

USE OF POLYPROPYLENE IN PAVEMENT CONSTRUCTION TO INCREASE EFFICIENCY

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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: Modification, Polypropylene, Flexible, Strength.

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 Breast 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

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. METHODOLOGY

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

2.1 Following basic materials are used: -

- Aggregates
- bituminous binder
- polypropylene

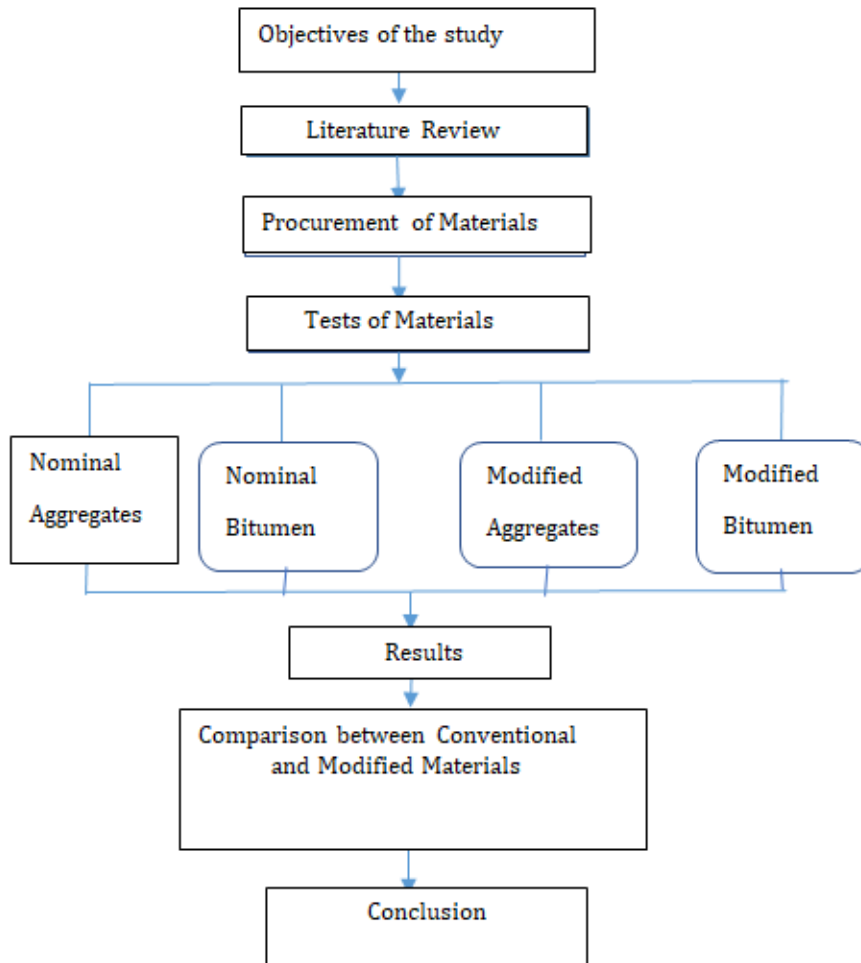


Fig 2.1: Flow chart of different steps which are used in research work

III. MODELING AND ANALYSIS

3.1 General

Different process is involved in construction process which are as follows: -

A. 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.

(b) Wet process

Waste plastic is ground and made into powder; 2.5 to 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.

3.2 Test for aggregates:

Following test are performed with aggregate: -

3.2.1. Specific gravity and water absorption test

3.2.2 Aggregate impact value test

3.2.3 Aggregate crushing value test

3.2.4 Los Angeles abrasion test

3.2.1 Specific gravity and water absorption test

Specific gravity test of aggregates is done to measure the strength or quality of the material while water absorption test determines the water holding capacity of the coarse and fine aggregates. The main objective of these test is to,

- (a). To measure the strength or quality of the material.
- (b). To determine the water absorption of aggregates.

Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. It is the measure of strength or quality of the specific material. Aggregates having low specific gravity are generally weaker than those with higher specific gravity values.

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%.

