

USING PLASTIC WASTE IN ROAD CONSTRUCTION- A Survey

K. I. Vishnu Vandana¹, M. Rajyalakshmi², N.S.P Sruthi³, S. Sai Prazwal⁴
 Assistant professor, Dept. of Mechanical Engineering,
 PVP Siddhartha Institute of Technology, Kanuru, Vijayawada, AP. INDIA^{1,2}
 UG Student, Dept. of Mechanical Engineering,
 PVP Siddhartha Institute of Technology, Kanuru, Vijayawada, AP. INDIA^{3,4}

Abstract: Plastic has amazing properties of strength, durability and light weight but it has a major drawback that it can take up to 500-1000 years to naturally degrade. Waste plastic affects humans, animals and marine life, as it increases pollution enormously and also causes soil infertility where dumped. But to take the advantage of its strength, long chain molecules and light weight polymers of carbon present in the plastic, it can be combined in different composites. Several attempts has been made to mix plastic in bituminous for road construction and also laboratory studies proved that waste plastic enhances the property of the mix. In the present paper the work carried out so far is discussed.

Index Terms - Plastic Waste, Road construction, pollution, light weight polymers

I. INTRODUCTION

Plastic is a material consisting of many of a wide range of synthetic and semi-synthetic organic compounds that can be moulded into solid objects. They are usually synthetic, most commonly derived from petrochemicals. Due to their relatively low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in an enormous and expanding range of products, from paper clips to spaceships. They have already displaces wood, stone, horn and bone, leather, paper, metal, glass and ceramic, in most of their former uses.

But there are many adverse effects of plastics on Our Environment:-

1. **Plastics Pollute Oceans And Beaches** - Garbage has been discarded into the oceans for as long as humans have sailed the seven seas or lived on seashores or near waterways flowing into the sea. Since the 1940s, plastic use has increased dramatically, resulting in a huge quantity of nearly indestructible, lightweight material floating in the oceans and eventually deposited on beaches worldwide.
2. **Plastic Bags Litter The Landscape** - Once they are used, most plastic bags go into landfill, or rubbish tips. Each year more and more plastic bags are ending up littering the environment. Once they become litter, plastic bags find their way into our waterways, parks, beaches, and streets. And, if they are burned, they infuse the air with toxic fumes.
3. **Plastic Bags Kill Animals** - About 100,000 animals such as dolphins, turtles whales, penguins are killed every year due to plastic bags. Many animals ingest plastic bags, mistaking them for food, and therefore die. And worse, the ingested plastic bag remains intact even after the death and decomposition of the animal. Thus, it lies around in the landscape where another victim may ingest it.
4. **Once plastic is produced, the harm is done once and for all.** Plastic defies any kind of attempt at disposal – be it through recycling, burning, or land filling.
5. **When you recycle a hazard, you create a hazard.**
6. **Recycling of plastic is associated with skin and respiratory problems,** resulting from exposure to and inhalation of toxic fumes, especially hydrocarbons and residues released during the process.

Recycling process:-

Plastic recycling refers to the process of recovering waste or scrap plastic and reprocessing it into useful product. Due to the fact that plastic is non-biodegradable, it is essential that it is recycled as part of the global efforts to reducing plastic and other solid waste in the environment.

1. **Waste Plastic Pyrolysis to Fuel Oil:-**Plastic Pyrolysis can convert petroleum based waste streams such as plastics into quality fuels, carbons. Given below is the list of suitable plastic raw materials for pyrolysis:

- Mixed plastic (HDPE, LDPE, PE, PP, Nylon, Teflon, PS, ABS, FRP etc.)
- Mixed waste plastic from waste paper mill.
- Multi Layered Plastic.

