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Utilization of Waste Plastic in Flexible Pavement – An Approach to Sustainable Development

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ABSTRACT: The debate on the use and abuse of plastics vis-à-vis environmental protection can go on, without yielding results until practical steps are initiated at the grassroots level by everyone who is in a position to do something about it. The plastic wastes could be used in road construction and the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems. The present write-up highlights the developments in using plastics waste to make plastic roads.

KEYWORDS: Waste Plastic, Sustainable Development, Pavement, testing, optimization.

I. INTRODUCTION

The growth in various types of industries together with population growth has resulted in enormous increase in production of various types of waste materials, world over. The creation and disposal of non-decaying waste materials such as Blast Furnace Slag, Fly-ash, Steel Slag, Scrap Tyres, Plastics, etc. have been posing difficult problems in developed as well as in developing countries. Considerable work has been done in various countries for the disposal of some of these waste products and utilization of some other products and there is a long list of published literature dealing with different aspects of these challenging problems. Attempts are still being made by various organizations and researchers to find methods for effective utilization of some of these waste materials.

II. LITERATURE REVIEW

Bahia and Anderson, (1984); studied the Bitumen is a thermo-visco-elastic material where temperature and rate of load application have a great influence on their behavior. They are classified as rheological materials since their viscosity stress and strain response is both time and temperature dependent. The binder consistency and hence ability to sustain and hold its fundamental cementing mechanism changes depending on its viscosity. In the study bitumen with penetration grade 60/70 were modified with sasobit wax (S), which is obtained from coal gasification using the Fischer-Tropsch process, with long-chain hydrocarbon.

Francis Hveem (1942), who was a project engineer of California Department of Highways, has developed the Hveem stability meter in 1927. He did not have any previous experience on judging, the required mix from its colour, hence he decided to measure various mixture parameters to find the optimum quantity of bitumen [Vallerga and Lovering 1985]. He had used the surface area calculation concept, (which was already in use, at that time for the cement concrete mix design), to estimate the quantity of bitumen actually required.

Roberts et al. (2002) the technique, of using bitumen in pavements, was first used on rural roads in order to prevent rapid removal of the fine particles such as dust, from Water Bound Macadam, which was caused due to fast growth of automobiles. At initial stages, heavy oils were used as dust palliative. An eye estimation process which is called pat test was used to estimate the required quantities of the heavy oil, in the mix.

Dr. R. Vasudevanand S. Rajasekaran(2007) states that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased Softening point and decreased Penetration value with a suitable ductility. When it used for road construction it can withstand higher temperature and load. The coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better

material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics.

P K Jain & Shanta Kumar (2011), Rutting is caused by accumulation of permanent deformations caused by repeated applications of traffic loads and it is a stress controlled cyclic loading Phenomenon. The process of deformation of bituminous surfacing is accelerated by increase of pavement temperature, reduction in stiffness of mix and increase in traffic loads. The aim of this paper is to report findings of study on increase in stiffness modulus of bituminous mixes by incorporation of waste polymeric packaging material (WPPM) to enhance pavement performance as well as to protect environment. This work presents studies on use of WPPM in road construction. Polymeric poly packs are used for packaging of milk for distribution to consumers and such bags after consumption of milk are thrown away. These used milk bags and other high density polyethylene (HDPE) based carry bags are used as additives in bituminous mixes.

Shukla and Jain (1984) described that the effect of wax in bitumen can be reduced by adding EVA (Ethyl Vinyl Acetate), aromatic resin and SBS in the waxy bitumen. The addition of 4% EVA or 6% SBS or 8% resin in waxy bitumen effectively reduces the Susceptibility to high temperatures, Bleeding at high temperature and brittleness at low temperature of the mixes.

