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Industrial Polypropylene Waste Used as Modifier in Asphalt Binder for Flexible Pavements

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***Abstract*— Various sorts of plastic become waste when its use and need giant areas of land for storage additionally inconvenient to recycle. Attributable to low biodegradability, unsafe plastic fails land filling that not a dominant methodology for disposal. Innovative methodology of waste disposal is investigated attributable to higher binding property of plastics in its liquefied state, by mistreatment them in construction of flexible pavement. This paper presents experimental results of the consequences of commercial plastic waste extra to boost properties of bitumen and aggregates. A radical method study by Dry method (5-18%) and Wet method (1-10%) combineing of blending extra with polypropylene waste by weight of VG-30 bitumen enhances properties of typical hydrocarbon mix. It's not solely confirm the physical impact on hydrocarbon and mixture however additionally reduces the process price within the producing of combine style for the carrying course of versatile pavements by up strength and sturdiness.**

Keywords— Industrial polypropylene waste, Bitumen, Aggregate, Non-Biodegradability, Bitumen Mix Design, Cost Analysis.

I. INTRODUCTION

Industrialisation boosts, production of polypropylene industrial waste originated from compound fibres business, mat production business generates vast quantity of waste however fails to dispose effectively. As a result of its frequent convenience towards man, Plastic a building blocks of today's fashion. Republic Indians uses fourteen million plenty of plastics and it's hoped to succeed in twenty two million tons by 2020.

Nowadays, every department of the economy ranging from agriculture to packaging, automobile, building construction or InfoTech has been just about revolutionized by the applications of plastics. Plastics bifurcates as LDPE (PE,PP,PS), HDPE, square measure used luggage, detergent bottles, milk pouches, bottle caps, film wrapping for biscuits, microwave trays for ready-made meals, drinking water bottles, toys, pipes, pens, medical disposables, etc. Production is growing speedily and also the drawback is what to try and do with plastic-waste is standstill. Studies have joined the improper disposal of plastic to issues as distant as carcinoma, fruitful issues in humans and animals, reproductive organ abnormalities and far additional.

According to recent studies, plastics will keep as long as 4500 years on earth as a result of their low biodegradability. To unravel this drawback, waste plastic are often reused fruitfully within the construction of roads. In hot and intensely wet climate, sturdy and eco-friendly plastic roads square measure most efficient.

Inadequacy of bitumen in future desires a deep thinking to confirm quick building. Industrial polypropylene waste has helpful characteristics and a property which ends to boost the properties of standard hydrocarbon achieves the value reduction objective. Lack of convenient methodology of disposal is one among the main problems for the civic authorities, particularly within the urban areas at a same time India desires an outsized network of roads for its swish economic and social development. For this purpose most required innovative methodology of formation hydrocarbon binder still as construction of carrying course for versatile pavement is investigate.

1.1 Background and Related Work

Sabina, Tabrez A Khan et al, (2009) described the comparative performance of conventional bituminous concrete mixes with bituminous concrete mixes containing plastic/polymer (8% and 15% by weight of bitumen),they concluded that Marshall stability of modified mixes was respectively (1.21 and 1.18) times higher than conventional mixes.[5]

Amit Gawande et al, (2012) used modified bitumen with the addition of processed plastic waste of about (5-10% by weight of bitumen) helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous concrete mix. [2]

Prasad et al,(2013),investigated the use of PET waste by mixing 2%,4%,6%,8%,10% with 80/100 grade bitumen and found that MSV, FV, bulk density increases with increase in PET content whereas VFB decreases.OBC was obtained as 5.4% and optimum content of PET was 8%.[1]

Mohamed et al carried out study in which CRT and LDPE were used to modify virgin asphalt which was added in 3%, 5%, 10%, and 15% by weight. Best results of Marshall Test were obtained below 10% most at 5%.

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1.2 Objective

1. To mix the economic polypropylene waste plastic with the hydrocarbon in testing laboratory expeditiously.
2. To investigate the properties of hydrocarbon and Aggregates with addition of commercial polypropylene waste as an additive.
3. To pick the optimum indefinite quantity of commercial polypropylene waste in asphalt binder formation.
4. To reinforce the properties of typical asphalt binder with addition of additive as industrial polypropylene waste.
5. To scale back the value of repairing and maintenance likewise as will increase sturdiness of binder.
6. To optimize the process price of typical asphalt binder.
7. To spot alternate technique for polypropylene waste reprocess in versatile pavement and so, provide support to property.

II. MATERIAS AND METHODS

2.1 Bitumen

As per IS:73-2013, VG-30 grade of bitumen was selected to prepare samples.

