

BITUMINOUS PAVEMENT MAINTENANCE WITH WASTE PLASTIC MATERIALS**Sahil Harshe^{*1}, Chandrashekhar Ghatole^{*2}, Abhinay Rehpade^{*3},****Furkan Sheikh^{*4}, Rahemeen Sheikh^{*5}**

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ABSTRACT

Plastic trash and its disposal pose a significant environmental problem, resulting in pollution and global warming. Plastic trash is added to bituminous mixtures to improve their characteristics and strength¹. It will also be a solution for plastic disposal and other pavement faults such as potholes, corrugation, ruts, and so on. Polyethylene, polystyrene, and polypropylene are the waste plastics used. The discarded plastic is shredded and covered over aggregate before being mixed with hot bitumen and utilised in the creation of pavements. This will not only strengthen the pavement, but it will also make it more durable. The titanium-di-oxide is utilised as a smoke absorbent substance, absorbing the smoke emitted by the automobiles. This cutting-edge technology will be a godsend in India's hot and humid atmosphere. It's both cost-effective and environmentally friendly. We examined soil factors to consider in pavement design, pavement design, and the technique of constructing flexible and plastic-smoke absorbent pavement in this study.

Keywords : plastic waste, flexible pavement, strength, eradication of pot holes.

I. INTRODUCTION

The disposal of waste plastic poses the greatest environmental threat. Potholes and corrugation are the most common problems on highways. 9. To address the aforementioned issues, plastic pavement will be a superior option. "Plastic" refers to a substance that contains one or more large molecular weight organic polymers that are solid in their completed state and can be moulded by their flow. Plastic has a great degree of resilience and degrades slowly. Plastic is also highly resistant to deterioration. Thermosets and thermoplastics are the two major kinds of plastic. 2,3. Because thermosets solidify irreversibly when heated, they have a high level of durability and strength and can thus be employed largely in building applications. Plastic is a non-biodegradable trash that contributes to global warming and the greenhouse effect. Various tests have been conducted to determine whether waste plastic may be reused productively. According to the literature, when waste plastic is added to heated aggregates, it forms a fine coat of plastic over the aggregate, and when these aggregates are mixed with binder, they have higher strength, resistance, and performance over time. Use of waste plastic, in addition to bitumen, extends the life and smoothness of the surface. It is both cost-effective and environmentally beneficial. Plastic shrinkage and drying shrinkage are reduced when plastic waste is used in pavement construction. The use of waste plastic enhances asphalt surface abrasion and slide resistance⁴. Because of the hot and humid atmosphere in India, plastic pavements are the best option. Titanium dioxide can be used to absorb the smoke from the automobiles. It also improves the plastic's mechanical properties, resulting in increased strength and resistance.

1.1 Objective

The following are the project's goals: conduct a soil test.

- To create a flexible pavement
- To create an asphalt pavement with a mix of gravel, plastic, and bitumen.
- On apply a plastic coating to the aggregate and include titanium dioxide.
- To put the bitumen and modified bitumen to the test.

1.2 Scope of The Project :

- To get rid of potholes
- To reduce global warming, greenhouse gas emissions, and pollution, the road's lifespan can be extended.
- Natural eco-friendly

1.3 Plastics Roads - General Introduction

The usage of plastic in road construction is not a novel concept. It's already being used as PVC or HDPE pipe mat crossings, which are made by connecting PVC (polyvinyl chloride) or HDPE (high-density polyethylene) pipes to create plastic mats. Transition mats are included on the plastic roads to make it easier for tyres to get up to and down from the crossing. By dispersing the weight throughout the surface, these techniques help protect wetland freight routes from rutting. However, scientists and engineers have been concerned about the usage of plastic trash for a long time⁶. Recent research in this area has revealed some promise in terms of employing plastic trash in road construction, i.e., plastic roads. A Bangalore-based company and a team of engineers from Bangalore's R. V. College of Engineering have discovered a method for utilising plastic garbage in road construction. The team conducted an initial study in 1997 to test for strength and durability. As a major component of the construction material, plastic carry-bags, throwaway cups, and PET bottles gathered from waste dumps are commonly used. Plastics melt when mixed with hot bitumen to form an oily film over the aggregate, which is then put on the road surface like a regular tar road.

Advantages :

- Reduce the amount of bitumen required by about 10%.
- Develop an environmentally friendly technology.
- Improvements in road fatigue life.
- Increase the road's strength and improve its performance.
- Increase the percentage of plastic garbage used.
- Smoke absorbent absorbs the gases generated during traffic congestion.

Disadvantages :

- Toxic present in the co-mingled plastic wastes would start leaching.
- But the presence of chlorine will definitely release HCL gas.

