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Use of Plastic Waste in Road Construction

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ABSTRACT

Plastic waste is one such resource, a major component of solid waste which is abundantly available and disposed of without proper treatment. There has been an exponential growth in municipal plastic waste disposal especially in urban areas which deteriorates the beauty of the landscape. Plastic was found to be an effective binder for bitumen mixes used in flexible pavements. This efficient method helps the pavements to resist higher temperature by minimizing the formation of cracks and reducing rainwater infiltration which otherwise leads to the development of potholes. These pavements have shown improved crushing and abrasion values and reduced water seepage. 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.

Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which is mixed together & laid down in layers then compacted. Now a day, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economic aspects.

Also considering the environmental approach, due to excessive use of polythenes in the day to day business, the pollution to the environment is enormous. Since the polythenes are not biodegradable, the need of the current hour is to use the waste polyethene in some beneficial purposes.

Keywords: ***Plastic Wastes, Bitumen, Aggregates, Plastic Roads, Plastic-Bitumen-Aggregate Mix.***

1. INTRODUCTION

Most of the paved roads in our country have granular sub base and base; bituminous base and wearing courses. Plastic is a very versatile material. Due to the industrial revolution, and its large scale production plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, electronics, electrical, building construction, communication sectors has been virtually revolutionized by the applications of plastics. Plastic is a non-biodegradable material and researchers found that the material can remain on earth for 4500 years without degradation. Several studies have proven the health hazard caused by improper disposal of plastic waste. Plastics, a versatile material and a friend to common man become a problem to the environment after its use. Disposal of a variety of plastic & rubber wastes in an eco-friendly way is the thrust area of today's research. Looking forward the scenario of present lifestyle a complete ban on the use of waste plastic cannot be put, although the waste plastic taking the face of a devil for the present and the future generation. But the use of waste plastics in road construction is gaining importance these days because plastic roads perform better than ordinary ones and the plastic waste considered to be a pollution menace, can find its use. The use of waste plastic for coating the aggregates of the bituminous mix found to improve its performance characteristics. Recycled polyethene carry bags were shredded into small sizes and is coated on aggregates of the mix at a specified temperature. Bituminous mixes were prepared with 60/70 bitumen and plastic coated aggregates/ordinary aggregates with cement as a filler material. The uses of plastic waste help in substantially improving the abrasion and slip resistance of flexible pavement and also allows to obtain values of splitting tensile

strength satisfied the specified limits while plastic waste content is beyond 30% by weight of mix. If the consistent mixing time and mixing temperature are not provided for bitumen– modifier mix, modified bitumen cannot exhibit good performance in situ, thus premature failures will occur. Therefore, there are certain recommended mixing time, mixing temperature and modifier content for all the polymers with a trademark. This all should be taken in mind while mixing and laying of roads is to be done using plastic waste. The plastic road would be a boon for India. In hot and extremely humid climate durable and eco-friendly plastic roads are of greatest advantages. This will also help in relieving the earth from all type of plastic waste.

2. LITERATURE REVIEW

1. **Fransis Hveem (1942) "Optimum quantity of bitumen inroads"** who was a project engineer of California Department of Highways, has developed the Hveemstabilometer in 1927. He did not have any previous experience on judging, the required mix of its colour, hence he decided to measure various mixture parameters to find the optimum quantity of bitumen [Vallerga and Lovering 1985]. He had used the surface area calculation concept, (which was already in use, at that time for the cement concrete mix design), to estimate the quantity of bitumen actually required.
2. **Anzar Hamid Mir (2015) "Plastic waste in pavement construction"** studied the visco-elastic nature of binders and found that the complex modulus & phase angles of the binders, need to be measured, at temperatures and loading rates which different resemble climatic and loading conditions.
3. **Vatsal Patel et al (2014) "Utilization of plastic waste in road"** described that the effect of wax in bitumen can be reduced by adding EVA (Ethyl Vinyl Acetate), aromatic resin and SBS in the waxy bitumen. The addition of 4% EVA or 6% SBS or 8% resin in waxy bitumen effectively reduces the Susceptibility to high temperatures, bleeding at high temperature and brittleness at a low temperature of the mixes.
4. **Kurmadasu Chandramouli et al (2016) "Plastic waste: its use in the construction of roads "** reported that asphalt concrete using polyethylene modified binders were more resistant to permanent deformation at elevated temperature and found improvement in stripping characteristics of the crumb rubber modified mix as compared to unmodified asphalt mix.
5. **Amit P. Gawande (2013)"Economics And Viability Of Plastic Road"** evaluated flexural fatigue life of asphalt concrete modified by 3% crumb rubber as part of aggregated and reported that fatigue life and creep properties of the polymer modified mixes increased significantly as compared to unmodified asphalt mixes.
6. **Justo et al (2002)** "**Asphalt concrete mixes"** at the Centre for Transportation Engineering, of Bangalore University, used processed plastic bags as an additive in asphalt concrete mixes. The properties of this modified bitumen were compared to that of ordinary bitumen. It was noted that penetration and ductility values, of modified bitumen, was decreasing with the increase in the proposrtion of the plastic additive.
7. **Sasane Neha .B. et al (2015) "Application of waste plastic as an effective construction material in flexible pavement"** polyethylene as one sort of polymers is used to investigate the potential prospects to enhance asphalt mixture properties. The objectives also include determining the best type of polyethylene to be used and its proportion. Two types of polyethylene were added to coat the aggregate High-Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE). The results indicated that grinded HDPE polyethylene modifier provides better engineering properties. The recommended proportion of the modifier is 12% by the weight of bitumen content. It is found to increase the stability, reduce the density and slightly increase the air voids and the voids of mineral aggregate.
8. **S. Rajasekaran et al (2009) "Reuse of waste plastic coated aggregate"** Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubber content and subsequent tests have been performed to determine the different mix design characteristics and for conventional bitumen (60/70) also. This has resulted in many improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67%).