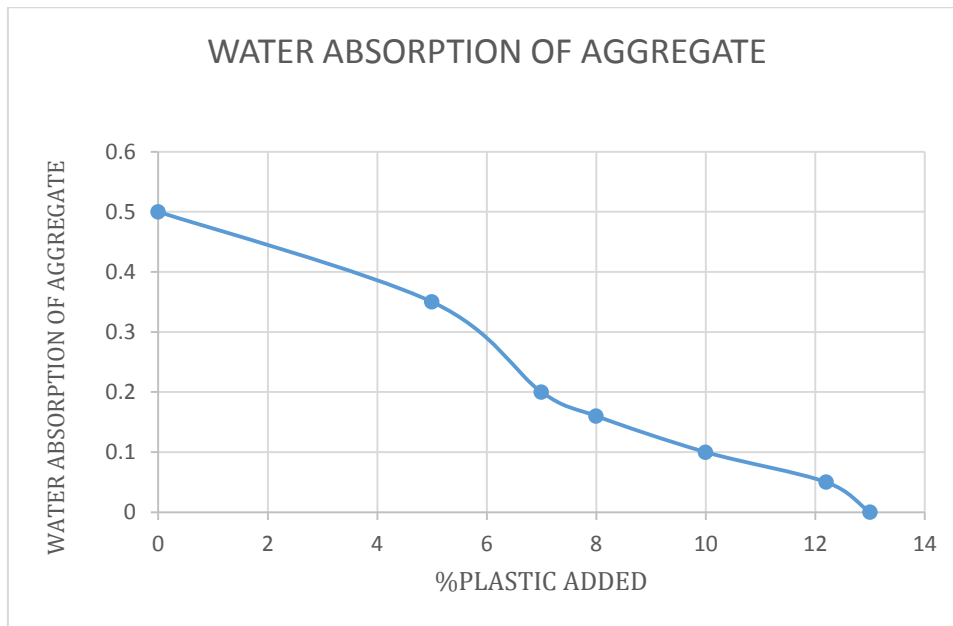


Fig 3.1: Variation of Water absorption capacity of aggregate with plastic added

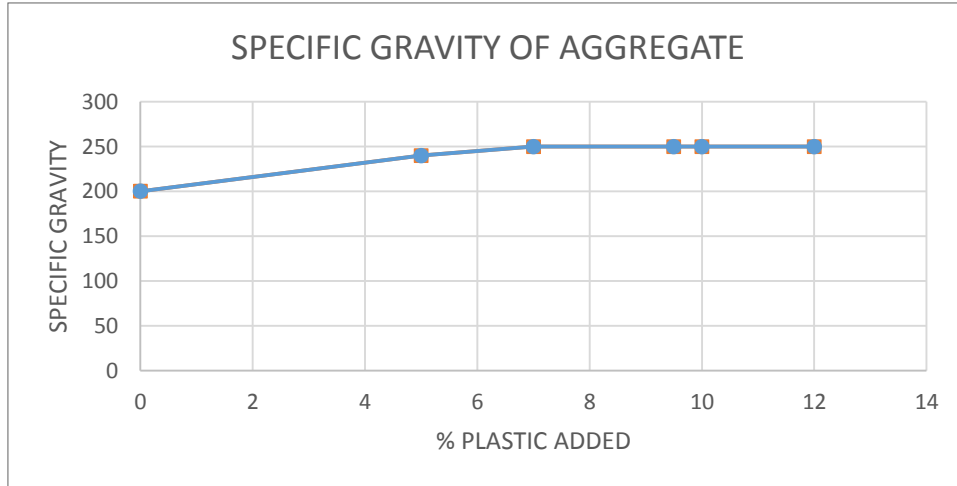


Fig 3.2: Variation in Specific gravity of aggregate with plastic added

3.2.2 Aggregate impact value test

Aggregates undergo significant wear and tear throughout their life. Aggregates must be hard and tough enough to resist crushing, degradation and disintegration and be able to transmit loads from the pavement surface to the underlying layers and eventually the subgrade. Testing the strength of parent rock alone does not exactly indicate the strength of aggregates in concrete. For this reason assessment of strength of the aggregates are made by using a sample bulk aggregates in standardized manner. The principal mechanical property of aggregate required in any construction is

1. Satisfactory resistance to crushing under the roller during construction
2. Adequate resistance to surface abrasion under traffic

Aggregates used in road construction should be strong enough to resist abrasion and crushing and also the impact load. If aggregates are weak, then the stability of pavement structure will be adversely affected. The toughness of aggregate is its ability to resist sudden load acting on it. The movement of vehicles on the road sometimes gives rise to impact loading which results in breaking of aggregates into smaller pieces. Therefore, the aggregates should have sufficient toughness to resist their disintegration due to impact. This characteristic of aggregate is measured by impact value test.

