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A Study on use of Plastic Waste (Polypropylene) in Flexible Pavements

T. Kiran Kumar[1], J.Vikranth[2],

[1]M.Tech and Assistant Professor, Department of Civil Engineering, ANITS, Visakhapatnam, Andhra Pradesh, INDIA

[2]M.E (Ph.d) and Associate professor, Department of Civil Engineering, ANITS, Visakhapatnam, Andhra Pradesh, INDIA

ABSTRACT

Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together & laid down in layers then compacted. Now a days, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects. Also considering the environmental approach, due to excessive use of plastics in the day to day business, the pollution to the environment is enormous. Since the plastic (polypropylene) are not biodegradable, the need of the current hour is to use the waste polypropylene in some beneficial purposes.

Keywords-- modifications, plastic polypropylene, flexible, techniques

I. INTRODUCTION

Plastic is everywhere in today's lifestyle and its disposal is a major problem. It is a non biodegradable product due to which these materials pose environmental pollution and problems like Brest cancer, reproductive problems in humans and animals and genital abnormalities. We can use of waste plastic in flexible pavements in such a manner that is gets coated over the surface of aggregate by heating (140˚C - 160˚C) because plastics like polypropylene, polyethylene, polystyrene used in PET bottles, disposal glasses, handbags, covers of various appliances etc. soften up to 160 ˚C. The experiments conducted in the laboratory depict good results and substantially increase the stability and durability of roads plus, making it a very effective step towards eco-friendliness compared to conventional and traditional techniques of flexible pavements construction.

1.1 OBJECTIVES OF THE STUDY:

Basic intention is to efficiently utilize the plastic waste in a constructive way so that it can be beneficial to society. Main objectives of current project work are:

1. To identify the optimum proportion of plastic waste to be added in the bitumen mix for getting the required strength.
2. To evaluate the properties of aggregates by coating plastic over it.
3. To evaluate the properties of polymer modified bitumen for different ratios of polypropylene (varying from 5%-13% by weight fraction).
4. To compare the experimental results with the conventional pavement and perform the economic analysis.

II. LITERATURE REVIEW

R.Vasudevan (2007) states that polymer bitumen blend is a better binder compared to plain bitumen. It can withstand softening point and increased penetration with suitable ductility. When it is used for road construction it can withstand higher temperature and load. The coating increases the porosity, absorption of moisture and improves soundness.

Sabina et al. (2009) studied the comparative performance of properties of bituminous mixes containing plastic/polymer (PP) (8% and 15% by weight of bitumen) with conventional bituminous concrete mixes with 60/70 penetration grade bitumen. Improvements like Marshall Stability, retained stability, individual strength and rutting was observed in plastic modified bituminous concrete mixes.

Gawande et al. (2012) summarizing review on waste plastic utilization in asphalting of roads They review shows to use plastic waste for construction purpose of roads to the pavements.

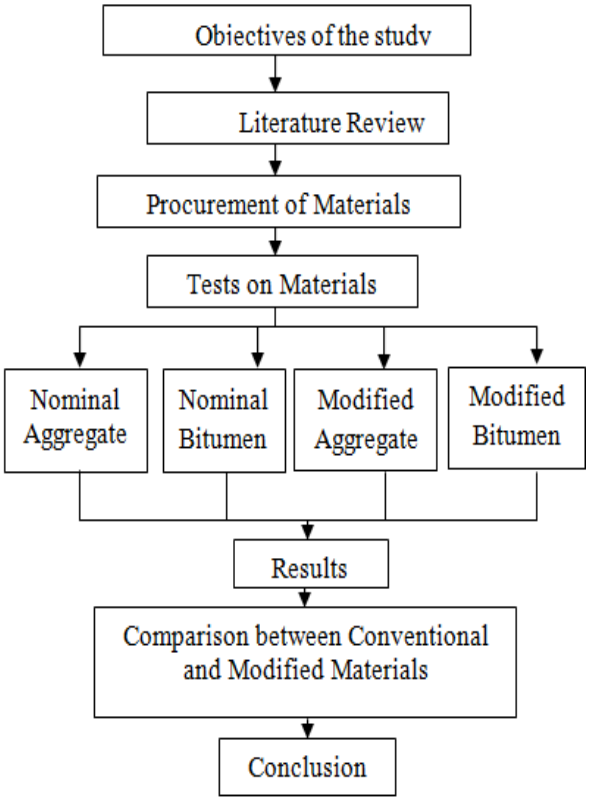
Avula Vamshi (2013) stated that polymer bitumen blend is a better binder compared to plain bitumen. It is based on softening point and decreased penetration with suitable ductility. When used for road construction it can withstand higher temperature.