III. PRELIMINARY STUDY OF WASTE PLASTIC

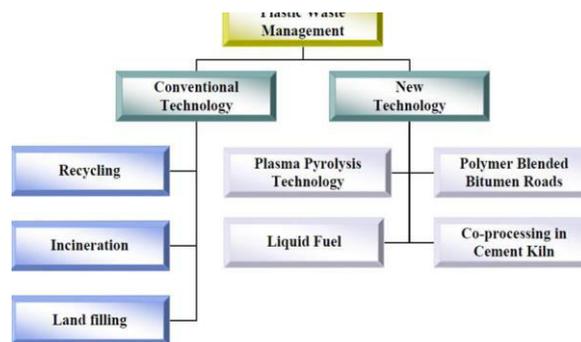


Figure 1: Ways of waste plastic utilization

The studied on the thermal behavior and binding property promoted a study on the preparation of plastics waste – bitumen blend and its properties to find the suitability of the blend for road construction. Polymer Modified Bitumen (PMB) using virgin polymers and recycled polymers are being studied and it has been found that the PMB can be used for flexible pavement. Use of plastic waste is the need of the hour.

Table 1: Comparison between Other Roads and Bituminous Plastic Mix Roads

Sr. No.	Other Roads	Bituminous Plastic Mix Roads
1	Strength is less.	Strength is more compared to other roads.
2	Resistance towards water stagnation is less i.e. pot holes may occur.	Resistance towards water stagnation is more i.e. no pot holes are found.
3	Blending takes place at 45°C for bituminous roads without plastic.	Blending plastic roads remains stable even at 55°C.
4	Durability is less.	Durability is more.
5	Maintenance cost is low.	Maintenance cost is more.

IV. LABORATORY EXPERIMENT& RESULT ANALYSIS

The uses of plastic materials like carry bags, cups, etc. are increasing. The consumption of plastics have increased from 4000 tons/annum (1990) to 4 million tons/annum (2001) and it is expected to rise to 7.5 million tons/annum during the year 2007. Nearly 50 to 60% of the total plastics are consumed for packing. They are prepared from PE, PP and PS. Once used, the plastics materials are thrown out. They do not undergo bio-decomposition. Hence, they are either land filled or incinerated. Both are not eco-friendly processes. They pollute the land and the air respectively.

Characterization of Experimental Material

Numbers of tests were carried on the materials that are to be used in preparation of bituminous concrete specimen for their suitability according to MORTH 2001 as well as respective IS Codes for the following materials:

- Basic materials
- Bitumen (Ordinary and modified)
- Natural aggregate.
- Waste plastic coated aggregates

Preparation of test sample



Figure 2: Prepared Test Sample

- Measure out 1500g of aggregate in the desired proportions. Heat the aggregate in the oven to the mixing temperature.
- Add bitumen at the mixing temperature to produce viscosity of 170 centistokes at various percentages both above and below the expected optimum content.
- Mix the materials in a heated pan with heated mixing tools.
- Return the mixture to the oven and reheat it to the compacting temperature.
- Place the mixture in a heated Marshall mould with a collar and base. Spade the mixture around the sides of the mould. Place filter papers under the sample and on top of the sample.
- Place the mould in the Marshall Compaction pedestal.
- the material with 75 blows of the hammer invert the, and compact the other face with the same number of blows.
- After compaction invert the mould .with the collar on the bottom, remove the base and extract the sample by pushing it out the extractor.
- Allow the sample to stand for a few hours to cool.
- Obtain the sample's mass in air and submerged, to measure density of specimen, so as to allow, calculation of the voids.



