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"PARTIAL REPLACEMENT OF BITUMEN WITH PLASTIC WASTE IN HOT MIX"

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ABSTRACT

Plastic waste is one such resource, a major component of solid waste which is abundantly available and disposed of without proper treatment. There has been an exponential growth in municipal plastic waste disposal especially in urban areas which deteriorates the beauty of the landscape. Plastic was found to be an effective binder for bitumen mixes used in flexible pavements. This efficient method helps the pavements to resist higher temperature by minimizing the formation of cracks and reducing rainwater infiltration which otherwise leads to the development of potholes. These pavements have shown improved crushing and abrasion values and reduced water seepage. It consists of waste plastic or bitumen (used as a binder) and mineral aggregate which is mixed together & laid down in layers then compacted and In this project, we are going to partially replace bitumen with plastic waste (2% to 14%).

Keyword: *Plastic waste, Bitumen, plastic Road , Low Density Polyethylene (LDPE).*

I. INTRODUCTION

Disposal of waste plastic consumer bags from the domestic has become a major problem to the agencies in the town and cities. The waste plastic bags available in the domestic waste mainly consist of low density polyethylene (LDPE). Plastic bags dumped in the dustbins find their way into the drainage system and clog them. Often, the severe burnt along the road side, which produces fumes causing air pollution. Industrial wastes from polypropylene (PP) and polyethylene terephthalate (PET) were studied as alternative replacements of a part of the conventional aggregates of concrete. Five replacement levels 10%, 20%, 30%, 40% & 50% by volume of aggregates were used for the preparation of the concretes.

India plastic processing has been carried out on a large scale. Up to 60% of industrial and municipal plastic waste comes from a variety of sources. The use of plastic waste for coating aggregates of the bituminous mix found to improve the performance of the pavement improving abrasion, slip resistance and increased the durability and fatigue life. Bituminous mix with recycled plastics mainly LDPE replacing 30% of 2.36 - 5mm aggregates showed 250% increase in Marshall stability and the mix density reduced to 16% and in addition to it the Indirect Tensile Strength (ITS) was also improved. On heating at 100-160'C polythene, polypropylene and polystyrene soften and exhibit good binding properties. Indian mass production of plastic waste, with great economic value, so the recovery of plastic waste plays an important role in employment. This helps the country's economic development.

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Table: 1 Waste Plastic And Its Sources

S.NO.	WASTE PLASTIC	ORIGIN
1	Low density poly –ethylene (LDPE)	Carry bags , milk pouches ,sacks, cosmetic and detergent bottles
2	High density poly-ethylene (HDPE)	Carry bags , bottle cap, house hold articles etc.
3	Polyethylene Tery-phthalate (PET)	Drinking water bottles etc.
4	Polypropylene (pp)	Bottle cap, biscuit vapors pockets etc.
5	Polystyrene (ps)	Clear egg packs, food trays egg box etc.
6	Polyvinyl Chloride (pvc)	Toys, pipe, mineral water bottles, credit card etc.

II. MATERIALS

A) Aggregate: Aggregate is a collective term for the mineral materials such as sand . gravel , and crushed stone that are used with a binding medium (such as water , bitumen , Portland , cement, lime , etc.) to from compound materials (such as bituminous concrete and Portland cement concrete). By volume , aggregate generally accounts for 92 to 96 percent of bituminous concrete and about 70 to 80 percent of Portland cement concrete . Aggregate is also used for base and sub-base courses for both flexible and rigid pavement . Aggregate can either be natural or manufactured . Natural aggregate are generally extracted from larger rock formations through an open excavation (quarry) . Extracted rock is typically reduced to usable sizes by mechanical crushing . Manufactured aggregate is often a bye product of other manufactured industries. Aggregate used in surface course can be divided into two types according to their size coarse aggregate and fine aggregate . Coarse aggregate are generally defined as those retained on the 2.36 mm sieve. Fine aggregate are those that pass through the 2.36 mm sieve and are retained on the 0.075 mm sieve . Aggregate required for the research work will be procured from the local market.

