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USE OF PLASTIC WASTE IN FLEXIBLE PAVEMENTS

Dr. Mulpuru Madhuri[1], Mr.Narise Murali krishna[2], Mr.Makena Lohith Venkat Ramana[3], Mr.Dandi Nandeeswara Rao[4], Mr.Appalabathula Rohill[5]

[1]Dr.Mulpuru Madhuri, Ph.D, Associate Professor, Department of Civil Engineering,
Sanketika Vidya Parishad Engineering College(SVPEC)
[2]Mr.Narise Murali Krishna, Student, Department of Civil Engineering,
Sanketika Vidya Parishad Engineering College(SVPEC)
[3]Mr.Makena Lohith Venkat Raman, Student, Department of Civil Engineering,
Sanketika Vidya Parishad Engineering College(SVPEC)
[4]Mr.Dandi Nandeeswara Rao, Student, Department of Civil Engineering
Sanketika Vidya Parishad Engineering College(SVPEC)
[5]Mr.Appalabathula Rohill, Student, Department of Civil Engineering,
Sanketika Vidya Parishad Engineering College(SVPEC)

Abstract - Disposal of waste materials including waste plastic bags has become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. Utilisation of waste plastic bags in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems. Plastic waste which is cleaned is cut into a size such that it passes through 2-3 mm sieve using a shredding machine. The aggregate mix is heated and the plastic is effectively coated over the aggregate. This plastic waste coated aggregate is mixed with hot bitumen and the resulting mix is used for road construction. The use of the innovative technology will not only strengthen the road construction but also increase the road life as well as will help to improve the environment. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. In my research work I have done a thorough study on the methodology of using plastic waste in bituminous mixes and presented the various tests performed on aggregates and bitumen.

KEYWORDS: Plastic Waste, Bitumen, Aggregates, Plastic Roads.

1.INTRODUCTION

Plastic roads were first developed by Rajagopalan Vasudevan in 2001, consisting of an asphalt mix incorporating plastic waste . The incorporation of plastics in roads could open an additional option for recycling post - consumer plastics. The durability of the roads laid out with plastic waste is much more compared with roads with asphalt with the ordinary mix. Roads laid with plastic waste mix are found to be better than the conventional ones. The binding property of plastic makes the road last longer besides giving added strength to withstand more loads.In recent years, applications of plastic wastes have been considered in road construction with great interest in many developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria.

1.1 USAGE OF PLASTIC:

- It is non-biodegradable
- Burning of these waste plastic bags causes environmental pollution.
- It mainly consists of low-density polyethylene
- To find its utility in bituminous mixes for road construction
- Laboratory performance studies were conducted on bituminous mixes. Laboratory studies proved that waste plastic enhances the property of the mix
- Improvement in properties of bituminous mix provides the solution for disposal in an useful way.
- Durable & corrosion resistant.
- Good insulation for cold, heat & sound saving energy and reducing noise pollution.
- It is economical and has a longer life.
- Maintenance free.
- Hygienic & problems.
- Ease of processing/ installation.
- Light weight.

2.MATERIALS USED

2.1 AGGREGATE

The aggregates are bound together either by bituminous materials or by cement. In a few cases, the rock dust itself when mixed with water forms slurry which acts as a binding medium.

The aggregates may be classified into natural and artificial aggregates. The natural aggregates again are classified as coarse aggregates consisting of crushed rock aggregates or gravels and fine aggregates or sand. The blast furnace slag obtained as by-product from blast furnaces is the one extensively used as road construction material.Stone aggregate used for road work should be hard, tough, durable and hydrophobic for bituminous surface. Gravel should be well graded (6.4mm to 38mm) and should have a fineness modulus of not less than 5.75. Sand should be sharp, well graded, clean of all silts, clay and organic matter. The quantity of aggregates used in first coat of surface dressing should be 0.15 m3 per 10 m2 area of 12mm nominal size. On the other hand, the quantity of aggregate used in second coat of surface dressing should be 0.15 m3 per 10 m2 areas and of 10 mm nominal size.

2.2 BITUMEN

Bitumen is a black, oily,viscous material that is a naturally-occurring organic byproduct of decomposed organic materials. Also known as asphalt or tar.Bitumen is used as binders in pavements constructions. Bitumen may be derived from the residue left by the refinery from naturally occurring asphalt. The grades of bitumen used for

pavement construction are known as paving grades and that used for waterproofing of structures are known as industrial grades. The grade of straight run bitumen is chosen depending upon the climatic conditions of the region in which surface dressing is to be constructed. In most parts of India 80/100 and 180/200 grade bitumen is used.
Bitumen: 60/70, 80/100 grade bitumen.

