Usage of Waste Plastic and Marble Dust in Flexible Pavements

Srikanth Ramvath[1] Dumpaty Sai Kiran[2] Kalagadda Bharath[3] Kurre Prashanth[4] PolasaManusha[5]
[1]Assistant Professor [2,3,4,5]B Tech Student
[1,2,3,4,5]Department of Civil Engineering
[1,2,3,4,5]Kshatriya College of Engineering, Jawaharlal Nehru Technology University, Nizamabad, India

Abstract— In this present electronic age the development of the country is going at a very fast phase. The highway plays a major role in the development of the country and also improves the standards of living people. The aim of this project involves to lay the flexible pavements with waste materials with the intension of reducing cost and unavailability of conventional material. In flexible pavements the layers are the mixture of fine aggregate, coarse aggregate, filler and binder About 6.3 million metric tons of waste plastic has generated every year throughout the world. In that 9% of plastic has been recycled. using this waste plastic will increase the melting point of bitumen and marble dust helps the partial replacement of fine aggregate will helps the enhance the life of roads and also solve the environmental problems. Plastic roads would be boon for the hot & extreme climate where it will increase the durable and eco- friendly roads. The experiment portrays the use of plastic waste & marble dust comparing with and without usage in flexible pavements. Usage of waste plastic by blending with bitumen at various measurements of 1%, 1.5%, 2%, 3%, 4%, 5%, 6%, 7%, 8% by the weight of bitumen. The marble dust is partially replacement in the weight of fine aggregate with various measurements 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%. At finally plastic at 5%, marble dust at 20% is replaced during the mixing process of marshal stability test will give the better strength value. The experiments includes penetration, ductility, flash & fire point, softening point, stripping, specific gravity, water absorption test, viscosity, loss on heating, spot test, Marshall stability test.

Key words: Waste Plastic, Marble Dust, Flexible Pavements

I. INTRODUCTION

A. General

Flexible pavement is composed of a bituminous material surface course and underlying base and sub base courses. The bituminous material is more often asphalt whose viscous nature allows significant plastic deformation. Flexible Pavement is so named as the pavement surface reflects the total deflection of all subsequent layers due to the traffic load acting upon it the aim of this project is to improve the quality and firmness of bituminous, enhance workability and constructability of Flexible pavements. A valuable advantage of plastic waste is to increase the reaction rate of bitumen and marble stone dust is used for the partial replacement of fine aggregate in the flexible pavement is that it can be opened for traffic within 24 hrs. after completion. Also the repair and maintenance of flexible pavement is easy and cost effective.

Experiments have been carried out to know whether this waste plastic can be reused productively. The experimentation at several institutes, private organizations indicate that the waste plastic, when added to hot aggregate bituminous mix will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength to the road, higher resistance to the water and better performance of the road over a period of time. Addition of Marble stone dust with the fine aggregates increases the strength and decreases the cost.

II. OBJECTIVES OF STUDY

- To examination the change of Flexural properties of the bitumen by balancing out with aggregates.
- To assess the impact of different parameters, for example, measurements of additives, time is balanced.
- To contrast the execution of plastic waste and regular stabilizer (Stone Dust).
- To perform Cost and Design Comparison.

III. MATERIALS AND METHODS

A. Materials

The materials used in this study for plastic flexible pavements were plastic waste, bitumen, marble stone dust and aggregates as the main matrix and other materials are given below:

- Overalls, gloves, masks, covered shoes or boots
- 1 melting barrel (an oil drum cut in half, 80cm wide and 50cm high). If possible use a shield to keep the fire concentrated under the barrel
- Stirring equipment (a spade with a metal shaft, or metal reinforcing rods with a metal paddle welded to the end)
- Firewood or other solid fuel
- Clean, dry, sieved aggregates
- Used engine oil

B. Description of various materials:

1) Plastic:

It is important to only select the correct type of plastic. This is because different types of plastic melt and burn at different temperatures and have different physical qualities. The process described here works well with LDPE1.

Water bags, non-woven plastic shopping bags and plastic film are usually made of LDPE. It is important that you do not use other types of plastic – it could be harmful to your health. Make sure your plastic waste is mainly clean. Remove all materials that are not LDPE (including other plastics). If you're not sure if something is LDPE, leave it out.

