Waste Plastic in Bituminous Mixes for Low Volume Roads – Indian Experience

Presented by

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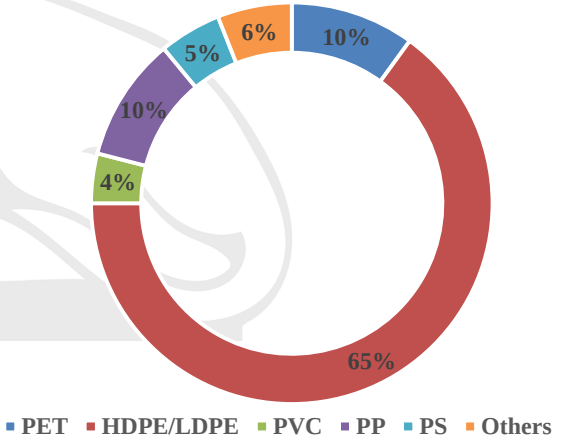
Contents

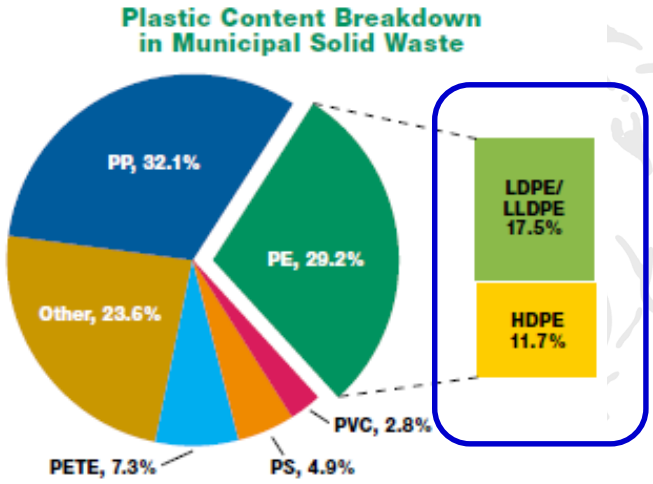
Introduction

- More than 200 million tons of plastic is consumed globally and the annual increase is approximately 5%.
- In **India** approximately 40-115 kg of plastic is generated per metric ton of solid waste.
- Cities like Lucknow produces **1200 MT/day** of MSW per day while Delhi produces **6800 MT/day.**
- Approximately 5.0 million tons per annum (TPA) plastic waste is generated in the country, which amounts to 15342 tons per day (TPD).
- Most commonly, the plastics are manufactured as packaging materials.
- Recyclability issue and un-organised disposal, associated with these materials, imposes ecological concern. Therefore, avenues of re-using the end of life or post-consumer plastic products are being continuously researched.

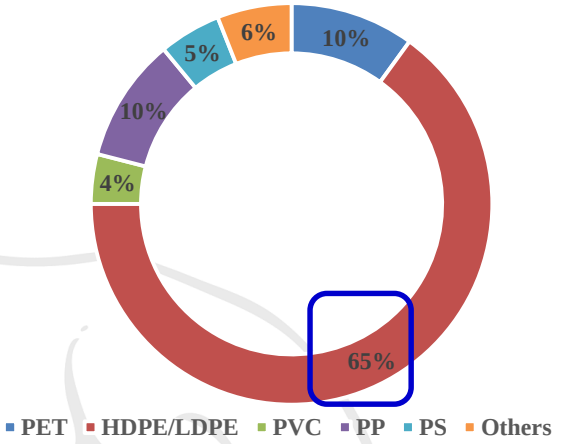


Introduction

Data Should be Location Specific!!



