Utilization of Plastic Waste in Bituminous Road Construction

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Abstract- *Our project study on the addition of waste plastic with bitumen gradually increasing 5 to 12%.The problems like bleeding are reduce in hot temperature region. The waste plastics thus can be put to use and it ultimately improves the quality and performance of road.*

Total material cost of the project is reduced. The use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure. The process is not only benefits economically but also give a solution to environmental problems.

Keywords- Plastic Waste, Incineration, Land filling, Fire Point, Flash Point

I. INTRODUCTION

Generally, for two types of road; materials used are concrete for rigid pavement roads and bitumen for flexible pavement roads. For economical road construction; new techniques and new material must be used. The steady increase in traffic intensity and a significant variation in seasonal temperature made a demand in improvement of road characteristics with the improvement in property of binder. Bitumen is a useful binder for road construction and grades of bitumen available on the basis of their penetration values are 30/40, 60/70, 80/100. Since, the plastic materials have become part and parcel of daily life, its availability is enormous. They either get mixed with Municipal Solid Waste or thrown over land area, If not recycled; their disposal is either carried out by land filling or by incineration leaving a certain impact on the environment.

TYPES OF PLASTICS

Plastics are classified into 2 types based on their physical properties. They are,

- Thermo setting plastic
- Thermo plastic

Thermo Setting plastic:

Thermosetting materials which once shaped cannot be softened or re moulded by the application of heat.
Reasons: Strong Covalent bonds and Cross-linked networks.
Examples: Bakelite, Epoxy, Melamine, Polyester, Polyurethane, Urea-Formaldehyde, Alkyd.

Thermo plastic:

Thermo plastic materials which can be formed into different shapes under application of temperature and pressure.

Examples:

- **Polyethylene Terephthalate:** Oil bottles,water bottles,soda bottles.
- **High Density Polyethylene:** Milk packets, detergent bottles, juice jugs.
- **Low Density Polyethylene:** Wrapping films, bags
- **Poly styrene:** In this phenyl group attached to every other carbon atom.
  Ex: To-go containers, Styrofoam cups
- **Poly Vinyl Chloride (PVC):**
  The poisonous Plastic,It is highly toxic throughout its life. itcan't be effectively recycled due to the many different toxic additives used to soften or stabilize PVC, which can contaminate the recycling batch .Hence this is not recycled.
  Eg: Plastic pipes, Shrink wrap, Food containers.

II. LITERATURE RIEVIEW

Incineration

Incineration means burning of solid waste in controlled conditions. The most usual practice of disposal of solid waste is burning in open fields .This slow burning at low temperature produces many hazardous gases. This waste contains inorganic matter also and because of this burning in heaps there is no control of supply of oxygen or rather there is no oxygen supply except that present in the voids. This incomplete combustion at a low temperature produces hazardous gases and these gases pollute the environment very

close to us. Particularly the gases produced by the burning of plastic, rubber and other such materials produce very much harmful gases.

Land Filling

- The most common and easy way of disposal of solid waste is dumping it on land. When the combined waste (inorganic and organic) is disposed on the land then the decomposition of the organic matter takes place in due course of time.
- This decomposition produces gases (like methane) and dark coloured dirty offensive water known as leachate. If the ground on which the waste is disposed is pervious then this leachate percolates and mixes with the ground water and badly pollutes it.
- The mixing of these pollutant through leachate makes the water polluted and contaminated. Secondly in open landfills the rain water increasesthe volume of leachate and mixes it with the ground or surface water source more easily. So the landfill should be so designed that it contains an impermeable barrier to stop the mixing of leachate with the water.

TYPES OF BITUMEN

- **Bitumen 80/100:** The characteristics of this grade confirm to of IS-73-1992. This is the softest of all grades available in India. volume roads and is still widely used in the country**.**
- **Bitumen 60/70:** This grade is harder than 80/100 and can withstand higher traffic loads. It is presently used mainly in construction of National Highways & State Highways.
- **Bitumen 30/40:** This is the hardest of all the grades and can withstand very heavy traffic loads. The characteristics of this grade confirm to that of S 35 grade of IS-73-1992. Bitumen 30/40 is used in specialized applications like airport runways and also in very heavy traffic volume roads in coastal cities in the country.
- **Viscosity grade Bitumen:** The new method of grading the product has now rested on the viscosity of the Bitumen (at 60^0C and135^0C).

