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An Experimental Investigation on Modification of Properties of Bitumen by using Poly Ethylene Terephthalate Waste

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Abstract

Unplanned and unorganized urbanization, rapid industrialization, changes in life style have increased the use of various types of plastics in daily life, which in turn has led to large scale accumulation of these waste. Erratic Disposal, Longer decomposition time of these plastic wastes is resulting environmental degradation. It is essential to use of various plastic waste materials in bituminous pavements. PET waste is one such kind of material which will improve the properties of bituminous mixes by adding PET waste.
This paper deals with use of Poly Ethylene Terephthalate Waste in bituminous mixes. The improvement in the various properties of bituminous mixes were found by adding PET waste in various percentages (0%, 2%, 4%, 6% and 8%) with VG-10 and VG-30 bitumen were found out experimentally .It was found that with the addition of PET waste there was an improvement in Marshall stability, Indirect tensile strength ,tensile strength ratio and various other properties.

Keywords: Flow, Marshall Stability, % air voids, Optimum Binder Content

Introduction

Background

One of the prime issues after our nation in recent years is environment security and preservation. Ever increasing wealth of distinct industries has attracted to consistent usage of impulsive resources and generation of full quantities of solid wastes. The huge quantities of surplus (such as rubble tires, bi focal, deny furnace live coal, warm slag, plastics, interpretation and demolition wastes) accumulating in stockpiles and landfills all over the map. The survival are causing disposal problems that are both financially and environmentally expensive. Maintenance and furthermore expansion of this massive road absorb requires huge quantities of quarried materials on a continuous basis.
Concerned about this, the scientists are looking for alternative materials for highway construction, and industrial wastes product is one such category. If these materials can be suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement.

PET Waste

Plastic is versatile material and a friend to common man becomes a problem to the environment after its use. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics. Road surface with neat bitumen can cause bleeding in hot climate, may develop cracks in cold climate, possess fewer loads bearing capacity and can cause serious damages because of higher axle load in present conditions due to rapid infrastructure development. This paper presents the use of PET waste in hot bituminous mixes to enhance pavement performance, protect environment and provide low cost roads. Polymer and plastic modified bitumen, often abbreviated as modified bitumen is obtained with the incorporation of selected thermoplastics and shredded plastic from discarded waste, natural plastic or any other suitable elastomers in bitumen.
Every year, 7.2 million tonnes of hazardous waste is produced and its disposal is becoming a major issue and about one km^2 of additional landfill area is needed every year. Indian government spends about Rs 1600 crores for treatment & disposal of these wastes. In addition to this, industries discharge about 150 million tonnes of high volume low hazard waste every year, which is mostly dumped on open low lying land areas..In this scenario, the conventional waste disposal methods are found to be inadequate.
Global consumption of PET bottles is nearly 20 million tonnes which is increasing by 15% every year however the recycling rate of PET bottles is just 29.3%, which is very low.

Aim

The major aim of this work is to study the improvement in properties of bituminous mixes by using PET waste.

Objectives

- Determination of physical properties of Aggregate, Bitumen and filler.
- Find out the improvement in the properties of Aggregate and Bitumen with the addition of adding different percentages of PET
- Comparison of modified and conventional dense bituminous mixes.

- Determination of mechanical properties of bituminous mixes prepared with modified bitumen at varying percentages of PET.
- Determination of OBC to find the improved stability and flow values.

Methodology

Various tests were conducted on Bitumen, Coarse aggregate. Also, the variation of properties of Coarse aggregate with the increase in % PET was found and the values obtained were shown below.

Table 1: Physical properties of Bitumen

Properties of Bitumen	Standard Value	Obtained Value
Softening Point,in ◦C	40	43.5
Ductility ,in Cm	75	73
Specific Gravity	0.97 – 1.02	0.97
Penetration	60-70 mm	61.33 mm
Flash and Fire point	175◦C 250◦C	178◦ C 230◦C

Table 2: Physical Properties of Coarse Aggregates

Properties of Coarse Aggregate	MORTH Specification Table 500-16	Obtained value
Crushing Strength	< 30%	27.80%
Hardness	< 30%	34.2%
Toughness	<25%	14.07%
Flakiness Index Elongation Index Combined Flakiness Elongation Index	<35% < 30%	11.7% 8.4% 17.64%
Specific Gravity	2.4-3.0	2.47
Angularity number	<13	7