Table: 2 Test of Aggregate

S. No.	Description	MORTH 2001 Specification	Result	IS Code
1	Aggregate impact value test	Max 30	4.03%	IS 2386 Part 4
2	Los Angeles Abrasion test	Max 30	15.82%	IS 2386-V-1963
3	Water absorption test	Max 2.5	0.3 %	IS 2386-III-1963
4	Flakiness Index	Max 30	24.5%	IS 1211-1978
5	Elongation Index	Max 30	18.17%	IS 1211-1978

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B) Bitumen: Bitumen acts as binding agent for aggregate in bituminous mixes. Generally in India bitumen used in road construction of flexible pavement is of grades 60/70 or 80/100 penetration grade . Both the grade of bitumen confirming to BIS standard will be used for the present studies.

Today the availability of the waste plastics is enormous as the plastic material have become part and parcel of daily life. They either get mixed with municipal solid waste and / or thrown over land area . If not recycled , their present disposal is either by land filling or by incineration. Both the processes have certain impact on the environment . Under this circumstance , an alternate use for the waste plastic is also the needed.

Thinner polythene carry bags are most abundantly disposed of wastes, which do not attract the attending rag pickers for collection for onward recycling, for lesser value. Again, these polythene/ polypropylene bags are easily compatible with bitumen at specified condition. The waste polymer bitumen blend can be prepared and a study of the properties can throw more light on their use for road laying. We are use 80/100 grade of bitumen in our project.

Table: 3 Test of Bitumen

S. No.	Description	Result	IS Code
1	Penetration Test	47 mm	IS : 1203 -1978
2	Ductility test	53.06 cm	IS : 1208 -1978

C) Plastic Waste: Another plastic that is considered a low hazard, Low Density Poly-ethylene is used in bags for bread, newspapers, fresh produce, household garbage and frozen foods, as well as in paper milk cartons and hot and cold beverage cups, milk pouches, sacks carry bags ,cosmetics and detergent bottles . While LDPE does not contain BPA, it may pose risks of leaching estrogenic chemicals, similar to HDPE.

Table: 4 Penetration Test on partially replace bitumen with plastic waste

S.NO.	Replace bitumen with plastic waste	Penetration (mm)
1	2%	58.33
2	4%	34.33
3	6%	23.66
4	8%	25
5	10%	21.33
6	15%	19.33

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Table: 5 Ductility test on partially replace bitumen with plastic waste.

S.NO.	Replace bitumen with plastic waste	Ductility (cm)
1	2%	28
2	4%	28.5
3	6%	27.5
4	8%	27.6
5	10%	27.66
6	15%	10

III. METHODOLOGY

1. Process of Preparation Of Road

Basic Process

- **Segregation** :- Plastic waste collected from various sources must be separated form other waste. Maximum thickness of 60 microns.
- **Cleaning Process:-**The plastic waste get cleaned and dried. For better mixing and removal of moisture from the waste plastic.
- **Shredding Process:-** The waste plastic should be will shredded and cut into small pieces. The well shredded or different plastic then mixed together.
- **Collection Process:-** The well shredded plastic then sieved, the wasting retained in 2.36mm sieve is collected.

2. Method of road Construction or field trial.

- **Dry process :-** For the flexible pavement, hot stone aggregate (170^{o}C) is mixed with hot bitumen (160^{o}C) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding property, penetration value and viscoelastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement. It is to be noted here that stones with 2% porosity only allowed by the specification.
- **Wet process :-** Waste plastic is ground and made into powder; 6 to 8 % 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. Normally, blending takes place when temperature reaches 45.5°c but when plastic is mixed, it remains stable even at 55°c. The vigorous tests at the laboratory level proved that the bituminous concrete mixes prepared using the treated bitumen binder fulfilled all the specified Marshall mix design criteria for surface course of road pavement. There was a substantial increase in Marshall Stability value of the mix, of the order of two to three times higher value in

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comparison with the untreated or ordinary bitumen. Another important observation was that the bituminous mixes prepared using the treated binder could withstand adverse soaking conditions under water for longer duration.

3. Dry Process of laying of plastic road

Process Step 1:- Plastics waste (Carry bags , milk pouches ,sacks, cosmetic) made out of LDPE cut into size between 2.36mm to 4.75mm using shredding machine.

Fig.1 Shredding Process

Process Step 2:- The aggregate are heated to 165^{o}c.

Fig.2 Heating Process of Aggregate

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Process Step 3:- The shredded plastic waste is to be added hot aggregate . It get coated uniformly over the aggregate within 30 to 60 seconds .

Fig. 3 Mix Of Shredded Plastic

Process Step 4:- The bitumen is to be heated up to a maximum of 160^{o}c .At the mixing a bitumen in hot aggregate.

