USE OF PET (POLY ETHYLENE TERAPHTALATE) IN BITUMINOUS PAVEMENT

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Abstract
Over the years, plastics have become the preferred packaging material by virtue of their superiority over other conventional materials. With the increasing use ofplastic as packaging material, post-consumer plastic wastes became an increasingly serious environmental issue.So,there is an immediate need for adoption of environment friendly technologies such as economic recycling, development of biodegradable plastics, conversion of plastic wastes into value added products and fuel, use of plastic wastes for road construction, recycling of PET bottles into fibers or bottle to bottle technologies etc. In this paper, an attempt was made to summarise the present scenario of plastics waste management vis-à-vis various disposal techniques, which need to be expeditiously taken-up with an eye oninnovative solutions.

Keywords: - *Poly Ethylene Teraphthalate, Flow, Plastics, stability, tensile strength*

1. INTRODUCTION

Increasing urbanization and industrialization have contributed for increased plastic generation. Safe disposal of waste plastic is a serious environmental problem. They pose a threat to the environment essentially due to the lack of an efficient collection and disposal system, as they are non-biodegradable. Plastics are most commonly used in the form of carry bags, packaging material, containers etc. Due to accumulation of plastic wastes as they are non- biodegradable, some of them are non-recyclable pose a serious threat to the environment(1) The best way of disposal of waste plastic is its recycling to the maximum extent and many developed countries have recycled waste plastics to manufacture various products. Studies have revealed that waste plastics have great potential for use in bituminous construction as its addition in small doses, about 5-10%, by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous mix, leading to improved longevity and pavement performance. The use of waste plastic thus contributes to construction of green roads. (5)The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

2. PLASTICS & PLASTIC WASTE

Among plastics, Polyethene forms the largest portion followed by Polyethylene Terephthalate (PET). It is obtained in massive quantity from bottles most commonly used for packaging of beverages and drinking water . India approximately produces 40 million tons of solid waste of which 12.3% is plastic which is discarded mainly in form of water bottles. Depending on their physical properties, they may be classified as thermoplastic and thermosetting materials. Thermoplastic materials can be formed into desired shapes under heat and pressure and become solids on cooling. On subjected to the same conditions of heat and pressure, they can be remolded. Thermosetting materials which once shaped cannot be softened/remolded by the application of heat. Table 2 gives the polymer demand in India from 1995 to 2011.The examples of some typical Thermoplastic and Thermosetting materials are tabulated in Table 3. Thermosetting materials are not used in pavement construction.. India has among the lowest per capita

consumption of plastics and consequently the plastic waste generation is very low as seen from the Table 4. India has among the lowest per capita consumption of plastics and consequently the plastic waste generation is very low as seen from the Table4. Table5 indicates the various sources of waste plastic generation.

TABLE1: Plastics Consumption in India[1]:

YEAR	CONSUMPTION (Tonnes)
1996	61,000
2000	3,00,000
2001	4,00,000
2007	8,500,000
2011	13,50,000

TABLE2: Polymer Demands In India (Million Tones)[1]

S No	Type of polymer	1995-96	2001-02	2006-07
1	Polyethylene	0.83	1.83	3.27
2	Polypropylene	0.34	0.88	1.79
3	Poly vinyl chloride	0.49	0.87	1.29
4	Poly Ethylene Teraphthalate	0.03	0.14	0.29

Source: National Plastic Waste Management Task Force (1997)

TABLE 3: Typical ThermoPlastic and ThermoSetting Resins [4]

SNo	THERMOPLASTIC	THERMOSETTING
1	Polyethylene Teraphthalate(PET)	Bakelite
2	Polypropylene (PP)	Epoxy
3	Poly Vinyl Acetate (PVA)	Melamine
4	Poly Vinyl Chloride (PVC)	Polyester
5	Polystyrene (PS)	Polyurethane
6	Low Density Polyethylene(LDPE)	Urea-Formaldehyde
7	High Density Polyethylene (HDPE)	