NAPA-2020 (Based on EPA 2017)



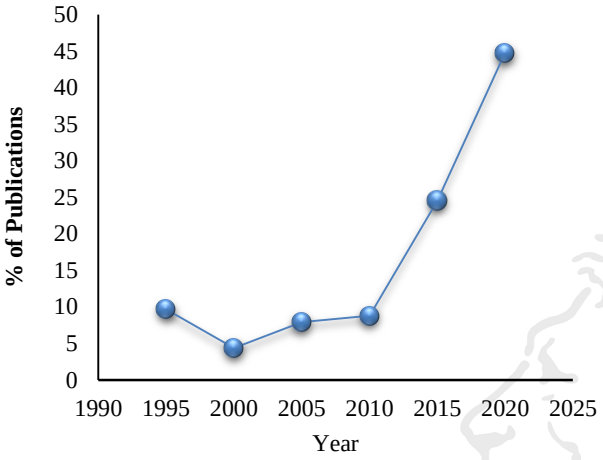
CPCB, India, 2015

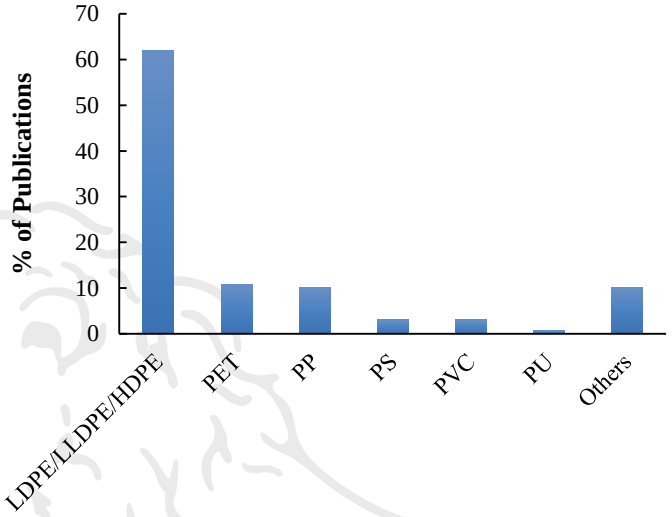
Background

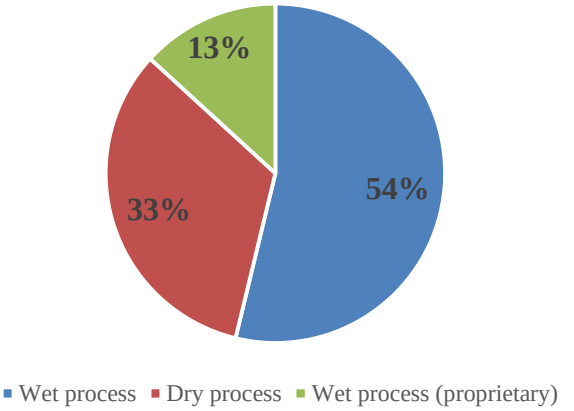
- Asphalt binder, in an asphalt mix, provide cohesion, keeping the graded mineral aggregates glued in a dense mass.
- It imparts the mix a complicated viscoelastic property, making it a distinct and unusual engineering material.
- Asphalt binder, with enhanced rheological properties, can significantly increase the resistance of the asphalt pavement to various distresses.
- Modification of asphalt binder, with virgin and waste polymers, has been found to be promising.
- Waste polymers from commonly manufactured polymeric materials can help in reduction of environmental burden and will provide a sustainable solution for asphalt binder modification.

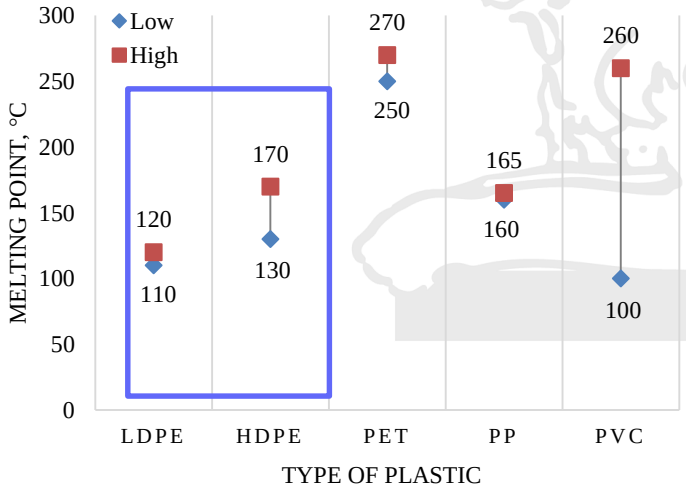
Use of **waste plastic**, for modification of asphalt binder and/or asphalt mixture, has been long considered as a suitable candidate in this direction.

