

## USE OF WASTE PLASTIC BAGS FOR CONSTRUCTION OF FLEXIBLE PAVEMENTS

MANDEEP KAUR<sup>1</sup>, HUMAIB NASIR<sup>1</sup> AND INSHA WANI<sup>2</sup>

*Department of Civil engineering, Lovely Professional University, Phagwara 144 411, Punjab, India*

(Received 18 October, 2019; accepted 26 November, 2019)

### ABSTRACT

Bitumen is considered as one of the widely accepted binder for construction of pavements apart from being available in various grades on the basis of its penetration values. Now a days due to increase in intensity of vehicles moving on roads apart from the varying temperature depending on everyday temperature or season wise, which require improvement in pavement properties, thereby concluding that improvement in properties of binder material is required. In today's scenario of rapid industrialization and production of goods on large scale, availability of plastics and plastic wastes have are gigantic as plastics have become important part of daily domestic life. Daily plastic wastes generated from various sources get either mixed with municipal solid waste or are thrown over large area. Thereby raising its need for recycling, if not recycled it is either dumped in landfills else burnt in incinerators which in turn deteriorate environment on large scale. Considering this fact, there is need to devise an alternative way for use of waste plastics to decrease their impact. Plastic wastes which consist of plastic bags and other used plastic such as pouches, tents can be used to coat aggregate and this stone which has been coated can be used for flexible pavement construction. The waste polymer blend can be prepared which when mixed with aggregates and used for pavement construction shows very high strength thereby not only improving binder properties but also decreasing the impact and quantity of plastic wastes on environment. This research work investigates how plastic waste bags can be used in bitumen mixes and used for construction of flexible pavements. An attempt is made to study the effect that plastic wastes can have on the properties of bitumen in which it is mixed by performing all required tests on bitumen and thereby devising a proper proportion in which plastic waste can be mixed with bitumen in an efficient and sustainable manner.

**KEY WORD** : Bitumen, Flexible pavement, Proportional sustainable

### INTRODUCTION

The disposal of various kinds of wastes from various industries has become a growing problem in today's world. These materials which cannot be dumped or decomposed cause threat to the environment. Many of these materials are non-bio degradable. Traditionally in road construction materials like soil, aggregates, bitumen, sand, etc. are used. The cost of these natural materials of good quality is increasing day by day. Also, the natural materials are exhaustible in nature and due to their continuous usage there is a decline in the quantity. Many alternative materials have found for the

construction purposes. And one such material is industrial waste. They can be used in construction and there can be a reduction in problems of disposal and pollution. Some of these materials have been tested keeping in mind the land these materials have occupied because of the absence of their disposal systems and because of their specifications which can be used to enhance the industrial wastes in the making of roads. The specifications required can be formulated and the solid waste can be used for road construction. This will have two benefits: The land will be cleared of the huge dumps the natural reserves can be preserved, and thus the environment can be protected. Plastics are not ecofriendly and

(<sup>1</sup>Asstt. Professor, <sup>2</sup> Student)

\*Corresponding author's email: Humaib.18648@lpu.co.in; Mandeep.kaur@lpu.co.in; inshawani61@gmail.com

also not degradable. Its disposal is generally done either by incineration or land filling which are both harmful to the environment and also hazardous. Plastic can be helpful to humans but after it is used it becomes a problem to the environment. Using waste with bituminous mixes can increase the performance of the pavement, be environment friendly. Polymer and plastic modified bitumen is obtained by mixing some thermoplastics and waste and natural plastic or elastomers which are suitable for bitumen. The studies carried out by CRRRI regarding the use of plastic waste bags in bitumen concrete mix proved that this improves the characteristics of the mix and also solves the problems of disposal. The results showed that the properties of strength improved as compared to the conventional mix. Also, the duration of the surface of the pavement is increased as compared to the normally used bituminous mix. Roads are the connecting lanes between two places, or it's a way constructed and modified according to the needs of the public. In ancient times roads were the paths paved by the humans and their burdens of animals and other heavy items what humans used to carry as they were nomads. With time humans started settling in different places which made the construction of roads necessary to travel from one place to another. Increase in traffic also increases the vehicular load on the surface of the roads. New construction techniques are being used. There is a need of management of required space for maximum traffic. This requires safe and effective designing of roads, highways and also managing space and providing proper drainage of water are some of the aspects which have to be taken care of properly. Managing time, money and resources are

important factors.

**STEPS OF ROAD CONSTRUCTION**

- I. Soil compaction
- II. Soil stabilization
- III. Routing operations
- IV. Construction of base layers
- V. Asphalt paving.
- VI. Asphalt compaction.
- VII. Concrete paving inset.
- VIII. Concrete paving offset.