In this test sample of standard aggregates kept in a mould which is subjected to fifteen blows of metal hammer of weight 14 kgs falling from the height of 38cms. The quantity of finer materials resulting from pounding will indicate the toughness of the sample of aggregates. As per IS 283-1970 Aggregates Impact Value is defined as the ratio of weight of fines formed to weight of total sample taken and is expressed in percentage.

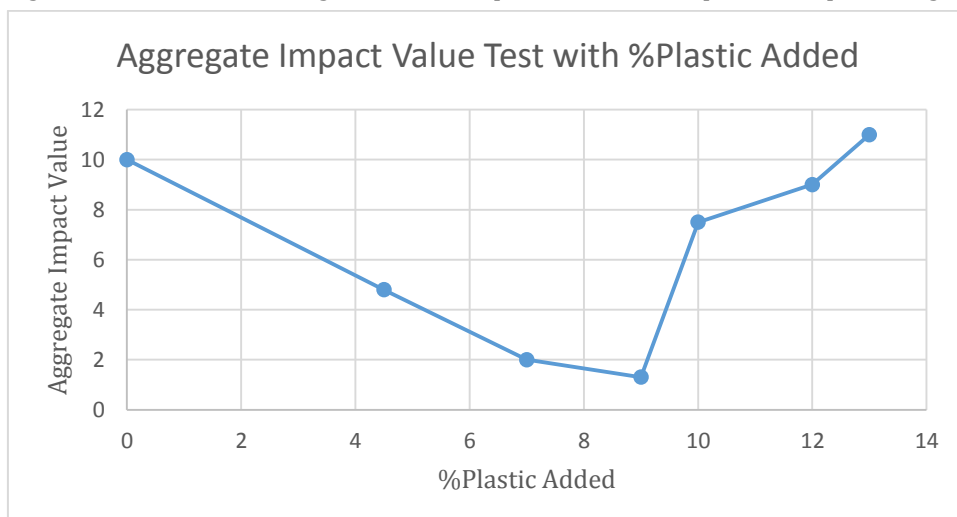


Fig 3.3: Variation in Aggregate impact value with plastic added

3.2.3 Aggregate crushing value

Aggregate crushing value test on coarse aggregates gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. Coarse aggregate crushing value is the percentage by weight of the crushed material obtained when test aggregates are subjected to a specified load under standardized conditions. Aggregate crushing value is a numerical index of the strength of the aggregate and it is used in construction of roads and pavements. Crushing value of aggregates indicates its strength. Lower crushing value is recommended for roads and pavements as it indicates a lower crushed fraction under load and would give a longer service life and a more economical performance. The aggregates used in roads and pavement construction must be strong enough to withstand crushing under roller and traffic. If the aggregate crushing value is 30 or higher' the result may be anomalous and in such cases the ten percent fines value should be determined instead.

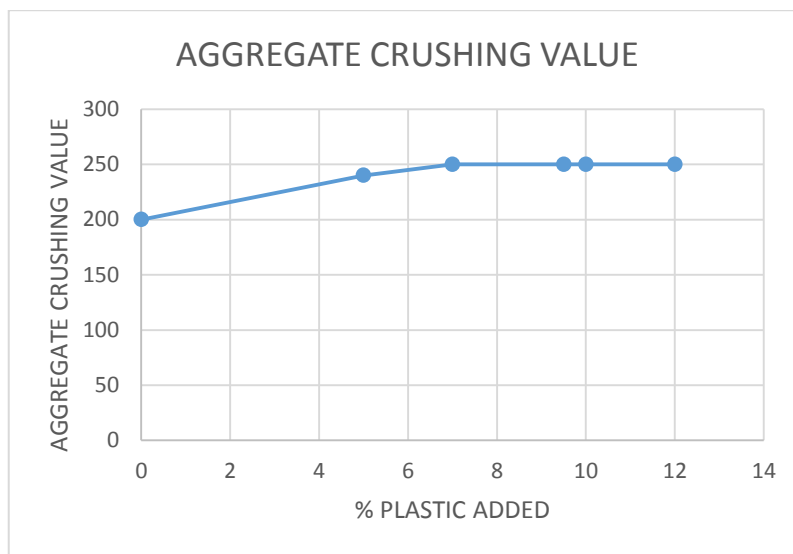


Fig 3.4: Aggregate crushing value test with plastic added

3.2.4 Los Angeles abrasion test

Los Angeles abrasion test on aggregates is the measure of aggregate toughness and abrasion resistance such as crushing, degradation and disintegration. This test is carried out by AASHTO T 96 or ASTM C 131: Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. The aggregate used in surface course of the highway pavements are subjected to wearing due to movement of traffic. When vehicles move on the road, the soil particles present between the pneumatic tyres and road surface cause abrasion of road aggregates. The steel rimmed wheels of animal driven vehicles also cause considerable abrasion of the road surface. Therefore, the road aggregates should be hard enough to resist abrasion. Resistance to abrasion of aggregate is determined in laboratory by Los Angeles test machine. The principle of Los Angeles abrasion test is to produce abrasive action by use of standard steel balls which when mixed with aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates. The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value.

