Use of Plastic in Bitumen Roads

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Abstract **- The waste plastic and its disposal is a significant danger to the climate, which brings about contamination and an unnatural weather change. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. In addition, it will also be a solution to plastic disposal & various defects in pavement viz., potholes, corrugation, ruts, etc. the waste plastic used are polyethylene, poly-styrene, poly-propylene. The waste plastic is shredded & coated over aggregate & mixed with hot bitumen and resulted mix is used for pavement construction. This will not only strengthen the pavement and also increases its durability. This innovative technology will be boon for Indian hot-humid climate. It's economical and eco-friendly.**

India has an avenue network of over 5,472,144 kilometers. 2nd biggest road community within the global. The plastic wastes may be used in road creation and the field checks withstood the stress and proved that plastic wastes used after proper processing as an additive might decorate the life of the roads and additionally remedy environmental troubles. Plastic use in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density polyethylene) pipes to form plastic mats. The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix. 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.

1.INTRODUCTION

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow, is called as "Plastic".

Plastic waste is a huge threat to the environment. In 2005, after monsoon rains flooded Mumbai, plastic bags were blamed for clogging the underground drainage system and intensifying the effect of the floods. In areas frequented by tourists, like Goa, heavy consumption of bottled water has resulted in trash on beaches, creating eyesores and endangering marine life. Even India's cows, considered sacred, have not been spared. After 3,000 cows died in Lucknow in 2000, the city investigated and found plastic bags in their stomachs. Apparently the bags had been ingested as the animals grazed at dump sites. With more than 35 tons of plastic waste generated by every Indian state, each day India is confronted with the big question of how to get rid of this non-biodegradable menace?

Nowadays we can use plastic in road construction purpose. 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. Processes for manufacturing bitumen mix road using plastic waste.

Roads using plastic waste have been constructed through simple process innovation in various states Tamil Nadu, Karnataka, Himachal Pradesh and to a lesser degree in Goa, Maharashtra and Andhra Pradesh. The concept of "Use of Plastic Waste in Road

Construction" was implemented in 2001 as a solution to the serious problem of disposal of Plastic Waste in India.

The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time.

There are two main processes namely:

1. DRY PROCESS
2. WET PROCESS

2. OBJECTIVES

The objective of this project:

1. To study the difference between conventional bituminous road and plastic waste modified bituminous road
2. To test the bitumen and the modified bitumen.
3. To analyze the amount of plastic waste being used in the construction of road and interpret the amount of waste disposed in a constructive way.
4. To coat the aggregate with plastic

3. LITRATURE REVIEW

Prof.C.E.G. Justo States that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter (m 3) of BC mix. Modified Bitumen improves the stability or strength, life and other desirable properties of bituminous concrete mix.

According to V.S. Punith, (2001), Some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mixes of road pavements. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction.

Mohd.Imtiyaz(2002) concluded that the mix prepared with modifiers shows: -Higher resistance to permanent deformation at higher temperature.

Sundaram & Rojasay (2008) studied the Effective blend technique for the use of plastic waste into bitumen for road laying and Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests.

Verma S.S. (2008). Concluded that Plastics will increase the melting point of the bitumen. This technology not only strengthened the road construction but also increased the road life.

Sabinaetal (2001) studied the comparative performance of properties of bituminous mixes containing plastic/polymer (PP) (8% and 15% by wt. of bitumen) with conventional bituminous concrete mix (prepared with 60/70 penetration grade bitumen). Improvement in properties like Marshall Stability, retained stability, indirect tensile strength and rutting was observed in Plastic modified bituminous concrete mixes.

Dr.R. Vasudevan (2007) - stated that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased softening point and decreased Penetration value with a suitable ductility.

Zahra Niloofar Kalantar (2012) - Many researches on PMA mixture have been conducted for the past two decades. Although addition of virgin polymers to asphalt for the purpose of enhancing the properties of asphalt over a wide temperature range in paving applications was contemplated quite some time ago, recycled polymer added to asphalt have also shown almost the same result in improving the road pavement performance as compared to virgin polymers.

Amit Gawande (2012) - The quantum of plastic waste in municipal solid waste (MSW) is increasing due to increase in population, urbanization, development activities and changes in life style which leading widespread littering on the landscape. Thus disposal of waste plastic is a menace and become a serious problem globally due to their non-biodegradability and un aesthetic view. Since these are not disposed scientifically & possibility to create ground and water pollution. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water.

