USE OF WASTE PLASTIC IN FLEXIBLE PAVEMENTS

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ABSTRACT

Disposal of waste materials including waste plastic bags has become a serious problem and waste plastics are burnt for disposal which cause environmental pollution. Utilization of waste plastic bags in bituminous mixes has proved that these increase the properties of mix in addition to solve the disposal problems. The aggregate mix is heated and the plastic is effectively coated over the aggregate. This plastic waste coated aggregate is mixed with hot bitumen and the resulted mix is used for in construction of road. These roads would be a boon for India's hot and extremely humid climate where temperatures frequently cross 50°C and rapid rains create havoc, leaving most of the roads with large potholes.Plastics are not eco-friendly as they are non-biodegradable. It is generally disposed by way of land filling or incineration of materials which are hazardous for environment. The better binding property of molten plastic has helped in finding out a safe method of disposal of waste plastics, by using them in road construction. Modified Bitumen is one of the main construction materials for green pavements. Use of plastic waste such as Low Density Polyethylene (LDPE) and Rubber Crumbs i.e. the rubber obtained by crushing waste tyres of vehicles, in the construction of flexible (Green) pavement is accreting importance. Thus it not only allows us to gather modifier rawmaterial at low cost, but also gives a solution towards ecological danger posed by greater use of non-biodegradable plastics.

Key words:Bitumen mix, Non-Biodegradability,Plastic Waste, Aggregates, Plastic Roads

I.INTRODUCTION

Polymer modified bitumen is emerging as one of the important construction materials for flexible pavements. Use of plastic waste in the construction of flexible pavement is gaining importance because of the several reasons. The polymer modified bitumen show better properties for road construction & plastics waste, otherwise considered to be a pollution menace, can find its use in this process and this can help solving the problem of pollution because most of the plastic waste is polymers. In India, it is estimated that over 33 lakh kilometers of road exists. The road transport carries close to 90% of passenger traffic and 70% of freight transport. Investigations in India and countries abroad have revealed that properties of bitumen and bituminous mixes can be improved to meet requirements of pavement with the incorporation of certain additives or blend of additives.

These additives are called "Bitumen Modifiers" and the bitumen premixed with these modifiers is known as modified bitumen. Modified bitumen is expected to give higher life of surfacing (up to 100%) depending upon degree of modification and type of additives and modification process used. Different types of modifiers used are Polymers, Natural Rubber and Crumb Rubber.Plastic is a very versatile material. Due to the industrial revolution, and its large scale production plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, electronics, electrical, building construction, communication sectors has been virtually revolutionized by the applications of plastics. Plastic is a non-biodegradable material and researchers are found that the material can remain on earth for 4500 years without degradation. Several studies have proven the health hazard caused by improper disposal of plastic waste. The health hazard includes reproductive problems in human and animal, genital abnormalities etc., Looking forward the scenario of present life style a complete ban on the use of plastic cannot be put, although the waste plastic taking the face of devil for the present and future generation. We cannot ban use of plastic but we can reuse the plastic waste.According to recent studies, plastics can stay unchanged for as long as 4500 years on earth with increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its biodegradability it creates stagnation of water and associated hygiene problems. In order to contain this problem experiments have been carried out whether this waste plastic can be reused productively. 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. Waste plastic such as carry bags, disposable cups and laminated pouches like chips, pan masala, aluminum foil and packaging material used for biscuits, chocolates, milk and grocery items can be used for surfacing roads.

Since 90's, considerable research has been carried out to determine the suitability of plastic waste modifier in construction of bituminous mixes. Zoorab & Suparma reported the use of recycled plastics composed predominantly of polypropylene and low density polyethylene in plain bituminous concrete mixtures with increased durability and improved fatigue life. Dense bituminous macadam with recycled plastics, mainly low density polyethylene (LDPE) replacing 30% of 2.36–5mm aggregates, reduced the mix density by 16% and showed a 250% increase in Marshall Stability, the indirect tensile strength (ITS) was also improved in the 'Plastiphalt' mixtures D.N. Little worked on the same theme and he found that resistance to deformation of asphaltic concrete modified with low density polythene was improved in comparison with unmodified mixes. It is found that the recycled polyethylene bags may be useful in bituminous pavements resulting in reduced permanent deformation in the form of rutting and reduced low temperature cracking of pavement surfacing. Bindu et al. investigates the benefits of stabilizing the stone mastic asphalt (SMA) mixture in flexible pavement with shredded waste plastic. Conventional (without plastic) and the stabilized SMA mixtures were subjected to performance tests including Marshall Stability, tensile strength and compressive strength tests. Triaxial tests

