Improving Rutting Resistance of Flexible Pavement Structure By Using Waste Plastic

Ankit Dhiman, Nitin Arora
M.E. Transportation Engineering Chandigarh University, Mohali 140413, Punjab, India
Assistant Professor, Department of Civil Engineering, Chandigarh University, Mohali 140413, Punjab, India

Abstract: On these days traffic is increasing faster rate on roads then various type of defects are produced on road that is rutting, raveling etc. A pavement structure have different layers purpose to transferred traffic loads to the sub grade. Rutting is one of the pavement distresses that effects the performance of road pavements. Waste plastic is the type of materials to use for improving the performance of flexible pavements against rutting. In this study utilization of waste plastic water bottles, cold drink bottles, polythene bags, parcel package polythene and films. This waste material clean and shredded small particles (1-3cm) sizes. Aggregate heated 170-200° and mix particles with different percentage (3%, 5%, 7%) properly coated on hot aggregate. This plastic waste coated aggregate is also mixed with hot bitumen. And perform some laboratory test (impact value test, moisture absorption test, marshal value test) on the sample and check the property of rutting resistance.

Keywords: Rutting resistance, Waste plastic, Flexible pavement, Plastic roads, Utilization of waste plastic.

1. Introduction

Rutting is caused by continuous longitudinal deformation in the wheel path in bituminous pavements, which can be action by overload on pavement structure they formed by permanent deformation caused from continuous heavy loads movement of the vehicle on pavement and that caused shear failure of the bituminous concrete. Some countries facing these problems on their flexible road pavements due to heavy loads and trying to resolve this failure. Rutting in flexible pavement is a serious problem of fatigue stress in bituminous pavement in high temperature in India and its rehabilitation cost is very high. In addition, rutting in pavements causes hydroplaning and safety concern for road users [1-4]. A distress and problems in pavement an economic burden on tax payer. Then this problems needs to be properly analysis through evaluation and measures so that the occurrence and resulting impacts are minimized. There are several factors that influence rutting. Use of high percentage of waste plastic also reduces the percentage of bitumen. It also increase the strength of the road [5,6]. Plastic waste helps to increase the
melting point of bituminous pavement. Plastic waste is used as modifier of bitumen to improve the properties of plastic roads when waste plastic added over hot aggregate with bitumen to give higher strength, and resistance to water. On these roads the main cause factor is heavily loaded trucks and continuous moving vehicle and after that heavy rainfall[7–10], see Table 1.

Table 1 :Physical Properties Of Waste Plastic

| Plastic Material | Nature of plastic | Thickness µ | Softening Point |
|------------------|-------------------|--------------|-----------------|
| Water bottle     | PET               | 210          | 170 – 180       |
| Cold drink bottle| PET               | 210          | 170 – 180       |
| Carry Bag        | Polyethylene      | 10           | 100 – 120       |
| Parcel cover     | Polyethylene      | 50           | 100 – 120       |
| Film             | Polyethylene      | 50           | 120 – 130       |