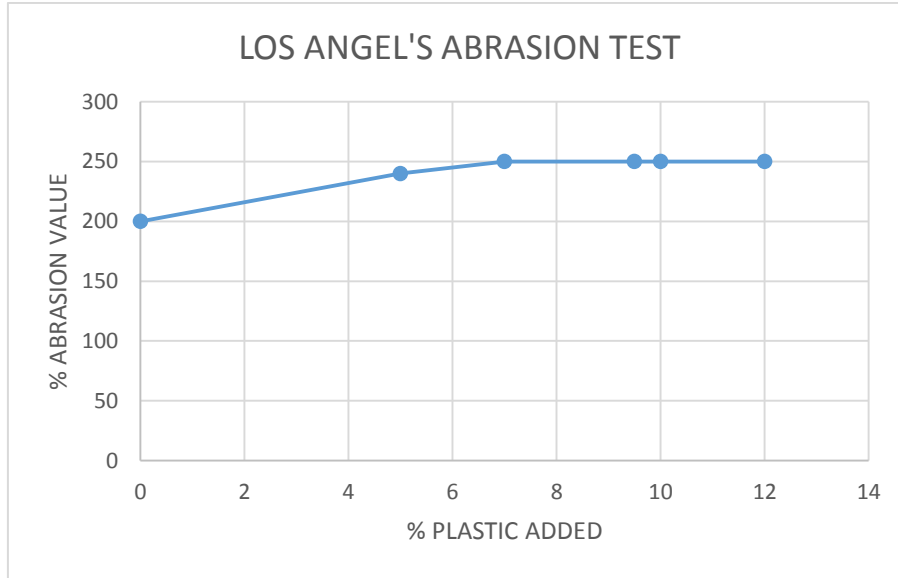


Fig 3.5: Variation in abrasion value of aggregates with plastic added

3.3 Test for bitumen:

Following test are performed with bituminous to check its different properties: -

3.3.1 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.

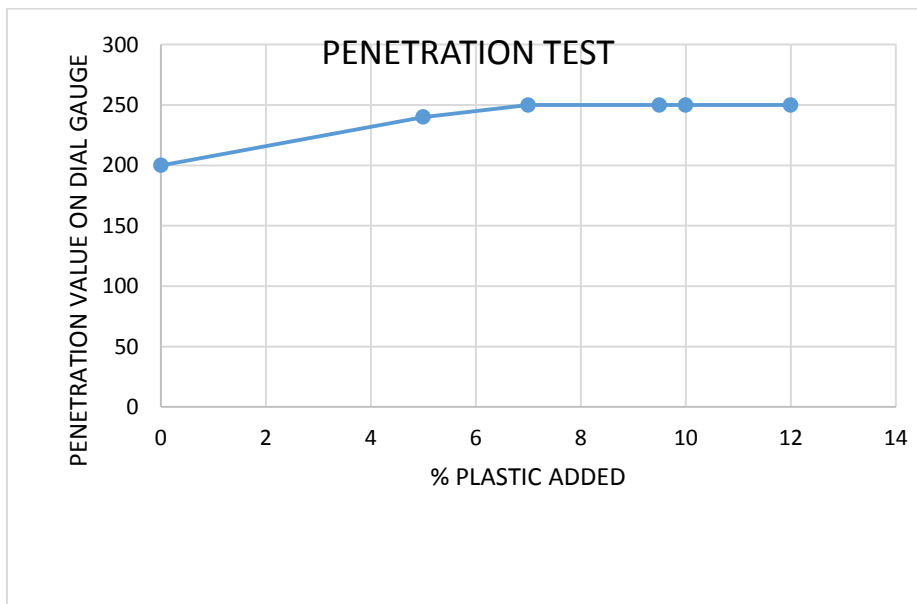


Fig 3.6: Variation in penetration value of bitumen with plastic content

3.3.2 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.

