

**GUIDELINES FOR
THE USE
OF
WASTE PLASTIC IN HOT
BITUMINOUS MIXES
(DRY PROCESS)
IN WEARING COURSES**



**INDIAN ROADS CONGRESS
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GUIDELINES FOR THE USE OF WASTE PLASTIC IN HOT BITUMINOUS MIXES (DRY PROCESS) IN WEARING COURSES

1 INTRODUCTION

1.1 The H-2 Committee in its meeting held on 15th June, 2012 decided to formulate guidelines for waste plastic Bitumen and entrusted this task to Dr. Sunil Bose. Accordingly, Dr. Sunil Bose prepared the initial draft and submitted to H-2 Committee in March, 2013. Thereafter, H-2 Committee deliberated on this draft in a series of meetings. The H-2 Committee finally, approved the draft document in its meeting held on 17th June 2013. The Highways Specifications & Standards Committee (HSS) approved the draft document in its meeting held on 19th July, 2013. The Council in its 200th meeting held at New Delhi on 11th and 12th August, 2013 approved the draft “Guidelines for the Use of Waste Plastic in Hot Bituminous Mixes (Dry Process) in Wearing Courses” after taking on board the comments offered by the members.

The Composition of H-2 Committee is as given below:

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Shri C. Kandasamy	Director General (Road Development) & Special Secretary, MORTH and President, IRC
Shri Vishnu Shankar Prasad	Secretary General, IRC

1.2 Safe disposal of waste plastic is a serious environmental problem. Being a non-biodegradable material it does not decay over time and even if dumped in landfills, finds its way back in the environment through air and water erosion, can choke the drains and drainage channels, can be eaten by unsuspecting grazing animals causing them illness and death, can contaminate the construction fill, etc. The best way of disposal of waste plastic is its recycling to the maximum extent and many developed countries have recycled waste plastics to manufacture various products, including some used in heavy construction, e.g. railway sleepers.

1.3 Studies have revealed that waste plastics have great potential for use in bituminous construction as its addition in small doses, about 5-10%, by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous mix, leading to improved longevity and pavement performance. The use of waste plastic thus contributes to construction of green roads.

1.4 Depending on their physical properties, they may be classified as thermoplastic and thermosetting materials. Thermoplastic materials can be formed into desired shapes under heat and pressure and become solids on cooling. On subjected to the same conditions of heat and pressure, they can be remolded. Thermosetting materials which once shaped cannot be softened/remolded by the application of heat. The examples of some typical Thermoplastic and Thermosetting materials are tabulated in **Table 1**. Thermosetting materials are not used in pavement construction.

Table 1 Typical Thermoplastic and Thermosetting Resins

Thermoplastic	Thermosetting
Polyethylene Terephthalate (PET)	Bakelite
Polypropylene (PP)	Epoxy
Poly Vinyl Acetate (PVA)	Melamine
Poly Vinyl Chloride (PVC)	Polyester
Polystyrene (PS)	Urea - Formaldehyde
Low Density Polyethylene (LDPE)	Alkyd
High Density Polyethylene (HDPE)	

1.5 Plastics can also be classified according to their chemical sources. According to sources of plastic, there are six general groups: Cellulose Plastics, Synthetic Resin Plastics, Protein Plastics, Natural Resins, Elastomers and Fibers. **Table 2** gives the source of waste

plastic generation. Only plastic conforming to Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), PET and Polyurethane shall only be used in pavement construction.

Table 2 Waste Plastic & its Source

Waste Plastic	Origin
Low Density Polyethylene (LDPE)	Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles.
High Density Polyethylene (HDPE)	Carry bags, bottle caps, house hold articles etc.
Polyethylene Terephthalate (PET)	Drinking water bottles etc.
Polypropylene (PP)	Bottle caps and closures, wrappers of detergent, biscuit, wafer packets, microwave trays for readymade meal etc.,
Polystyrene (PS)	Yoghurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging etc.
Polyvinyl Chloride (PVC)	Mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, folders and pens, medical disposables; etc.

1.6 There are two processes namely dry process and wet process for manufacturing bituminous mixes using waste plastic. In the dry process, processed waste plastic is added after shredding in hot aggregates where as in the wet process, processed waste plastic in the form of powder is added in the hot bitumen.

2 SCOPE

These guidelines deal with the specifications and use of waste plastic in wearing course using dry process, their advantages, application, manufacturing, transportation, storages, and quality testing requirements.

3 ADVANTAGES AND LIMITATION OF USING WASTE PLASTIC AS MODIFIER AND BINDER

Laboratory as well as field performance studies/investigations carried out in India (**Appendix-1**) identifies following advantages in using waste plastic in bituminous mixes.

- Higher resistance to deformation.
- Higher resistance to water induced damages.
- Increased durability and improved fatigue life.
- Improved stability and strength.
- Disposal of waste plastic and thereby environment friendly.