Bhageerathy K.P, et al. (2014) "Studied use of biomedical waste in bituminous road construction". This

paper described that the waste is to be added 2%, 3%, 5%, 7% and show the good results in the properties of material like aggregate crushing value, optimum bitumen, impact value etc.

III. METHODOLOGY

The following process will be followed systematically as shown in the form of flow chart.



3.1 Basic Materials

The materials used are as follows.

i. Aggregates
ii. Bituminous Binder
iii. Polypropylene.

IV. EXPERIMENTAL WORK

4.1 General

It involves mainly 2 processes. i.e.,

a) Preparation of samples
b) Testing

4.2 CONSTRUCTION PROCESS

There are two important processes namely dry process and wet process used for bitumen mix flexible pavement.

A. Dry Process:

For the flexible pavement, hot stone aggregate (170˚C) is mixed with hot bitumen (160˚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 viscous-elastic 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.

➢ **Advantages of dry process:**

- Plastic is coated over stones – improving surface property of aggregates.
- Coating is not so easy & temperature required is same as road laying temp.
- Flexible films of all types of plastics can be used.
- Doubles the binding property of aggregates.
- Bitumen bonding is strong than normal.

B. Wet Process:

Waste plastic is ground and made into powder; 2.5to 12.5% 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 to make bitumen 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.

➢ **Advantages of Wet Process:**

This Process can be utilized for recycling of any type, size, shape of waste material (Plastics, Rubber etc.)

4.3 TESTS FOR AGGREGATE:

4.3.1 Specific Gravity & Water Absorption Test [IS:2386 (Part 3) 1963]
4.3.2 Aggregate Impact Value Test [IS 2386 (part 4) 1963]
4.3.3 Aggregate Crushing Value [IS:2386 (Part 4) 1963]
4.3.4 Los Angeles abrasion test [IS:2386 (Part IV)–1963]

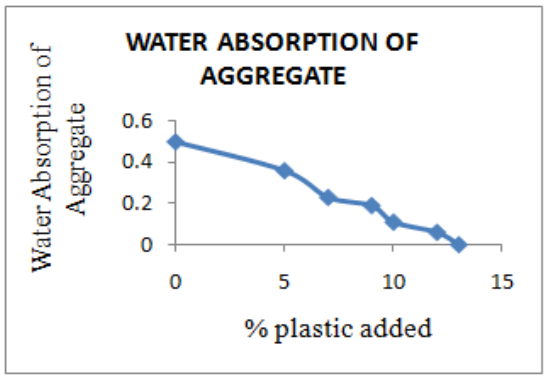
4.4 TESTS FOR BITUMEN

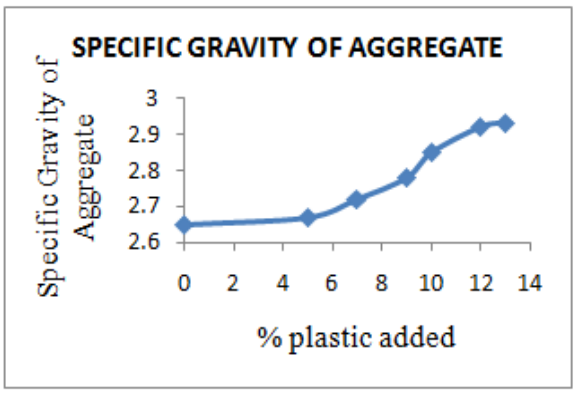
4.4.1 Penetration Test [IS:1203-1978]
4.4.2 Softening Point Test [IS:1205-1978]
4.4.3 Ductility Test [IS:1208-1978]
4.4.4 Viscosity Test [IS:1206 -1978]
4.4.5 Flash Point and Fire Point [IS:1209-1978]
4.4.6 Specific Gravity Test [IS:1202-1978].