2. Waste Plastic in Rural Roads Construction:- Plastic Roads are found to perform better compared to those constructed with conventional bitumen. Further it has been found that such roads were not subjected to stripping when come in contact with water. With the experience gained over the years of construction of roads using waste plastic, CRRI as well as TCE has firmed up the specifications for the use of waste plastic and shared the specifications with organizations willing to construct the roads with waste plastic. Given below is the list of suitable plastic raw materials in the construction of rural roads:

- Films (Carry Bags, Cups) thickness up to 60micron (PE, PP and PS)
- Hard foams (PS) any thickness
- Soft Foams (PE and PP) any thickness.
- Laminated Plastics thickness up to 60 micron (Aluminum coated also) packing materials used for biscuits, chocolates etc.,

Several experiments have been carried out whether this waste plastic can be reused productively in the construction of roads. The experimentation in several cases 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. Therefore, in the present work it is studied the different ways of using plastic in laying roads and concluded the best way of using plastic as raw material in laying roads. So through this process, the bane of abhorrent plastic waste can now become a boon and a source to roads. This will reduce plastic in landfills, reduce emissions and be a reliable alternative to the bituminous materials.

II.LITERATURE REVIEW

Johnson Kwabena Appiaha et al (2017) [1] gave a paper for using plastics in road construction through improving the viscoelastic behaviour and change its rheological properties by adding High density polyethylene (HDPE) and Polypropylene. By adding them increases in softening point, decreasing penetration, overall dynamic and absolute viscosities of the binder. Amit Kumar Sahul, R. K Singh et al (2016) [2], his work proves that it is good to use them in heavy traffic due to better binding, better surface condition for prolonged period and reduces the use of bitumen 10%. Kurmadasu Chandramouli at el (2016) [3] in this paper author mentioned the uses and the availability of plastic to use in the bitumen mix for road construction which is a effective way to reduce potholes due to the rain and hot conditions. By adding the plastic it increases melting point of bitumen and also increases the road life. The author also mentioned about the durability, strength and cost of adding the plastic to the roads. R.S Deshmukh et al (2015)[4] conducted an experiment on utilization of waste tyres in bituminous mixes which in turn used in wearing coarse in flexible road pavement and conclude that plastic increases the melting point of bitumen as a result lifetime of roads increases by reducing sound pollution and thermal cracking. Rajdip Paul et al (2015)[5] has analyzed & studied how the properties changes by mixing various proportions of waste plastic in bituminous and asphalt, and conclude that by using plastic waste we can reduce the need of bitumen by around 10%. And the use of anti-stripping agent can be avoided. Sandeep Runde et al (2015)[6] conducted an experiment on Effective utilization of plastic waste and also analyzed the physical properties of pavement by use of plastic waste instead of replacing bitumen percentage. Bright Aforla et al (2015) [7] has worked on AC-10 bitumen and proved that by adding 2% polymer composition as a modifier to AC-10 bitumen can give perfect AC-20 bitumen properties. And that will help to improve the Marshall stability, strength. Devesh Ojha et al (2014)[8] proposed Design of flexible pavement using waste plastics and proposed a project of worthy 73 lakhs (approx), by concluding that by this project potholes, rutting and ravelling formed can be avoided. The sound pollution can be reduced. Ajim S .Sutar et al (2015)[9] conducted an experiment and done investigation on use of low density polyethylene (LDPE) in bituminous for road construction. Compared the variations in the properties with its original properties. Shweta N. Rokdey et al (2015)[10] in this paper author mentioned about the reuse of plastic waste by using certain processing in use of road construction, also author organised a comparison between the use of normal mix, bitumen mix and compared the life time showed the drastic increase in it. Vatsal Patel et al (2014) [11] given a review by case studying some of the roads laid in India, and proposed various cost estimations for different proportions of mixing waste plastic in bitumen. Rishi Singh Chhabra et al (2014) [12] worked on rubbers in the road pavement and concluded that by mixing the rubber aggregate in bituminous, the flexural strength of the roads increases. Their by the roads can withstand heavy traffic. S. Rajasekaran et al (2013) [13] studied on waste plastic coated aggregates in road pavement. He deducted that the waste plastics like polyethylene polypropylene polystyrene do not produce toxic gases during heating. And also conducted various tests for the mixture and summarized that the use of anti-stripping agents can be avoided and cost can be reduced. Mr. P. B Rajmane et al (2013) [14] worked on different types of plastics like carry bags, cups and Thermocoles by using these a coating is provided on the aggregate for road construction. Their will increase the effective utilization of waste plastics in the construction of flexible pavement as a binder material for replacing the content of bitumen and in ideal process it is successful application. Thus plastic increases the malting point of the bitumen. Hence using of plastic waste in road construction is one of the best method. The use of innovative technology and also increases the road life. But plastic roads would be Boon for hot and external humid climate (temp should not cross 50°C.). Amit P. Gawande et al (2013) [15] given his idea of using the plastics in road and pavement constructions using the wet process and dry process, economic features and cost estimation for the raw materials, processing cost, Bitumen E.t.c. Mr. Mahesh M Barad et al (2013) [16] he stated the using of the mix polymer coated aggregate and tyre modified bitumen for increasing the strength and a way to reduce the more polymer dispersion in bitumen by cooling and can be modified by