Table 3: Variation of properties of Coarse Aggregate with varying % of PET

Properties of Coarse Aggregate	MORTH Specification Table 500-16	Obtained value
0	27.02	25.35
2	23.91	24.07
4	23.37	20.71
6	18.37	16.07
8	15.69	13.85
10	11.35	10.78

Marshall specimens were prepared with various % of bitumen ranging from 3.5% to 6% of bitumen content and Marshall experiment is conducted and the Optimum binder content was calculated by drawing various graphs.
The Optimum Bitumen content was calculated and obtained is 4.77%. Various graphs were prepared which shows the variation of marshall properties with increase in % PET., which are shown below.

Table 4: Marshall Stability Properties of the Asphalt blend at various PET content

PET Content (%)	0	2	4	6	8	10
Marshall Stability (kN)	32.39	35.99	37.79	39.59	40.49	38.69
Marshall flow (mm)	2	3	3.25	3.5	4	4.5
Bulk Density (G_b)	1.96	2.0	2.05	2.1	2.07	2.07
Air void in total mix (V_v) (%)	7.76	4.76	3.52	3.12	3.07	3.07
Volume of bitumen (V_b)	9.63	9.83	10.08	10.32	10.17	10.17
Air void in mineral aggregate (VMA) (%)	17.39	1459	13.60	13.44	13.24	13.24
Air void filled with bitumen, (VFB)	55.37	67.37	74.11	76.78	76.81	76.81

