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Plastic Waste Road Construction in Madhya Pradesh

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ABSTRACT

Plastic or polythene bags, these non-biodegradable toxic items have been playing a major role in degrading our environment, especially our oceans. But now there might be a solution to tackle this mounting problem, using plastics to build roads. The idea is to create roads that are durable and also to get rid of potholes. Given the current plastic crisis, the aim of this case study is to make sure that plastic waste does not reach the landfills or water bodies and to ensure that the 3 R's – Reduce, Reuse and Recycle are implanted effectively.

Key words: Non- Biodegradable, Plastic Waste, Recycle

1. INTRODUCTION

From being one of the biggest littering items, stagnating water bodies to choking drains during monsoons, plastic waste has turned into a crisis that needs to be addressed immediately. In 2015, the Indian Government made it mandatory for all road developers in the country to use plastic waste for road construction after Rajagopalan Vasudevan, a professor from Madurai's Thiagarajar College of Engineering, laid out a process of building roads by recycling plastic waste[3]. While trial and error experiments are going on across the country, cities like Indore are already using this technique.

In a first in the state, Madhya Pradesh Rural Road Development Authority (MPRRDA) has put plastic waste to constructive use to lay 22 roads. MPPRDA has so far utilized at least 17 tonnes of plastic waste for construction of these roads which cumulatively will measure 35 km in length, going by the fact that it takes 0.5 tonnes of such waste to make each km of road.

As a pilot project, first laying of roads was started in four districts of Bhopal, Indore, Jabalpur and Raisen. The state capital's road connecting Sehore road to Pipaliya Dhakad village was first such constructed road using plastic waste.

Mayor Alok Sharma said that in Bhopal daily 800 tonne waste is generated and 120 tone plastic waste in generated. Now with this initiative scientific utilization of plastic waste will be possible. The Bhopal Municipal Corporation and the district administration have decided to repair as well as construct roads in I Bhopal with plastic waste. In preparing roads using plastic waste, 10% of the waste is used as substitute to traditional materials. After the success of the pilot project, roads were constructed in other districts including Rajgarh, Dhar, Badwani, Ujjain, Khargone and Dewas.
The roads have been tested on parameters like abrasion value, water absorption, impact value and have been found to be of higher strength. These roads were constructed on controlled conditions and several tests conducted on site. Now MPRRDA plans to construct 15% of roads with plastic waste. On an average they make 3000 km long roads every year and 15 of these means utilizing more than 200 tonnes of such waste, which otherwise is a problem for civic bodies and a environmental hazard. Plastic below 40 micron in thickness, which is most hazardous, is best material in constructing roads.

In India's cleanest city Indore, which is presently recycling half of it's plastic waste daily, utilizing elements of plastic in road making is slowly gaining a momentum. Of the 13 tonnes of plastic waste that the city generates daily, nearly 30 per cent of it is being used for road construction.

1.1 Plastic Roads: An Answer to Plastic Waste Crisis and Poor-Quality Roads

In terms of monetary benefits, using plastic waste instead of tar is definitely a cost-effective option. A mere 10-20 paise is spent per kilo of shredded plastic, whereas 20 rupees are spent on one kilo of tar. Hence if plastic waste is channelized in road construction across India, the civic bodies can save upto 2500 rupees per tonne. In addition to this, no new machinery is required for producing this mixture and the maintenance cost of the road is almost nil. The process of shredding takes place at a bare minimum cost.

The roads made out of plastic-tar combination have proved to be eco-friendly. Tar is fossil fuel and hence by reducing the usage of tar, we are indirectly reducing carbon footprints. Besides, there is no leaching of plastics and no effect of radiation like UV on roads. There are no liquid industrial effluents and no floor washings as it is a dry process.

The strength and finishing of roads when waste plastic is used is much better than tar. These roads have a better resistance to water and water stagnation as well. The huge problem of water clogging on roads is likely to decrease as the plastic

roads have lesser chances of being striped or developing potholes. In order words, the life span of the road is substantially increased.

1.2 Objectives

1.To study the various steps involved in plastic road construction.
2.To understand the construction methods involved in making plastic roads.
3. To view and compare the test results of bitumen and plastic modified bitumen.
4.To understand the challenges involved in implementation of such projects.

2. REVIEW OF LITERATURE

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 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.

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 non-biodegradability and un aesthetic view. 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.

4) 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.

3. METHODOLOGY

The methodology involves utilizing participatory and applied research methods in achieving objectives identified earlier.

The participatory method involves engaging with multiple stakeholders involved in the implementation of plastic roads. In order to develop a complete understanding and impact of the successful innovative practice, stakeholders are involved in the learning exchange process.

