Use of Waste Plastics in the Pavements of the Flexible Road in the Highway Construction

[1]Neeraj kumar, [2]Ashish Verma, [3] Mr.Amit kumar yadav, [4]Mr. Chhabi Lal singh

[1]M.Tech, [2]M.Tech, [3]Assistant Professor & Head of Civil Engineering Department, [4]Assistant professor
Department of Civil Engineering,

J.S University, Shikohabad, Firozabad, India

Abstract

Plastics are user friendly but not eco-friendly as they are non-biodegradable. Generally it is disposed by way of land filling or incineration of materials which are hazardous. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics, by using them in road laying. Modified Bitumen is one of the important construction materials for flexible pavements. Use of plastic waste (LDPE) and Crumb Rubber i.e. the rubber obtained from the waste tyres of vehicles, in the construction of flexible pavement is gaining importance. It is also worth mentioning that, the modifier raw-material has been sourced from disposed waste plastic and crumb rubber. This not only allows us to collect modifier raw material at low cost, but also provides a solution towards ecological menace posed by increased use of plastics (non-biodegradable).an attempt has been made to use waste plastic, Low Density Polyethylene (LDPE) and Crumb Rubber, blended using dry process for LDPE and wet process for CRMB. Marshal method of bituminous mix design was carried out for varying percentages of LDPE and Crumb Rubber to determine the different mix design characteristics .the utilization of waste materials as replacement of the non-renewable products that need mining as well as processing has become very common. With the release of code IRC: SP: 98: 2013 of Indian Road Congress (IRC), the path for using plastic waste in the formation of roads all over the country has been cleared. Probable application of plastic waste in flexible pavement construction are studied and various positive and negative aspects of plastic waste use in pavement construction are focused here in this paper. Various reviewed studies relating plastic road technology reveal increase in resistance to deformation, increased durability, improved fatigue life, stability, strength, damages.

Keywords: *plastic waste, waste material, road construction, plastic road*

Introduction

India has the second-largest road network in the world, spanning a total of 5.89 million kilometres (kms). This road network transports 64.5% of all goods in the country and 90% of India's total passenger traffic uses road network to commute. Road transportation has gradually increased over the years with improvement in connectivity between cities, towns and villages in the country. In India, sale of automobiles and movement of freight by roads is growing at a rapid rate. Highway construction in India increased at 17.00% CAGR between FY16-FY21. Despite pandemic and lockdown, India has constructed 13,298 km of highways in FY21.

In FY21, 13,298 kms of highway was constructed across India. In June 2021, the Ministry of Road Transport and Highways constructed 2,284 kms of national highways compared with 1,681 kms in June 2020.

In October 2020, the foundation stone was established for nine National Highway projects—with a total length of ~262 kms—worth >Rs. 2752 crore (US$ 371.13 million) in Tripura.

The Government of India has allocated Rs. 111 lakh crore (US$ 1.4 trillion) under the National Infrastructure Pipeline for FY 2019-25. The roads sector is likely to account for 18% capital expenditure over FY 2019-25.

In October 2020, The National Investment and Infrastructure Fund (NIIF) is making progress towards integrating its road and highway portfolio. The NIIF has acquired Essel Devanahalli Tollway and Essel Dichpally Tollway through the NIIF master fund. These road infra-projects will be supported by Athaang Infrastructure, NIIF's proprietary road network, assisted by a team of established professionals with diverse domain expertise in the transport field.the Union Minister of State for Road, Transport and Shipping has stated that the Government aims to boost corporate investment in roads and shipping sector, along with introducing business-friendly strategies, that will balance profitability with effective project execution. According to the data released by Department for Promotion of Industry and Internal Trade Policy (DPIIT), construction development sector attracted Foreign Direct Investment (FDI) inflow worth US$ 26.08 billion in the between April 2000 and March 2021.

Material and methods

In plastic roads (composites of plastic with other materials) construction generally following materials are Used-

a. **Aggregates-** of size 20mm, 10mm and stone dust / lime as filler.

b. Bitumen- for binder different grades of bitumen 60/70 or 80/100 can be opted.

a. Plastic Waste- collected from various garbage dumps in the shredded form is used (PVC) is not used because of the high toxicity).

A. Plastic Waste Specifications

Following types of plastic wastes can be used in rural road construction-, films of

a. Hard foams polystyrene (PS) and Soft foams polypropylene (PP) and polyethylene (PE) of any thickness.

b. Films of polystyrene (PS), polypropylene (PP) and polyethylene (PE) up to 60micron thickness.

c. Laminated plastics (metal coated also) up to 60micron thickness.