2.3 WASTE PLASTIC

TYPES OF WASTE PLASTIC (POLYMER)	SOURCES
Low density polyethylene (LDPE)	bags, sacks, bin lining and squeezable detergent bottles etc
High density polyethylene (HDPE)	bottles of pharmaceuticals, disinfectants, milk, fruit juices, bottle caps ete
Polypropylene (PP)	bottle cap and closures, film wrapping for biscuits, microwave trays for ready-made Meals 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, etc.

3 PROCESSING DETAILS

3.1 COLLECTION OF WASTE PLASTIC

Waste plastic is collected from roads, garbage trucks, dumpsites or compost plants, or from school collection programs, or by purchase from rag-pickers or waste-buyers at Rs 5-6 per kg. Effective collection of waste plastic requires collaboration between individuals, communities, businesses, and government entities to ensure proper disposal and recycling.

3.2 CLEANING AND SHREDDING OF WASTE PLASTIC

Cleaning and shredding waste plastic are crucial steps in preparing it for recycling or repurposing.
Sorting Before cleaning and shredding, the waste plastic needs to be sorted. This can involve separating different types of plastic (e.g., PET, HDPE, PVC) and removing any contaminants such as paper, metals, or other non-plastic materials.

CLEANING:

- **Mechanical Washing:** Waste plastic is often subjected to mechanical washing processes, where it's agitated and rinsed with water and detergent to remove dirt, debris, and contaminants.
- **Chemical Washing:** Some plastics may require chemical washing to remove stubborn contaminants or residues. This process involves using solvents or chemical solutions to dissolve or loosen contaminants from the plastic surface.
- **Drying:** After washing, the plastic needs to be dried to remove excess moisture. This can be done using centrifugal dryers, hot air dryers, or other drying methods to ensure the plastic is completely dry before shredding.

SHREDDING

- **Size Reduction:**Waste plastic is shredded into smaller pieces to increase its surface area and facilitate further processing. Shredding can be done using various types of equipment, such as granulators, shredders, or crushers, depending on the desired output size and the type of plastic.
- **Granulation:** Shredded plastic may undergo further processing called granulation, where it's ground into even smaller particles or pellets. This makes the plastic easier to handle and melts more uniformly during the recycling process.
- **Quality Control:** Throughout the cleaning and shredding process, quality control measures are implemented to ensure the plastic meets specific standards for recycling or repurposing. This may involve visual inspection, sampling, and testing for purity, moisture content, and other properties.
- **Storage and Transportation:** Cleaned and shredded plastic is typically stored in bulk or packaged for transportation to recycling facilities or manufacturing plants where it will be processed into new products.

3.3 MIXING

The aggregate mix is heated to 165^0c (as per the HRS specification) in central mixing plant. Similarly the bitumen is to be heated up to a maximum of 160ºc.

The 8% of waste plastic to the weight of bitumen are added in the conveyor belt or special mechanical device is developed which will spray the plastics inside the chamber to coat the plastics effectively.

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.

3.4 LAYING OF BITUMINOUS MIX

The plastics waste coated aggregate is mixed with hot bitumen and the resulting mix is used for road construction. The road laying temperature is between 110°c to 120°c. The roller used is 8-ton capacity.

4.TEST CONDUCTED ON MATERIALS

4.1 AGGREGATE IMPACT VALUE

Purpose:

The Purpose Of Determining The Aggregate Impact Value Is To Assess Its Resistance To Disintegration Against Impact Loading.

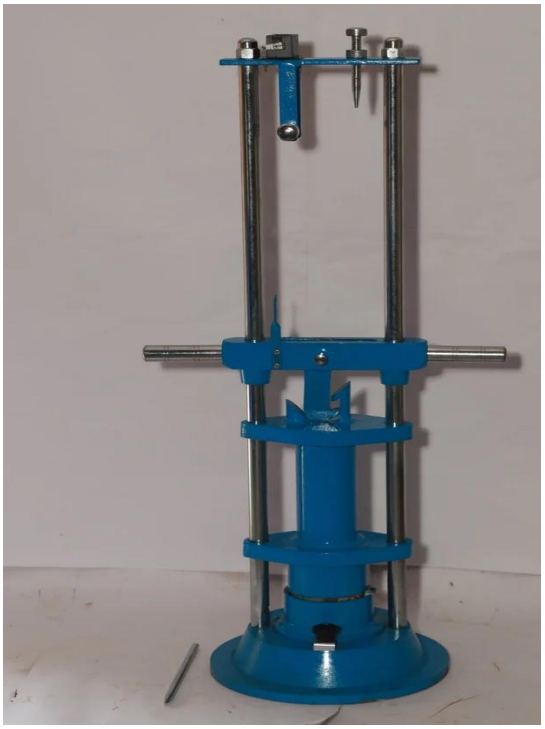
Procedure:

1. Take The Test Sample Consisting Of Aggregates The Whole Of Which Passes 12.5 Mm Is Sieve And Is Retained On 10 Mm Is Sieve. Dry The Aggregate Comprising The Test Sample In An Oven For A Period Of Four Hours Or Till Such Time That Its Weight Becomes Constant At A Temperature Of 105oc To 110 Oc.Cool The Aggregates.

