National Conference on Recent Research in Engineering and Technology (NCRRET-2015)
International Journal of Advance Engineering and Research Development (IJAERD)
e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Utilization of Waste Plastic in Construction of Pavement

H. K. SHARMA
M. E. STUDENT (TRANSPORTATION ENGG.): TITS, MODASA
MODASA-383315 (GUJARAT), INDIA
Sharmaharesh142@gmail.com

Abstract— The aim of paper is to analyze & study how the waste plastic will be effectively utilized in construction of pavement as a binder material for replacing the content of bitumen and in detail process & its successful application In an Indian city solid waste management is the thrust area. Of this various waste materials, plastic waste and municipal solid waste are of great concern. On the other side, the road traffic is increasing, traffic intensity is increasing. The load bearing capacities of the road are to be increased. Plastic waste can be used as a coating over aggregate and this coated stone can be used for road construction. The mix polymer coated aggregate have shown higher strength. Use of this mix for road construction helps to use plastics waste. Once the plastic waste is separated from municipal solid waste, the organic matter can be converted to use.

Keywords— Pavement; Plastic waste; solid waste.

INTRODUCTION

Scientists and engineers are constantly searching on different methods to improve the performance of asphalt pavements. According to recent studies, plastics can stay unchanged for as long as 4500 years on earth with increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. In general there are three types of road rigid pavement roads, flex rigid pavement and flexible pavement roads. For rigid roads material used is concrete and for flexible roads bitumen is used. In India mostly the flexible pavement roads are available. And for economical road construction new techniques, new material is used. The significant variation in daily and seasonal temperature demand improved road characteristics. Any improvement in the property of the binder is needed. Bitumen is a useful binder for road construction. Different grades of bitumen like 30/40, 60/70 and 80/ 100 are available on the basis of their penetration values. The steady increase in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature demand improved road characteristics. Any improvement in the property of the binder is the needed. In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength of the road. But its resistance towards water is poor. Anti-stripping agents are being used. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with organic synthetic polymers like rubber and plastics. Studies on this subject are going on both at national and international level. This Concept of Utilization of Waste Plastic in Bituminous Mixes for Road Construction has been done since 2000 in India, They can return to the earth as beneficial additives in bitumen roads.

INTRODUCE TO WASTE PLASTIC

Waste plastics - as binder and modifier 130°C Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Moreover the softened plastics have a binding property. Hence, the molten plastics materials can be used as a binder and/or they can be mixed with binder like bitumen to enhance their binding property. This may be a good modifier for the bitumen, used for road construction. The uses of plastic waste helps 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 missing and laying of roads is to be done using plastic waste. 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 reliving the earth from all type of plastic waste.

NECESSITY OF THE STUDY

Plastic waste replaces 10% to 15% of bitumen, and thereby saves approximately Rs.35000 to Rs.45000 per kilometre of a road stretch. Inclusion of plastic waste in road construction eliminates the plastic shrinkage cracking of road surface and reduces the drying shrinkage to some extent. Following are the need of study.

A) Disposal of waste plastic is a major problem.
B) It is non-biodegradable
C) Burning of these waste plastic bags causes environmental pollution.
D) It mainly consists of low-density polyethylene
E) To find its utility in bituminous mixes for road construction
F) Laboratory performance studies were conducted Waste plastics (polythene carry bags, etc.) on heating soften at

around d on bituminous mixes. Laboratory studies proved that waste plastic enhances the property of the mix
G) Improvement in properties of bituminous mix provides the solution for disposal in a useful way.

METHODOLOGY

Following Tests were conducted to investigate the properties of the aggregate as well as bitumen.

TESTS FOR AGGREGATE

-Sieve Analysis of Aggregates
-Specific Gravity & Water Absorption Test [IS: 2386 (Part 3) 1963]
- Aggregate Impact Value Test [IS: 2386 (part 4) 1963]
- Aggregate Crushing Value [IS: 2386 (Part 4) 1963]
- Flakiness & Elongation Index Test [is: 2386 (part 1) 1963]

TESTS FOR BITUMEN

- Penetration Test [Is: 1203-1978]
- Softening Point Test [Is: 1205-1978]
- Ductility Test [IS: 1208-1978]
- Viscosity Test:
- Flash Point and Fire Point

MATERIALS USED

1) AGGREGATE:
Aggregate of 20mm, 10 mm.
Stone Dust and Lime as Filler

2) BITUMEN :
60/70, 80/100 grade bitumen

3) WASTE PLASTIC:
Waste plastic in the shredded form.