Table No.1 VG bitumen and equivalent penetration grade

Viscosity grade (VG)	General Applications	Equivalent Penetration grades
VG - 40	Intersections of roads, heavy traffic, higher temperatures	30 - 40
VG - 30	Most suitable for Indian road condition	60 - 70
VG - 20	Areas of cold climate at high altitude	…
VG - 10	Spraying applications, very cold regions	80 - 100

2.2 Aggregates

Aggregate of 10 mm and 6mm was obtained from a local Quarry of required grade and size.

Table No.2 Physical properties of aggregates

Test Description	Specification	Values
Combined Flakiness and Elongation Index (%)	IS 2386(Pt. I - 1963)	18
Water Absorption (%)	IS 2389(Pt. I- 1963)	0.5
Specific Gravity	IS 2389(Pt. I- 1963)	2.65
Impact value (%)	IS 2389(Pt. I- 1963)	16

2.3 Plastic Waste

Polypropylene is one of the low density polyethylene polymers collected from the Mat production industry in shredded form. It is used as anadditive in asphalt which plays arole of modifier.

Table No.3 Characteristics of PP

Characteristics	PP Waste
Tensile Strength	0.95-1.30 N/mm^2
Impact Strength	3-30 kj/m^2
Max. Temperature Use	80°C
Melting point	160°C
Density	0.905 g/cm^2

III. EXPRIMENTAL METHODS

3.1 Laboratory Tests

A) Tests on Aggregate

1. Specific Gravity Test [IS:2386(Part 3)]
2. Water Absorption Test [IS:2386(Part 3)]
3. Aggregate Impact Value Test [IS:2386(part 4)]
4. Stripping Value Test [IS:6241]

B) Tests for Bitumen

1. Softening Point Test [IS:1205-1978]
2. Ductility Test [IS:1208-1978]
3. Flash Point and Fire Point [1448(P:69)1969]
4. Specific Gravity

C) Marshall Stability Test

3.2 Processes for Sample Preparation

1. Dry Process
2. Wet Proces

1) Dry process

Process includes primary mixing of shredded PP waste over hot aggregates. After coating, coated aggregates are added into hot bitumen along with cement filler and Crush sand to obtained homogeneous bituminous mix for wearing course of flexible pavement.

2) Wet process

Process starts with initial mixing of shredded PP waste in hot bitumen with continuous stirring. Simultaneously, hot aggregates are added into modified bitumen along with crush sand and cement filler to obtained homogeneous bituminous mix for wearing course of flexible pavement.

IV. OBSERVATIONS

A) Tests on Aggregate

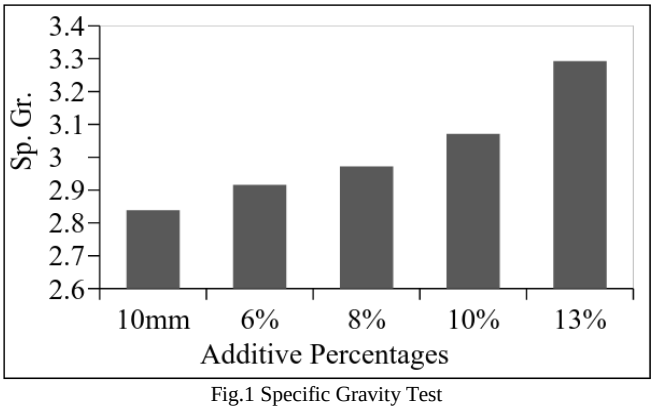

Fig.1 Specific Gravity Test

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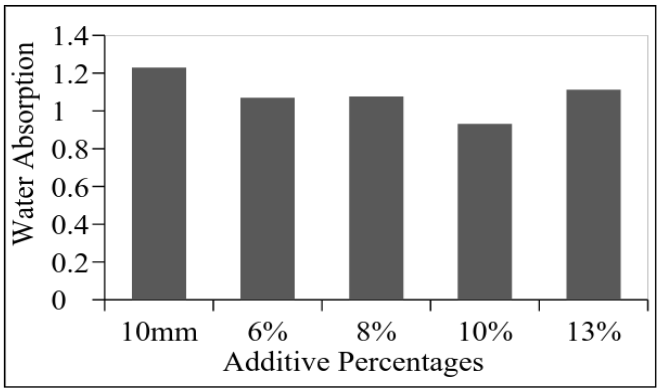