Figure 3: Aggregate, Shredded Plastic, & Plastic Coated Aggregate

V. EXPERIMENTAL RESULTS

Results Obtained for without addition of waste plastic

Table 2: Marshall Stability value for 0% plastic waste

Sr. No.	% of bitumen	Weight of sample (gm)	Height (cm)	Bulk density (gm/cc)	% Air Voids	% V.M.A.	Stability (KN)	Flow (mm)
1	2.5	1372	7.5	1985	5.55	28.75	15.19	2.19
2	3	1360	7.5	2010	5.32	28.94	15.54	2.56
3	3.5	1345	7.4	2030	4.86	29.45	15.92	3.32
4	4	1296	7.3	2039	4.56	29.7	16.45	3.54
5	4.5	1307	7.3	2024	4.27	29.85	16.78	4.12
6	5	1297.5	7.3	2041	4.07	30.23	17.01	4.45
7	5.5	1357.5	7.5	1990	4.10	30.45	16.87	4.65
8	6	1372	7.5	1945	4.12	30.76	16.54	4.87
9	6.5	1331.5	7.4	1910	4.12	30.96	15.99	5.12

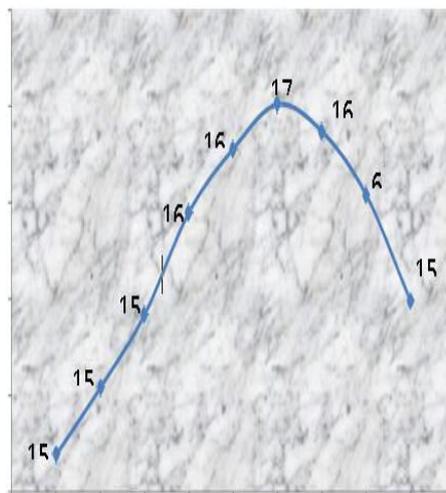


Figure 4: Stability (KN) Vs % of bitumen content for 0% plastic mix

Result obtained for 5% waste plastic added

Table 3: Marshall Stability value for constant 5% plastic waste

Sr. No.	% of bitumen	Weight of sample (gm)	Height (cm)	Bulk density (gm/cc)	% Air Voids	% V.M.A.	Stability (KN)	Flow (mm)
1	3	1338	7.4	1954	5.74	31.02	17.98	2.54
2	3.5	1294	7.3	2020	5.53	31.29	18.34	2.92
3	4	1297	7.3	2041	5.39	31.5	19.03	3.45
4	4.5	1308	7.3	2056	5.13	32.1	19.54	3.78
5	5	1295.5	7.3	2030	4.91	32.51	19.91	4.1
6	5.5	1374	7.5	1992	4.96	33.21	19.74	4.51
7	6	1332	7.4	1950	5.02	33.65	19.45	4.73
8	6.5	1326	7.4	1881	5.07	33.85	18.87	4.96

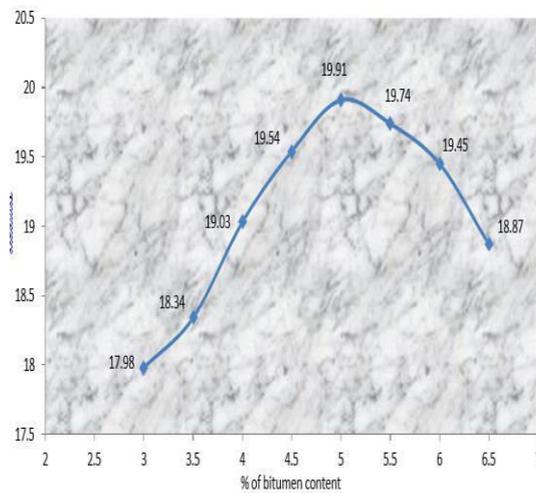


Figure 5: Stability (KN) Vs % of bitumen content for 5% plastic mix

Results obtained for 10% plastic addition

Table 4 : Marshall Stability value for constant 10% plastic waste

Sr. No.	% of bitumen	Weight of sample (gm)	Height (cm)	Bulk density (gm/cc)	% Air Voids	% V.M.A.	Stability (KN)	Flow (mm)
1	3	1310	7.4	1900	5.85	40.05	19.32	2.89
2	3.5	1312	7.4	1956	5.65	40.5	19.64	3.12
3	4	1308	7.4	2042	5.43	41.21	20.32	3.56
4	4.5	1330	7.5	2084	5.12	41.83	20.81	3.7
5	5	1295	7.3	2104	5.02	42.12	21.03	4.1
6	5.5	1332	7.5	2075	5.14	42.65	20.87	4.62
7	6	1374	7.5	1995	5.21	42.94	20.45	4.86
8	6.5	1378	7.5	1925	5.28	43.12	19.83	5.13