TABLE 4: Plastic waste consumption [4]

S No	Description	World	India
1	Per capita per year consumption of plastic (kg)	24	6-7
2	Recycling (%)	15-20	60
3	Plastic in Solid Waste (%)	7	9

TABLE 5: Sources of Waste Plastic [4]

Waste Plastic	Origin
Low Density Polyethylene (LDPE)	Carry bags,sacks,milk pouches, bin lining, cosmetic and detergent bottles.
High Density Polyethylene (LDPE)	Carrybags,bottlecaps,household articles etc., Drinking water bottles etc.
Polyethylene Teraphthalate (PET)	Bottle caps and closures, wrappers of detergent, biscuit, wafer packets, microwave trays for readymade meal etc.,
Polypropylene (PP)	Yoghurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging etc.
Polystyrene (PS)	Mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, folders and pens, medical disposables etc.
Polyvinyl Chloride (PVC)	

3. RESEARCH ON WASTE PLASTICS USE IN ROAD CONSTRUCTION:

Vasudevan et al[5] utilized polythene/poly propylene Bags for integrated development of Rural and Arterial road network for socio-economic Growth. He studied both dry and wet mixing process by adding polymer with respect to the weight of bitumen used. Author reported that polymer bitumen blend is a better binder compared to plain bitumen resulting higher Marshall Stability and decreasing the possibilities of pot-holes formation.

Verma et al [6] studied that plastic increases the melting point of the bitumen and makes the road flexible during winters resulting in its long life. According to author while a normal “highway quality” road lasts four to fiveyears, plastic-bitumen roads can last up to 10 years and it 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.

Sabina et al.[7] evaluated the performance of waste plastic/polymer modified bituminous mix and observed that the results of marshal stability and retained stability of polythene modified bituminous concrete mix increases 1.21 and 1.18 times higher than that of conventional mix by using 8% and 15% (by weight of bitumen) polythene with respect to 60/70 penetration grade of bitumen. But modified mix with 15% polyethylene showed slightly decreased values for Marshall Stability than that of the mix with 8% modifier in their results.

Bindu and Beena et al[8] studied how Waste plastic acts as a stabilizing additive in Stone Mastic asphalt when

the mixtures were subjected to performance tests including Marshall Stability, tensile strength, compressive strength tests and Tri-axial tests. There results indicated that flexible pavement with high performance and durability can be obtained with 10% shredded plastic.

Habib et al.[9] studied rheological properties of bitumen modified by thermoplastic namely linear low density polyethylene (LLDPE), high density polyethylene (HDPE) and polypropylene (PP) and its interaction with 80 penetration grade of bitumen through penetration test, ring & ball softening point and viscosity test. It was observed that thermoplastic copolymer shows profound effect on penetration rather than softening point. According to author Visco-elastic behaviour of polymer modified bitumen depend on the concentration of polymer, mixing temperature, mixing technique, solvating power of base bitumen and molecular structure of polymer used and PP offer better blend in comparison to HDPE and LDPE.

Punith and Veeraragavan et al.[10] studied Behavior of Asphalt Concrete Mixtures with reclaim.ed polyethylene as additive. The dynamic creep test (unconfined), indirect tensile test, resilient modulus test, and Hamburg wheel track tests were carried out in their investigation on blend of PE (2.5, 5.0, 7.5, and 10% by weight of asphalt) with (80/100) paving grade asphalt and observed that the rutting potential and temperature susceptibility can be reduced by the inclusion of PE in the asphalt mixture.

Sui and Chen et al.[11] studied application and performance of polyethylene as modifying additive in asphalt mixture. They added polyethylene as additive to hot mineral aggregate for few minutes, and then added the asphalt mixing together which simplifies the construction process and reduces the cost of construction. They concluded that there is improvement on high temperature stability, low temperature cracking resistance and water resistance on modification and evaluate polyethylene as additive in the technical, economic and environmental aspects.