Sunil J. Kulkarni (2015) - Minimization of waste material is important aspect of the modern growth and development initiatives. Plastic is used in various

domestic and industrial applications. Use of plastic bags and bottles is very common. The disposal of plastic waste is major problem due to non-biodegradable nature of plastic. The plastic can be used as feedstock for ethanol like products. It can be used for road construction and other construction related activities. The current review summarizes the research on use of waste plastic

Rishi Singh Chhabra (2014) - In the highway infrastructure, a large number of originates materials and technologies have been invented to determine their suitability for the design, construction and maintenance of these pavements. Plastics and rubbers are one of them. Also considering the environmental approach, due to excessive use of polythene in day to day business, the pollution to the environment is enormous. The use of plastic materials such as carry bags, cups, etc. is constantly increasing day by day. Since the polythene are not biodegradable, the need of the current hour is to use the waste polythene in some beneficial purposes. The use of these materials as a road construction proves eco-friendly, economical and use of plastic gives strength in the sub-base course of the pavement.

Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. This technology not only strengthened the road construction but also increased the road life.

4. METHOD AND METHODOLOGY

WET PROCESS:

1. Waste plastic bags collect first.
2. Collected plastic waste sorted as required thickness.
3. Normally polyethylene 60 micron or below is used for the further process.
4. Generally, less micron plastic is easily mixable in the bitumen at higher temperature (160-170 degree Celsius)
5. Collected plastic was cut into fine pieces as far as possible.
6. Then sieve it through 4.75mm sieve and retain on 2.36mm sieve was collected.
7. First bitumen heated at about 160-170 c temp. which is melting temperature.
8. Then piece was added into this.
9. At constant temp. mixture was stirred manually for about 20-30min.

Plastic waste is ground and made into powder 6 to 8%. Plastic is added to the bitumen at 160‘C. The process did not yield a homogenous mix with prominent separated solid deposits of mix therefore wet process was not adopted and therefore we have not conducted any experiments on wet process.

Dry process

In the dry process, the processed waste plastic is shredded and added to the hot aggregate. The Indian Road Congress (2013) and National Rural Roads Development Agency (2019) indicates that the shredded waste plastic size should preferably be 2-3 mm for better spread and coating on the aggregate. Dust and other impurities should not exceed 1%. The shredded waste plastic is then added to the aggregates that are heated to 170ºC. The shredded waste plastic softens and melts to form a coating around the aggregates. The bitumen is also heated to 160ºC and the plastic-coated aggregates are then mixed with bitumen and used for road construction.

Laboratory testing’s:

Test on aggregates

1. Aggregate crushing test
2. Los Angeles abrasion test
3. Impact test

Test on bitumen

1. Penetration test
2. Softening point test
3. Viscosity test
4. Marshall Stability test.

Tests on Aggregates

1.Aggregate Crushing Test

To achieve a high quality of pavement, aggregates possessing high resistance to crushing or low aggregate crushing value are preferred.

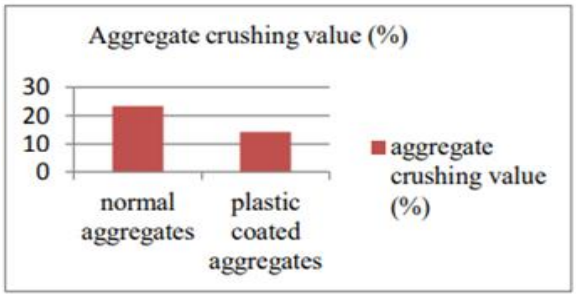

Figure 1 – Aggregate crushing value

2.Los Angeles Abrasion Test

The principle of Los Angeles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregate and steel balls used as abrasive charge. Pounding action of these balls also exists during the test and hence the resistance to wear and impact is evaluated by this test.

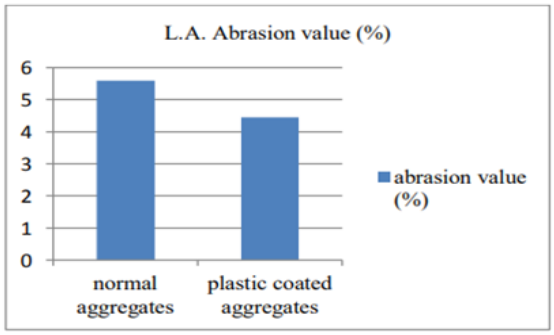

Figure 2 – Aggregate Los Angeles Abrasion value

3.Impact Test

The test is designed to evaluate the toughness of stone or the resistance of the aggregates to fracture under repeated impacts is called impact test. The aggregate impact test is commonly carried out to evaluate the resistance to impact of aggregates and has been standardized by ISI.