**MATERIALS USED FOR PAVEMENT SURFACES**

- 1. Aggregates
- 2. Bitumen

**Bitumen**

Bitumen acts as binder for construction purposes. Based upon the penetration value, bitumen is classified into various grades e.g. 30/40, 60/70, 80/100. For the roads to be improved, a binder of good quality is required. Bitumen is an organic liquid which is sticky, black, viscous, and is completely soluble in carbon disulfide. It consists of high condensed polycyclic aromatic hydrocarbon. Crude bitumen in the petroleum form which is tar like and sticky, is thick and heavy and for it to flow has to be heated or diluted. It is in the form of cold molasses at room temperature. When fractional distillation of crude oil is done, refined form of bitumen is obtained. It has highest boiling point of 525 °C. Asphalt is obtained by mixing aggregates and bitumen. Tar is viscous, black material which is a result of destructive distillation of coal.

Materials Used for Pavement Surfaces

<b>Aggregates</b>	<b>Bitumen</b>
According to the production methods: Natural aggregates/ By-product aggregates	
Processed aggregates	
Colored aggregates	Cutback bitumen
According to the Petro logical characteristics:	
Igneous rocks	
Sedimentary rocks	
Metamorphic rocks	Bitumen emulsion
According to particle size: Fine aggregates	
Coarse aggregates	Bituminous primers
According to unit weights: Normal weight aggregates	
Light weight aggregates	Modified bitumen
Heavy weight aggregates	

### Uses of Bitumens

- A. The basic purpose for which bitumen is used is for construction of roads.
- B. It is used for water proofing purposes. It is also used for roofing felt production and flat roof sealing.

### Bitumen Production

Bitumen is obtained when crude petroleum is refined and bitumen is left as a by-product. Different number of refinery processes are used like straight distillation, solvent extraction, etc. can be used to produce bitumen having varying consistencies. This type of process used depends upon the origin and characteristics of crude oil.

### Requirements of Bitumen

The property required in a particular type of bitumen depends upon the mix type and construction. Bitumen should not be susceptible to high temperature. If the temperature is high, the bitumen may become unstable and soft. If the temperature is low the bitumen becomes brittle and can develop cracks. Care should be taken that such things should not happen. The viscosity should be checked when mixing and compaction is done. Tests should be conducted on affinity and adhesion between bitumen and aggregates.

### Plastic Material

#### a) Wet Process

The classification of plastics is usually done by the chemical structure they possess and the polymer backbone and side chain. The classification can be done in the groups of acrylics, polyesters, silicones and halogenated plastics. Classification can be done on chemical processes used in synthesis, e.g., condensation, cross linking. Plastics can be classified into two types: (I) thermoplastics, (II) thermosetting polymers. When plastics do not undergo any change in their chemical nature and composition they are classified as thermoplastics. e.g., polyethylene, polypropylene, polytetrafluorethylene (PTFE). When the process of thermosetting occurs, an irreversible chemical reaction occurs, e.g., vulcanization of rubber. The plastic properties are to a great extent classified by organic chemistry of polymer, e.g., hardness.

### Different Types of Waste Plastic (Polymer) and its Origin

Type of waste plastic	Origin
Low density polythene (LDPE):	Bags, bins, sacks, detergent bottles, etc.
High density polythene (HDPE):	Pharmaceutical bottles disinfectant, milk bottles, juice bottles, bottle caps, etc.
Polypropylene (PP):	Bottle caps, wrapping for biscuits, trays used in microwaves for readymade meals, etc.
Foamed Polystrene	Food trays, egg boxes, disposable cups, protective packaging etc.
Polyvinyl Chloride (PVC)	Mineral bottles, credit cards toy, pipes and gutters, electrical fittings, furniture, folders and pens, medical disposables; etc.

### A. Advantages of Using Plastic in Flexible Pavements

1. Increased Marshall Stability Value with stronger roads.
2. Resistance against rainwater and stagnation of water.
3. No stripping, no potholes.
4. An increase in the binding and bonding of the mixture is better.
5. There's a reduction in the aggregate pores and this leads to reduction in rutting and raveling.
6. No effect of radiation like UV radiation.
7. The strength of road is increased by 100%.
8. The load withstanding property increases. It helps to satisfy the need for increased road transport.
9. Value addition to the waste plastics (cost per kilogram increased from Rs 4 to Rs12).
10. Cost of road construction is decreased.
11. Maintenance cost of roads is almost negligible.
12. Plastic waste disposal will no longer be a problem.
13. Using plastic waste on road has helped to find a solution to the burial of the waste.
14. Employment for unemployed will be generated.