3. OBJECTIVES

1. To prepare the Marshall Stability samples with plastic waste and without plastic waste.
2. To perform Marshall Stability test on the samples prepared.
3. To compare the various properties of the bituminous road and plastic bituminous road.
4. To identify the optimum proportion of waste plastic to be added in the bitumen mix for getting the required strength.
5. To reduce the disposal problem of plastics.

4. METHODOLOGY

- Segregation: Plastic waste collected from various sources is separated from other wastes.

Fig1. Segregation of plastic

- Cleaning process: Plastic waste is cleaned and dried.

Fig2. Cleaning of plastic

- Shredding process: Plastics will be shredded or cut into small pieces.

Fig3. Shredded plastic

- Collection process: The plastic waste retaining on 2.36 mm IS sieve is collected.

Fig4. Collection of shredded plastic

- Testing of materials: Tests will be performed on the materials i.e. aggregate and bitumen.
  1. Following are the tests to be performed on aggregate:
  a) Aggregate impact value test
  b) Los Angeles abrasion test
  c) Water absorption test
  d) Specific gravity test
  e) Stripping value test

  2. Following are the tests to be performed on bitumen:
  a) Penetration value test
  b) Ductility test
  c) Flash & fire point test
  d) Softening point test

- Preparation of samples: Six Marshall Stability samples will be prepared out of which three will be with the plastic of varying percentage (5%, 10%, and 15%) and three samples without plastic waste.
- Performing Marshall Stability test: Marshall Stability test will be performed on all of the samples prepared.

5. RESULTS

Following are the tests performed and the results obtained

1. TESTS ON AGGREGATE

Table-1: Results of tests on aggregate

Stone Aggregate	Plastic Content (%)	Aggregate Impact Value	Los Angeles Abrasion Value	Specific Gravity	Water Absorption	Stripping Value
Without Plastic	0	10.79%	12.85%	2.5	3.2%	1%
With Plastic	10	9.27%	11.70%	2.66	2%	Nil
	15	8.94%	10.65%	2.7	1.1%	Nil

2. TESTS ON BITUMEN

Table-2: Results of tests on bitumen

Test	Result	Range
Ductility test	77.50 cm	Minimum 40 cm
Penetration value	83 mm	80-100 mm
Softening point	48.25^{0}C	45-60^{0}C
Flash point test	280^{0}C	> 175^{0}C
Fire point test	302^{0}C	

3. MARSHALL STABILITY TEST:

Table-3: Marshall Stability and flow value

Sample No.	Bitumen content (%)	Plastic content (% by weight)	Marshall stability(kg)	Flow value (mm)
1	4	0	950	3.1
2	5	0	1170	3.3
3	6	0	1240	3.6
4	4	5	1560	3.9
5	5	10	1720	4.5
6	6	15	1980	5

Chart-1: Stability (kg) and bitumen content (%)