Fig. 4(a) Heating Process

Fig. 4(b) Mixing Process of Bitumen

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Process Step 5:- The plastic waste coated aggregate is mixed with got bitumen and the resulted mix is used for block . The block laying temperature is between 110^{o}c to 120^{o}c .

Fig. 5(a) Placing of Material

Fig. 5 (b) Material Compact by Rammer

Fig. 5 (c) Casting Of Block

IV. RESULT AND CALCULATION

Marshall Stability Test

A. Optimum Bitumen Content

The Marshall Test result conducted on mixes with varying bitumen percentages are show in table. After conducting Marshall Tests on the Marshall specimens, the Marshall Stability value was found out.

ISSN : 2455-9679
Impact Factor : 2.865

Table: 6 Optimum Binder Content Tabulations

Sample	Binder content	Marshal Stability value in kg	Flow Value in 0.25 mm unit	Bulk Specific Gravity	Air Voids %	Voids Filled by bitumen %
A	5	1034.691	8.5	2.316	5.08	68
B	5.5	3071.45	10.15	2.316	4.64	71.51
C	6	3149.94	12.20	2.316	3.9	79.14

Graphs are plotted to determine the Stability value, unit weight and flow value; Based on which the Optimum Binder Content (OBC) is determined. OBC was found out to be 6%.

B. Optimum Plastic Content

The Marshall Test results conducted on mixes with varying LDPE content are shown as shown in table. After conducting Marshall Tests on the Marshall specimens, LDPE replace bitumen content 6% (72 gm)by weight.

Table: 7 Optimum Binder Content Tabulations

Sample	LDPE replace bitumen content % by weight	Marshal Stability value in kg	Flow Value in 0.25 mm unit	Bulk Specific Gravity	Air Voids %	Voids Filled by bitumen %
A	2	4087.794	9.40	2.316	4.13	75.7
B	4	3078.58	8.50	2.316	4.09	75.92
C	6	3139.752	8.50	2.316	4.10	75.91
D	8	4087.94	7.40	2.316	4.05	76.17
E	10	3073.791	7.50	2.316	4.051	76.20
F	12	3077.568	7.40	2.316	4.027	76.34
G	14	4094.92	7.10	2.316	4	76.50

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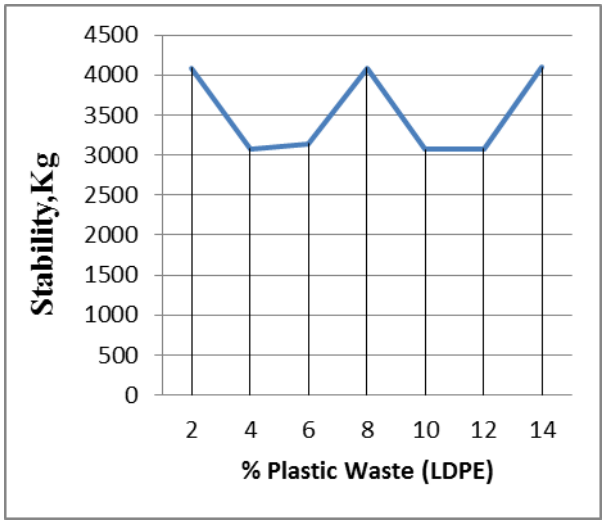

Fig. 6 Graph showing Marshall Stability Vs % Plastic Waste (LDPE)

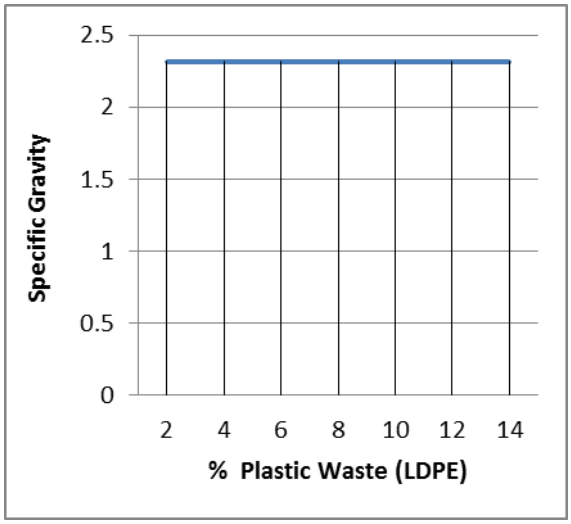

Fig. 7 Graph Bulk Specific Gravity Vs % Plastic Waste (LDPE)

