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Plastic Roads Road Construction from Garbage Plastic

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ABSTRACT

Disposal of waste plastic is a major problem. It is non biodegradable & It mainly consists of low-density polyethylene. Burning of these waste plastic bags causes environmental pollution. To finds 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. Plastic roads mainly use plastic carry bags, disposable cups and bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like the normal tar road.

Keywords : Bitumen, Aggregate, Plastic and Environmental safety.

I. INTRODUCTION

The technology was initially developed and patented by Rajagopalan Vasudevan of the Thiagarajar College of Engineering. He developed an innovative method to reuse plastic waste to construct better, more durable and very cost-effective roads. This method will help in making roads much faster and also will save the environment from dangerous plastic waste. The roads also show greater resistance to damages caused by heavy rains. In an interview with the better India, he explained, "The advantages of using waste plastics for road construction are many. The process is easy and does not need any new machinery. For every kilo of stone, 50 gms of bitumen are used and 1/10th of this is plastic waste; this reduces the amount of bitumen being used. Plastic increases the aggregate impact value and improves the quality of flexible pavements. Wear and tear of the roads has decreased to a large extent."[1]

The plastic-bitumen road-laying technique covered under a patent held by the Thiagarajar College of Engineering in 2006.[2] Dr Vasudevan has since made it free to use for the greater good. The technology is simple and is described in a dedicated.

It involves

a) collecting gaebage plastics, including plastic carry bags, cups, soft and hard foams, and laminated plastics;

b) cleaning it by washing;

c) shredding it to a uniform size;

d) melting the waste plastics at 165°C, and blending it with hot aggregates and bitumen and using this mixture to lay the road.[3]

II. CONSTRUCTION

Since plastic roads are a relatively new idea, construction processes vary. In Jamshedpur, India, roads are created from a mix of plastic

and bitumen.[3] These roads are made from recycled plastics, and the first step in constructing them is to collect and manage the plastic material. The plastics involved in building these roads consists mainly of common post-consumer products such as product packaging.[4]

A. Materials used in plastic road

Aggregates:

Aggregates of 20mm and 10mm.

Stone dust and lime as filter.

Figure: 1 Aggregates

Bitumen: 60/70, 80/100 grade bitumen.

Figure: 2 Bitumen

Waste plastic:

Waste plastic in the shredded form(PVC is not used).

Figure: 3 Shredded Plastic

B. Construction Process

Step 1: Plastics waste (bags, cups, bottles) made out of PE,PP and PS cut into a size between 2.36mm and 4.75mm using shredding machine.

Figure: 4 Shredded Plastic

Step 2: The aggregates mix is heated to 165^{0}C (as per HRS specification) and transferred to mixing chamber. Amount of plastic to be added is 8% of bitumen.

Figure: 5 Shredded plastic mixed with Aggregate

Step 3: Similarly the bitumen is to be heated upto a maximum of 160^o C (HRS specification) to have good binding and to prevent week bonding (monitoring the temperature is very important).[6]

Figure: 6 Heating of bitumen

Step 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, giving an oily look.

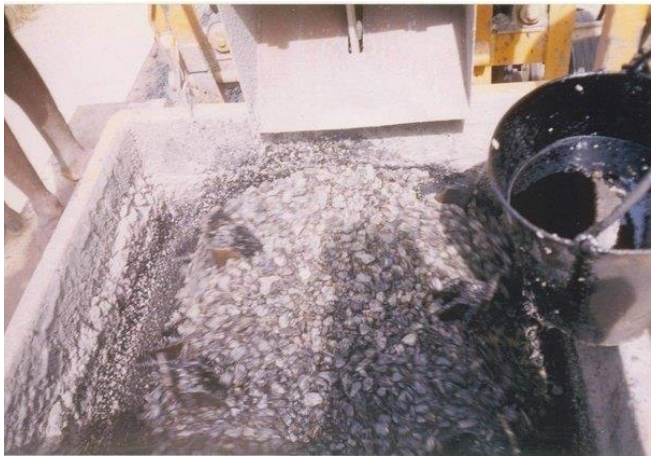

Figure: 7 Shredded plastic with hot bitumen

Step 5: The plastics waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The roller used in 8 tone capacity.