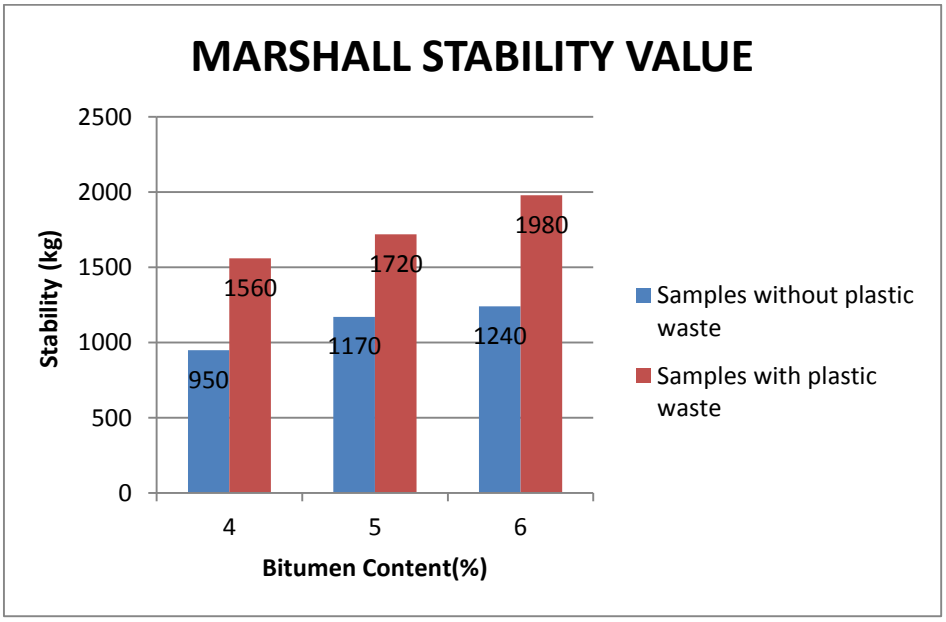
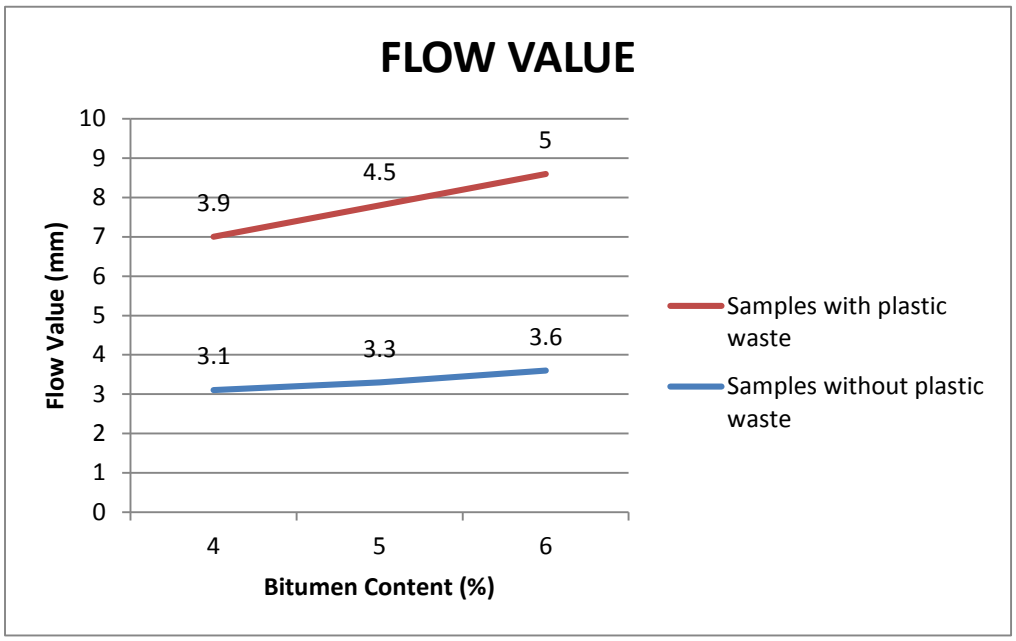


Chart-2: Flow value (mm) and bitumen content (%)



6. CONCLUSION

From the study of the behavior of plastic waste modified BC, we can conclude that the modified mix possesses improved Marshall Characteristics. It is observed that Marshall Stability value increases with plastic content and we observed that the Marshall Flow value decreases upon addition of polythene i.e. the resistance to deformations under heavy wheel loads increases. From all the experiments performed we can conclude that the addition of plastic waste enhances the various properties of an ordinary bituminous road. Considering these factors we can assure that we can obtain a more stable and durable mix for the pavements by polymer modifications. This small investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period. This study will have a positive impact on the environment as it will reduce the volume of plastic waste to be disposed of by incineration and land filling. It will not only add value to plastic waste but will develop a technology, which is eco-friendly.

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