III. METHODOLOGY

Steps involved in construction of plastic road laying:

This process starts with the collection of plastic waste from various places like dumping yards. Then they have to be segregated and stored in a safe place. The plastic waste (bags, cups, water bottles etc...) which is collected is cleaned and dried for some time. Such plastic waste which is composed of PE, PP, and PS is shredded into sizes ranging 2.36mm to 4.75mm. Shredding can be done using shredding machine. PVC should be eliminated because of its highly toxic nature.

Heating of aggregates

- Then Aggregates should be selected based on the requirements of the road construction. In dry-process the aggregate mix is heated to 165^0C and transferred to mixing chamber. Monitoring the temperature is very important otherwise the desired properties of the aggregate may vary.

- **Dry Process**

In this process the hot stone aggregate (170^0C) is coated with plastics and then mixed with hot bitumen (160^0C) and this mixes used for road laying. When coated with plastics the road quality is improved with respect to voids, moisture absorption and soundness. The plastic coating decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavements. This process is used for the isolated works.

- **Wet Process**

In this process waste plastic is grounded and made into powder. 6 to 8 % plastics 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. 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 temperatures increases.

- **TESTS**

There are several tests to be done to check the properties of bitumen and strength of polymer coated bitumen aggregates. They are,

a.Penetration index.
b.Softening point.
c. Ductility.
d. Flash and Fire point.
e. Marshall Stability test.
f. Impact and Los angel’sAbrasion test.

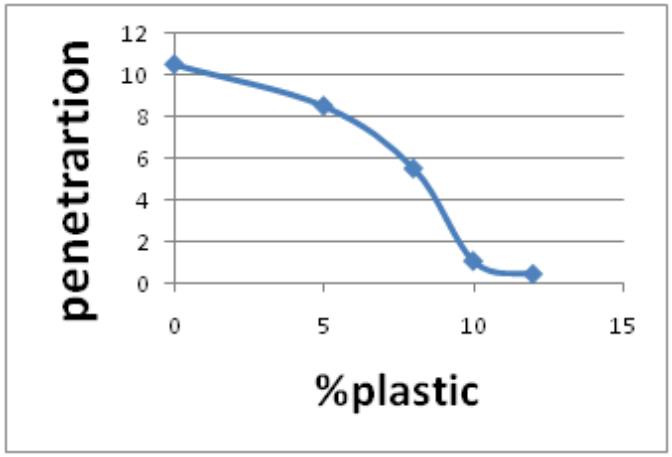
IV. RESULTS AND DISCUSSION

Penetration test

1. The hardness or the quality of bitumen is assessed by this test.
2. A standard needle is allowed to penetrate under the load 100gm, through the sample kept at 25^0C for 5 sec.
3. More penetration index impairs surface applications.

Penetration Index test

S.no.	% of Plastic	Penetration Index (mm)
1	0	10.5
2	5	8.5
3	8	5.5
4	10	1.06
5	12	0.43

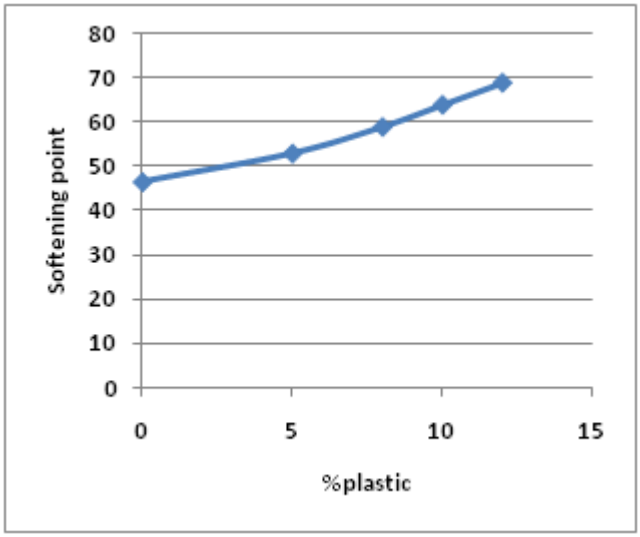


Plot for Penetration

Softening Point

- This is measured by Ball and Ring test. Bitumen is melted and casted into discs of two numbers in standard rings Steel ball is kept on each Casted disc of bitumen and the whole standard carrying these two Discs immersed in water or glycol bath.
- Temperature at which sample detaches from the die and falls indicates the softening point.
- Higher the softening point better the consistency of bitumen.

