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Replacement of Bitumen with Waste Thermoplastic and Crumb Rubber

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Abstract: Plastic replace the other material easily due to this product cost is less. It is more economical than any other material but its large drawback is its disposal problem. Waste plastic affects the environment as well as human life in large extent. Thermo-plastic has properties due to this it can be used in the construction of road, because of this the construction cost is less. In this paper some amount of bitumen is replaced with thermoplastic and crumb rubber together to achieve more strength and durability in pavement construction.

Introduction: Plastic use becomes essential in daily basis because plastic is cheaper than any other material that's why is demand increases day by day. But as the demand increases its disposal problem also increases. Plastic is non-biodegradable product so its affect environment as well as human health. Due to all these reasons, it becomes necessary to use this plastic in a proper way. Use of plastic in road construction is a beneficial way. The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time. Therefore, it is proposed that we may use waste plastic and crumb rubber in the construction of roads.

Literature Review:

Utibe J. Nkanga, Johnson A. Joseph, various proportions of polymeric materials blended with bituminous mix were characterized. Strength and performance of bitumen/plastic blends were tested through marshall stability test, extraction test, sieve analysis, water absorption tests and bulk density. The results showed that bitumen/plastic blend has higher marshall stability of range 14.03 to 14.80 KN compared to conventional bituminous mixcsample which has a value of 11.35 KN. They also showed higher void air, lower bulk density and Marshall flow than the conventional bituminous mix. The results from the proportions of aggregate and quarry dust used in sieve analysis showed ratio 50:50 to be more appropriate for bitumen/plastic blends.

Majed A. Alhussain, Feras F. Almansoor, Low Density and High-Density Polyethylene and Crumb rubber were used as additions to base bitumen. Complex modulus (G*) and phase angle (δ) obtained from Dynamic Shear Rheometer (DSR) are the basic perimeters used to evaluate the behavior of the binder in respect to rutting and fatigue cracking. It was concluded that Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), and Crumb Rubber (CR) modified binder showed significant improvement in rheological properties of the binder.

Johnson Kwabena Appiah, Berko-Boateng, Trinity Ama Tagbor, this study examines the effect of blending waste thermoplastic polymers, namely high-density polyethylene (HDPE) and Polypropylene (PP) in Conventional AC-20 graded bitumen, at various plastic compositions. The plastics were shredded and blended with the bitumen 'in-situ', with a shear mixer at a temperature range of 160°C–170°C. Basic rheological parameters such as penetration, ring & ball softening point and viscosity tests were employed to determine the resulting changes from base bitumen. FTIR spectroscopy was also

employed to study the chemical functionalities present in the bitumen composite. The properties of the unmodified bitumen were found to be enhanced with the changes recorded in the rheological properties of the polymer modified bitumen (PMB). It was observed that polypropylene polymer, showed profound effect on homogeneity and compatibility with slight linear increment in the viscosity, softening and penetration values as against relatively high changes for HDPE modified bitumen.

Amit Gawande, G. Zamare, V.C. Rengea, Saurabh Tayde, G. Bharsakale, in this paper developed techniques to use plastic waste for flexible pavements has reviewed. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water.

Methodology:

Material used: Thermoplastic, Bitumen, Aggregate, Crump rubber

On heating at 100 - 160°C, plastics such as polyethylene, polypropylene and polystyrene, and crumb rubber soften and exhibit good binding properties. Blending of the softened plastic and crumb rubber with bitumen results in a mix that is suitable for road laying.

Few tests are conducted on Bitumen and their results are as follows:

Penetration Test	
Sample	**Penetration (mm)**
I	66
II	68
III	60

Ductility Test	
Sample	**Ductility in mm**
I	50
II	48
III	58

Softening Point Test	
Sample	**Softening temperature (^{0}c)**
I	40^0C
II	39^0C
III	42^0C

Fire and Flash Point Test	
Fire point of Bitumen	195^0c
Flash point of Bitumen	175^0c

Sample 1 (13 mm)