Applied research methods are used for producing the case studies for the state. The emphasis in the case studies was on strategy□oriented documentation. An analytical framework was developed for the case study. The framework was analysed through qualitative and quantitative measures.

3.1 Steps Involved

1. Plastics waste cut into a size between 2.36mm and 4.75mm using shredding machine.
2. The aggregate mix is heated to 165°C (as per the HRS specification) and transferred to mixing chamber. Amount of plastic to be added is @8% of bitumen
3. Bitumen is to be heated up to a maximum of 160°C (HRS Specification) to have good binding and to prevent weak bonding.
4.At the mixing chamber, the shredded plastics waste is to be added. It get coated uniformly over the aggregate within 30 to 60 seconds
5.The plastics waste coated aggregate is mixed with bitumen and the resulted mix is used for road construction.
6.The road laying temperature is between 105°c to 120 °c. And the rollers are used.

3.2 Construction Methods

Plastic waste can be used in hot mix to improve physical properties of bituminous aggregate mix by ‘Dry Process’ or ‘Wet Process’. The technology as developed and explained by Dr Vasudevan, a Chemistry Professor at Thiyagaraja College of Engineering, Madurai, incorporates the use of ‘Plastone’, a mixture of stone chips and waste plastic bags (thickness 40□70 μm) which is heated at 150□170 degree celsius during production, in laying roads, pavements and flooring purposes as an alternative to interlocking paver blocks.

At this processing temperature, the plastic waste is heated enough to act as an adhesive in binding stone chips and not generating any toxic gases. The aggregate becomes water proof after getting coated with molten plastic.

This step is followed by the addition of hot plastic□aggregate mix to hot bitumen while maintaining the process temperature. This approach is known as ‘Dry Process’ shown in Figure 1.

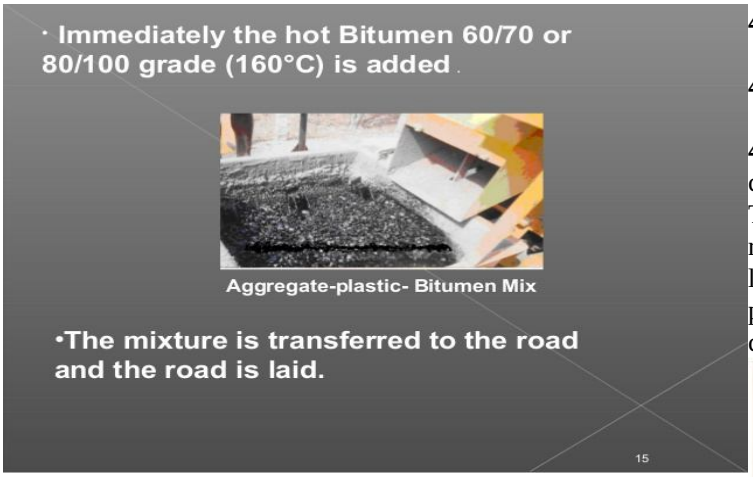

Figure 1 Aggregate Plastic Bitumen mix

The 'Wet Process' involves mixing of plastic to hot bitumen followed by mixing with hot aggregate. Both the processes lead to the formation of plastic modified bituminous aggregate mix with enhanced properties imparting strength, stability and durability to the roads.

Recently, a new method called has been developed which incorporates mixing of materials at lower temperatures. This method is known as the 'Cold Mix' method. This process offers the following advantages over the hot mix:

1. The heating of aggregate and binder is not required.
2. It is an environmentally friendly approach which conserves energy. An impressive 50% of energy saving in case of cold mix over hot mix has been reported. Therefore, it can be considered to be a green bituminous mix for road construction.
3. It is a straightforward preparation using only a small set up on site. A manual production for small scale job is also feasible.
4. It is a suitable method particularly for construction of roads in remote and isolated areas of a country.
5. The method is suitable for road construction in wet or humid condition.
6. Cold mix is a versatile method due to availability of a large number of grades of emulsion and cut backs.
7. It offers an economical and high production approach.

The dry process employing 8% plastic waste as a partial replacement of Optimum Bitumen Content (OBC) in Conventional Mix (CM) has been found to enhance the fatigue, strength, stiffness and hence the performance of the road pavements in comparison to wet process. For these reasons, dry process has been widely accepted as a standard method for blending plastic into bituminous mix to be used for constructing road pavements.

4.RESULTS AND DISCUSSIONS

4.1 Tests on Aggregates

4.1.1 Aggregate Crushing Strength- The strength of the coarse aggregate may be assessed by aggregate crushing test. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied compressive load. To achieve a high quality of pavement, aggregates possessing high resistance to crushing or low aggregate crushing value are preferred as shown in Figure 2.