TESTS CONDUCTED ON MATERIALS

1. Bitumen:

i) Penetration Test – 35 mm
ii) Ductility Test – 6.5 N/mm2
iii) Softening Point Test – 70˚ C
iv) Flash & Fire Point – 265˚ C & 290˚ C

2. Aggregate:

i) Specific Gravity - 2.82
ii) Water Absorption Test - 2.1 %
iii) Impact Value Test - 8.77 %
iv) Abrasion Test – 15.7 %

3. Plastic:

3.1 Types of Plastics:
-PET, polyethylene terephthalate
-HDPE, high-density polyethylene
-PVC, polyvinyl chloride
-LDPE, low-density polyethylene
-PP, polypropylene
-PS, polystyrene

3.2 Waste plastic shredding:
Shredding is the process of cutting the plastic into small sizes between 2.36mm to 4.75mm with the help of the plastic shredding machine viz. Agglomerater and Scrap Grinder. In Agglomerater, thin films of poly-ethylene and polypropylene carry bags are shredded and in Scrap Grinder a solid plastic material are shredded i.e. plastic bottles, drip lines, electric cable lines etc.

3.3 Details of Shredding Machine:
a) Agglomerator: For shredding of poly-ethylene "Agglomerator" is used. In this process a thin plastic waste carry bags cut in small pieces with the help of fix and rotator blades this whole process required 20-25 minutes for shredding.

b) Specification of Agglomerator:
- Vessels size 600mm dia. X 900mm ht.
- Rotatory knives-4.
- Fix knives -6.
-Ph induction A.C. motor-30hpmake Crompton greaves ATK 222 Model SE/A2 30 HP.
- Length of blade-200mm.

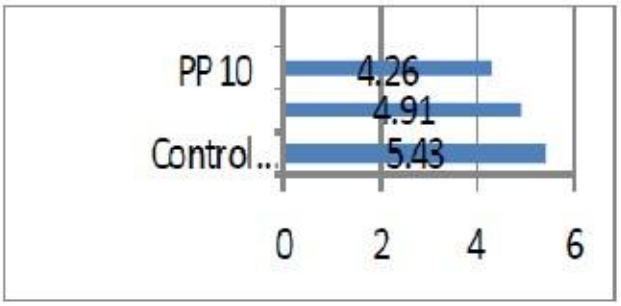
Type Of Plastic	Formation	Density (gm/cm3)	Chemical Softening point
Low Density Poly-ethylene Plastic (LDPEP)	(-CH2-CH2-)n	0.9 to 0.95	100˚C to 120˚C
High Density Poly-ethylene Plastic (HDPEP)	(-CH2=CH2)n	0.95 to 0.96	120˚C to 130˚C

DISCUSSION AND RESULTS

On the basis of above methodology, various aspects regarding the Polymer coated aggregates are being discussed below:

Aggregate Impact Value

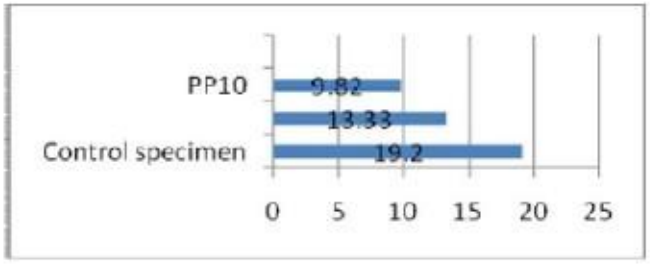
The coating of plastics improves Aggregate Impact Value, thus improving the quality of the aggregate. Moreover a poor quality of aggregate can be made useful by coating with polymers. It helps to improve the quality of flexible pavement. This shows that the toughness of the aggregate to face the impacts. Its range should be less than 10%.



Graph: Comparison of Aggregate Impact Value Test Results

AGGREGATE CRUSHING VALUE

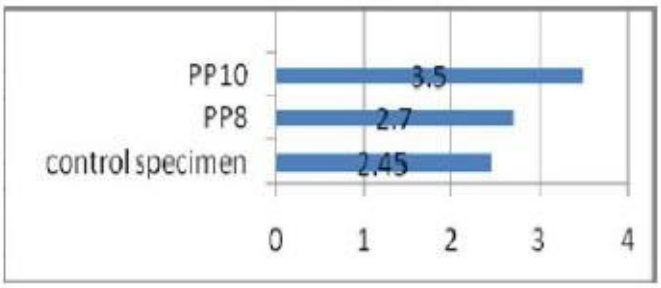
The aggregate with lower crushing value indicate a lower crushed fraction under load and would give a longer service life to the road. Weaker aggregate would get crushed under traffic load. It is clearly seen from Table- that plastic coated aggregates shows the lower crushing value and which can be withstand to traffic load more efficiently than the plain aggregates. The results show that the aggregates are within the range according to ISS. Its range should be less than 30-35%.