S.no.	% of Plastic	Softening Point (^{0}c)
1	0	46.5
2	5	53
3	8	59
4	10	64
5	12	69

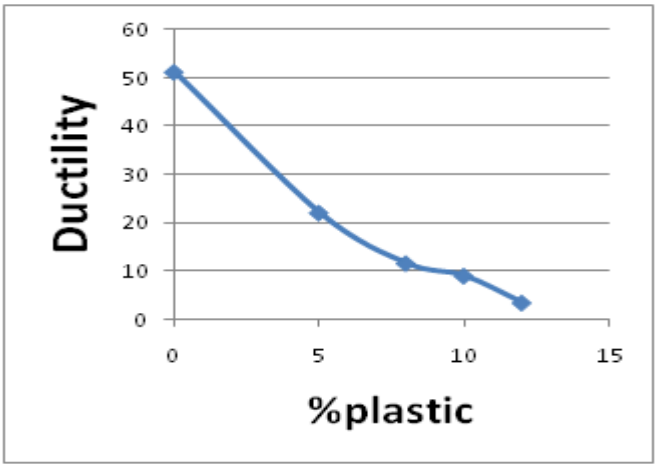


Plot for Softening point

Ductility test

1. Bitumen should possess high ductility for surface applications
2. It is measured by ductilometer
3. It is the measure of capacity of bitumen to elongate or stretch
4. Higher the capacity to elongate higher the ductility.

S.no.	% of Plastic	Ductility (cm)
1	0	51.2
2	5	22
3	8	11.5
4	10	8.9
5	12	3.3



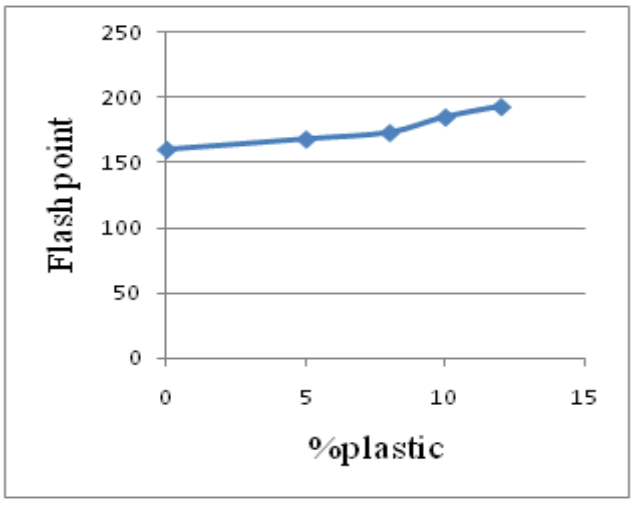
Plot for Ductility

Flash and Fire point test:

In the interest of safety, legislation has been introduced in most countries fixing minimum flash point limits to prevent the inclusion of highly inflammable volatile fractions in kerosene distillates

Flash point test:

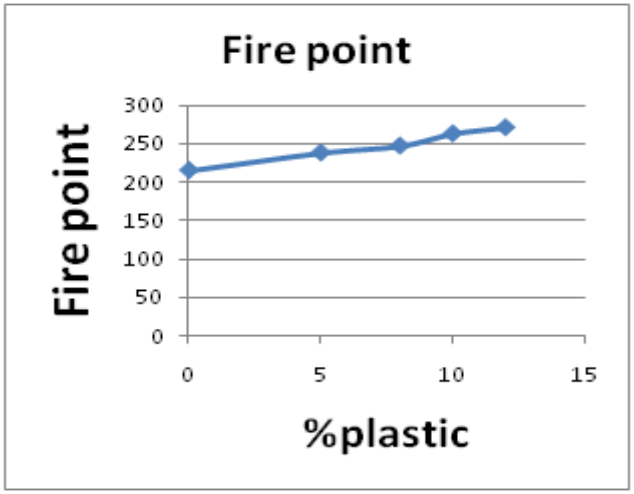
S.no.	% of Plastic	Flash point (^{0}c)
1	0	160
2	5	168
3	8	173
4	10	185
5	12	193



