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Ecofriendly Flexible Pavement Incorprating Waste Plastic

Ravindra N Patil [1], Abhishek M Loya[2], Prerna R Patil[3]

[1]*Civil Engineering Department, Sandip Foundation's SIEM Nashik, ravindra.patil@siem.org.in*
[2] *Civil Engineering Department, Sandip Foundation's SIEM Nashik, abhishek.loya@siem.org.in*
[3] *Civil Engineering Department, Sandip Foundation's SIEM Nashik, prerna.patil@siem.org.in*

Abstract— The plastic wastes could be used in road construction and the field tests withstood the stress and proved that plastic wastes used after processing as an additive would enhance the life of the roads and also solve environmental problems. Research highlights the developments in using plastics waste to make plastic roads. Plastic roads mainly use plastic carry-bags, disposable cups and PET bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road. Roads laid with plastic waste mix are found to be better than the conventional ones. The binding property of plastic makes the road last longer besides giving added strength to withstand more loads. Plastics will increase the melting point of the bitumen. Plastic roads would-be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C.

Keywords- Plastic Waste, PET (Polyethylene Terephthalate), Bitumen, Penetration, Ductility, Softening, Viscosity

I. INTRODUCTION

The present paper represents the developments in using plastics waste to make plastic roads. Plastic is everywhere in today's lifestyle. It is used for packaging, protecting, serving, and even disposing of all kinds of consumer goods. With the industrial revolution, mass production of goods started and plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, building construction, communication or InfoTech has been virtually revolutionized by the applications of plastics. Use of this non-biodegradable (according to recent studies, plastics can stay unchanged for as long as 4500 years on earth) product is growing rapidly and the problem is what to do with plastic-waste. Studies have linked the improper disposal of plastic to problems as distant as breast cancer, reproductive problems in humans and animals, genital abnormalities and even a decline in human sperm count and quality. If a ban is put on the use of plastics on emotional grounds, the real cost would be much higher, the inconvenience much more, the chances of damage or contamination much greater. The risks to the family health and safety would increase and, above all the environmental burden would be manifold. Hence the question is not 'plastics vs. no plastics' but it is more concerned with the judicious use and re-use of plastic-waste. Use of waste plastic has made a good progress in bituminous road construction in recent years. Waste plastic are used in bituminous courses Viz BM BC SDBC PMC and MSS. This research was on attempt to evaluate the addition of waste PET bottles to bituminous concrete (BC) wearing course mix of aggregate gradation I along with plain 80/100

Manufacturing of bitumen:

The refining of petroleum crude in refineries is carried out on the principle of "Fractional Distillation" crude oil is heated in tube still. The volatiles are separated in a fractionating column

gasoline; kerosene; gas oil and heavy oil get separated thus. Stream is injected into the fractionating column to assist in the process. This residue is collected as bitumen.