However following need to be ensured in order to achieve the advantages of these specifications;

- The material shall consist of only low density polyethylene (LDPE) or high density polyethylene (HDPE), PU (available in limited quantity as waste) and PET.
- Black coloured plastic waste is a result of repeated recycling and should not be used.
- PVC shall not be used since they release lethal levels of dioxines.
- The Thermo Gravimetric Analysis (TGA) of thermoplastics has revealed gas evolution and thermal degradation may occur beyond 180°C. Thus misuse or wrong implementation of this technology may result in release of harmful gases, premature degradation, if the temperatures are not maintained during construction.

4 MATERIALS

4.1 Bitumen

The bitumen for bituminous mixes for wearing course with waste plastic shall comply with the Indian Standard Specifications for viscosity graded paving bitumen IS 73. Guidelines for selection for grade of viscosity graded paving bitumen shall be in accordance with the IRC:111-2009.

4.2 Aggregates

The aggregates shall comply to IRC:111-2009, for dense graded mixes and IRC:14-2004, IRC:SP:78-2008 and IRC:110-2005 for open graded mixes respectively.

4.3 Filler

The filler for dense graded mixes shall comply with IRC:111-2009.

4.4 Waste Plastic

- The waste plastic shall conform to the size passing 2.36 mm sieve and retained on 600 micron sieve.
- Dust and other impurities shall not be more than 1 percent. The process is indicated in **Appendix-2**. An easy method to determine the quantity of impurity is to determine the ash content at 600°C.
- To ascertain the ability of plastic to mix with the binder, the melt-flow value shall be tested as per ASTM D 1238-2010, for which the range shall be as follows:

For LDPE: 0.14-58 gm/10 min

For HDPE: 0.02-9.0 gm/10 min

5 DESIGN OF MIX

The requirements for waste plastic modified design and open graded mixes are as follows:

5.1 Dense Graded Mixes

The properties for dense graded mixes are indicated in **Table 3**.

Table 3 Requirements for Waste Plastic Modified Dense Graded Bituminous Pavement Layers

Minimum stability (kN at 60°C)	12.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Marshall Quotient (kN/mm)	2.5-5
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3 – 5
Retained Stability (%)	98
ITS (min) MPa	0.9
VMA	16
VFB	65-75
Quantity of Waste Plastic % by weight of bitumen	6 to 8 depending on low rainfall or high rainfall areas

5.2 Open Graded Mixes

Waste Plastic @ 6 to 8 percent of the weight of the bitumen can be used for Open-Grade Premix Surfacing and Mix Seal surfacing mix. Quantity of bitumen can be reduced correspondingly.

6 MANUFACTURING OF BITUMINOUS MIX USING WASTE PLASTIC

The scope of the present guidelines is restricted to dry process only for the following reasons;

- Plastic is coated over stones - improving surface property of aggregates.
- Coating is easy & temperature required is same as road laying temp.
- Use waste should be 6-8 percent by weight of bitumen depending on the climatic conditions of high and low rainfall areas.
- Flexible films of all types of plastics can be used.
- Doubles the binding property of aggregates.
- No new equipment is required.

- Bitumen bonding is stronger than normal.
- The coated aggregates show increased Stability of the mixes.
- Better performance after construction based on the experience gained for medium level city traffic.
- No evolution of any toxic gases as maximum temperature is 180°C.

6.1 Dry Process

In order to ensure that the quality of the finished waste plastic product is consistent the following process (**Appendix-1**) must be adhered to before considering its use in bituminous construction:

- a) Collection of waste plastic
- b) Cleaning and shredding of waste plastic
- c) Shredding Machine
- d) Mixing of shredded waste plastic, aggregate and bitumen in central mixing plant

7 CONSTRUCTION

Construction operation shall be in accordance with the IRC:111-2009, IRC:14-2004, IRC:110-2005 and IRC:SP:78-2008 for dense graded and open graded mixes respectively.

8 CONTROLS

Controls shall be in accordance with the IRC:111-2009, IRC:14-2004 and IRC:110-2005 and IRC:SP:78-2008 for dense graded and open graded mixes respectively. Besides, plastic shall be tested for impurity and melt flow value. Three sample be tested for each day work or when there is change in the source of plastic.

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Appendix-1

(Refer Clause 3)

Case studies in India

- In Tamil Nadu, length of roads around 1000 m in various stretches were constructed using waste plastic as an additive in bituminous mix under the scheme “1000 km Plastic Road”, and found that, the performance of all the road stretches are satisfactory.
- The performance of the road stretches constructed using waste plastic in Bangalore (Karnataka) are also found to be satisfactory. More than 2000 km have been laid so far.
- In Delhi a number of test sections about 50 km were laid and most of them are performing well.