### B. Advantages of Waste Plastic Bituminous Mixture

1. Strong roads with increased value of Marshall Stability.
2. Resistance against stagnation of water.

3. Increase in the binding property and better bonding of the mix.
4. Reduction of pores in aggregates.
5. No leaching of plastics.

## METHODOLOGY

### Preparation of Plastic Waste Material

- a) *Plastic waste scenario*: now-a-days, the use of plastics such as plastic cups, glasses, carries bags, etc. is increasing day by day. 50-60% of plastics produced are used for packing.
- b) *Waste plastic shredding*: It is the process in which plastic is cut into small sizes of 2.36- 4.75 mm by a plastic shredding machine. Thin films of polyethylene, polypropylene bags are shred in agglomerator and solid waste material is shred in scrap grinder i.e., cable lines, plastic bottles, etc.

### Basic Processes

- a) Segregation process
  - b) Cleaning process
  - c) Shredding process
  - d) Collection process
1. **Segregation**: Plastic waste is collected from various sources. It is separated from other wastes. Maximum thickness is of 60 microns.
  2. **Cleaning Process**: Plastic waste is cleaned and dried.
  3. **Shredding Process**: Shredded plastic is cut into small pieces. Then various types of plastic wastes are mixed together.
  4. **Collection Process**: The plastic waste retained is collected. Two processes are used in construction of plastic roads.

**Wet Process**: The waste plastic is directly mixed with hot bitumen at 160 °C and the mixture is mixed using mechanical stirrer. This mixture has additional stabilizing agents and this requires proper cooling. Because of the huge investments it is not very popular and also it requires larger plants and large equipments than the dry process.

- Plastic bags are collected first.
- The plastic waste collected, is sorted as required.
- Polyethylene below 60 micron is used for the further processes.
- Plastic of less micron can easily be mixed at high temperature in the bitumen(160-170°C)
- Plastic collected is cut into fine pieces.
- It is sieved through sieves of 4.75mm and retained on 2.36mm sieve and collected.

- Bitumen is heated at about 160-170°C which is melting temperature.
- Then pieces are added.
- Mixture is stirred manually for 20-30min at constant temperature.
- Polymer bitumen mixture of different composition is prepared & is used for conducting different tests.

*Dry Process* Plastic waste when collected is segregated and stored. Segregation is done because some plastics cannot be used due to safety concerns like PVC flux sheets, etc. Then plastic is cleaned because the plastic collected has already been used for packing purposes and contains residual substances like little pieces of food, etc. then the plastic is shredded which reduces the thickness to 2 to 4 mm. after this the aggregate is heated up to 160° to 170° C and plastic is added. A coating of uniform layer is applied and gives a oily look. Bitumen is added and mixture is completely mixed before it is laid. Bitumen is added to the mixture at 155° to 163°C the temperature has to be maintained carefully so that binding is strong.

### Tests Conducted On Bitumen

- a. Penetration test
- b. Ductility
- c. Flash point
- d. Fire point

### Determining the Marshall Stability of Bituminous Mixture

The test is conducted for determination of Marshall Stability of bituminous mix as per ASTM D 1559. The principle of this test is based on the fact that Marshall Stability is Resistant to plastic flow of specimens which are cylindrical of a Bituminous mix and loaded on the lateral surface. It's the load carrying capacity of the mixture at 60°C and is measured in kilograms. The apparatus needed for

S. No.	Tests	Results	
		Plain Bitumen	Modified Bitumen (8% plastic replaced)
1.	Penetration	62mm	55mm
2.	Ductility	72mm	48mm
3.	Flash point	227 °C	260 °C
4.	Fire point	258 °C	285 °C
5.	Softening point	48 °C	50 °C
6.	Specific gravity	0.99	1.1

Determination of the Marshall Stability of bituminous mix is

1. Marshall stability apparatus
2. Balance and water bath

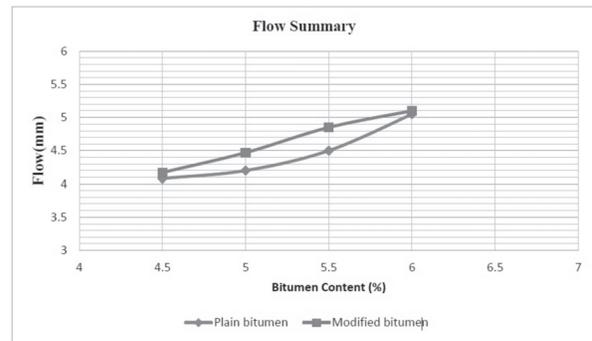
The sample is needed from Marshall Stability graph and selected proportions of coarse aggregate, fine aggregates and filler in such a way, so that the required specification is fulfilled. Total weight of the mix should be 1200g.