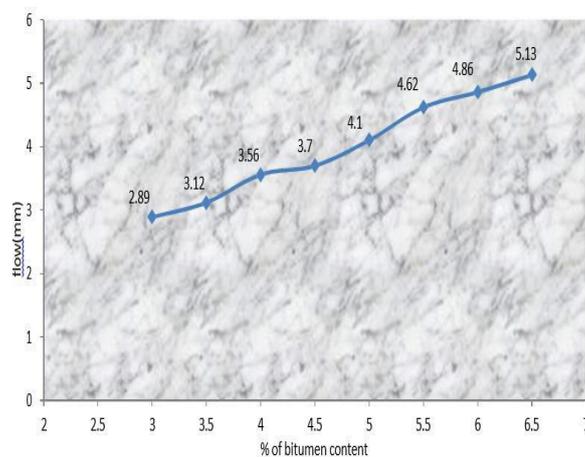


Figure 6: Flow (mm) Vs % of bitumen content for 10% plastic mix

Results obtained for 15% Plastic Addition

Table 5: Marshall Stability value for constant 15% plastic waste

Sr. No.	% of Bitumen	Weight of sample (gm)	Height (cm)	Bulk density (gm/cc)	% Air Voids	% V.M.A.	Stability (KN)	Flow(m. m)
1	3	1312	7.4	2120	6.56	44.54	17.98	3.01
2	3.5	1324	7.4	2170	6.32	45.01	18.34	3.34
3	4	1328	7.5	2231	5.98	45.32	19.03	3.76
4	4.5	1335	7.5	2275	5.76	45.64	19.54	4.09
5	5	1364.5	7.5	2305	5.45	45.81	19.91	4.56
6	5.5	1362	7.5	2285	5.5	46.15	19.74	4.97
7	6	1308	7.4	2258	5.57	46.42	19.45	5.43
8	6.5	1334	7.5	2204	5.65	46.75	18.87	5.87

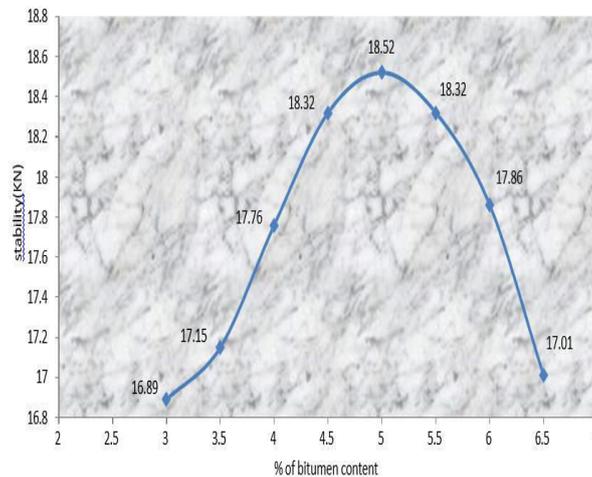


Figure 7: Stability (KN) Vs % of bitumen content for 15% plastic mix

VI. CONCLUSION

From the study of the behavior of polythene modified BC it was found that the modified mix possesses improved Marshall Characteristics as mentioned below. It is observed that Marshall Stability value increases with polyethylene content up to 10% and thereafter decreases. We observe that the Marshall Flow value decreases upon addition of polythene i.e. the resistance to deformations under heavy wheel loads increases. Also the values of the parameters like VMA, VA are within the required specifications.

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