4.3.1 Specific Gravity & Water Absorption:

The specific gravity of an aggregate is an indirect measure of its strength. The more specific gravity the more is the strength. The value of specific gravity of plain aggregate is less as compare to that of plastic coated aggregate. Since aggregates having low specific gravity are generally weaker than those with higher specific gravity values, the results say that the specific gravity of the aggregates are increased increasing its strength. Its range should be within 2.5-3.0%.

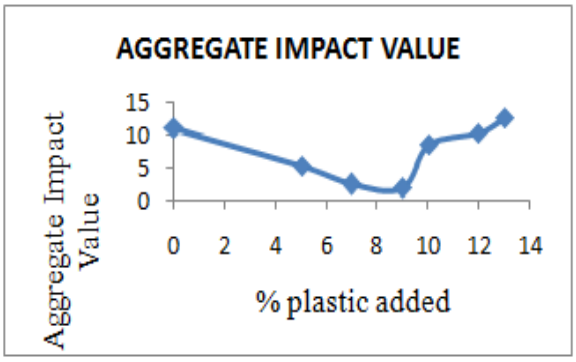
The aggregate is chosen also on the basis of the moisture absorption capacity. The aggregate when coated with plastics improved its quality with respect to moisture absorption. The coating of plastic decreases the moisture absorption and helps to improve the quality of the aggregate and its performance in the flexible pavement. The results show that the moisture absorption of the aggregate is within the range of IRC specifications which reduced to nil due to coating. Its range should be less than 1%.





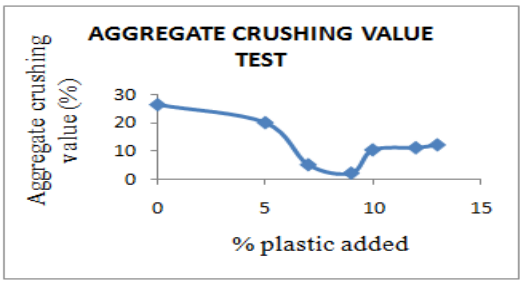
4.3.2 Aggregate Impact Value:

The coating of plastics improves Aggregate Impact Value, thus improving the quality of the aggregate. Moreover a poor quality of aggregate can be made useful by coating with polymers. It helps to improve the quality of flexible pavement. This shows that the toughness of the aggregate to face the impacts. Its range should be less than 10%.



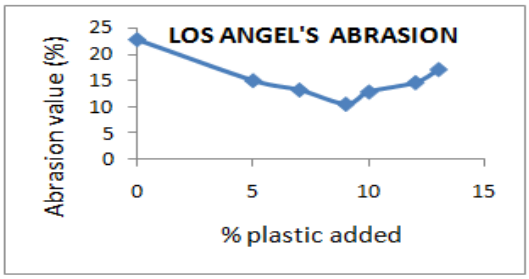
4.3.3 Aggregate Crushing Value:

The aggregate with lower crushing value indicate a lower crushed fraction under load and would give a longer service life to the road. Weaker aggregate would get crushed under traffic load. It is clearly seen from graph that plastic coated aggregates shows the lower crushing value and which can be withstand to traffic load more efficiently than the plain aggregates. The results show that the aggregates are within the range according to ISS. Its range should be less than 30-35%.



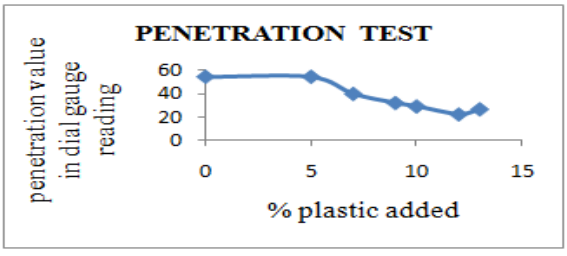
4.3.4 Los Angeles abrasion test:

The repeated movement of the vehicle will produce some wear and tear over the surface of pavement. This test gives that wear and tear in percentage. Under this study the percentage of wear and tear values of plastic coated aggregate is found to be in decreasing order with respect to the percentage of plastics. When the Los Angeles abrasion value of plain aggregate value is compared with the plastic coated aggregates the values are less for coated aggregates. The results obtained are within the range hence can be used for the construction. Its range should be less than 35%.