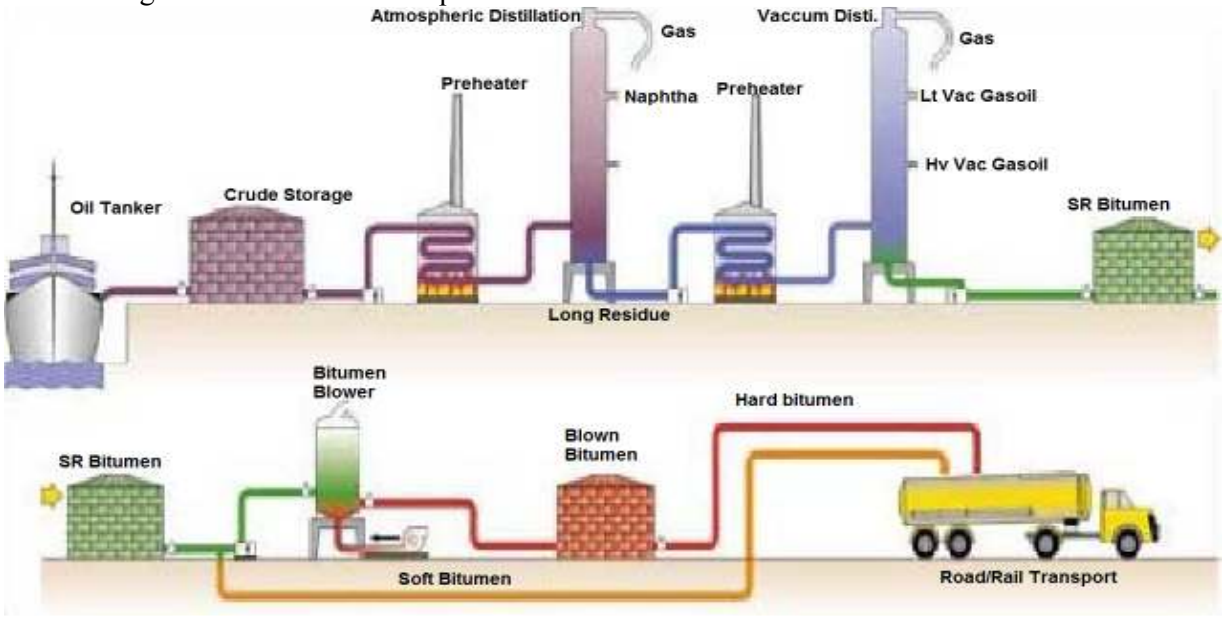


Fig1.1 Manufacturing of Bitumen

In the modem refining process, the distillation is achieved in two or three ages. In the first stage, the crude oil is first passed through a tube still operating at a relatively low temperature (less than 350°c), to take off, in a fractioning column operating at atmospheric pressure, the light ends of the crude oil. i.e. naphtha and kerosene. The "topped crude" is then passed through another still for subsequent transfer to another column operating under vacuum, with the assistance of stream injection. A more modem system dispenses with stream injection and relies on dry vacuum only, thus enabling a wider range of bitumen to be produced.

II. METHODOLOGY

It was divided into two stages. In which first stage involves Basic process on PET bottles which includes Collection of PET Bottles, Cleaning Process, Shredding Process and Collection Process. Second stage was all about field trials on modified bitumen.

Stage 1

1) Collection of PET Bottles:

We visited various places and waste recycles industries in Nashik. We found that the daily waste was about 5-10 tone. And hence we can use the waste PET bottles in the construction of road pavements. We visited to following place Gate Way Hotel, Express Inn, Plastic Recycling Industry at Satpur MIDC.

2) Cleaning

Once the waste plastic has been collected it was separated into its many forms then cleaning process can begin, this usually start with washing to remove paper labels, adhesive and other impurities, all the labels on plastic containers, bottles etc. This process Need for completely removal of impurities as these will lower the quality of finished recycled plastic.

3)Shredding

We cannot add the waste bottles directly in the bitumen, as the waste was in the form of bottles. So we have to grind the waste material in the shredding machine. This can be used to grind

various plastic materials in small pieces. The machine was available at Plot 69 Shobha Plastic MIDC Satpur 422007 and its efficiency ranges between 20 to 60 kg /hr. according to the need we get it from there. The component parts of the machine are Hopper, Electric Motor, Shredding blade etc.

3) Collection

The plastic waste retaining on 2.36 mm IS sieve was collected and used for further work.

Fig. 2- Shredding of PET

Stage 2

Field Trials: There are two field trials: Dry Process, Wet Process.

Dry Process: In this experiment we have adopted Dry Process. In which shredded plastic was added along with bitumen (160^0C) to the aggregates heated up to 170^0C. Plastic was coated over stones – improving surface property of aggregates. Coating is easy & temperature required was same as road laying temp.

III. EXPRIMENTAL INVESTIGATION

3.1 Ingredients Used:

1) Aggregates: The following tests on aggregates were done:

Table 1: Physical Property of Aggregates:

Sr. No.	Test description	Test method	Result
1	Aggregate impact value	IS:2386 (Pt IV-1963)	18 %
2	Aggregate crushing value	IS:2386 (Pt IV-1963)	14.85 %
3	Specific gravity	IS:2386 (Pt IV-1963)	2.67
4	Water Absorption (%)	IS:2386 (Pt III-1963)	0.4
5	Combined flakiness and Elongation index (%)	IS:2386 (Pt 1-1963)	19.51 %

2) Bitumen:

80/100 grade bitumen was used in this study. The physical properties of bitumen were tested and results are tabulated as:

Table 2: Physical Properties of Bitumen

Sr. No.	Test Description	Result
1	Penetration	65
2	Ductility	75+
3	Specific gravity	1.00
4	Softening Point	50
5	Flash point ^{0}C & Fire Point	240-270

3) Waste plastic: Polyethylene Terephthalate (PET) is linear thermoplastic, long-chain molecule consists of repeating units, white but bluish resin made from terephthalic acid and ethylene glycol through poly condensation. Plastic PET is very important raw material used in man-made fibers. PET is a kind of polyester material for fiber, injection molded parts, as well as blow-molded bottles and jars. Special grades are offered with the required properties for the different applications.

Properties of PET:
PET consists of carbon, hydrogen and oxygen. It can be incinerated without residues for energy recovery. PET is the most valuable of the recyclable plastics. Also it is reusable as fiber filling for clothing, pallet strapping molding, carpeting, as well as in the manufacture of PET containers.