II. LITERATURE REVIEW

Sr. No.	Author	Year	Content
1.	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.
2.	Zahra Nilofar Kalantari	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. This paper is a review of the use of polymers in asphalt pavement. In this study, a critical review on the history and benefits of using waste and virgin polymer in asphalt is presented followed by a review of general studies on using polymers in asphalt in order to improve the properties of pavement.
3.	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 nonbiodegradability 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.
4.	Sunil J. Kulkarni	2015	Minimization of waste material is important aspect of the modern growth and development initiatives ⁴ . 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.
5	S. Rajasekaran	2009	“Reuse of waste plastic coated aggregate” Marshall’s mix design was carried out by changing the modified bitumen content at constant optimum rubber content and subsequent tests have been performed to determine the different mix design characteristics and for conventional bitumen (60/70) also. This has resulted in many improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67%).

III. COMPARATIVE STUDY

3.1 Central Mixing Plant (CMP) :

A central mixing plant can also be used for the dry process. Up the conveyor belt, the shredded plastic is mixed in with the aggregate. This is poured into the steaming cylinder. The bitumen is applied after the aggregate has been covered with plastic. After that, the mixer is placed into a dipper lorry and sent for road laying. CMP allows for greater temperature control and mixing of the material, resulting in a more uniform coating. This has been implemented in our project.

The conventional aggregates and plastic coated aggregates, as well as bitumen and modified bitumen, are all tested in this comparative study (10 percent of bitumen replaced by plastic). The numerous tests conducted for the comparison study are as follows:

- Test on aggregates
 - i. Aggregate crushing test
 - ii. Los Angeles abrasion test
 - iii. Impact test
- Test on bitumen
 - i. Penetration test
 - ii. Softening point test
 - iii. Viscosity test
 - iv. Marshall Stability test.

IV. TESTS

4.1 Tests on Aggregates

4.1.1 Aggregate Crushing Test :

Aggregate crushing tests can be used to determine the coarse aggregate's strength. The aggregate crushing value is a measure of how resistant a material is to crushing when subjected to a progressively applied compressive load. Aggregates with a strong resistance to crushing or a low aggregate crushing value are preferable for high-quality pavement.

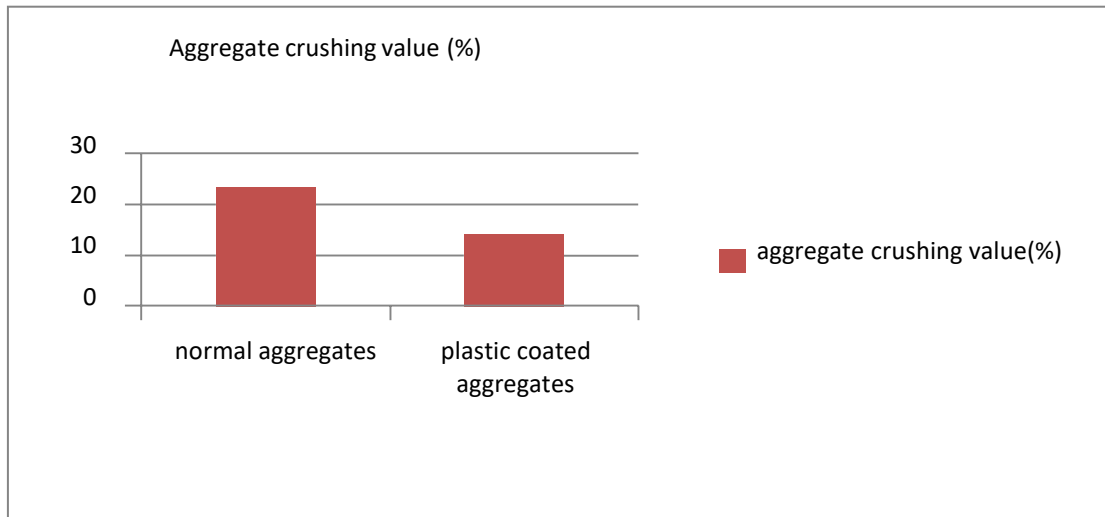


Fig. 1 Aggregate crushing value

4.1.2 Abrasion Tests

The road stones employed in the surface course are prone to wear action at the top due to traffic movements. As a result, road stones should be tough enough to withstand traffic abrasion. Abrasion tests are used to determine the hardness of stones and whether or not they are suitable for certain road construction projects. Any of the three tests listed below can be used to conduct an abrasion test on aggregate.

- Los Angeles abrasion test
- Deval abrasion test
- Dory abrasion test

The Los Angeles abrasion test, on the other hand, is chosen since the test results have been linked to pavement performance.