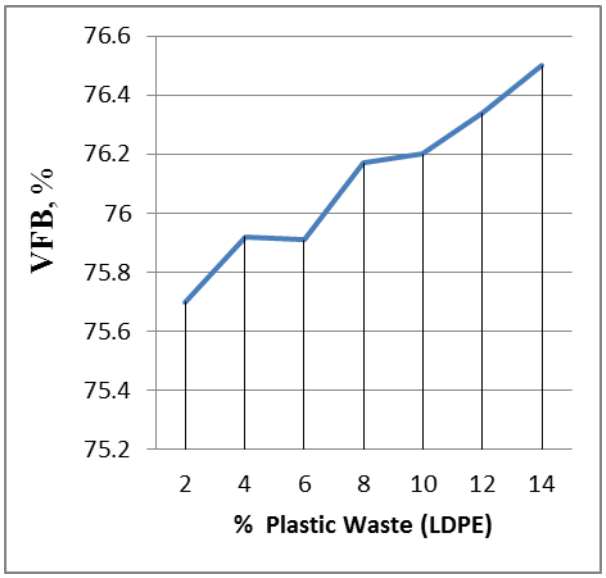

Fig. 8 Graph showing VFB Vs % Plastic Waste (LDPE)

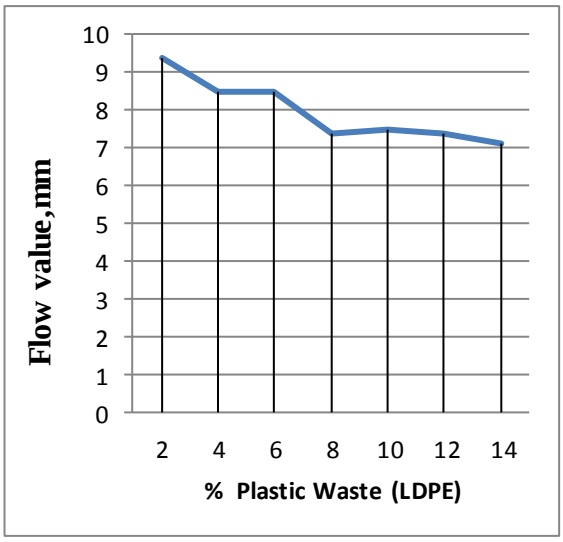

Fig. 9 Graph showing Flow Value Vs % Plastic Waste (LDPE)

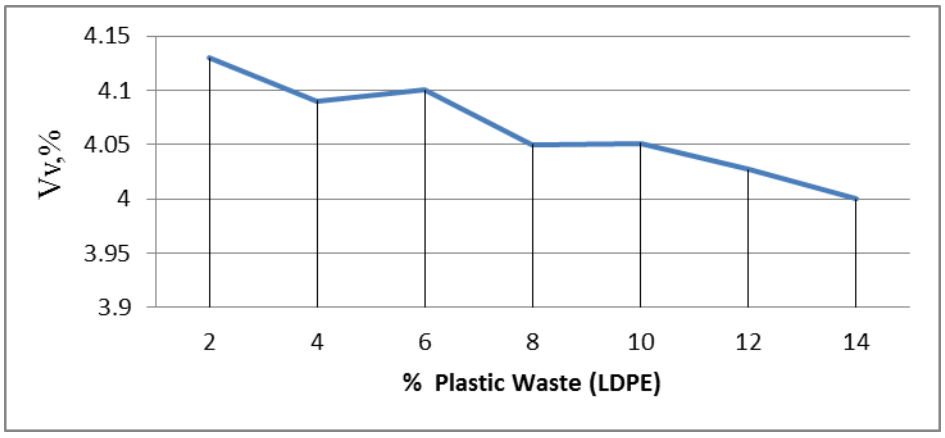

Fig. 10 Graph showing Vv vs % Plastic Waste (LDPE)

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V. CONCLUSION

Plastic coating on aggregates is used for the better performance of roads. This helps to have a better binding of bitumen with plastic wasted coated aggregate due to increased bonding and increased area of contact between polymers and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. The addition of waste plastic modified bitumen shows good result when compared to standard result. The optimum content of waste plastic to be used is between the range of 2% to 14% in this project. Marshall Stability and Flow value of waste plastic hot mix have good result as compared to normal bitumen hot mix. The problems like bleeding are reduce in hot temperature region.

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