Fig.2 Water Absorption Test

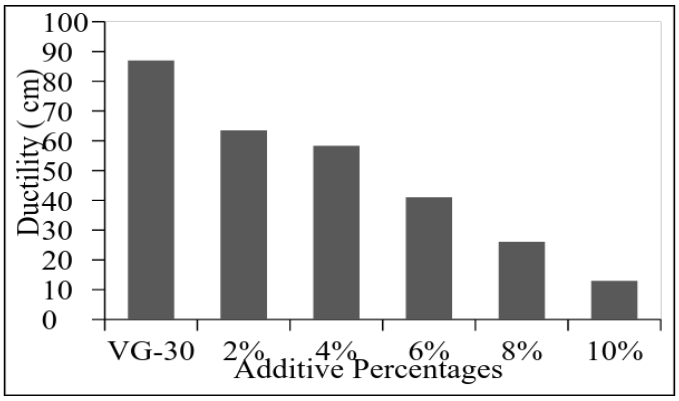

Fig.6 Ductility Test

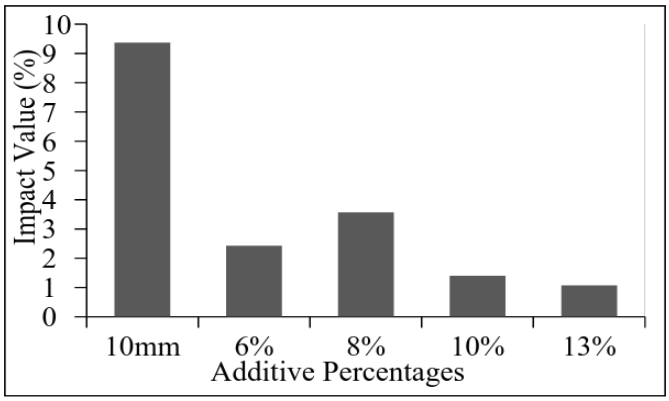

Fig.3 Impact value Test

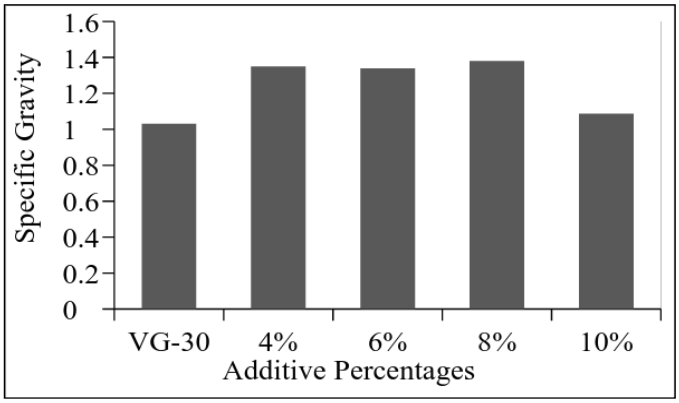

Fig.7 Specific Gravity Test

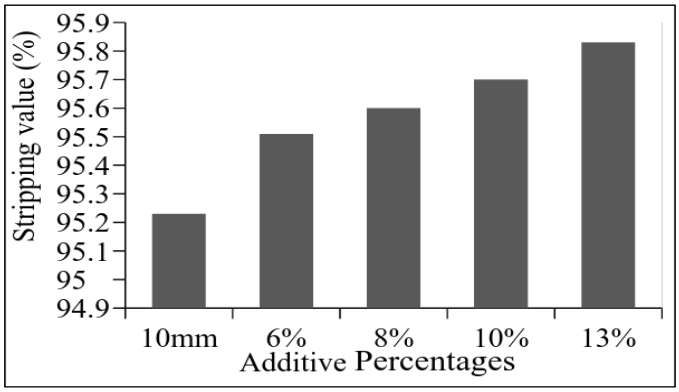

Fig.4 Stripping Value Test

B) Tests for Bitumen

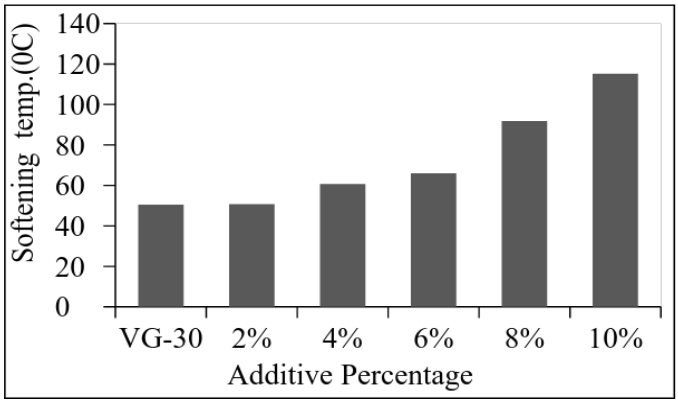

Fig.5 Softening Point Test

Table No.4 Flash and Fire Point Test

Sr. No.	Additive (%)	Flash Point (^{0}C)	Fire Point (^{0}C)
1	VG-30	176	210
2	4%	148	169
3	6%	152	180
4	8%	162	194
5	10%	190	224