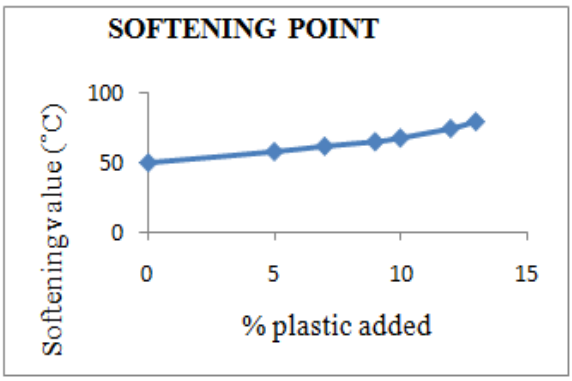
4.4.1 Penetration of Bitumen:

Penetration of a bituminous material is the distance in tenths of millimeter that standard needle will penetrate vertically into a sample under standard conditions of temperature, load and time. With increase in polypropylene plastic waste it was observed that the penetration of bitumen is decreases.



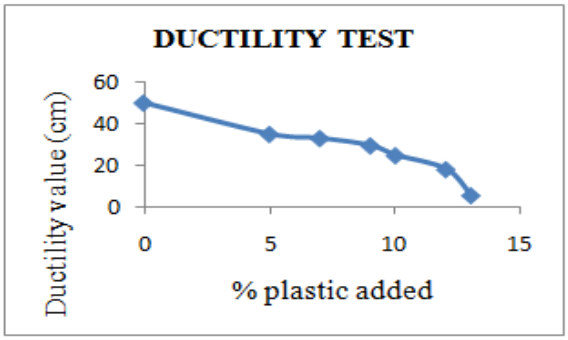
4.4.2 Softening Point of Bitumen:

Softening point is the temperature at which the substance attains a particular degree of softening under specified conditions of test. It was observed that with increase in plastic content the value of softening value increases. The value of softening point shows the bitumen is susceptible to temperature or not.



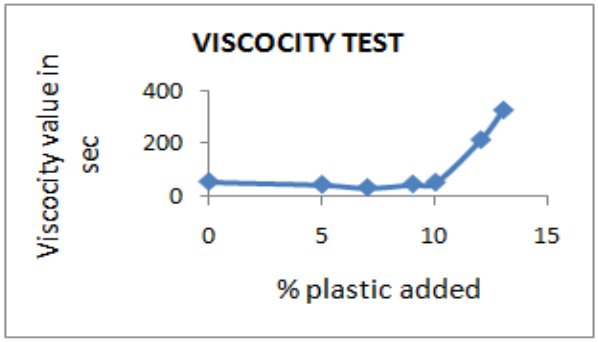
4.4.3 Ductility Value of Bitumen:

The ductility of bituminous material is the distance in centimeters to which it will elongate before breaking when a briquette specimen of the materials is pulled at a specified speed and at specified temperature.



4.4.4 Viscosity Value of Bitumen:

Viscosity is defined as inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate into the voids and also coat the aggregates and hence affects the strength characteristics of the resulting paving mixes.



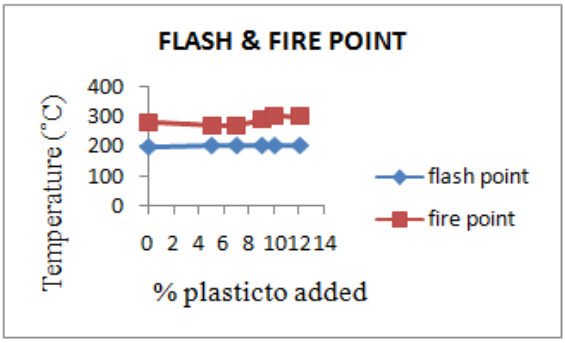
4.4.5 Flash Point and Fire Point of Bitumen:

Bituminous materials leave out volatiles at high temperatures depending upon their grade. These volatile catch fire causing a flash. This is very hazardous and it is therefore essential to qualify this temperature for each bitumen grade.

Flash point: The flash point of a material is the lowest temperature at which the vapour of substance momentarily takes fire in the form of a flash under specified condition of test.