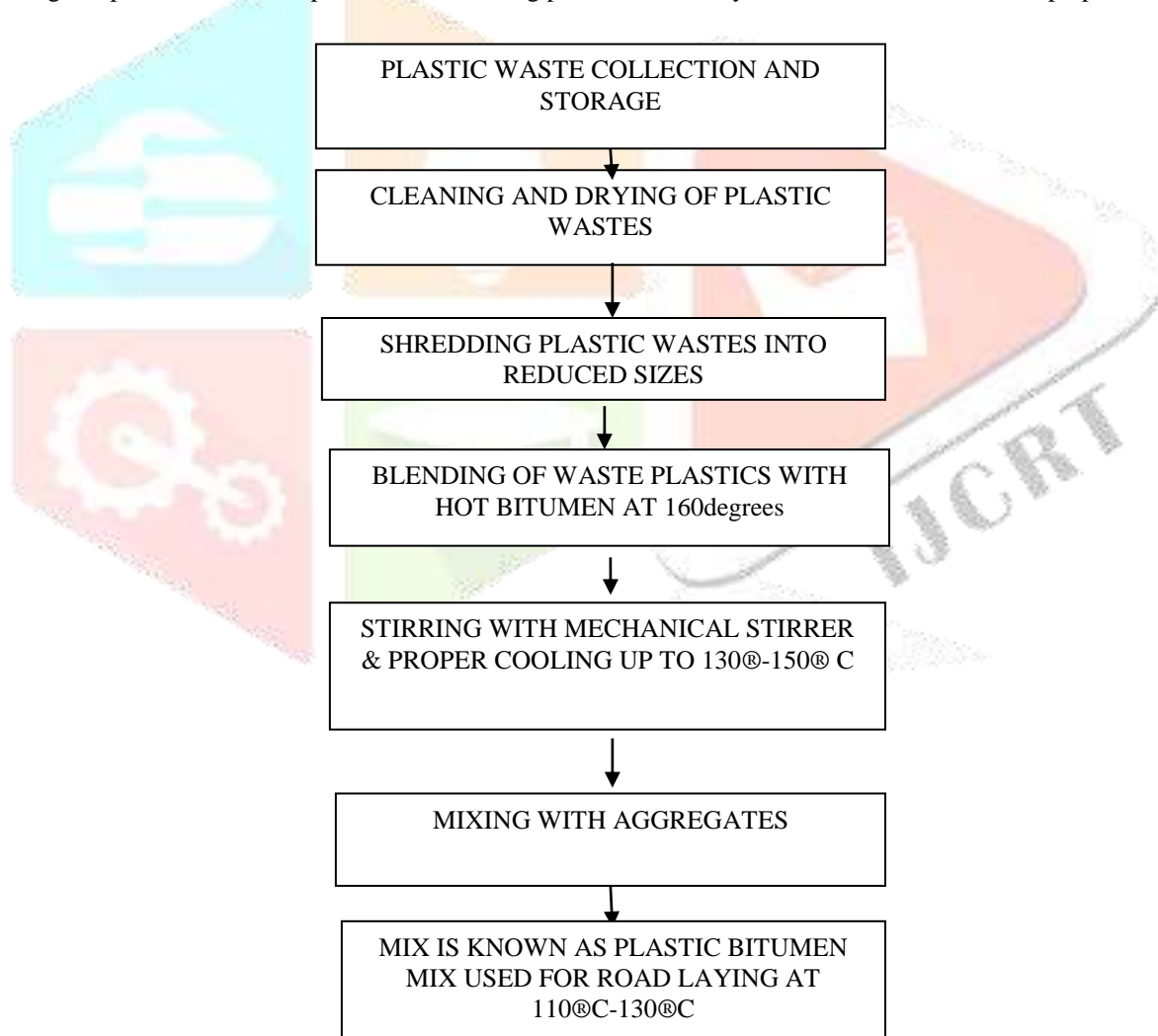
modified process(dry process) which helps in better binding bitumen with the plastic-wasted coated aggregate. Mercy Joseph Poweth at el (2013)[17] worked on the maintaining of CBR value by adding the quarry dust along with soil plastic mix to be in within range and for getting suitable pavement subgrade and increase dry density. Miss Apurva J Chavan at el (2013) [18] in this paper author produced set of tests like sieve analysis, Specific gravity& Water absorption test, followed by Aggregate crushing and impact values and tests on bitumen which proves the efficiency of the bitumen mix and comparison is done between the increase and decreased values with effective ways to produce a mix. Mrs.Vidula Swami at el [19] in this paper the usage of plastic waste and applications are discussed as follows due to the increase in the percentage of polymer results in decreased penetration value which shows increase in the hardness of bitumen and ductility is decreased and will have better resistance towards water due to better binding property and also reduced the cost of the project by 7.99%.