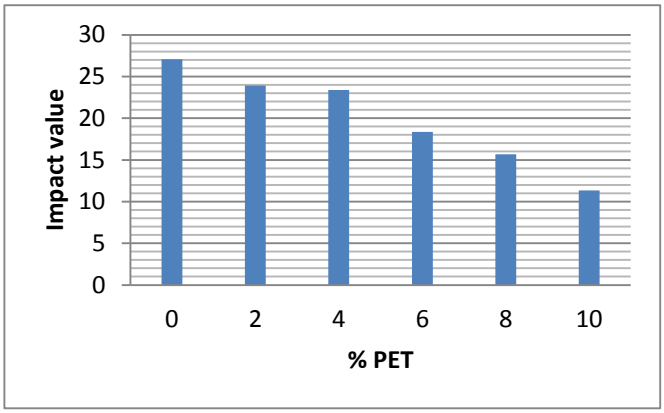

Figure 1: Graph showing variation of % PET and Impact Value

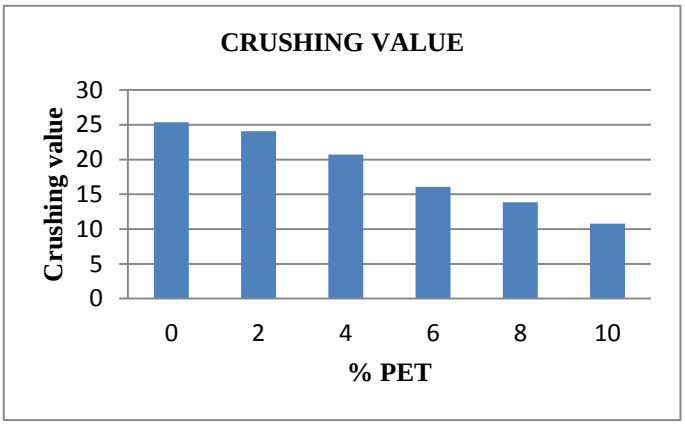

Figure 2: Graph showing variation of % PET and Crushing Value

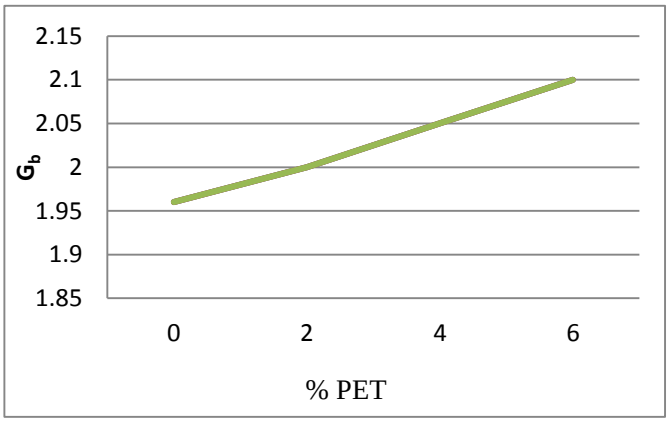

Figure 5: Graph showing variation of G_b with % PET

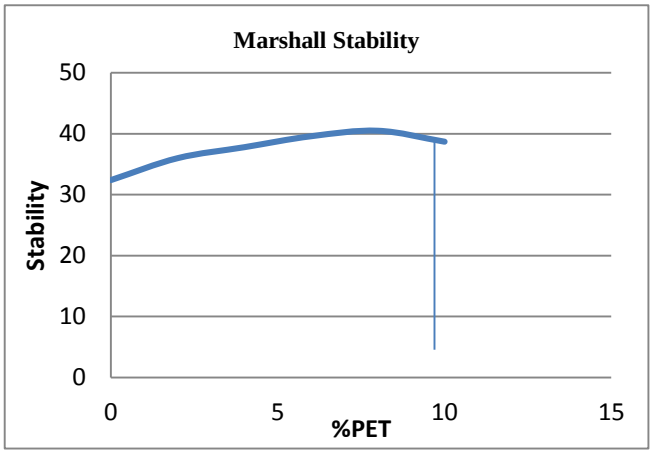

Figure 3: Graph showing variation of % PET and Stability Value

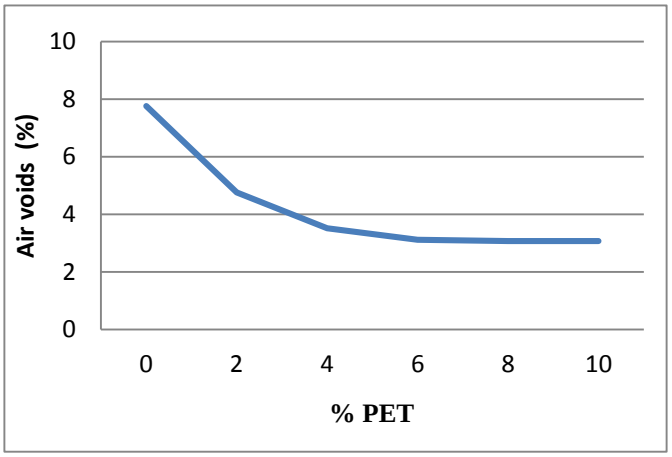

Figure 6: Graph showing variation of air voids with % PET

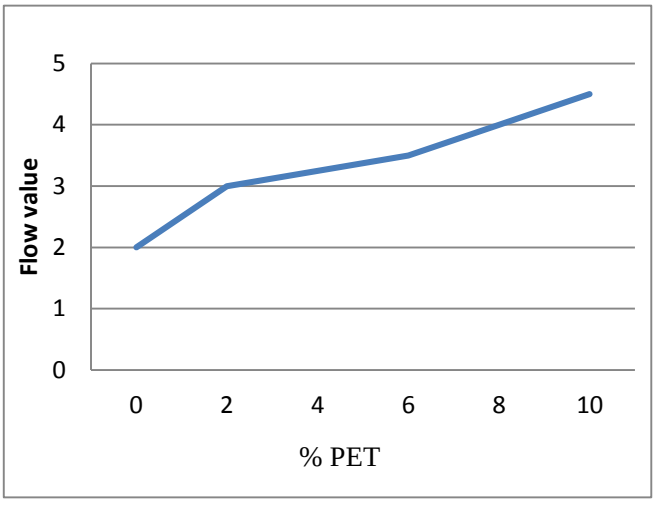

Figure 4: Variation of flow value with % PET

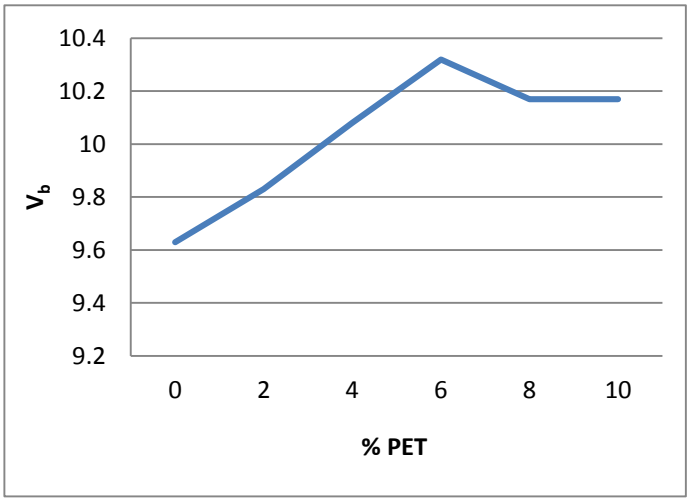

Figure 7: Graph showing variation of V_b value with % PET

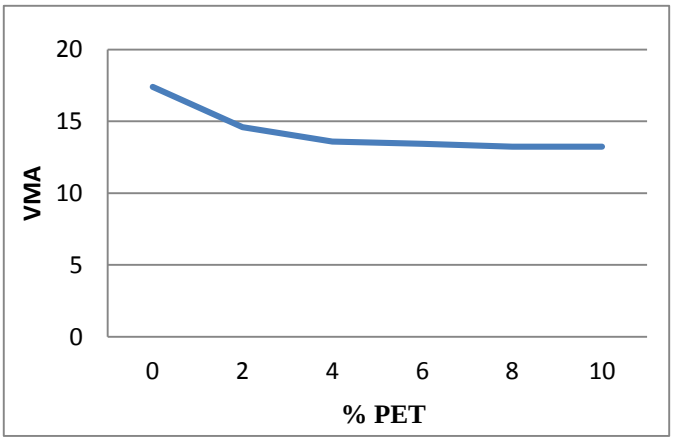

Figure 8: Graph showing variation of VMA value with % PET

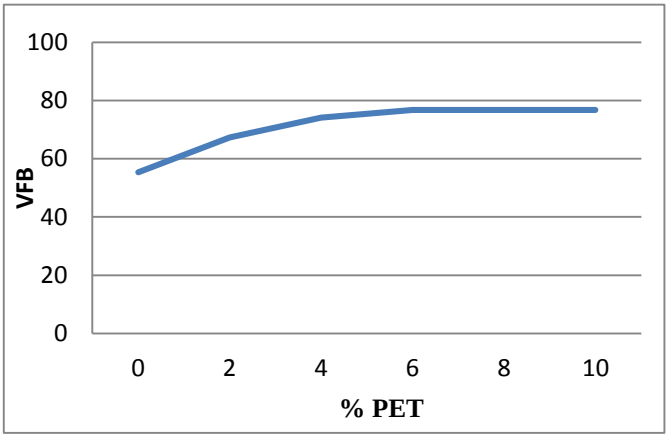

Figure 9: Graph showing variation of **VFB** With % PET

Conclusion

From the various experiments conducted, it has been found that

- The different values of coarse aggregates obtained from different tests were within the limit as per MORTH specifications.
- The different test values of bitumen are within the limit as per IS 73-2006 for VG30.
- With the increase in % PET content, there was a decrease in Aggregate impact value and Aggregate Crushing value.
- There is a decrease in Aggregate impact value of 15.67 % with the addition of 10% PET.
- There is a decrease in Aggregate crushing value of 14.57% with the addition of 10% of PET.
- From the experiments conducted, obtained value of Optimum bitumen content found was 4.77%.
- Marshall Stability achieve the local specifications requirement with 8% PET Waste.
- The VMA (% Voids in mineral aggregate) and VFB (% Air voids filled with bitumen) values decreases as the percentage of PET Waste increases.
- Marshall stability value has increased from 32.39KN for 0% PET to 40.49KN for 8% PET and again decreases for 10% PET (38.69KN).
- Flow value has increased from 2mm for 0% PET to 4.5mm for 10% PET.
- Bulk density has increased from 1.96 for 0% PET to 2.07 for 10% PET.
- Air voids has decreased from 7.76 for 0% PET to 3.07 for 10% PET.
- Air voids in mineral aggregate has decreased from 17.39 for 0% PET to 13.24 for 10% PET.
- Air voids filled with bitumen has increased from 55.37 for 0% PET to 76.81 for 10% PET.
- From the results it can be concluded that 8% of PET Waste is giving better stability compare to various percentage of PET Waste.

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