V. CASE STUDY

.AIPL, Pune currently corporate works on the project name as “Development and construction of 45 m wide Pune categorical road to Bhakti Shakti chowk”. For that project a Link road is attaches from road to Mukai Kivale of 2.5 km Patch. Composition style for the carrying course of flexible pavement of link road to road is as follows;

Table No.5 Mix Design followed by AIPL

Sr. No.	Type of Aggregates	%	Exact Weight
1	10mm	35 %	420 gm
2	6mm	15 %	180 gm
3	Stone Dust	48 %	576 gm
4	Cement Filler	2 %	24 gm
5	Total	100 %	1200 gm
6	Bitumen (VG-30)	5.5 %	66 gm

Main aim is to reduce cost as well as amount of bitumen effectively.

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VI. BITIMINOUS MIX DESIGN

VG-30 bitumen is modified with polypropylene waste for Wearing Course of Flexible Pavement.

Table No.6 Dry Process of Mix Design

Material Composition for BC - 5 %		
Sr. No.	Particular	
1	Aggregate	Proportion
2	10 mm	30.00%
3	6 mm	20.00%
4	Stone Dust	48.00%
5	Cement filler	2.00%
6	PP Waste	8% /wt. of bitumen
7	VG-30 Bitumen in %	5.00%
8	Compacted Density (Lab)	2.512 gm/cc

Table No.7 Process of Mix Design

Material Composition for BC - 5.29 %		
Sr. No.	Particular	
1	Aggregate	Proportion
2	10 mm	30.00%
3	6 mm	20.00%
4	Stone Dust	48.00%
5	Cement filler	2.00%
6	PP Waste	4% /wt. of Bitumen
7	VG-30 Bitumen in %	5.29%
8	Compacted Density (Lab)	2.528 gm/cc

VII. MARSHALL STABILITY TEST

Varying percentages of waste, Stability of dry process ranges 13.30 – 21.13 KN while flow was between 3.57 – 5.42 mm and Stability of wet process ranges 13.65– 25.38 KN while Flow was between 4.82 – 6.81mm while bitumen reduces 5.5-5% satisfies IS recommendations and MORTH limits.