III. METHODOLOGY

In modified bitumen preparation there are two types of processes.

1.WET PROCESS:

The wet process was employed; Samples were prepared, using melt-blending technique. Bitumen (400g) was heated in oven till fluid condition and polymer was slowly added. The speed of the mixer was kept above 120rpm and temperature, between 160_C and 170_C. The concentration of PP and HDPE, ranged from 0.5% -3% by weight of blend with an increment of 0.5%. Mixing was continued for 30mins-1hr to produce homogenous mixtures. The polymer modified bitumen (PMB) was then sealed in containers and stored for further testing. Empirical test such as penetration, softening point and viscosity were then conducted on the prepared samples.



2.DRY PROCESS:

Mixing the appropriate quantity of dry shredded waste plastic with hot aggregate prior to production of bituminous mixes at hot mix plant by varying percentage of plastic by weight of mix.

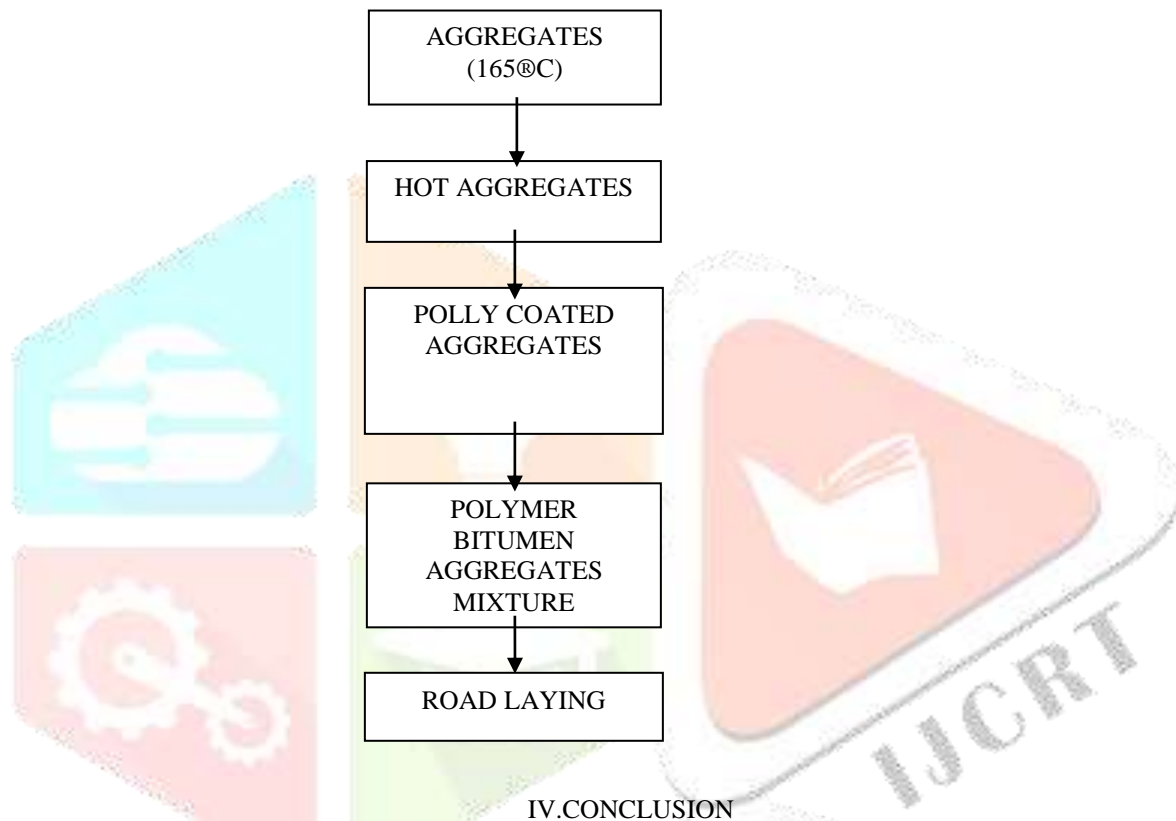
(i) Various types of waste plastic are collected, analysed as per their type and sent for storage.