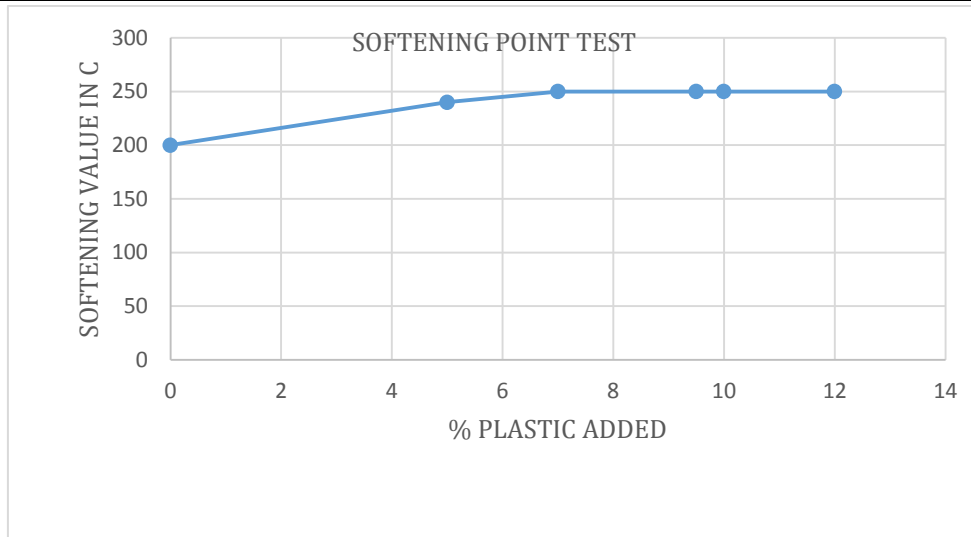


Fig 3.7: Variation in softening value of bitumen with plastic content

3.3.3 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.

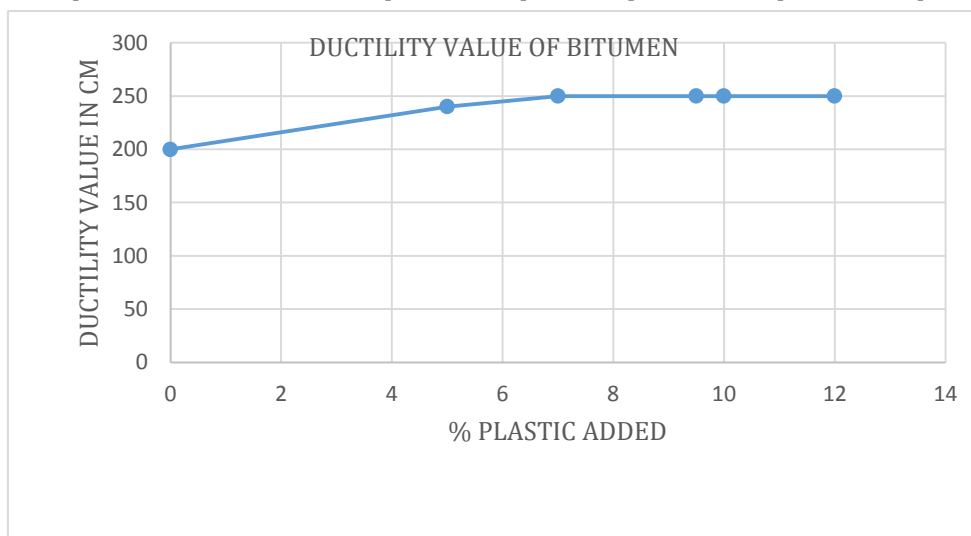


Fig 3.8: Aggregate crushing value test with plastic added

3.3.4 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.