Plot for Flash point

Fire point test

S.no.	% of Plastic	Fire point (^{0}c)
1	0	215
2	5	238
3	8	247
4	10	263
5	12	271



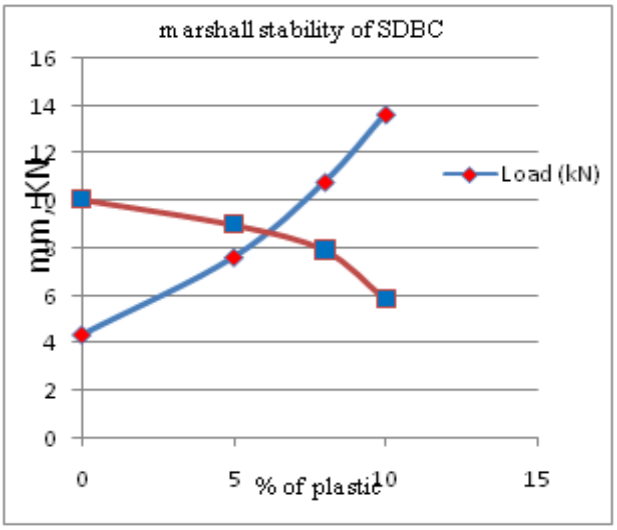
Marshall Stability

Marshall Stability measures the maximum load Sustained by the bituminous material at a loading rate of 50.8 mm/min. Marshall Stability is related to the Resistance of bituminous materials to distortion, displacement, rutting and shearing stresses.

Marshall Stability of SDBC in wet process

S.No.	% of Plastic	Load(KN)	Displacement(mm)
1	0	4.37	10.02
2	5	7.63	8.96
3	8	10.8	7.90
4	10	13.65	5.85

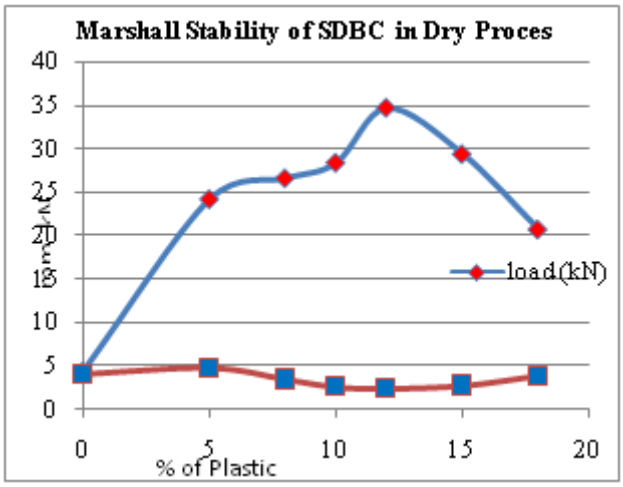
Marshall Stability Test (Wet process)



Plot of Load and Displacement (Wet process)

Marshall Stability of SDBC in DRY Process:

S.No.	% of Plastic	Load(KN)	Displacment (mm)
1	0	4.37	4.02
2	5	24.19	4.69
3	8	26.59	3.43
4	10	28.38	2.59
5	12	34.69	2.43
6	15	29.37	2.74
7	18	20.70	3.83



Plot of Load and Displacement (Dry process)

V. CONCLUSIONS

- This review intended to find the effective ways to reutilize the hard plastic waste particles as bitumen modifier for flexible pavements.
- The addition of waste plastic modifies the properties of bitumen.
- The modified bitumen shows good result when compared to standard results.
- The use of modified bitumen with the addition of processed waste plastic of about 5-12% by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous concrete mix, resulting which improves the longevity and pavement performance with marginal saving in bitumen usage.
- The problems like bleeding are reduce in hot temperature region.
- The waste plastics thus can be put to use and it ultimately improves the quality and performance of road. Total material cost of the project is reduced by 7.99%.
- The use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure.
- The process is not only benefits economically but also give a solution to environmental problems.