(ii) These segregated wastes are then cleaned and dried to remove impurities from them. Then cut into a size of 1.18-4.36 mm using shredding machine, (PVC waste should be eliminated).

(iii) The aggregate mix is heated to 165oC (as per the HRS specification) and transferred to mixing chamber. Similarly the bitumen is to be heated up to a maximum of 160oC (HRS Specification) to have good binding and to prevent weak bonding. (Monitoring the temperature is very important).

(iv) At the mixing chamber, the shredded plastics waste is to be added over the hot aggregate. It gets coated uniformly over the aggregate within 30 to 45 secs, giving a look of oily coated aggregate.

(v) The plastics waste coated aggregate is mixed with hot bitumen at the temperature range between 150oC-165oC. The resulted mix of temperature range 130oC-140oC is used for road construction. The road laying temperature is between 110oC-120oC and using the roller of 8 ton (min.) capacity.



Plastic has become the most common material since the beginning of the 20th century and modern life is unthinkable without it. Unfortunately, what makes it so useful, such as its durability, light weight and low cost, also makes it problematic when it comes to its end of life phase. The massive pollution of world with plastic waste is therefore emerging as a global challenge that requires a global response. By studying, different plastic roads laying processes, it is understood that waste plastic may be converted into useful roads without producing toxins during the process. But the effects of different plastic additives, presented in the waste plastic, on the quality of the gases produced from different process are yet to be investigated. More tests are needed to verify the different process of mixing plastic in bituminous mix in a pilot scale particularly for treatment of mixtures of bulk plastics. At the same time more laboratory tests are to be performed to characterize the plastic mixed samples. 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

REFERENCES

1. Johnson Kwabenaappiah, Victormanaberko-Boateng, Trinityamatagbor, "Case Studies in Construction Materials" <https://www.journals.elsevier.com/case-studies-in-construction-materials>. Volume 6, June 2017.
2. Amit Kumar Sahu, R. K Singh, 2nd International Seminar On — "Utilization Of Non-Conventional Energy Sources for Sustainable Development of Rural Areas" International Journal of Recent Trends in Engineering & Research (IJRTER) Volume 03, Issue 01; January -2017