4.1.3 Los Angeles Abrasion Test :

The Los Angeles abrasion test is used to determine the percentage wear caused by relative rubbing between the aggregate and the steel balls employed as an abrasive charge. This test evaluates the resistance to wear and impact due to the pounding action of these balls during the test.

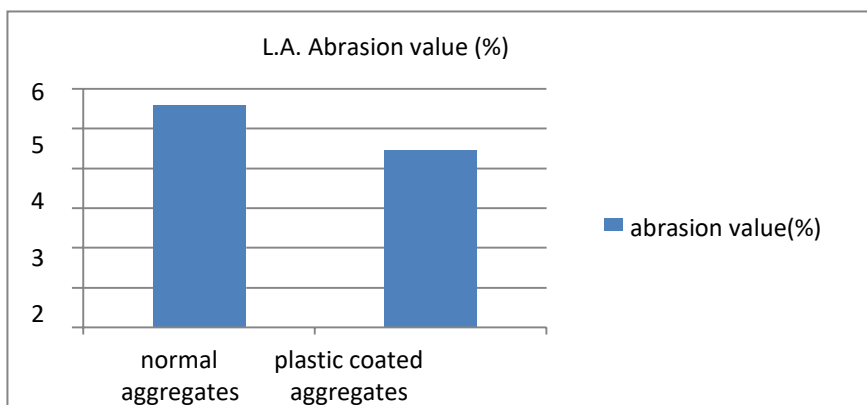


Fig. 2 Aggregate Los Angeles Abrasion value

4.1.4 Impact Test :

The impact test is used to determine the toughness of stone or the resistance of aggregates to fracture under repeated impacts. The aggregate impact test is a widely used method for determining aggregate impact resistance, and it has been standardised by ISI.

The aggregate impact value is a relative measure of aggregate to impact, but the resistance to progressively increasing compressive stress has a distinct effect.

For aggregate to be utilised in the wearing course of pavements, the aggregate impact value should not generally exceed 30%. For bituminous macadam, the highest allowable value is 35 percent, and for water bound macadam base course, the maximum permissible value is 40 percent.

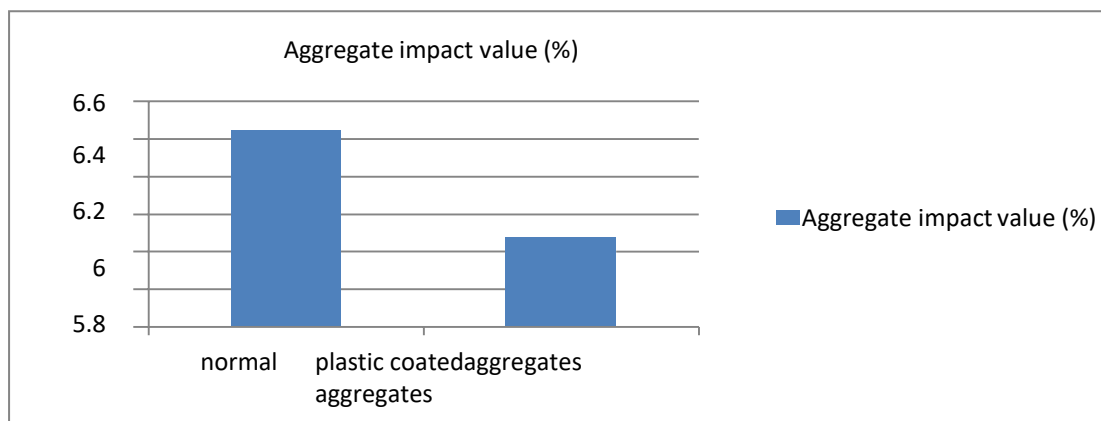


Fig. 3 – Aggregate impact value

4.2 Tests on Bitumen penetration Test :

The penetration test is used to determine the bitumen's hardness. The penetration of a bitumen is the distance in tenths of millimetres that a standard needle can penetrate into it under a load of 100gm applied for 5 seconds at 25 degrees Celsius. The softness of bitumen is indicated by the penetration value (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

4.3 Softening Point Test :

The theory underlying this test is that the softening point is the temperature at which the substance softens to a specific degree under the test conditions.

The temperature at which the bitumen softens to a given degree under the conditions of this test is referred to as the softening point.