Appendix-2

(Refer Clause 4.4)

Processing details:-

- i) collection of waste plastic
- ii) cleaning and shredding of waste plastic
- iii) mixing of shredded waste plastic, aggregate and bitumen in central mixing plant
- iv) laying of bituminous mix

a) **Collection of waste plastic:**

Waste plastic is collected from roads, garbage trucks, dumpsites or compost plants, or from school collection programmes, or by purchase from rag-pickers or waste-buyers



Fig. 1 Collection of Waste Plastic

b) **Cleaning and shredding of waste plastic:**

Waste plastic litter in the form of thin-film carry-bags, use-and-throw cups, PET bottles, etc. these are sorted, de-dusted, washed if necessary.



Fig. 2 Cleaning Process

c) **Shredding machine**

Plastic waste which is cleaned is cut into a size between 2.36 mm and 600 microns and of maximum size 2.36 mm length and 2.00 mm width using a shredding machine.

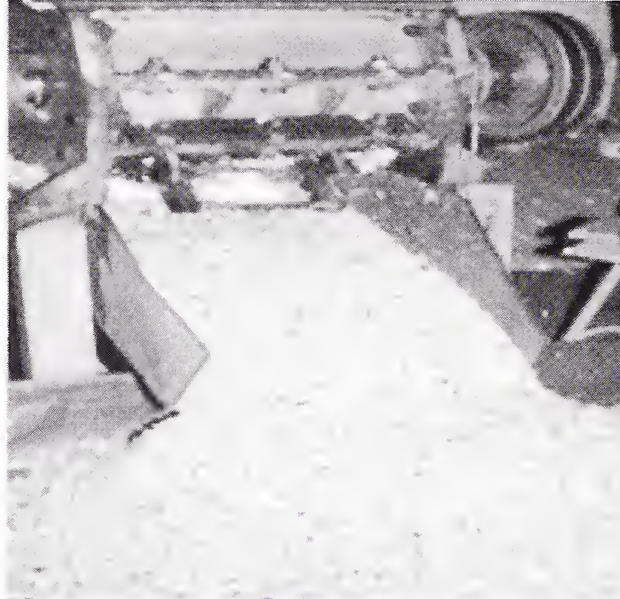


Fig. 3 Shredding Machine

d) **Mixing of shredded waste plastic, aggregate and Bitumen in Central mixing Plant:**

The aggregate mix is heated to 140-175°C in Central mixing plant. The requisite percentage of waste plastic to the weight of bitumen is injected with a pipe under compressed air in the drum of a drum mix plant through a pipe at 2/3 length of the drum or through an opening over the pugmill in the case of a batch mix plant. The waste plastic initially coats the heated aggregates. In the next stage bitumen is added to the aggregates, the temperature of the binder shall conform to the temperature depending on the grade of binder and the type of mix. The plastics waste coated aggregate is mixed with hot bitumen for 15 secs and the resulting mix transported for road construction.

Central mixing plant helps to have better control of temperature and better mixing of this material thus helping to have a uniform coating and heated bitumen is also sprayed.

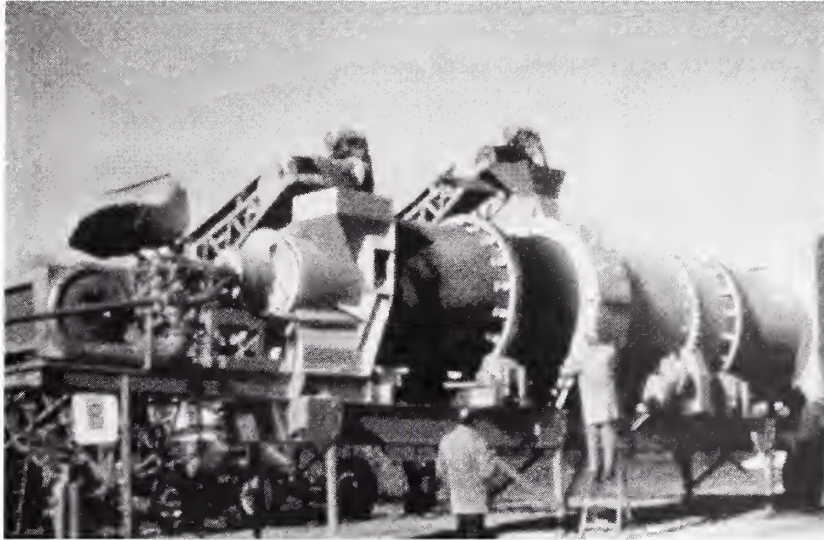


Fig. 4 Central Mixing Plant

e) **Laying of bituminous mix:**

The road laying temperature is between 110°C to 120°C for waste plastic bituminous mix . The roller used can be of any specified capacity.

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