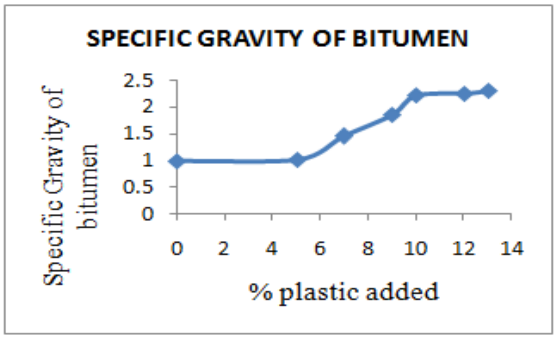
Fire point: The fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test.

The clearly shows with addition of polypropylene content to the bitumen increases the value of flash and fire points.



4.4.6 Specific Gravity of Bitumen:

The specific gravity of bitumen is an indirect measure of its strength. The more specific gravity the more is the strength. The value of specific gravity of conventional bitumen is less as compare to that of plastic coated bitumen. From the graph of specific gravity, the results say that the specific gravity of the bitumen are increased increasing its strength. Its range should be within 0.97-2.5 depending on type of additive (plastic waste) added.



V. SIGNIFICANCE AND CONCLUSION

5.1 Comparison

Following is the tabular form showing the results of conventional and modified aggregate and bitumen

SNO	EXPERIMENT	CONVENTIONAL ROADS	MODIFIED ROADS
1	Penetration Of Bitumen @25˚C(mm)	55	32
2	Softening Point(˚C)	49.9	68
3	Viscosity Value (Sec)	55	52.3
4	Ductility Value(cm)	50	29.5
5	Flash & Fire point (˚C)	195&280	200&300
6	Specific Gravity of Bitumen	0.946	2.2
7	Aggregate Impact value (%)	11.03	8.42
8	Crushing Value (%)	26.4	2
9	Water Absorption (%)	0.5	0
10	Specific Gravity of Aggregate	2.65	2.85
11	Los Angel's abrasion value (%)	22.8	10.5

5.2 Significance of The Test Results:

Property	Ordinary roads	Plastic roads	Significance
Penetration value	More	Less	Less penetration value bitumen are used in hot climate regions and high penetration value represents it was used in a cold regions
Softening point	Less	More	Softening point has particular significance for materials to be used as joint and crack fillers. Higher softening point ensures that they will not flow during service. Higher the softening point, lesser the temperature susceptibility. Bitumen with higher softening point is preferred in warmer places.
Viscosity value	More	Less	At high fluidity or low viscosity, bitumen binder simply lubricates the aggregate particles instead of providing an uniform film thickness for binding action. Low fluidity or high viscosity does not enable the bitumen to coat the entire surface of aggregate in the mix easily and also resists the compactive effort and resulting mix is heterogeneous in character
Ductility value	More	Less	Bitumen with low ductility value may get cracked especially in cold weather.
Flash & fire point	Less	More	This represents how long we can heat the bitumen sample in the field and no fires occur during the heating operation.
Specific gravity of bitumen	Less	More	Higher the value of specific gravity shows higher strength
Aggregate Impact value	More	Less	Aggregate impact value gives the relative strength of aggregates against impact loading. Lesser value of impact value shows high strength and high value of impact shows weak materials
Aggregate Crushing value	More	Less	Aggregate crushing value gives the relative strength of aggregates against crushing loading. Lesser value of crushing value shows high strength and high value of crushing shows weak materials
Water Absorption of Aggregates	More	Less	Aggregates should be low water absorption capacity and high value of water absorption shows the aggregate consists flakey and

			weak materials
Specific gravity of aggregate	Less	More	Specific gravity is directly proportional to strength
Los Angel's Abrasion value	More	Less	For an aggregate to perform satisfactory in pavement, it must be sufficiently hard to resist the abrasive effect of traffic over long period of time. The soft aggregates will be quickly ground to dust, whilst the hard aggregates are quite resistant to crushing effect

VI. CONCLUSION

From the experimental results conducted on the plastic waste, aggregate and bitumen, we can concluded that,

1. The optimum value of plastic waste added from the experimental results is 9 to 10% by weight.
2. Adding of plastic waste in the bitumen resulted in increase in the properties of bitumen and aggregate
3. Reduces the quantity of bitumen upto 9-10 % by weight and reduces the cost of construction of flexible pavement.
4. By using plastic waste in the construction of flexible pavement we can reduce the impact on the Environment.

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