Figure: 8 Mixing of plastic, bitumen and aggregate

Step 6: The road laying temperature is between 110 to 120° C. And the rollers are used have capacity 8 tone generally.[5]

Figure; 9 Plastic road

III. USAGE BY INDIAN CITIES

Chennai was among the first cities globally to adapt the technology in a big way when the municipality commissioned 1000 km of plastic roads in 2004.[6] Since then all major municipalities in India have experimented with the technology including Pune, Mumbai, Surat, Indore, Delhi, Lucknow etc.[7]

Chennai: While the plastic roads may be a new concept in many parts of India, Chennai has been experimenting with it since 2011. Chennai has used nearly 1,600 tonnes of plastic waste to construct 1,035.23 kilometres length of roads in recent years, which include N.S.C Bose road, Halls road, Ethiraj Silai Street and Sardar Patel Street.

Pune: Using bitumen technology on waste plastic, the Pune Municipal Corporation constructed a 150-metre stretch of Bhagwat lane at Navi Peth near Vaikunth Crematorium in 2016. The other trial patches in Pune include Dattawadi Kaka Halwai Lane, Katraj Dairy, Magarpatta City HCMTR Road, Kavde Mala Road, Koregaon Park Lane No 3 and Yeravada Sadal Baba Darga Road from Chandrama Chowk.

Jamshedpur: Jamshedpur Utility and Services Company (JUSCO), which is a subsidiary company of Tata Steel, constructed a 12-15 km road in the steel city as well as Tata Steel Works using plastic road, including a nearly 1 km stretch in Ranchi, 500m stretch each in Dhurwa and Morabadi, 3 km of roads in Chas and Jamtara each and 500m stretch in Giridih.

Indore: Dating 2014, the Madhya Pradesh Rural Road Development Authority (MPRRDA) has constructed around 35 km of roads in 17 districts with plastic waste.[8]

Surat: The idea of using plastic-bitumen mix was executed in January 2017. The problem of potholes significantly reduced as no cracks developed in areas where roads were layered with waste plastic.[7]

The technology has penetrated deeply and has found application even in far flung areas such as Meghalaya, where a village converted 430 kg of plastic waste into a kilometer long road in 2018.

In December 2019, India has built 21,000 miles of roads using plastic waste. Till now, the country has almost 33,700 km of plastic roadways that means every 1 km road uses 1 million plastic bags.[9]

IV. COMPARATIVE STUDY

A. Softening Point Test

The principal of this test is that softening point is the temperature at which the substance attains a particular degree of softening at specified condition. This test denotes the temperature at which the bitumen attains a particular degree of softening under the specification of this test. The test is carried out by ring and ball apparatus. The brass ring consist test sample of bitumen is suspended in liquid like water or glycerine at a given temperature. The steel ball is kept upon the bitumen sample and medium of liquid heated at a 5° C/min. Record the temperature if the softened bitumen touches the metal plate which is at a particular distance below. Generally lower temperature susceptibility indicates higher softening point and is preferred in hot climates.[10]

Sr no.	Bitumen in %	Plastic in %	Softening point in(°C)
1	100	0	43
2	98	2	48
3	96	4	57
4	94	6	61
5	92	8	63

Table no. 1

Softning point of bitumen with addition of plastic

B. Maintenance

Due to relatively short life of this technology this review did not find any evidence that result in maintenance of plastic roads. According to Centre for Innovations in Public Systems (2014) roads constructed with plastic modified bitumen needs maintenance after 10 years of service compared to 5 years required to normal road after service, however impact of traffic on the road were not reported. McRuber's recycle waste plastic products were used for resurfacing A7 (A major trunk road) in the UK's Lake District.

Plastic-bitumen composite roads have better wear resistance than standard asphalt concrete roads. They do not absorb water and have better flexibility, which results in less rutting and less need for repair. Road surfaces remain smooth, need minimal maintenance and absorb sound better.