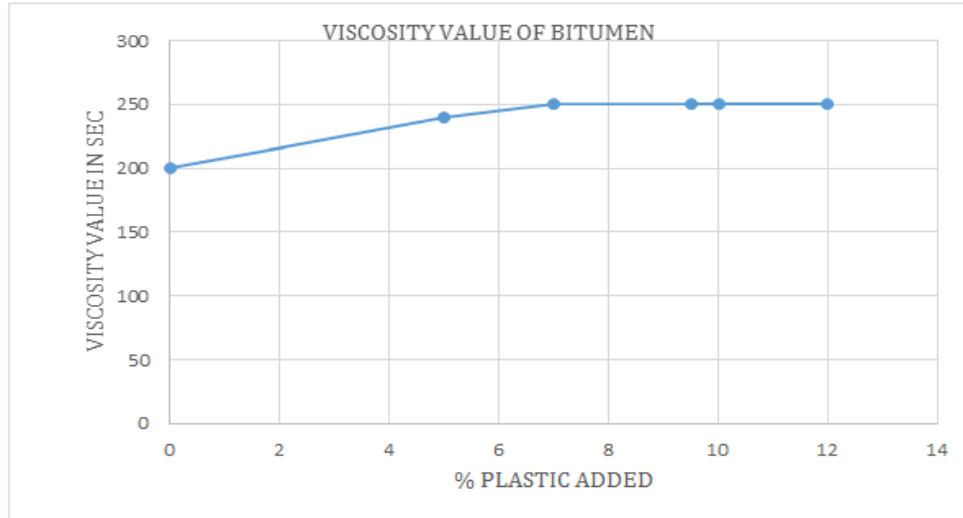


Fig 3.9: Variation in penetration value of bitumen with plastic content

3.3.5 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.

(a) 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.

(b) 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.

3.3.6 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.

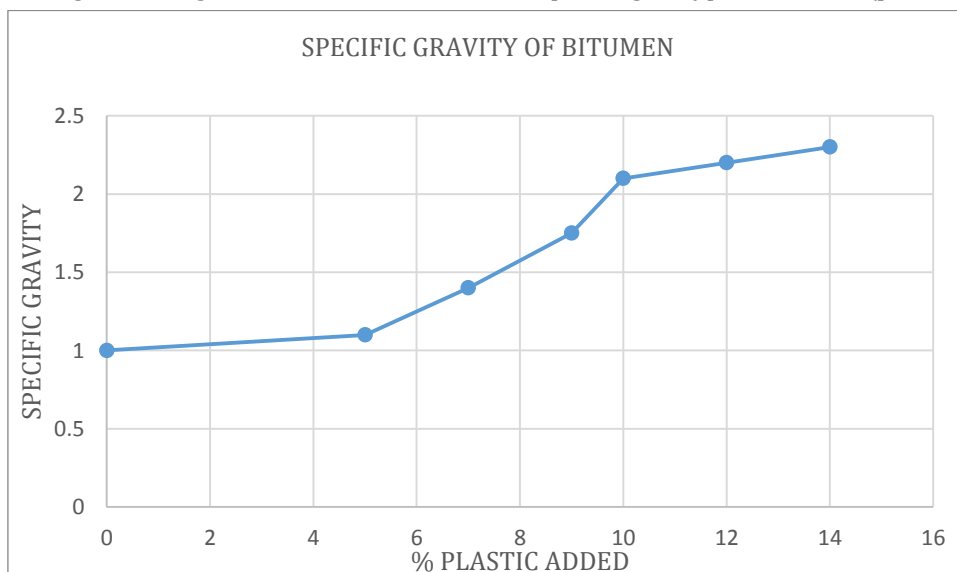


Fig 3.10: Variation in specific gravity of bitumen with plastic content

IV. RESULTS AND DISCUSSION

Following results table shows change in different Test values of bitumen with and without using polypropylene.

S.NO	EXPERIMENT	CONVENTIONAL ROAD	MODIFIED ROAD
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 (in cm)	50	29.5
5	Flash and 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

Results Significance

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 cold regions
Softening point	less	more	Softening point has particular significance for material 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 aggregates 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 aggregate 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 aggregate against crushing loading. Lesser value of crushing value shows high strength and high value of impact crushing shows weak materials.
Water absorption of aggregates	more	less	Aggregate should be low water absorption capacity and high value of water absorption shows the aggregate consists flakey and weak material.
Specific gravity of aggregate	less	more	Specific gravity directly proportional to strength
Los Angeles 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 aggregate will be quickly ground to dust, whilst the hard aggregates are quite resistant to crushing effect

V. CONCLUSION

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

1. The optimum value of plastic waste added from the experimental results is 8 to 9% by weight.
2. Adding of plastic waste in the bitumen resulted in increase in the properties of bitumen and aggregate from this the efficiency of pavement increased against different weathering conditions and different types of loads.
3. By Using polypropylene, it can Reduces the quantity of bitumen up to 8-9 % by weight and reduces the cost of construction of flexible pavement. So, it can make an economical construction.
4. By using plastic waste in the construction of flexible pavement we can reduce the impact on the Environment. So, we can make a clean and healthy environment by using polypropylene.

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