Summary of Literature Review









- **Wet process**: 2-8% by weight of binder.
- **Dry process:** 0.2-1% by weight of aggregates.
- PET/PS/PC: replaced as aggregates.
- Dry process: un-homogenous .
- Wet process: easily applied in batch mix plant.
- Steric stabilizers and compatibilizer for storage stability.
- Except PVC (chlorine based di-oxines) others can be used. Data on health and environmental hazard is insufficient.

Indian Specification

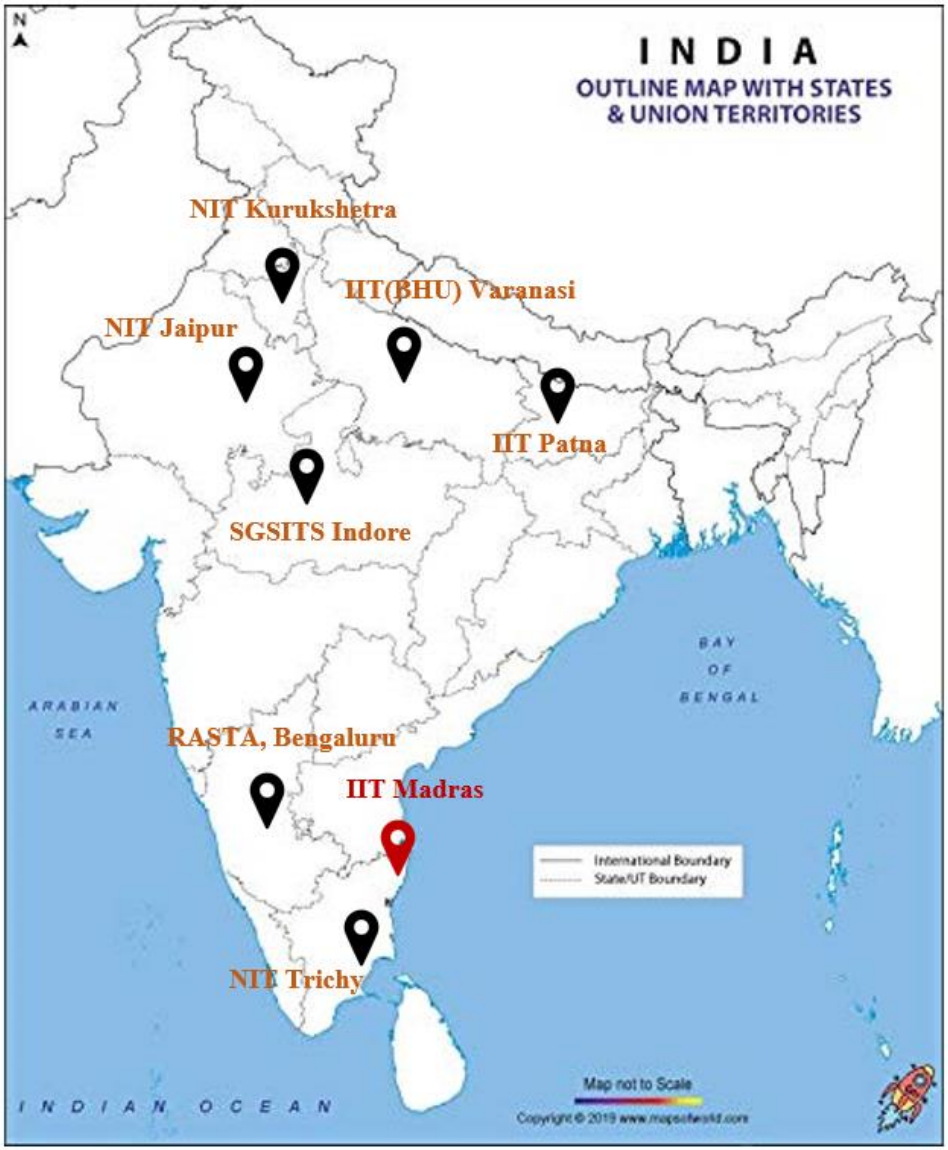
- In India, IRC SP 98-2020 provides the guidelines for use of waste plastic in HMA wearing course.
- This guideline is based on dry process, wherein only the use of LDPE and HDPE are recommended.
- Waste plastic, 8% by weight of bitumen, can be used to satisfy a set of Marshall mix design properties.
- Shredded plastic passing 2.36 mm and retained on 600 microns with a maximum width of 2 mm to be used
- No reduction in OBC should be considered
- Under the umbrella of Pradhan Mantri Gram Sadak Yojna (PMGSY), about 13,139 Km length of rural roads have been constructed using waste plastic in India.