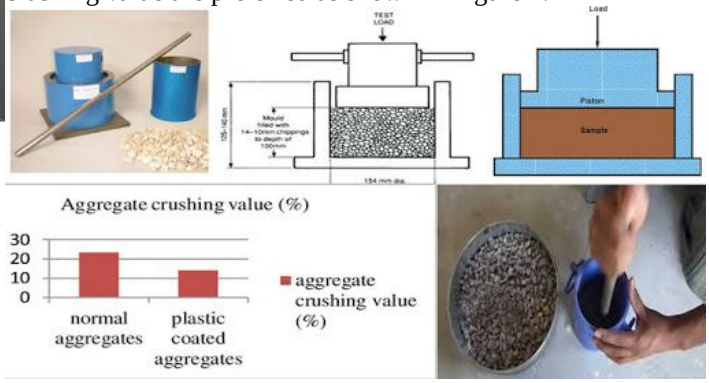

Figure 2 Aggregate crushing test

4.1.2 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 as shown in Figure 3.

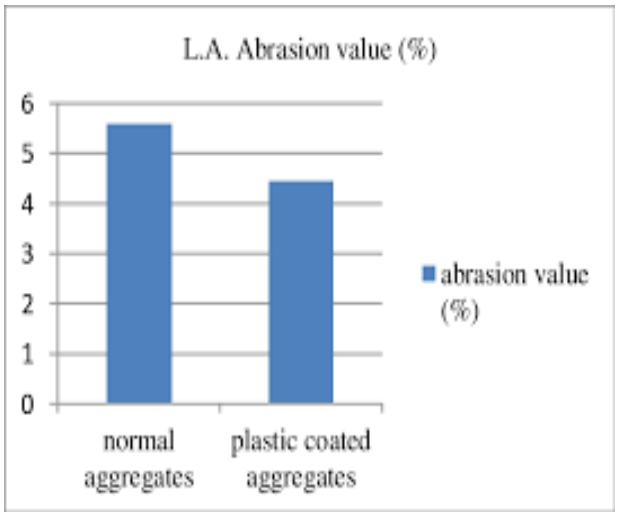

Figure 3 Los Angeles Abrasion value

4.1.3 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 as depicted in Figure 4.

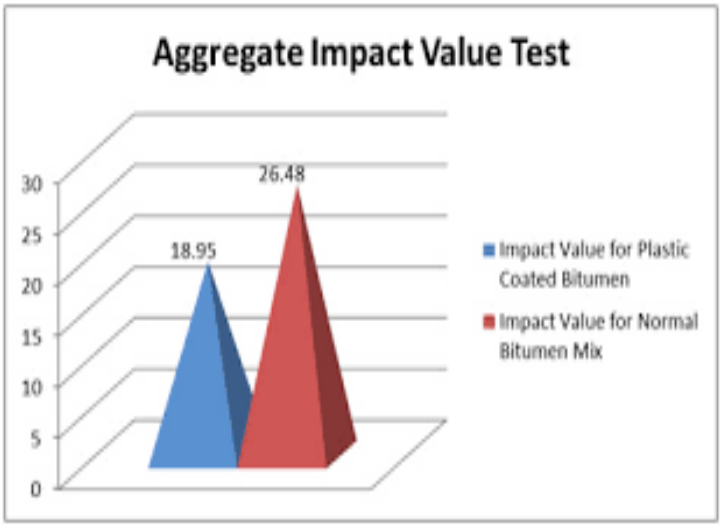

Figure 4. Aggregate impact value test

4.1.4 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 as shown in Figure 5.

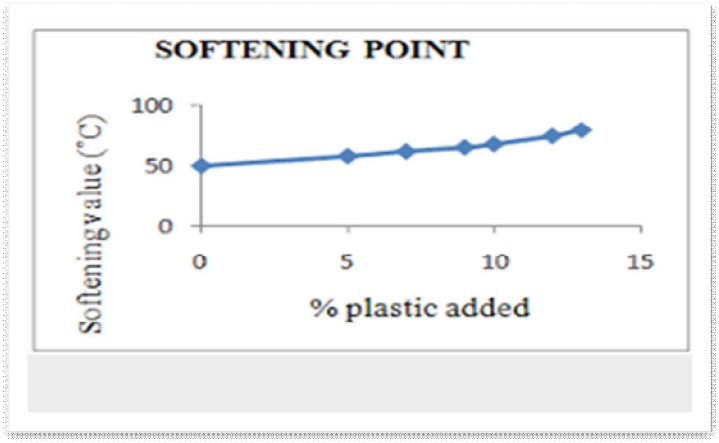

Figure 5. Softening point

- 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.

5. 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. The use of smoke absorbent material (titanium di-oxide) by 10% of polymer content can reduce the vehicular pollution.

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