Graph: Comparison of Aggregate Crushing Value Test Results

SPECIFIC GRAVITY

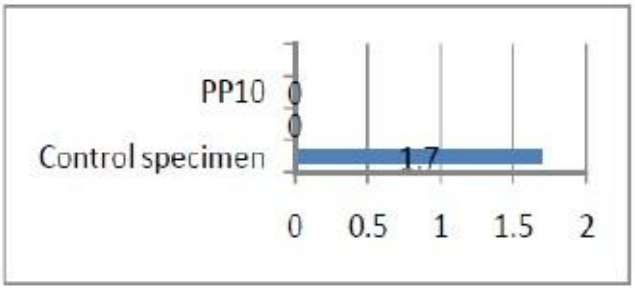
The specific gravity of an aggregate is an indirect measure of its strength. The more specific gravity the more is the strength. The value of specific gravity of plain aggregate is less as compare to that of plastic coated aggregate. Since aggregates having low specific gravity are generally weaker than those with higher specific gravity values, the results say that the specific gravity of the aggregates are increased increasing its strength. Its range should be within 2.5-3.0%.



Graph: Comparison of Specific Gravity Test Results

WATER ABSORPTION

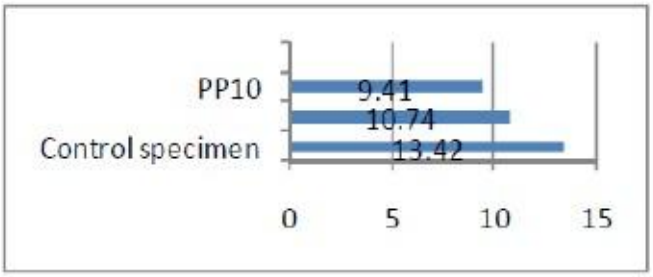
The aggregate is chosen also on the basis of the moisture absorption capacity. The aggregate when coated with plastics improved its quality with respect to moisture absorption. The coating of plastic decreases the moisture absorption and helps to improve the quality of the aggregate and its performance in the flexible pavement. The results show that the moisture absorption of the aggregate is within the range of IRC specifications which reduced to nil due to coating. Its range should be less than 10%.



Graph: Comparison of Water Absorption Test Results.

LOS ANGELES ABRASION VALUE

The repeated movement of the vehicle will produce some wear and tear over the surface of pavement. This test gives that wear and tear in percentage. Under this study the percentage of wear and tear values of plastic coated aggregate is found to be in decreasing order with respect to the percentage of plastics. When the Los Angeles abrasion value of plain aggregate value is compared with the plastic coated aggregates the values are less for coated aggregates. The results obtained are within the range hence can be used for the construction. Its range should be less than 35%.



Graph: Comparison of Los Angeles Test Results

CONCLUSION

The generation of waste plastics is increasing day by day. The major polymers namely polyethylene, polypropylene, polystyrene show adhesion property in their molten state. Plastics will increase the melting point of the bitumen. The waste plastic bitumen mix forms better material for pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for pavement is one of the best methods for easy disposal of waste plastics.

The use of the innovative technology not only strengthened the road but also increased the road life as well as will help to improve the environment and also creating a source of income. 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. 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. In short we can conclude that, using plastic waste in mix will help reduction in need of bitumen by around 10%, increase the strength and performance of road, avoid use of anti stripping agent, avoid disposal of plastic waste by incineration and land filling and ultimately develop a technology, which is eco friendly. Increased traffic conditions will and are reducing the life span of roads. Plastic roads are means of prevention and ultimately will be the cure. It will save millions of dollars in future and reduce the amount of resources used for construction.

Acknowledgment

The authors are grateful to many persons who provided assistance with this paper and the study upon which it draws. Especially thankful to the Dr. H. R. Varia sir, Principle of Tatva Institute of Technological studies, Modasa, for their contributions to this study, and for their valuable support during the making of this paper.

REFERENCES

1 Afroz Sultana S K, K.S.B. Prasad "Utilization of Waste Plastic as a Strength Modifier in Surface Course of Flexible and Rigid Pavements" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248

2 P K Jain, Shanta Kumar & J B Sengupta, "Mitigation of rutting in bituminous roads by use of waste polymeric packaging materials" Indian Journal of Engineering & Materials Sciences Vol. 18, June 2011, pp. 233-238

3 R Vasudevan., Nigam S.K., Velkennedy R., Ramalinga Chandra Sekar A.,Sundarakannan B. "Utilization of Waste Polymers for Flexible Pavement and Easy Disposal of Waste Polymers", International Conference on Sustainable Solid Waste Management, 5 - 7, Chennai, India pp-105-111, 2007.

4 Dr. Y. P. Gupta, Chairman, YASTK, and Consultant, Allahabad bypass project Professor (Rtd.) Civil Engineering, MNNIT, Allahabad, and Shailendra Tiwari & J. K. Pandey, QC Engineer HCC Ltd and BCEOM, Allahabad Bypass Project.