Test Condition/Mix Parameter	Specification
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Marshall Stability (kN at 60°C), Minimum	12
Marshall Flow (mm)	2 to 4
Marshall Quotient (Stability/flow, kN/mm)	2.5 to 5
Air Voids (%)	3 to 5
Voids in Mineral Aggregates (VMA, %), Minimum	15
Voids Filled with Bitumen (VFB, %)	65 – 75
Retained Marshall Stability (%), Minimum **OR** Retained Indirect Tensile Strength (Tensile Strength Ratio, %)	90 90
Quantity of Waste Plastic (% by weight of bitumen)	8

Field Study by NRIDA

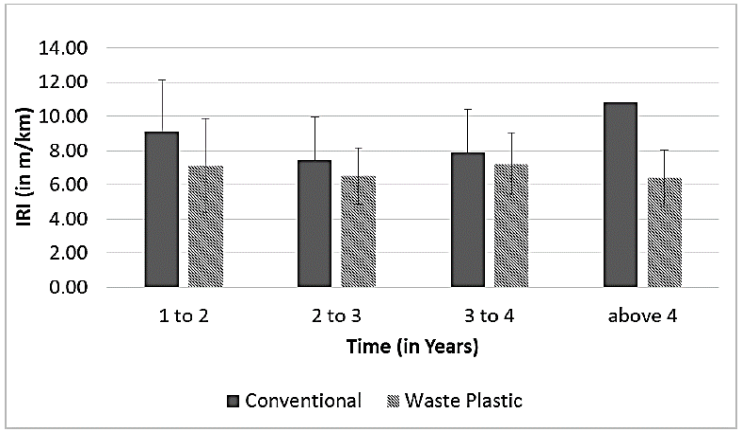
- In order to promote the technology and appreciate the recycling strategy of using waste plastics in bituminous pavements, NRIDA undertook a 2 year field research study in the year 2019.
- Different states in the country where waste plastic technology was implemented were selected.
- The main aim of the study was to carry out performance assessment of rural roads constructed using waste plastics and compare its performance the conventional HMA wearing course.
- The scope of the study included carrying out pavement condition survey (as per IRC 82-2015) for calculation of pavement condition index (PCI), field and laboratory testing of materials from different pavement layers, and to estimate the net present value (NPV) based on cost of construction and maintenance.
- Various research institutes (IIT Madras being the monitoring institute), were identified to carry out the field investigations.
- On an average, 50 km road sections (including technology and conventional roads) were selected by each Institute