2. Aggregate Shall Be Filled In The Cylindrical Measure In 3 Layers By Tamping Each Layer By 25 Blows.Determine The Net Weight Of Aggregate In The Measure(W_1) . Transfer The Sample From The Measure To The Cup Of The Aggregate Impact Testing Machine And Compact It By Tamping 25 Times.

4. The Hammer Is Raised To Height Of 38 Cm Above The Upper Surface Of The Aggregate In The Cup And Is Allowed To Fall Freely On The Specimen.
5. After Subjecting The Test Specimen To 15 Blows, The Crushed Aggregate Is Sieved On Is 2.36 Mm Sieve.
6. Weigh The Fraction Passing Through Is 2.36 Mm Sieve (W2).

Aggregate Impact Value (Aiv) =$\{W_2 / W_1\}$ X 100



Aggregate Impact Value(%)	**Nature**
0-10	Exceptionally Strong
10-15	Strong
15-20	Medium
Above 20	Weak

4.2 WATER ABSORPTION OF AGGREGATE:

Purpose:

Water Absorption Shows The Porosity Of Aggregates In One Way. The More, It Absorbs, The Less It Is Durable.

Procedure:

The Test Piece About 1 Kg Shall Be Washed To Remove Dust And Immersed In Distilled Water In A Glass Vessel At A Room Temperature 20oc To 30oc For 24 H.The Initial Weight Of The Sample(A) Soon After Immersion And Again At The End Of The Soaking Period, Entrapped Air Shall Be Removed By Gentle Agitation. This Will Be Done By Rapid Clock Wise And Anticlock Wise Rotation. The Vessel Shall Then Be Emptied And Test Piece Be Allowed To Drain. The Test Piece Shall Then Be Placed On A Dry Cloth And Gently Surface Dried With The Cloth.

It Shall Be Transferred To A Second Dry Cloth When The First One Removes No Further Moisture. It Shall Be Spread Out Not More Than One Stone Deep On The Second Cloth And Left Exposed To Atmosphere Away From Direct Sunlight Or Any Other Source Of Heat For Less Than 10 Min Until It Appears To Be Completely Surface Dry.
The Sample Shall Then Be Weighed (B). The Water Absorption Shall Be Calculated From The Formula.

Water Absorption =(B – A)/A*100

Water Absorption Value(%)	**Use Of Aggregate**
0-2	Surface Course
2-4	Base Course
Above 4	Subbase Course And Below

4.3 BITUMINOUS STRIPPING OF AGGREGATE TEST:

Purpose:

The Stripping Value Indicates The Property Of Adhesion Of Aggregates With Different Types Of Bituminous Binders So That The Suitability Of Aggregates Could Be Ascertained.

Procedure:

1. Take About 200g Of Aggregates Passing 20 Mm Sieve And Retained On 12.5 Mm Sieve.
2. Dry, Clean And Mix With 5 Percent Binder By Weight In A Small Casserole, Binder Being Heated Previously To 1600c If Bitumen And 1100c If Tar.
3. Heat The Aggregate Before Mixing To A Temperature Of 1500c And 1000c If These Are To Be Mixed With Bitumen And Tar Respectively.
4. Transfer The Contents To A 500 Ml Beaker After Complete Coating Of The Mixture And Allow To Cool At The Room Temperature For About Two Hour.
5. Cover The Beaker And Keep It In A Water Bath With Care That The Level Of Water In Water Bath Comes Upto At Least Half The Height Of Beaker.
6. Take Out The Beaker After 24 H, Cool It At Room Temperature And Estimate The Extent Of Stripping Visually When The Specimen Is Still Under Water.
7. Calculate The Stripping Value As The Ratio Of Uncovered Area To The Total Area Expressed As APercentage.
8. Conduct Three Tests And Express The Mean Of Three Results To The Nearest Whole Number As The Stripping Value.

5.CONCLUSION

The generation of waste plastics is increasing day by day. The major polymers namely polyethylene, polypropylene, polystyrene show adhesion property in their molten state Plastics will increase the melting point of the bitumen. The waste plastic bitumen mix forms better material for pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for pavement is one of the best methods for easy disposal of waste plastics.
The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income.

Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste.

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