2) Bitumen or Asphalt:

Asphalt, also known as bitumen is a sticky, black, and highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product, and is classed as a pitch. Before the 20th century, the term asphalt was also used. The word is derived from the Ancient Greek.

Naturally occurring asphalt is sometimes specified by the term "crude bitumen". Its viscosity is similar to that of cold molasses, while the material obtained from the fractional distillation of crude oil boiling at 525 °C (977 °F) is sometimes referred to as "refined bitumen".

3) Marble stone dust:

Marble stone is a naturally occurring material rock which is formed by the collapsed asteroids and its constituent particulates. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non – tropical coastal settings is silica (silica dioxide or SiO2), usually in the form of quartz.

IV. MANUFACTURING PROCESS

A. Melting barrel

To make the melting barrel, cut a simple oil drum in half and attach three legs made of rebar. With the legs attached, the ideal height of the barrel is 50cm, and 80cm wide. Try to make the burner big enough that you can hold a good amount of liquid plastic but not so tall that it is tricky to mix. If you can sink the legs into the ground it will make the barrel more stable for mixing.

B. Proportions

The strength of the road depends on the mix with Plastic waste, Bitumen and Marble stone dust ratio. Laboratory tests indicate that the optimum mixture is 5% of LDPE is mixed to the 100% of Bitumen blend and 20% of marble stone dust is added to the fillers, however it is strongly recommended that you try different mixes for yourself. Try starting with 1% plastic and then increasing the proportion to see what works best for you. A mix of 5% works well for roads.

As a rough guide, one standard rice sack of plastic with around 200 plastic bags (weighing around 2.5 kg) makes one paving slab.

C. Step wise procedure

1) Select the right plastic

It is important to only select the correct type of plastic. This is because difference types of plastic melt and burn at different temperatures and have different physical qualities. The process described here works well with LPDE[1].

D. Shredding

Plastic waste used in this project is polyethylene which is of less than 20 microns, so this can also cause somewhat air pollution by using the plastic covers without cutting. There is a problem of non mixing of plastic waste with bitumen blend while heating process due to not cutting of plastic waste. So in order to eradicate the pollution and mixing problems the plastic cover's are shredded before using.

Polyethylene carry bags were cut into pieces using a shredding machine. It was sieved and the plastics pieces passing through 4.75mm sieve and retaining at 2.36mm sieve were collected.

E. Characterization of blend

1) Melting process

Light a small fire under the metal drum and gently heat it. These plastic pieces were added slowly to the hot bitumen of temperature around 170-180^{0}C. The mixture was stirred well using mechanical stirrer for about 20-30 minutes. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests .

Make sure the fire does not get too hot. Do not stand directly over the melting barrel; try to avoid breathing any gases from the fire; and take care as tools can get hot.

2) Mixing process

Keep mixing thoroughly until all the plastic has melted and there is a consistent black liquid. Sometimes LDPE lumps can remain even at very high temperatures. Stirring and heating must continue until all lumps are removed and a homogenous paste is obtained, since they affect the strength of the material. This can take up to 20 minutes. Do not let the liquid get so hot that it burns strongly – it will not work as a building material if this happens. A few flames from the liquid is acceptable. Add sand until you have the required mixture and keep mixing so that the plastic, which acts as a binder, is very well mixed in and looks like grey cement.

F. Characterization of Plastic Waste Bitumen Blend for Flexible pavement

1) Melting process

Plastic waste along with bitumen is melted at temperatures 170° -180°c for 20- 30 minutes.

2) Heating process

Aggregates such as coarse aggregates, marble stone dust, robo sand, cement as filler material at different proportions are heated in an oven at 75°c up to 30 minutes. This process is called Pre-heating process. This pre-heating process is done before the mixing process.

3) Mixing process

After the formation of bitumen blend the pre-heated aggregates are added to this blend and mixed well in such a way that the aggregates are totally combined with bitumen blend, if not mixed well the binding property will be decreased.