The aggregate impact value should not normally exceed 30% for aggregate to be used in wearing course of the pavements. The maximum permissible value is 35% for bituminous macadam and 40% for water bound macadam base course.

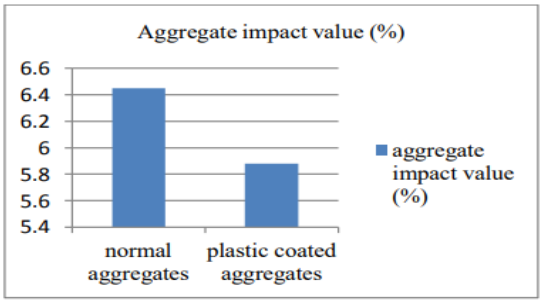

Figure 3 – Aggregate impact value

Tests on Bitumen-

1. Penetration Test

Penetration test is to determine the hardness of the bitumen. The penetration of a bitumen is the distance in tenths of millimeter that a standard needle will penetrate into the bitumen under a load of gm applied for 5 seconds at 25 degrees C. Penetrations value indicates the softness of bitumen higher the penetration softer is the bitumen).

S. No	Penetration Value (mm) Plain Bitumen	Penetration Value (mm) Modified Bitumen (10% Plastic Replaced)
1	79	67
2	63	49

Table 1 – test result of penetration value of bitumen vs Penetration Value (mm) modified Bitumen

2.Softening Point Test

The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test. Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of this test.

Sample No	Softening point(^{0}C) (plain bitumen)	Softening point(^{0}C) 10% bitumen replaced by plastic
1	69.2	80.7
2	70	81.2

Table2– test result of softening point of bitumen and modified bitumen (bitumen replaced by plastic)

3.Viscosity Test

Viscosity is defined as the inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. Viscosity is the general term for consistency and is the measure of resistance to flow. Many researchers believe that grading of bitumen should be by absolute viscosity units instead of the conventional penetration units.

The degree of fluidity of the binder at the application temperature greatly influences the strength characteristics

4.Marshall Stability Test

Table 3 – Percentage of bitumen content

S. No	Bitumen content(%)	Modified bitumen(gm)
1	4.5	5.9
2	5.0	6.0
3	5.5	6.6
4	6	7.2

Table 4 – Test results of Marshall Stability test

S.No	Bitumen Content (%)	Weight of mix(g)	Weight in air(g)	Weight in water (g)	Stability of bitumen Stability of modified		Flow (mm)	Diameter(cm)	height (cm)
					Plain bitumen	Modified bitumen			
1	4.5	1255.5	1256.5	733	14.7	17.95	1.99	10	6.3
2	5	1253	1255.5	734	19.47	23.44	2.38	10	6.4
3	5.5	1257	1259	736	13.46	18.21	2.88	10	6.5
4	6	1268	1270	748	8.9	13.10	2.59	10	6.4

5. RESULT

- The crushing value reduces from 23.32 to 14.22 for normal and plastic-coated aggregate. The value was reduced by 40%. Lower the aggregate crushing value higher is the strength.
- The aggregate impact value of plastic-coated aggregate was reduced by 9% than the normal aggregate. It's the higher toughness of plastic-coated aggregates.
- Los Angeles abrasion value indicates the hardness of the aggregates. The abrasion value plastic coated aggregates were 21% less than the normal aggregates.
- The penetration value of bitumen is higher than the bitumen mixed with the plastic.
- The bitumen softens 10oC less than the bitumen replaced with plastic.
- The stability of modified bitumen (10% bitumen replaced by plastic) is higher than the normal bitumen.

6. FUTURE SCOPE

1. Road accidents due to potholes will be reduced to a greater extent
2. Cost of construction will be reduced
3. Strength of the road increased (increased Marshall Stability Value)
4. Better resistance to water and water stagnation
5. No stripping and have no potholes in the pavement
6. Increased binding and better bonding of the bitumen mix
7. Increased load withstanding property of road
8. Overall consumption of bitumen decreases
9. Maintenance cost of the road is almost nil
10. The road life period is substantially increased
11. No effect of radiation like UV

7. CONCLUSION

The plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption. This results in the reduction of ruts and there is no pothole formation. The plastic pavement can withstand heavy traffic and are durable than flexible pavement. The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road. This new technology is eco-friendly.

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