### Procedure to Determine Marshall Stability of Bituminous Mixture

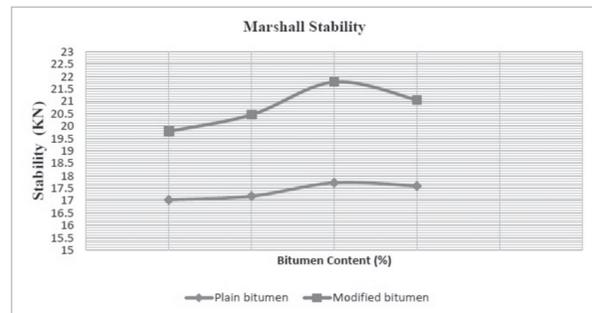
1. The weighed aggregates are heated along with bitumen separately up to 170 °C and 163 °C respectively.
2. They are mixed thoroughly and transferred to the compaction mould which is arranged on the compaction pedestal.
3. 75 blows are given on the top side of the specimen mix with a standard hammer (45cm, 4.86kg). Specimen is reversed and given 75 blows again. The mould with the specimen is cooled down for a few minutes.
- 4.

BITUMEN CONTENT	FLOW (mm)		BITUMEN CONTENT	STABILITY (KN)	
	Plain Bitumen	8 % bitumen replaced by plastic waste		Plain Bitumen	8 % bitumen replaced by plastic waste
4.5 %	4.08	4.18	4.5 %	17.03	19.78
5.0%	4.20	4.17	5.0%	17.18	20.46
5.5%	4.40	4.85	5.5%	17.72	21.78
6.0%	5.05	5.1	6.0%	17.59	21.05

- 5.
6. The specimen is removed from the mould by pushing gently. the specimen is marked and cured at room temperature, overnight.
7. A series of specimen are prepared by similar method with different quantities of bitumen content, and an increment of 0.5% (3 specimens) of bitumen content.



8. Before testing the mould, the moulds are kept in the water bath having a temperature of 60 °C for 30 minutes.
9. The stability of the mould is checked on the Marshall Stability apparatus.



### SIGNIFICANCES

As compared to plain bitumen, the polymer bitumen is a better binder. This blend has an increase in the softening point and there is a decrease in penetration value with suitable ductility. In tropical regions where the temperature is high the blend can be used in road construction as the penetration value is decreased and load carrying capacity is increased. There is no stripping value of blend with aggregate, so, it's water resistant. There's an increased value of Marshall Stability. There is no toxic gas produced and it's a solution for the disposal of plastic waste. Using plastic in construction of road has proved to be a better place for the disposing plastic and solving the disposal problems and helping to make a better road. It has also helped to avoid the commonly used techniques of disposal of plastic wastes like land filling and incineration, which are harmful to the environment.

### CONCLUSION

1. When plastic waste is added to bitumen its properties are modified.

2. The modified bitumen gives better results than the standard result.
3. The optimum content of waste plastic used is between the ranges of 5% to 10%.
4. There is a reduction of problems like bleeding in regions of hot temperature.
5. Sound absorption is a property of plastics which can also help in the reduction of noise pollution of heavy traffic.
6. The plastic wastes can be used and it improves the quality and performance of road.
7. Total material cost of a project is reduced by 7.99%.

## REFERENCES

- Menaria, Yash and Rupal Sankhla. 2015. Use of waste plastic in flexible pavement-green roads. *Open Journal of Civil Engineering*. 5.03 : 299.
- Punith, V. S. Effect of plastic modifiers on bituminous mix properties. Seminar report, II Semester in ME highway Engineering Department of Civil Engineering, Bangalore University, India. 2001.
- Sivarasa, S. and Prabhu, V. Utilization of waste plastics & Carbon Rubber in Bitumen.
- Swami, Vidula, 2012. Use of waste plastic in construction of bitumenous road. *International Journal of Engineering Science and Technology*. 4.5
- Vasudevan, R. and Rajasekaran, S. 2007. Utilization of Waste Plastics in Construction of Flexible Pavements (Reuse of waste plastics- a path - breaking initiative). Verma S.S. (I.C.J.), (2008). Roads from plastic waste.