Institutes Involved



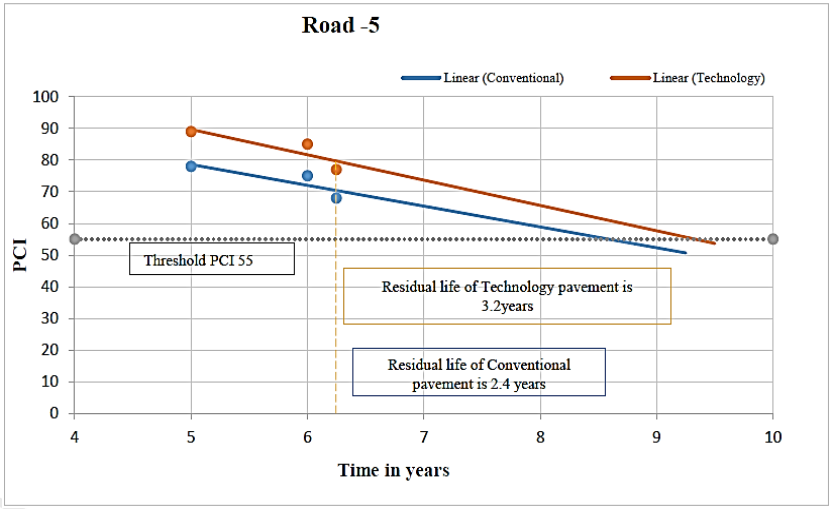
Key Findings

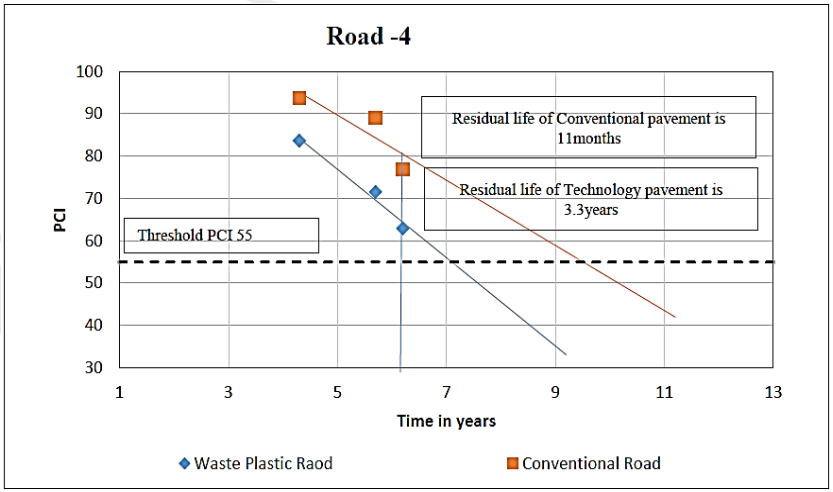
- Field investigation, laboratory study, and subsequent analysis carried out by different institutions were found to be in favor of using waste plastic for rural road construction. Some of the key findings are as follows:
  - Quantitative presence of waste plastics in HMA was not reported by most of the Institutes. Due to difficulty in analysis of waste plastic modified asphalt mixtures, other advanced technologies are required. Based on IR spectroscopy results, RASTA Bengaluru concluded presence of 1.3% to 6.4% plastic content which is less than the desired value (8%).
  - IRI values of waste plastic roads were found to be lower than the conventional roads in most of the test sections. This indicates that the rate of deterioration of waste plastic roads in lower than the roads constructed using conventional technology. See Figure aside.
  - Data from Bihar indicated that material and transportation cost is lower for waste plastic roads. Additionally, total embodied energy (MJ/km) and embodied carbon ($kgCO_2$/km) is lower for waste plastic roads.