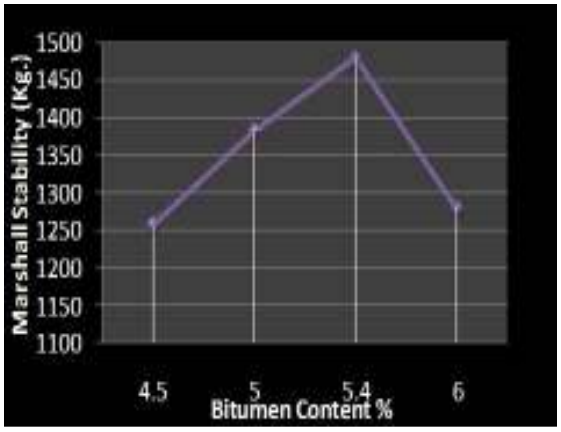
3.2 Laboratory Mix Design

The bituminous mix was design using Marshal Method of the mix design. The Marshal test was conducted to determine the optimum binder content of the bituminous concrete mix as per ASTM D-l559-1965. Marshal specimens were prepared with varying binder content 4.5, 5.0, 5.5, and 6.0 percent by the weight of aggregate. Three specimens for each combination were prepared to obtain optimum binder content for the bituminous concrete mix is as show in the Table no.3.2

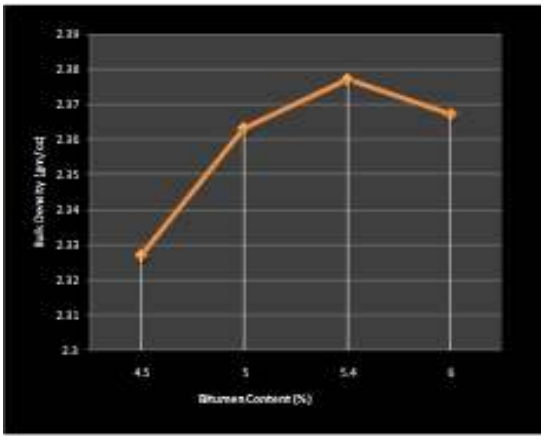
Table 3: Properties of Bituminous Concrete to determine optimum binder content

Property	Binder content by weight of aggregate (%)			
	4.5	**5.0**	**5.5**	**6.0**
Marshal Stability (Kg.)	1258	1383	1480	1280
Bulk density (gm/cc)	2.327	2.363	2.377	2.367
Flow values (mm)	2.6	3.5	4.2	4.6
Air Voids (%)	6.8	4.6	3.4	3.2
Voids filled with bitumen VMA (%)	59.7	70.7	78.7	80.9
OBC (Optimum bitumen content) (%)	**5.4**			

From the result it was found that the OBC was 5.4 per cent by weight of aggregate.



Graph 1- Bitumen Content vs. Bulk Density



Graph 2- Bitumen Content vs. Marshall Stability

Optimum Waste Plastic Content:

- Varying percentage of waste plastic by weight of bitumen was added into heated aggregate.
- Marshall Specimen with varying waste Plastic content was tested for bulk density and stability
- Maximum value of stability was considered as criteria for optimum waste plastic content

IV. RESULTS AND DISCUSSION

Waste plastic were added by the varying the properties from 2-12 per cent by weight of bitumen with an increment of 2 percent (2. 4, 6, 8, 10, and 12). The modifier was added into the heated aggregate just before mixing the bitumen at the optimum 5.4 percent binder content. It was found that the optimum modifier (waste plastic) contents were 8 per cent by weight of bitumen.

4.1 Results Of Test Carried Out On Bitumen:

Table-4.1- Results of Test Carried Out On Bitumen

Test	Percentage Replacement						
	0%	2%	4%	6%	8%	10%	12%
Penetration	95	101.5	102.75	103.5	104.75	110	112
Ductility	94cm	93cm	92.5cm	85.7cm	86cm	82 cm	80 cm
Softening	43^0	43.5^0	44.5^0	44.8^0	45.2^0	47^0	47.5^0
Viscosity	54.5sec	65 sec	73 sec	79 sec	86 sec	91 sec	95 sec

4.2 Comparative Study:

The comparison of volumetric properties of modified mix and the conventional mix with, 8 percent of waste plastic and OBC was studied.

Table 4.2: Comparison of volumetric properties of the mixes

Properties	Modified Mix (waste plastic)	Conventional mix
Marshal stability (kg.)	1750	1475
Bulk density (gm/cc)	2.37	2.374
VFB (Voids Filled with Bitumen) (%)	73	76
Flow values (mm)	4	4.25
VMA (Voids in mineral Aggregate (%)	16.5	15.6
Retained Stability (%)	98	88
Indirect tensile strength	6.8	9.0

4.2 Cost Analysis:

Table 4.3: Comparison of volumetric properties of the mixes

Cost Of Bitumen (Per MT)	Cost saving Due to 8 % plastic replacement (Per MT)	Cost Of processed Waste Plastic (Per MT)	Total Cost Saving on Bitumen (Per MT)	% Cost Saving (Per MT)
48900	3912	1000	2912	5.9 %

Above analysis shows that cost of construction of flexible pavement can be reduces up to **5.9%** by replacing bitumen with waste plastic.

V. CONCLUSIONS

Conclusions were made regarding this research it reduce the need of bitumen up to 8%, Increase the strength and performance of road**,** Reduce cost of road construction up to 5.9%**,** Develop a technology, which is eco-friendly, Generate jobs for rag pickers.

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