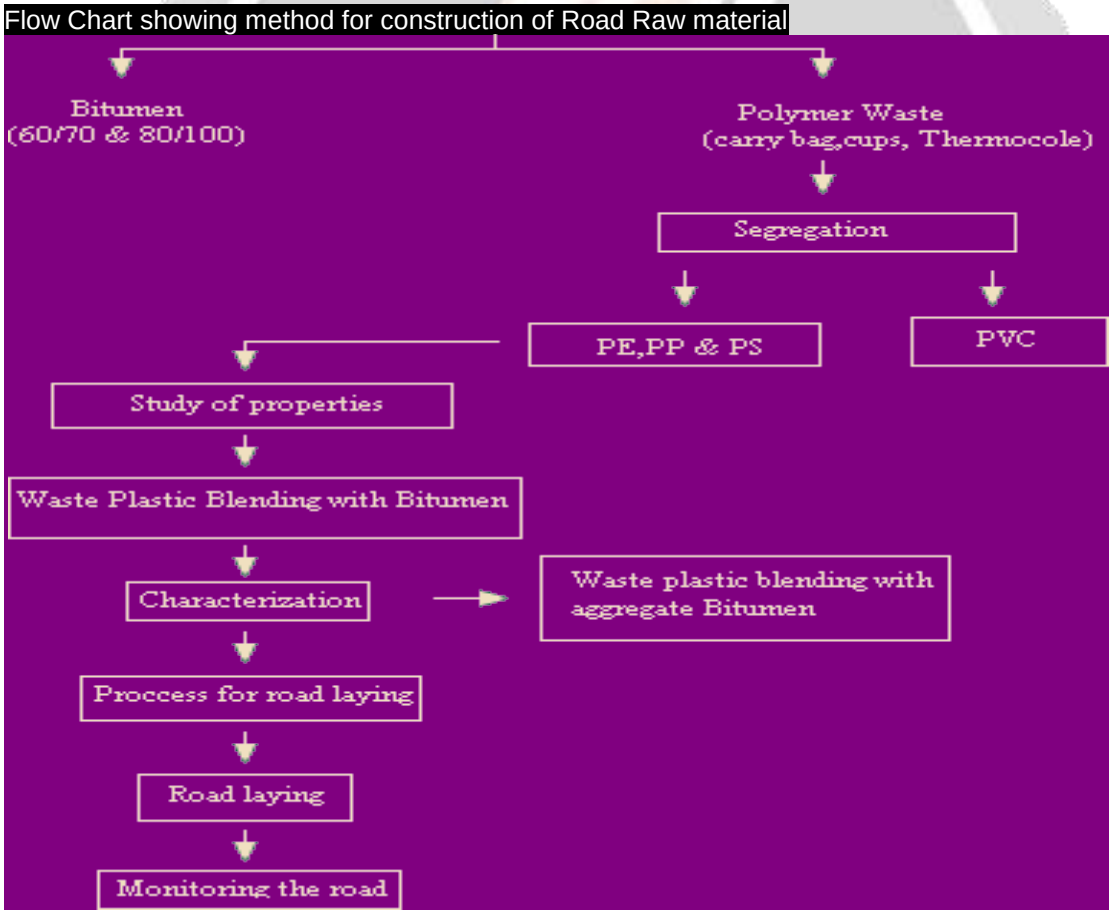

Figure 1: **Shows that the flows chart of road process.**

B. Process of Road Construction Using Plastic Waste

The basic process for road construction using plastic waste includes following steps-

a. Plastic Waste Collection: In first step, various plastic wastes as characterized in above specifications are collected from various sources.

b. Segregation: Other wastes are separated out from the plastic waste collected from various garbage dumps in above first step.

c. Cleaning and drying: the separated waste is cleaned properly and dried.

d. Shredding: After segregation and cleaning-drying step the waste collected is broken and is graded into a size of 2.36 mm to 4.75 mm IS sieve with the help of a shredding machine.

e. Heating Process: Before transferring to the mixing chamber the aggregate mix is heated to 165^{o}C to 170^{o}C and for preventing weak bonding the bitumen is heated up to the temperature of 160^{o}C.

f. Surface Coating: At the mixing chamber, the shredded plastic waste gets coated uniformly over the surface of the aggregates and shows an oily look within approximately one minute of time.

g. Construction: The aggregates after mixing with the combined mixture of the plastic waste and the bitumen are used for laying the road between the temperature of 110^{o}C to 120^{o}C.

C. Method of Mixing

Dry process is preferred for isolated works. According to the recommendations of CRRI and Dr. Vasudevan the percentage of shredded plastic waste should be 8%, and 10% respectively. However, 8% can be adopted as the optimum plastic waste content for blending the bitumen for use in plastic road construction . Conference Proceeding of National Conference on Innovative Trends in Civil Engineering (NCITCE 2018)

a. Dry Process: Different plastic wastes collected from various garbage dumps are broken and are graded into a size of 2.36 mm to 4.75 mm IS sieve with the help of a shredding machine. In dry mixing process, the aggregate mix is heated separately to the temperature of 170oC and gets coated with the plastic waste over the surface and the bitumen is also heated up to a maximum temperature of 160oC. Thereafter in the mixing chamber both the mixes (surface plastic waste costed aggregates and the hot bitumen) are mixed together.

b. Wet Process: By using mechanical stirrer plastic waste is mixed with hot bitumen at 160^{o}C directly. Because of the heavy cost and large mix plant requirements the process is not commonly used.

c. Characteristics of Plastic Coated Aggregates Liquefied plastic waste exhibit good bonding properties. Different test results for plastic coated aggregates indicate improvement in several properties, e.g. strength, hardness, toughness, duration.