5 Al-Hadidy A.I., Yi-qiu Tan (2009), "Effect of polyethylene on life of flexible pavements", Construction and Building Materials, Vol. 23

6 Aravind K. , Das Animesh, (2007), "Pavement design with central plant hot-mix recycled asphalt mixes", Construction and Building Materials, Vol. 21, Dept. of Civil Engg., Indian Institute of Technology Kanpur, India, pp 928–936.

7 Dhodapkar A N., (Dec. 2008), "Use of waste plastic in road construction", Indian Highways, Technical paper, Journal, P No.31-32.

8 Dun Qiao.,(2010), "Utilization of sulfate-rich solid wastes in rural road construction in the Three Gorges Reservoir", Resources, Conservation and Recycling, Vol.54, College of Materials Science and Engineering, Chongqing University, China, pp 1368–1376.

9 I.Vegas, J.A. Iban˜ez, J.T. San Jose´, A. Urzelai.,(2008), "Construction demolition wastes, Waelz slag and MSWI bottom ash: A comparative technical analysis as material for road construction", Waste Management, Vol. 28, pp 565–574.

10 Khan Amjad, Gangadhar, Murali Mohan Murali and Raykar Vinay,(1999) "Effective Utilization of Waste Plastics in Asphalting of Roads", R.V. College Of Engineering, Bangalore.

11 M. Wahlstroem.,(Oct 1999), "Environmental quality assurance system for use of crushed mineral demolition Wastes in road constructions", Waste Management, Vol. 20, pp 225-232.

12 R. Vasudevan.,(2011), "A technique to dispose waste plastics in an ecofriendly way – Application in constructionof flexible pavements", Construction and Building Materials, Vol. 28, Department of Chemistry, ThiagarajarCollege of Engineering, Madurai, Tamil Nadu, India, pp 311–320.

13 Sangita.,(2011), "Effect of waste polymer modifier on the properties of bituminous concrete mixes", Construction and Building Materials, Vol. 25, Central Road Research Institute, New Delhi, India, pp 3841–

3848.
14 S.E. Zoorob, L.B. Suparma.,(2000), “Laboratory design and investigation of the properties of continuously graded Asphaltic concrete containing recycled plastics aggregate replacement (Plastiphalt)”, Cement & ConcreteComposites Vol. 22, School of Civil Engineering, (CEMU), The University of Leeds, UK.
15 S.Lidelo¨w, A. Lagerkvist.,(2007), “Evaluation of leachate emissions from crushed rock and municipal solidWaste incineration bottom ash used in road construction”, Waste Management, Vol.27, pp 1356–1365.
16 Verma S. S., (Nov. 2008), “Roads from plastic waste”, Science Tech Entrepreneur, The Indian Concrete Journal,P.No.43 - 44.
17 Yue Huang, Roger N. Bird, Oliver Heidrich 2.,(2007), “A review of the use of recycled solid waste materials in asphalt pavements”, Resources, Conservation and Recycling, Vol.52, School of Civil Engineering and Geosciences, Newcastle University, UK, pp 58-73.
18 Annette R. Hill, Andrew R. Dawson, Michael Mundy.,(2001), “Utilisation of aggregate materials in road construction and bulk fill”, Resources, Conservation and Recycling, Vol. 32, School of Civil Engineering,University of Nottingham, Australia, pp 305–320.
19 Bandopandhyay T. K., (Jan. - Mar. 2010),“Construction of Asphalt Road with Plastic Waste”, Indian Center for Plastic in Environment (ICPE), ENVIS – Eco- Echoes, Vol.11, Issue 1.
Sinan“Use of waste high density polyethylene as bitumen modifier in asphalt Concrete mix”, Materials Letters, Vol. 58, pp 267–271.
20 IS: 2720 (Part 1). 1979. Method of test for Soils: Part 1, Preparation of Dry Soil Samples for Various Tests.
IS: 2720 (Part 2). 1979. Method of test for Soils: Part 2
IS: 2720 (Part 3). 1979. Method of test for Soils: Part 3
21 IS: 2720 (Part 4). 1979. Method of test for Soils: Part 4
IS: 2720 (Part 5). 1979. Method of test for Soils: Part 5
22 IS: 2720 (Part 7). 1979. Method of test for Soils: Part 7
23 IS: 2720 (Part 16). 1979. Method of test for Soils: Part
24 16
25 Foose, G.J, Benson, C.H., and Bosscher, P.J. (1996)
26 „Sand reinforced with shredded waste tyres , Journal of
27 Geotechnical Engineering,
Vol. 122, No. 9, 760-767.
28 Prasad, Prasada Raju, Ramana Murthy „Use of Waste Plastic and Tyre in Pavement Systems , IE(I) Journal-CV, Vol.89, pp 31-35, 2008
http://www.wikipedia.com