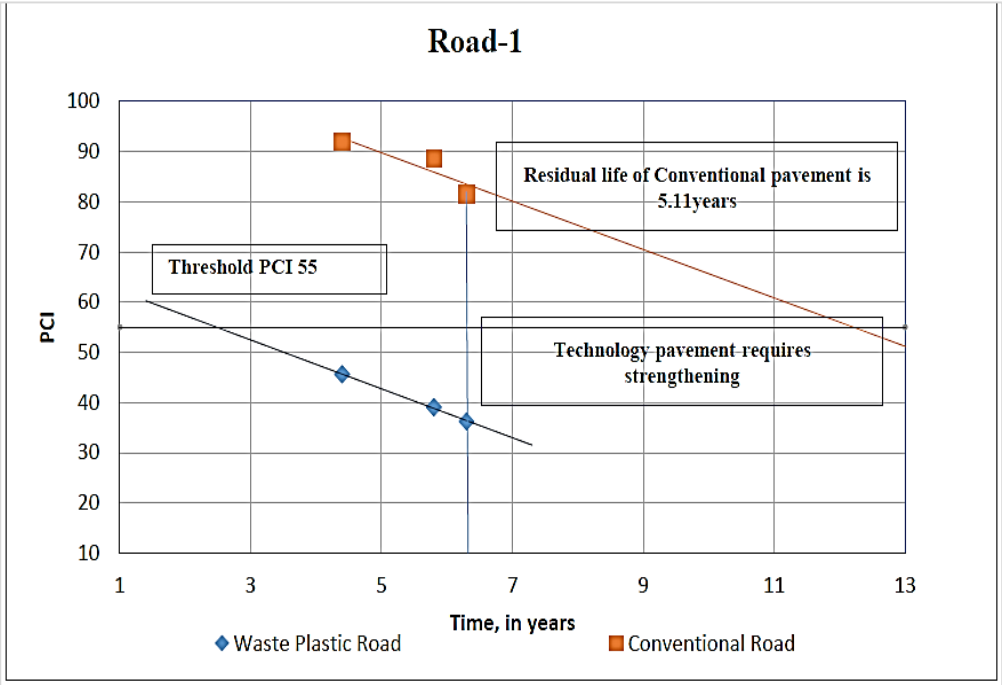
Key Findings

- Benkelman beam study carried out on sections in Rajasthan indicated similar to lower values of deflection in waste plastic road sections in comparison to conventional roads. Analysis based on IRI values were inconclusive.
- Comparison of road roughness data (MERLIN) from two cycles indicated that the percentage increase in roughness in conventional road is higher than for waste plastic roads. This indicates that waste plastic roads are more durable in comparison to roads constructed using conventional hot mix bituminous mixtures.
- Two out of three road sections in Bengaluru showed higher remaining life (based on a terminal PCI of 55) for waste plastic road sections in comparison to conventional roads. These variations can be seen through the provided figures.



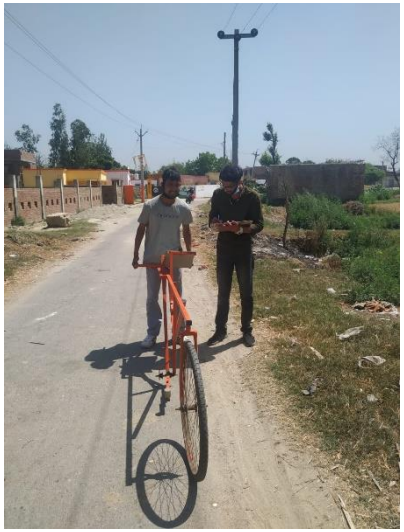


Key Findings



Conclusions

- Based on literature review, present status of incorporating waste plastics in road construction, and investigations down by NRIDA, following conclusions can be drawn from the study:
  - Literature indicates success on use of wet modification technique for use of waste plastic in HMA. India presently used dry process which has more variability in terms of manufacturing and performance. Research is required in understanding and developing best practices for use of wet process in asphalt binder modification using waste plastics.
  - More study is required to quantify the amount of waste plastic used during the construction of HMA with waste plastic.
  - Field study carried out by NRIDA indicates improvement in IRI, PCI and durability of pavement surface constructed using waste plastic. Therefore, use of waste plastic in HMA should be promoted, but through an engineered process. This will ensure optimization of cost and performance.

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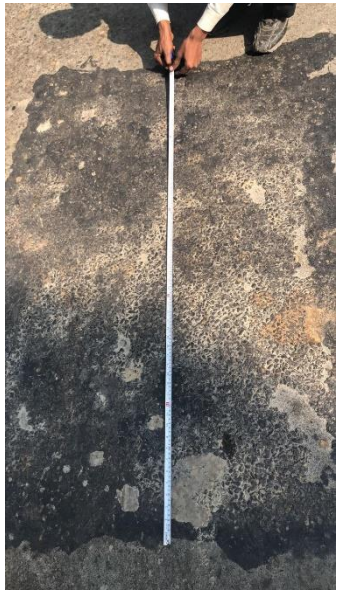


CEMENT
CHAMPION

THANK YOU

There is no silver bullet, but patience, partnership, and open communication are essential to determine if plastic in asphalt can be the next great recycling story (NAPA).

Without Education We are merely Apes!!
Prof. BB Pandey