were also conducted with varying percentage bitumen by weight of mineral aggregate (6% to 8%) and by varying percentage plastic by weight of mix (6% to 12% with an increment of 1%). Plastic content of 10% by weight of bitumen is recommended for the improvement of the performance of Stone Mastic Asphalt mixtures.10% plastic content gives an increase in the stability, split tensile strength and compressive strength of about 64%, 18% and 75% respectively compared to the conventional SMA Mix. Triaxial test results show a 44% increase in cohesion and 3% decrease in angle of shearing resistance showing an increase in the shear strength. The drain down value decreases with an increase in plastic content and the value is only 0.09 % at 10% plastic content and proves to be an effective stabilizing additive in SMA mixtures. Stone Mastic Asphalt is a gap graded bituminous mixture containing a high proportion of coarse aggregate and filler. It has low air voids with high levels of macro texture when laid, resulting in a waterproof layer with good surface drainage. Stabilizing additives are needed in the mastic which is rich in binder content to prevent the binder from draining down from the mix. Polymers and fibers are the commonly used stabilizing additives in SMA. Based on many research reports and engineering case studies has been shown that the use of stone mastic asphalt (SMA) on road surfaces can achieve better rut-resistance and durability. Recycled LDPE of a size between 0.30 and 0.92mm replacing 15% aggregates in asphalt surfacing nearly doubled the Marshall quotient, and increased the stability retained (SR) by 15%, implying improved rutting and water resistance. A 20% increase of binder content was required in this case.

II.PROPOSED METHOD OF WORK

A) Preparation of blend:

Polyethylene carry bags were cut into pieces using a shredding machine. It was sieved and the plastics pieces passing through 4.75mm sieve and retaining at 2.36mm sieve were collected. These plastic pieces were added slowly to the hot bitumen of temperature around 170-180^{0}C. The mixture was stirred well using mechanical stirrer for about 20-30 minutes. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests.

B) Characterization of Blend

- Separation test (IRC-SP: 53-1999)

  Samples of different composition were prepared and subjected to the separation test. The following observations were made on the basis of their softening point values. Homogeneity was obtained approximately up to 1.5% blend. Beyond this composition, the variation of softening point was much higher for the top and bottom layer of the test samples showing that there is a separation of polymer from bitumen on standing.
- Determination of softening point (IS: 1205-1978)

  The blend of different composition with different percentage of plastic waste has been prepared and their softening points were determined as given in Table-1. It is observed that the softening point increases by the

addition of plastic waste to the bitumen. Higher the percentage of plastic waste added, higher is the softening point. The influence over the softening point may be due to the chemical nature of polymers added.

SOFTENING POINT (IN C)

% OF POLYMER IN BITUMEN	POLYETHYLENE	POLYPROPYLENE	POLYSTYRENE
0	50	50	50
0.5	52	57	53
1	60	62	60
1.5	62	63	61

TABLE NO.1(VARIATION IN SOFTENING POINT)

- Penetration Test: (IS: 1203-1978) Samples having different percentage of plastic waste in bitumen were prepared and their penetration values determined as per the IS Code given in Table-2. The penetration values of blends are decreasing depending upon the percentage of polymers and the type of polymer added the increase in the percentage of polymer decreases the penetration value. This shows that the addition of polymer increases the hardness of the bitumen.

PENETRATION VALUE AT 25 C(IN mm)

% OF POLYMER IN BITUMEN	POLYETHYLENE	POLYPROPYLENE	POLYSTYRENE
0	70	70	70
1	68	68	68
1.5	67	68	68
2	64	64	65

TABLE NO.2(VARIATION IN PENETRATION VALUE)

- Ductility

  Table-3 shows that the ductility is decreasing by the addition of plastic waste to Bitumen. The decrease in the ductility value may be due to interlocking of polymer molecules with bitumen.

DUCTILITY(IN cm)

% OF POLYMER IN BITUMEN	POLYETHYLENE	POLYPROPYLENE	POLYSTYRENE
0	75	75	75
1	66	50	50
1.5	53	48	45
2	35	33	37

TABLE NO.3(VARIATION IN DUCTILITY)

- Flash and fire point (IS: 1209-1978) The studies of flash and fire points of the plastic waste-bitumen blend helps to understand the inflammability nature of the blend. Flash & fire point of plain Bitumen is 175-210^{0}C. From the experimental results it is observed that the inflammability of the blend is decreasing as the percentage of polymer increases. The blend has developed better resistance to burning. The polymer bitumen blend road surfaces will be less affected by fire hazards.