The construction process is extremely eco-friendly as no toxic gases are released. The plastic waste helps

increase the strength of the road, reducing road fatigue. The roads are more weather resistant (rain water, high and low temperature).[11]

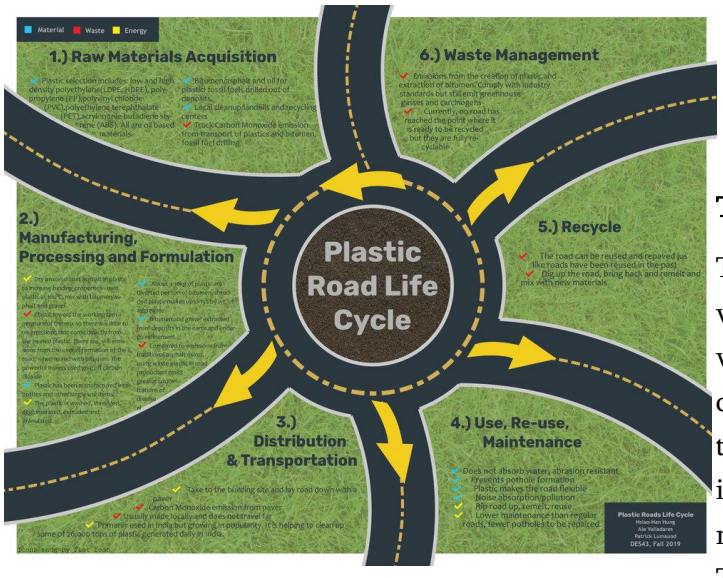

Figure: 10 Life cycle of plastic road

V. CHALLENGES

Health and environmental hazards

Two chemical hazards associated with the application of waste plastic within road construction identified by Chakraborty and Mehta in 2017.

- During the cleaning process leaching of toxic components.
- During the road construction process generating chlorine hazardous based gases.

But after laboratory experiment in 2019 reported that both leachate and toxic fume generation were negligible and did not have any adverse effects.[4]

Collecting and Sorting of waste plastics

Some of the method follow for the collecting, sorting and cleaning of waste plastic. For the construction of the waste plastic road the plastic should be good quality system for collecting, sorting and cleaning of waste plastic.

The following types of waste plastic can be used for the road construction therefore separation of waste is important,

- Films (carrier bags, disposable cups) of thickness up to 60 microns (PE, PP, PS)
- Hard foams (PS) of any thickness
- Soft foams (PE and PP) of any thickness
- Laminated plastics of thickness up to 60 microns

Training for construction workers

The health and safety concerned training of the workers is mandatory. Also they should be provided with an understanding the type of waste and method of handling. Similarly, the training is mandatory for the contractors, workers, and engineers should involve for the awareness of both plastic waste management and its use in road construction. Training manuals and handbooks pertaining to the same may be drafted.[10]

Regulatory framework

An adequate regulatory framework for the use of waste plastics in road construction, drawing on evidence-based standards, is important to establish the legal as well as technical basis for the use of this technology. Governments could register providing the highways/road authorities with the mandate to oversee the use of waste plastics in road construction.

Titanium dioxide, also known as titanium (IV) oxide or titania, is the naturally occurring oxide of titanium, chemical formula TiO.

When used as a pigment, it is called titanium white, Pigment White 6 (PW6), or CI 77891. Generally, it is sourced from ilmenite, rutile, and anatase.

Titanium dioxide is used for the absorption of the smoke gases exhausted from the vehicle then level of the pollution will be decreases.

It can mix not only with dry resin powder, but also with liquid containing plasticizer. Another way of application is to process titanium dioxide into color master batch first, and then take it into use. The

particle sizes of most titanium dioxides for plastic are small.

VI. CONCLUSION

Plastics increase the melting point of the bitumen. The use of this plastics in road construction is an innovative technology which not only strengthens the road but also increases the road life. The analysis in this paper reveals that durability, strength and cost.

In addition to the improvement of the quality of the road, this technology has helped to use the waste polymers obtained from domestic and industrial packing materials. This has added more value to the dry process as this process helps to dispose 80 percentages of the waste polymers usefully by an eco-friendly method. This has already been accepted by the Central Pollution Control Board, New Delhi. They have already released a guideline on the technique of the road laying by dry process and its advantage. The organization also extends 50 percentages subsidiaries for laying Plastic Tar Road.

The removal of bitumen is very slow and difficult and nearly 85 percentage only is removed. The rest is held at the surface of the aggregate by the coated polymers. The residue, when washed further with a solvent for polymer called decline both bitumen and polymer are removed. This confirms the observation found in this research. This also explains the improvement in the stripping property .The molten polymer acts as a good binder and hence this acts as a good substitute in the preparation of flexible pavement mix. The quantity of bitumen is reduced to the extent of polymer used, in the mix preparation.

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