G. Moulding process

The aggregates and the bitumen were mixed thoroughly until the aggregates were well coated. The thoroughly cleaned specimen mould assembly and the compaction hammer were heated to 160 °C. The collar was removed and the surface of the mix was smoothened with a trowel to a slightly rounded shape. Temperature of the mixture immediately prior to compaction was maintained at 150°C. The collar was replaced, and the mould assembly was placed on the compaction pedestal in the mould holder, and the top of the specimen was given 75 blows. The base plate and the collar were removed and the sample was inverted and the mould reassembled. The inverted face was also given 75 blows.

V. EXPERIMENTS CONDUCTED

A. Experimental procedures on characterization of blend

1) Penetration test

It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimetre to which a standard loaded needle will penetrate vertically in 5 seconds.

The test should be conducted at a specified temperature of 25°C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 70/80 bitumen means the penetration value is in the range 70 to 80 at

standard test conditions. In hot climates, a lower penetration grade is preferred.

Fig. 1: shows a schematic Penetration Test setup.

At different measurements different results are obtained in penetration test.

2) Ductility test

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking.

For 5% of plastic waste- bitumen blend we have got the highest ductility test value, it is of 85cm.

Fig. 2: deformation of blended bitumen

Fig. 3: preparation of mould

3) Softening pointing test

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted by using Ring and Ball apparatus

This softening point test is done to know the temperature at which the bitumen softens.

Fig. 4: Softening point test

For 5% of plastic waste- bitumen blend we have got the medium softening point test value, it is of 55°c.

4) Flash and fire point test

At high temperatures depending upon the grades of bitumen materials leave out volatiles. And these volatiles catch fire which is very hazardous and therefore it is essential to qualify this temperature for each bitumen grade The fire point is defined as the lowest temperature under specified test conditions at which the bituminous material gets ignited and burns.

Fig. 5: Temperature correction

For 5% of plastic waste- bitumen blend we have got the highest flash point value and fire point test value, it is of 300°c and 350°c

B. Experimental procedures on characterization of the plastic waste- bitumen

1) Marshall stability test

In the Marshall test method of mix design three compacted samples are prepared for each binder Content. At least four binder contents are to be tested to get the optimum binder content. All The compacted specimens are subject to the following tests:

- Bulk density determination.
- Stability test.
- Evaluation and adjustment of mix design

a) Stability test

In conducting the stability test, the specimen is immersed in a bath of water at a temperature of 60° ± 1°C for a period of 30 minutes. It is then placed in the Marshall Stability testing machine and loaded at a constant rate of deformation of 5 mm per minute until failure. The total maximum in kN (that causes failure of the specimen) is taken as Marshall Stability.. The total amount of deformation is units of 0.25 mm that occurs at maximum load is recorded as Flow Value. The total time between removing the specimen from the bath and completion of the test should not exceed 30 seconds.

Fig. 5: Testing the sample

2) Stripping test

Due to seasoning affects and environmental causes the upper most layer of bitumen pavement is eroded and small white patches are formed up on the pavement. This patches or eroding is known as stripping of bitumen pavement. So to find out the stripping value of bitumen pavement stripping test is conducted by adding bitumen, plastic waste at different proportions.

Fig. 6: stripping test

VI. RESULTS

S. NO	TESTS	RESULTANT VALUS
1	Penetration test	70/80
2	Ductility test	85 cm
3	Softening point test	55°C
4	Flash & fire point test	300°C & 350°C
5	Marshall stability test	850 kg/mm
6	Stripping test	2%

VII. CONCLUSION

1) The addition of waste plastic and marble stone dust modifies the properties of bitumen.
2) The modified bitumen shows good result when compared to standard results.
3) The optimum content of waste plastic of 5% and 20% of marble stone dust.
4) The problems like bleeding are reduce in hot temperature region.
5) Plastic has property of absorbing sound, which also help in reducing the sound pollution of heavy traffic.
6) The waste plastics thus can be put to use and it ultimately improves the quality and performance of road.
7) Total material cost of the project is reduced by 7.99%.

As road pavement life is doubled when we use this novel technique for road construction, we have to pay only Rs. 25000/- more, instead of spending Rs. 10,80,000/- for its up gradation in just 2-3 years, thus saving Rs.10,50,000/- per Km.

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