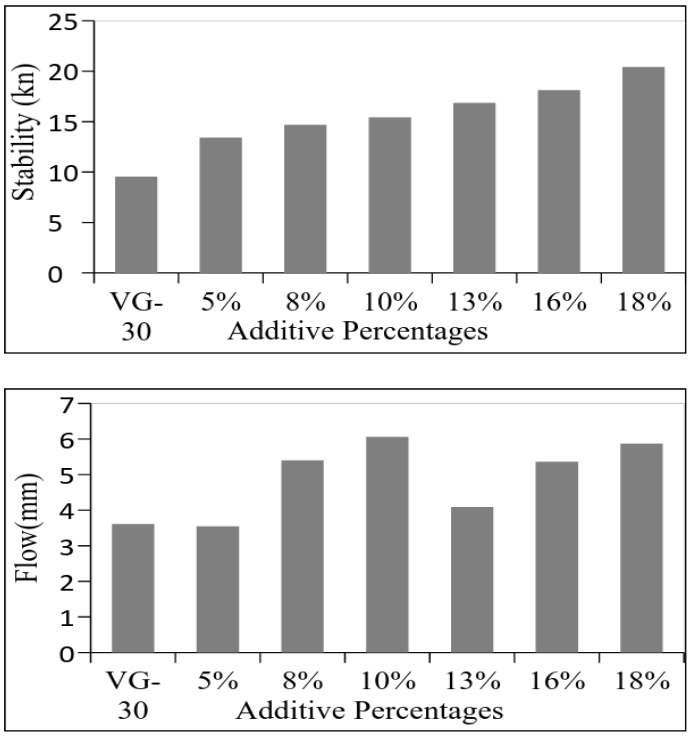

Fig.8 Test Results of Dry Process of Bituminous Mix Design

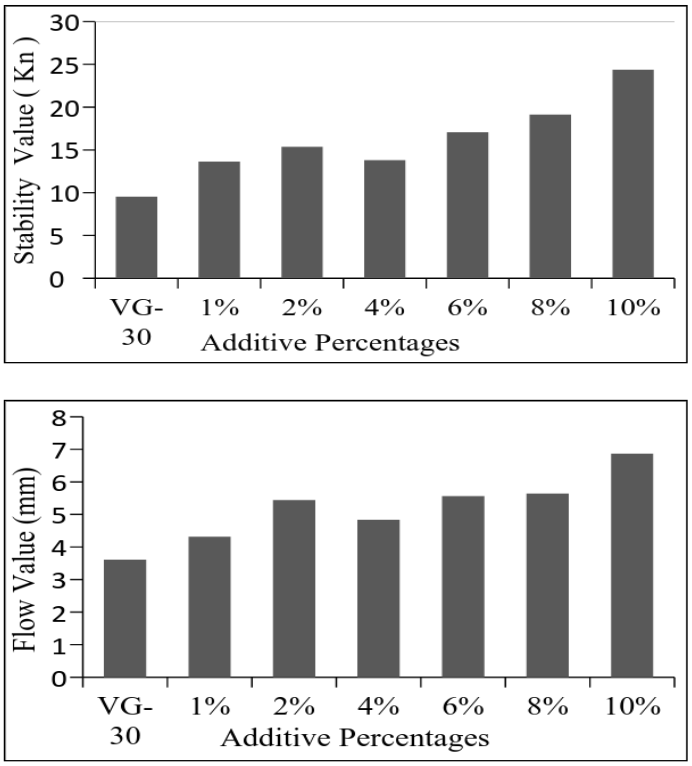

Fig.9 Test Results of Wet Process of Bituminous Mix Design

VIII. ECONOMY OF PROCESS

Table No.8 Statistical Material Cost Analysis and Savings

Materials	Conventional Bitumen	Dry Process	Wet Process
Bitumen	84.86 T	77.15 T	81.62 T
Cost	28,85,240	26,23,100	27,75,080
Net Saving of Bitumen	-	7.71 T	3.24 T
PP Waste	-	6.17 T	3.26 T
Cost	-	92,250	48,900
Total Cost for 1km road	43,53,507	41,83,617	42,92,247
Net Saving	-	1,69,890	61,260

IX. CONCLUSION

1. Specific Gravity of standard aggregate increases from 2.85 to 2.916 for 6% PP waste and 3.071 for 10% PP waste.
2. Water Absorption reduces to nil for 10% PP and 1.13% for 13% PP waste with respect to standard specimen.
3. Aggregate Impact value of standard specimen was 9.37%. It reduced to 2.43% for 6% PP waste and 1.40% for 10% PP waste. Hence toughness of aggregate increases to face the impacts. The roads can sustain heavy traffic and show better durability.

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4. MORTH recommendations for minimum Stripping value for aggregates is 95%, experimental result for standard specimen is 95.23%. The stripping value varies from 95.60% for 8% PP waste and 95.70% for 10% PP waste. Hence as we increase in the amount of PP waste in standard specimen Stripping value goes on increasing with positive results.
5. IS specifications for Softening temperature of standard specimen is minimum 47^0C, while test results for 2% PP waste gives 50.75^0C and 4% PP waste gives 60.75^0C. In India, maximum temperature is up to 50°C hence, it finalizes that up to 4% PP waste is allowed.
6. IS specifications for Ductile nature of bitumen, permissible limit is minimum 40 cm for VG-30 grade. Lab experiment result shows 58.3 cm for 6% PP waste and 41 cm for 6% PP waste. As amount of % PP waste increases, ductility of standard specimen affected and goes on decreasing suddenly.
7. By MORTH limits for Bituminous Mix Design and IRC:SP:98-2013 Guidelines for the use of waste plastic in hot bituminous mixes in wearing course , Dry process of mix design gives most satisfactory results within permissible limits.
8. Marshall Stability Test result helps to integrate the stability of mix as well as flow as per IRC: SP: 98-2013. Increase in stability shows that increase in Strength as well as Durability of mix. Also, dry process utilizes huge amount of PP waste not only gives eco friendly method of disposal but also achieve sustainable growth.
9. Cost analysis on the basis of material cost suggests that Dry process of mix design directly reduces the processing cost more than1 lakh rupees. Almost 6 T of PP waste directly utilize with net saving of 7 T of bitumen of cost 2,38,840.

In brief, Dry process not only helps to save natural resources but also reduce the non-biodegradable PP waste by around 4% by using wet process and 8% by using dry process. Disposal methods like incineration and land filling are totally avoided and ultimately develop a technology, which is eco-friendly. This increases the strength and performance of road.

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