IV. POSITIVE ASPECTS

A well **constructed plastic road** will l**ead to** the following **benefits.**

1. **Resistance** and **road performance have increased. Proceedings of** the National Conference on Innovative Trends in Civil Engineering (NCITCE 2018) 129

2. **Reduce** bitumen **requirements** by around 10%. **So reduce** the cost.

3. It is more resistant to low temperatures (i.e. cold) and rainwater.

4. No stripping and no holes.

5. Maintenance costs are reduced to almost zero.

6. Create jobs for rag pickers and develop environmentally friendly technology.

7. The life on the road has increased considerably.

V. NEGATIVE ASPECTS

Some of the disadvantages of plastic roads are

1. **Cleaning process:** Toxic substances in plastic waste can start to seep in. During the road laying process: the presence of chlorine will surely release harmful HCL gas.

After laying the pavement: Once the pavement is laid, its elements are not inert.There is a marginal increase in costs due to the mixing requirements for shredded plastic waste and bitumen, but this is offset by a large portion of the total volume of the mixture resulting in lower bitumen requirements.

2. Many global problems can be solved by using non-biodegradable waste such as plastics in road construction.

3. There is a general increase in the life of roads by choosing these technologies in pavement construction.

4. The properties of bitumen are improved with the addition of plastic waste. The mixture obtained shows a good result compared to the standard results.

5. Due to the plastic, rainwater does not filter. There are therefore fewer maintenance needs.

6. The binding properties are also improved with these technologies.

7. There is an increase in peel resistance for aggregates coated with plastic waste followed by bitumen.

8. Most of the properties of plasticized aggregates continue to improve the plastic waste content up to 7%.Subsequently, with a further increase in the content of plastic waste, the values start to revert slightly to the negative side.

Compared to conventional materials, using road materials that include plastic waste has the following benefits:

(i) reduces whole life cost,
(ii) longer service life,
(iii) preserves natural resources, and
(iv) Reduces plastic waste in landfills.

Comparison

The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix. Roads laid with plastic waste mix are found to be better than the conventional ones. The binding property of plastic makes the road last longer besides giving added strength to withstand more loads. While a normal 'highway quality' road lasts four to five years it is claimed that plastic-bitumen roads can last up to 10 years. Rainwater will not seep through because of the plastic in the tar. So, this technology will result in lesser road repairs. And as each km of road with an average width requires over two tones of polyblend, using plastic will help reduce non-biodegradable waste. The cost of plastic road construction may be slightly higher compared to the conventional method. However, this should not deter the adoption of the technology as the benefits are much higher than the cost. Plastic roads would be a boon for India’s hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. Already, a kilometer long test-track has been tested in Karnataka using this technology. The government is keen on encouraging the setting up of small plants for mixing waste plastic and bitumen for road construction. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste.

Conclusions:-

Due to the expected increase in road construction and its impact on the environment, the requirement for more sustainable and low-maintenance road infrastructures has become very important. This working paper presents a summary of practices and recent developments in the use of plastic waste on rural road projects. The findings are very encouraging as the hypothetical flexible–rigid pavement scores the overall best balance of these points.

REFERENCES

1. Vasudevan , R, Saravanavel, S, Rajsekaran , S, and Thirunakarasu, D (2006) "Utilization of Waste Plastics in Construction of Flexible Pavements", Indian Highways, Vol. 34 No.7 IRC, pp 5-20.

2. Sridhar, R Bose , S Kumar, G and Sharma G, (2004) "Performance Characteristics of Bituminous Mixes Modified by Waste Plastic Bags" Highway Research Bulletin , No 71, IRC pp 1-10.a

3. IRC:48-1972, "Tentative Specifications for Bituminous Surface Dressing Using Pre-Coated Aggregate", Indian Roads Congress.

4. Utilization of Waste plastic Bags in Bituminous Mixes (November 2002), CRRI Report submitted to M/s KK Plastic Waste Management Ltd. (Bangalore). Conference Proceeding of National Conference on Innovative Trends in Civil Engineering (NCITCE 2018) 130

5. S.Rajasekaran1*, Dr. R. Vasudevan2, Dr. Samuvel Paulraj3, Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite For Road Application – Green Method, American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-02, Issue-11, pp-0113.

6. Brajesh Mishra*, M.K. Gupta**, A Study on Use of Plastic Coated Aggregates in Bituminous Concrete Mixes of Flexible Pavement, Int. Journal of Engineering Research and Application ISSN: 2248-9622, Vol. 7, Issue 10, (Part -7) October 2017, pp.26-33.

7. Flynn F. (1993) "Recycled Plastic finds home in Asphalt Binder" Journal Roads and Bridges.

8. "EnviroNews Archives - Plastics Recycling and The Need For Bio- Polymers", Vol. 9 No. 4 - October 2003

9. National Rural Roads Development Agency Ministry of Rural Development, GoI., Guidelines for the use of Plastic Waste in Rural Roads Construction.