A ring and ball device is used to administer the test. At a specific temperature, a brass ring carrying a bitumen test sample is suspended in a liquid such as water or glycerine. The bitumen sample is placed on a steel ball, and the liquid medium is heated at a rate of 5 degrees Celsius per minute. When the softened bitumen comes into contact with a metal plate that is set at a certain distance below, the temperature is recorded. In general, a greater softening point means

4.4 Viscosity Test :

The inverse of fluidity, viscosity, is defined as The fluidity of bituminous material is thus defined by its viscosity. The measure of resistance to flow is viscosity, which is a broad term for consistency. Many scientists feel that absolute viscosity measurements, rather than traditional penetration units, should be used to grade bitumen. The strength qualities are heavily influenced by the binder's fluidity at the application temperature.

V. METHODOLOGY

We will use the above-mentioned research in this project. The research indicated above was done for Plastic Roads, however we will use the same principles for road maintenance. According to Dr. R. Vasudevan, one kilometre of road takes one tonne of plastic and nine tonnes of bitumen. That amount of plastic isn't available.

As a result, if we utilise the same strategy for road maintenance, we will have enough plastic to complete the task. This synthetic bitumen may be used to patch potholes and seal cracks, making the maintenance process much easier. The plastic material is shredded to a specific size using a shredding machine in this procedure.

The aggregate mix is then heated to 165°C and transported to the mixing chamber, while the bitumen is heated to 160°C to ensure effective binding. During the heating process, it's critical to keep an eye on the temperature. After that, the shredded plastic trash is mixed in with the aggregate. Within 30 to 60 seconds, it coats the aggregate uniformly, giving it an oily appearance. The heated bitumen is combined with the plastic waste coated aggregate, and the resulting mix is used for road construction. The temperature for laying the road is between 110 and 120 degrees Celsius. The roller utilised should have an 8-ton capacity. So, using the process outlined above, we will fix potholes and crack seal the roadways.

We will first remove all dust particles from the pothole, and if the area of the pothole is larger, we will use coarse aggregate, and then we will fill the pothole with plastic bituminous mixture and roll it with a roller. This procedure does not require traffic to be stopped, and when plastic is used, the applied layer will not wear off and will adhere firmly, saving us money on future road repair.

The discarded plastic is shredded and covered over aggregate before being mixed with hot bitumen and utilised in the creation of pavements. This will not only strengthen the pavement, but it will also make it more durable. The titanium dioxide is utilised as a smoke absorbent substance, absorbing the smoke produced by the automobiles.

A thin protective wearing surface is put to a pavement or foundation course as a bituminous surface treatment (BST), also known as a seal coat or chip seal. All of the above can be provided via BSTs: The underlying pavement is protected by a waterproof covering. Skid resistance has been improved. At roughly 170 °C, the shredded plastic is combined and melted. The melted plastic is then sprayed with hot bitumen. After mixing, the mixture is laid out in the same way as conventional asphalt concrete is placed out. In the Netherlands, no large-scale, systematic technique to building roadways completely of plastics has been used to date.

Pyrolysis is one of the most used methods for transforming plastic waste into fuel. This method necessitates extremely high temperatures for the polymers. Materials are separated, allowing them to be reused in an environmentally acceptable manner.

The National Highways Authority of India (NHAI) is an autonomous government entity in India that is in charge of managing and maintaining a network of national highways. The Ministry of Road Transport and Highways oversees it.

Plastics contain a lot of energy, which may be transformed into power, synthetic gas, fuels, and recycling feedstocks for new plastics and other chemistry products. In addition to reducing waste sent to landfills, recovering this plentiful energy complements plastics recycling.

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Segregation of plastic



Cleaning of plastic



Shredded plastic



Collection of shredded plastic

VI. RESULTS AND DISUSSION

- For normal and plastic coated aggregate, the crushing value drops from 23.32 to 14.22. The price has been slashed by 40%. The higher the strength, the lower the aggregate crushing value.
- Plastic coated aggregate had a lower aggregate impact value than conventional aggregate, which was reduced by 9%. Plastic coated aggregates provide a better toughness.
- The aggregates' hardness is determined by the Los Angeles abrasion value. Plastic coated aggregates had abrasion values that were 21% lower than conventional aggregates.
- Bitumen has a higher penetration value than bitumen that has been combined with plastic.
- The bitumen softens at a lower temperature than the bitumen that has been replaced with plastic.
- Modified bitumen has a higher stability than regular bitumen (10% bitumen replaced by plastic).

VII. CONCLUSION

The plastic is combined with bitumen and gravel to improve the road's performance. The aggregates are coated with a polymer that decreases voids and moisture absorption. This prevents the formation of potholes and reduces the number of ruts. Plastic pavement is more durable than flexible pavement and can endure heavy traffic. The usage of plastic mix lowers the bitumen concentration by 10% while increasing the road's strength and performance. This revolutionary technology is non-polluting. Vehicle pollution can be reduced by using a smoke absorbent substance (titanium dioxide) with a 10% polymer content.

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