminous materials: determination of softening point." BIS, New Delhi.
12. IS: 1208 (1978) "Method for testing tar and bituminous materials: determination of ductility value." BIS, New Delhi.
13. http://zydexindustries.com/

Authors

First Author- Siddhesh Katkar, Undergraduate, Shree L.R. Tiwari College of Engineering
Second Author-Amol Bhosale, Undergraduate, Shree L.R. Tiwari College of Engineering
Third Author- Shubham Shinde, Undergraduate, Shree L.R. Tiwari College of Engineering
Fourth Author-Suraj Shrivastav, Undergraduate, Shree L.R. Tiwari College of Engineering

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