Gawande et al.[12] gave an overview on waste plastic utilization in asphalting road by using both wet and dry method. They said that use of modified bitumen with the addition of processed waste plastic of about 5-10% by weight of bitumen helps in improving the longevity and pavement performance with marginal saving in bitumen usage and according to them use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure.

Khan and Gundaliya et al[13] stated that the process of modification of bitumen with waste polythene enhances resistance to cracking, pothole formation and rutting by increasing softening point, hardness and reducing stripping due to water, thereby improving the general performance of roads over a long period of time. According to them the waste polythene utilized in the mix forms coating over aggregates of the mixture which reduces porosity, absorption of moisture and improves binding property.

Vargas et al.[14] analysed the chemically-grafted polyethylene as asphalt modifiers. Their results show that the softening point of asphalt increased, while the penetration degree decreased in blends prepared with grafted polyethylene and the phase distributions of micrographs from fluorescence microscopy show that non-grafted polyethylene polymers were not readily miscible with asphalt. The results of rheological tests carried out in their study indicate that most of asphalt blends exhibit improved performance at higher temperature with grafted polyethylene such as enhancing rutting resistance, flow activation energy and superior time–temperature-dependent response as compared to the reference polyethylene blends.

4. RESEARCH ON PET WASTE USE IN ROAD CONSTRUCTION:

Zahra Niloofar Kalantar,Mahrezand karim et al.[15] carried out various studies samples with and without PET waste .results suggested that PET mixes resulted higher resistance ton rutting and permanent deformation, decreases the consistency.PET modified binders have higher resistance to permanent deformation,rutting due to higher softening point compared with conventional binders.

Ahmadinia et al.[16] carried out an experimental research on the application of waste plastic bottles (Polyethylene Terephthalate (PET)) as an additive in stone mastic asphalt (SMA). Wheel tracking, moisture susceptibility, resilient modulus and drain down tests were carried out in their study on the mixtures that included various percentages of waste PET as 0%, 2%, 4%, 6%, 8% and 10% by weight of bitumen content. Their results show that the addition of waste PET into the mixture has a significant positive effect on the properties of SMA

which could improve the mixture's resistance against permanent deformation (rutting), increase the stiffness of the mix, provide lower binder drain down and promotion of re-use and recycling of waste materials in a more environmentally and economical way.

Rahman and Wahab et al.[17] used recycled polyethylene terephthalate (PET) as partial replacement of fine aggregate in modified asphalt in their investigation. In term of economic value, it shows that this recycled PET could reduce cost of road construction because this recycled material is cheaper than bitumen and easy to obtain, which also improves the level of performance and the service life of the road. It can be concluded from their study that the application of recycled PET modified asphalt gives more advantages compared to the conventional asphalt mixture especially in term of permanent deformation.

5. CONCLUSION:

The use of waste plastic for road construction can save the environment, increase the service life of roads, reduce the consumption of petroleum products and serve the society with additional income for those associated with it. When compared with the control section, the stretches resurfaced using plastic coated aggregates have shown improved functional performance in terms of better surface condition, delayed pothole and crack initiation and progression, desirable skid resistance and surface texture.

In Dry process, the aggregate is modified by coating with polymers and producing a new modified raw material for flexible pavement. Patent has been obtained for this process. The coating of plastics over aggregate also improves the quality of the aggregate. Dry Process helps us to Use higher percentage of plastics waste, Reduce the need of bitumen by around 10%.,increase the strength and performance of the road, reduces the cost, provide employment for rag pickers .

In Wet Process,Waste plastic is ground and made into powder ,some % of plastic is mixed with the bitumen. Plastic increases the melting point of the bitumen and makes the road retain its flexibility during winters resulting in its long life. Use of shredded plastic waste acts as a strong "binding agent" for tar making the asphalt last long. By mixing plastic with bitumen the ability of the bitumen to withstand high temperature increases. The plastic waste is melted and mixed with bitumen in a particular ratio.

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