3. Kurmadasu Chandramouli, Allipilli Satyaveni, Mallampalli.Ch. G.Subash, "Plastic Waste: It's Use In Construction Of Roads", IJARSE Vol.No.5, Special Issue No.(01),February 2016.
4. R S Deshmukh, L S Kendre, L C Chaudhari, S S Hirve and S P Shinde, "Use Of Non-Biodegradable Material In Bituminous Pavements", IOSR Journal Of Mechanical And Civil Engineering (IOSR-JMCE), IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)e-ISSN : 2278-1684, p-ISSN : 2320-334XPP 62-67 2015.
5. Rajdippaul and Debashishbattacharya, "Use Of Waste Plastic in Construction Of Road", Global Journal Of Engineering Science And Researches, (6):June2015 ISSN-2348-8034 Impact Factor-3.15 June 2015.
6. Sandeep R Unde and Prof. Dr. S.C.Potnis, "Effective Utilization Of Plastic Waste In Flexible Pavement And Analysis By Experiments", International Journal Of Engineering Sciences & Research Technology, ISSN: 2277-9655 (I2OR), Publication Impact Factor: 3.785,June 2015.
7. Bright Aforla, Anthony Woode, David Kwame Amoah and Samuel Yeboah Baako, "Assessment Of Suitability Of Plastic Waste In Bituminous Pavement Construction", Civil And Environmental Research, Vol.7, 2015.
8. Devesh Ojha and Dilip Kumar, "A Proposed Design Of Flexible Pavement Using Waste Plastic", International Journal Of Engineering And Management Research, Volume-4, Issue-5, October-2014.
9. Ajim S. Sutar, Sanket D. Awasare and Anuja A. Kukalekar: "Experimental Investigation On Use Of Low Density Polyethylene (LDPE) In Bituminous Road Construction", Journal Of Information, Knowledge And Research In Civil Engineering, Volume 3, Issue 2, Oct 2015.
10. Shweta N. Rokdey ,P. L. Naktode, M. R. Nikhar, " Use Of Plastic Waste In Road Construction", International Journal Of Computer Applications (0975 – 8887) International Conference On Quality Up-Gradation In Engineering, Science And Technology (ICQUEST2015) 2015"
11. Vatsal Patel, Snehal Popli and Drashti Bhatt, "Utilization Of Plastic Waste In Construction Of Roads", International Journal Of Scientific Research, Volume 3, Issue 4, April 2014.
12. Rishi Singh Chhabra and Supriya Marik, "A Review Literature On The Use Of Waste Plastics And Waste Rubber Tyres In Pavement" ,International Journal Of Core Engineering & Management(IJCEM) Volume 1, Issue 1, April 2014.
13. S.Rajasekaran, Dr. R. Vasudevan and Dr. Samuvel Paulraj, "Reuse Of Waste Plastics Coated Aggregates-Bitumen Mix Composite For Road Application – Green Method",American Journal Of Engineering Research (AJER), Volume-02, Issue-11,2013
14. Mr.P.B.Rajmane, Prof. A.K.Gupta and Prof.D.B.Desai, "Effective Utilization Of Waste Plastic In Construction Of Flexible Pavement For Improving Their Performance," IOSR Journal Of Mechanical And Civil Engineering (IOSR-JMCE) ISSN: 2278-1684, Pp: 27-30 2013
15. "Amit P. Gawande", "Economics and Viability of Plastic Road: A Review" Journal of Current Pharmaceutical Sciences 3(4), 2013, 231-242 ISSN 2277-2871.
16. Mr. Mahesh M Barad "Journal of Information, Knowledge and Research in Civil Engineering" Use Of Plastic in Bituminous Road Construction Mr. Mahesh M Barad Pg Student Amgoi Wathar, Kolhapur Issn: 0975 – 6744| Volume 3, Issue 2 Page 208 Oct 2015.
17. Mercy Joseph Poweth, Solly George, Jessy Paul, "Study On Use Of Plastic Waste In Road Construction" , International Journal Of Innovative Research In Science, Engineering And Technology Vol. 2, Issue 3, March 2013.
18. Miss Apurva J Chavan, "Use Of Plastic Waste In Flexible Pavements" International Journal Of Application Or Innovation In Engineering& Management (IJAIEM)Volume 2, Issue 4,"ISSN 2319-4847" April 2013
19. Mrs.Vidula Swami, Abhijeet Jirge, Karan Patil, Suhas Pat il, Sushil Patil, Karan Salokhe, May 2012, "Use of waste plastic in construction of bituminous road". <https://www.coursehero.com/file/24611771/Use-of-waste-plastic-in-construction-ofpdf/>