Sieve sizes (mm)	**Retain weight (gm)**	**Retain weight (%)**	**Cumulative % retain**	**Cumulative % retain passing**
19				100.00
16	340	3.40	3.40	96.60
12.5	4230	42.30	45.70	54.30
10	4625	46.25	91.95	8.05
4.75	805	8.05	100	0

2.36				
1.18				
0.6				
0.3				
0.15				
0.075				
Total	10000			

Sample 2 (6 mm)

Sieve sizes (mm)	Retain weight (gm)	Retain weight (%)	Cumulative % retain	Cumulative % retain passing
19				
16				
12.5				100
10	3620	36.20	36.20	63.80
4.75	6380	63.80	100	0
2.36				
1.18				
0.6				
0.3				
0.15				
0.075				
Total	10000			

Sample 3 (dust)

Sieve sizes (mm)	Retain weight (gm)	Retain weight (%)	Cumulative % retain	Cumulative % retain passing
4.75				100
2.36	1565	31.10	31.10	68.90
1.18	2295	45.90	77	23
0.6	545	10.90	87.90	12.10
0.3	285	5.70	93.60	6.40
0.15	145	2.90	96.50	3.50
0.075	135	2.70	99.20	0.80
PAN	40	0.80	100	0
Total	5000			

Semi –dense bituminous concrete (SDBC)

Sieve sizes (mm)	Cumulative % passing 13mm	Cumulative % passing 6mm	Cumulative % passing dust	Combined % passing	
19	100	100	100	25+25+50	100
13.2	54.30	1001	1088.6	13.6+25+50	88.60
4.75	0	0	100	0+0+50	50
2.36	0	0	68.90	34.45	34.45

1.18	0	0	23	11.50	11.50
0.6	0	0	12.10	6.05	
0.3	0	0	6.40	3.20	3.20
0.15	0	0	3.50	1.25	
0.075	0	0	0.80	0.40	0.40
PAN	0	0	0	0	

Gradation is made by taking 25% 13 mm, 25% 6mm, 50% dust

Casting of Marshall Stability Mould

For each mould 1200 gm material is required and Bitumen percentage is 5.25% of total material. (By weight.)

Casting of control cubes.

- 13 mm aggregate - 300 gm
- 6 mm aggregate - 300 gm
- Dust -576 gm
- Cement - 24 gm
- Bitumen -59 gm

Casting of 5% replacement CUBES

- 13 mm aggregate - 300 gm
- 6 mm aggregate - 300 gm
- Dust -576 gm
- Cement - 24 gm
- Bitumen -55 gm (5.25% of 1200gm material)
- Waste Plastic - 4 gm

% of plastic	Moisture absorption	Soundness	Voids	Aggregate crushing test	Losangeles abrasion	Aggregate impact value
NIL	4%	5%	4%	26%	37%	25.4%
1%	1%	NIL	2.2%	21%	32%	21.20
2%	1%	NIL	1%	20%	29%	18.50
3%	.5%	NIL	NIL	NA	NA	NA
5%	.35%	NIL	NIL	NA	NA	NA
10%	.12%	NIL	NIL	NA	NA	NA

Results and Discussions

Improved Characteristics of Plastic and Crumb Rubber Coated Aggregates
Water Absorption (%)

% of polymer coated over aggregate	Wt. of added plastic in (gm)	Sample 1	Sample 2	Sample 3	Average
-	-	0.56	0.57	0.55	0.56
0.5	2.50	0.44	0.40	0.42	0.42
0.75	3.75	0.32	0.28	0.28	0.29
1.0	5.00	0.24	0.22	0.20	0.22

Cost will be decreased due to using waste plastic in Construction of road the following is cost benefits analysis:

25mm SDBC-10m sq. COST BENEFIT ANALYSIS

Material needed	Plain bitumen process	Plastic-tar Road
80/100	11250kg	10125kg
Plastic waste	-	1125kg
Cost	Rs.393750	(BIT) Rs.354375+(plastic) Rs.13500=Rs.367875
Cost reduced	NIL	Rs.25875.00
Carbon credit achieved on avoiding burning of plastic	NIL	3.50 tonnes

Conclusion

Plastics will increase the melting point of the bitumen. The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste.

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