III.RESULT

The studies of properties of the plastic waste-blended bitumen show that the addition of plastic waste to bitumen increases softening point, decreases penetration value and ductility, increases flash point and fire point, increase Marshall stability value and improve anti-stripping properties. Yet the above process has its own limitations

- The preparation of such modified bitumen needs high power stirrer with thermostatic facilities to maintain the temperature between160-180^{0}C. Any increase in the temperature could affect the properties of bitumen.
- The proper storage of such polymer-blended bitumen is very important. It should be stored in a freezer and it is also referred that it is stable for 6 hrs at a temperature of 180^{0}C
- It was also observed from the separation test that when the plastic was mixed beyond the soluble range (from 2% and above) the excess plastic material got separated on cooling.
- These limitations necessitated developing an alternate method for using higher percentage of plastic waste for flexible pavement.

Preliminary studies on the use of plastic-waste as a blending material with bitumen, suggest that the blends behave similar to PMB, thus having improved properties compared to plain bitumen. It is also observed that this process of blending has limitation. At high percentage of blending there is separation of plastic. Hence, process modification was needed and a new product namely plastic waste coated aggregate was developed. This product is not only easy to prepare but also helps to use higher percentage of plastic-waste for coating without much of difficulty.

The coating of molten-plastic over the aggregate will reduce water absorption. This shows that the voids at the surface were reduced. Lesser the voids better the quality of the aggregate. Otherwise, the air entrapped in the voids would cause oxidation of bitumen resulting in stripping, pothole formation etc. Moreover, the presence of water in the voids is detrimental to adhesion between aggregate and the binder namely bitumen. Hence the aggregate with lesser voids is considered to be good for better road construction. These observations help to conclude that plastic-waste coated aggregate can be considered as more suitable material for flexible pavement construction.

IV.CONCLUSION

Polymer Modified Bitumen is used due to its better performance. But in the case of higher percentage of polymer bitumen blend, the blend is a more polymer dispersion in bitumen, which get separated on cooling. This may affect the properties and quality of the blend and also the road laid using such blend. In the modified process (dry process) plastics-waste is coated over aggregate. This helps to have better binding of bitumen with the plastic-waste coated aggregate due to increased bonding and increased area of contact between polymer and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in reduced rutting, raveling, and there is not pothole formation. The road can withstand heavy traffic and show better durability.

The dry process thus helps to:

- Use higher percentage of plastic waste
- Reduce the need of bitumen by around 10%
- Increase the strength and performance of the road
- Avoid the use of anti-stripping agents.
- Reduce the cost to around Rs. 5000/Km. of single lane road
- Carry the process in situ
- Avoid disposal of plastic waste by incineration and land filling
- Add value to plastic waste
- Generate jobs for rag pickers
- Develop a technology, which is eco-friendly

REFERENCES

[1.] Al-Hadidy A.I., Yi-qiu Tan (2009), "Effect of polyethylene on life of flexible pavements", Construction and Building Materials

[2.] Justo C.E.G., Veeraragavan A "Utilization of Waste Plastic Bags in Bituminous Mix for Improved Performance of Roads", Centre for Transportation Engineering, Bangalore University, Bangalore, India, 2002.

[3.] Aslam Shahan-ur-Rahman "Use of Waste Plastic in Construction of Flexible Pavement", New Building Materials & Construction World, 2009.

[4.] Khan Amjad, Gangadhar, Murali Mohan Murali and Raykar Vinay (1999) "Effective Utilization of Waste Plastics in Asphalting of Roads", R.V. College Of Engineering, Bangalore.

[5.] IRC, "Guidelines for the Design of flexible pavements," IRC: 37-1970, Indian Roads Congress.

[6.] ISI, "Indian Standards Specifications for Roads Tar", IS: 215, Indian standard Institution.

[7.] IRC, "Tentative Specifications for Bituminous Surface dressing Using Pre-coated Aggregates," IRC: 48-1972, Indian Roads Congress.

[8.] Verma S. S., (Nov. 2008), "Roads from plastic waste", Science Tech Entrepreneur, The Indian Concrete Journal, P.No.43 - 44.