2. Literature Review

[1] “utilization of marginal materials as an ingredient in bituminous mixes. They used plastic waste as additive on bituminous mix on pavement. In their study, the properties of bituminous mix modified with shredded plastic waste were investigated. The work carried out by mixing shredded waste plastic with heated aggregates in dry process. [2] study investigated that the coating of plastic layer reduces the porosity, cavity of aggregates, absorption of moisture and improves soundness. Coated layer of waste plastic on aggregate bitumen mix make better material for flexible pavement construction and that mix gives higher Marshall Stability value Then the use of waste plastics for flexible pavement is the best method for easy dispose of waste plastics. Use of plastic bags in roads to helps easy way of disposal of waste plastic, better road and prevention of rutting on flexible pavement and environment pollution.[3] Effective blend technique for the use of plastic waste into bitumen for road laying and Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests waste plastic investigation and result get plastics will increasing the melting point of the bitumen. The use of waste plastic in bituminous mix not only give strength of the road construction but also increasing the road long life,[4] overview on use of waste plastic for utilization in asphalt of roads. In this study reviewed techniques of using plastic waste of road construction in flexible pavements,[5] use plastic waste for construction The use of recycled waste plastic in pavement asphalt represents a valuable outlet for such materials. The use of modified bitumen with the addition of processed waste plastic of about 5-10% by weight of bitumen helps in substantially improving the marshall stability, strength, fatigue life and other desirable properties of bituminous concrete mix, resulting which improves the longevity and pavement performance with marginal saving in bitumen usage. [6] Reusing of waste plastics coated aggregates and bitumen mix composite for road application followed by green method. Various waste by products are analysed and their characteristics were listed. The waste plastics were melted and coated to conventional aggregates and tested. The results conclude that the performance of plastic-tar road is good for heavy traffic due to better binding with increased strength and better surface condition for a prolonged period of exposure to variation in climatic changes.[7] “Use of plastic Waste in flexible pavements” This has resulted in reducing rutting, ravelling and there is no pothole formation. It helps to give a better bonding of bitumen as a binder.[8] Use of biomedical plastic waste in bituminous road construction. In this study that the Marshall stability value of waste plastic to modify bituminous mix that found to be 51 percent more than the normal mix then it gives and found it increase the load carrying
capacity of pavement. In this study found that the waste plastic is an effective construction material on flexible pavement. It indicates that the increase of waste plastic in bitumen mix then increases the properties of aggregate and bitumen in the bituminous mix.[9] this study evaluate the effects of using waste polyethylene tere phthalate (PET) as a modifier on properties of asphalt mixtures. The rutting performance of asphalt mixtures that percentages (0%,0.25%,0.5%,0.75%,1%) and PET sizes 10 × 2.5, 20 × 2.5, and 30 × 2.5 mm were evaluated through dynamic creep test and Hamburg wheel tracking device. Results got that the rutting resistance of mixtures increases by addition of PET contents with increase in PET sizes. [10] Using rice husk ash (RHA), as a waste byproduct of rice milling addition of 20% RHA with bitumen penetration grade, ductility, softening point, rotational viscosity and dynamic shear rheo meter were conducted result got 20% RHA sample was the better mix regarding rutting resistance.[11] A nation’s development mainly depends on the development of transportation of the country. Flexible pavements is that of the major use in India for road road construction, It is most suitable to increase the life of the bituminous pavements. Flexible pavement is that have many problems like rutting, cracking, and other failures due to heavy traffic loads and melting point. In this project, we have used the waste.[12] Study Enhancing asphalt binder by adding 0.2% and 0.5% plastic waste powder obtained by grinding waste bottle plastics to asphalt binder. Result got 0.2%and 0.5% would meet super pave asphalt binder resistance to rutting would be equivalent to a higher asphalt binder grade than tested which would enhance its rutting resistance at operational temperature,[13] study modified binder from shredded waste plastic fibers from carry bags and cement carry bags of 4% different samples base bitumen (VG-10), VG-10 + 4% Carry Bags fibers and VG-10 + 4% Cement Carry Bags fibers, which were tested. Binder found suitable for its application in warmer areas as shown by PG test results in terms of rutting factor. Wet procedure of mixing the waste plastic shredded fibers for preparing the bituminous mixtures resulted in lowest fatigue life but was found the best mix regarding the rutting resistance. The bitumen was modified with 2%, 4%, 6%, 8% and 10% Domestic food pack obtained from domestic waste. After Based on the marshal test conducted, an optimum modifier content of 6.7% by weight of the OBC is recommended for use in the hot mix asphaltic wearing course of increase in rutting resistance.

3. Objectives

- To determine the effect of waste plastic in the flexible pavement to check for behavior under rutting.
- To reduce problem of rutting in flexible pavement or utilization of waste plastic
- To use the plastic waste for the generation of bituminous concrete having better stability.

4. Methodology-Research Process

The Process Followed includes: Collection of materials, Preparation of sample, Laboratory test perform on the sample of bitumen plastic mix, Determine the rutting resistance., Suggest the majors to reducing rutting in the flexible pavement by utilizing waste plastic

4.1. Preparation Waste Particles

The collected waste material were washed with water, sun-dried and cutting. The dried waste cut to the size by a scissor. The waste plastic particles were cut to minimum 1 cm and a maximum of 3cm size [11–13], see in figure 1.
4.2 Preparation of mixes

Bituminous mix with waste plastic were prepared in mixing pan. When preparing the mix, aggregate was heated to 175°C and bitumen to 160°C. A quantity of aggregate was placed in the pan and bitumen was added to the heated aggregate. Waste plastic ingredients were mixed using a spatula. In modified mixes, a specific amount of waste particles was added to the aggregate before the aggregate was heated at 175°C. The aggregate was then mixed with the addition of melted bitumen. For the modification of bituminous mixes, different percentages of waste particle bags in the size of 1 cm to 3 cm were added to the heated aggregate at 175°C just before the addition of bitumen when the sample was prepared for testing. The quantity of polythene bags varied from 3%, 5%, and 7% by weight of the total bituminous mix [14–16], see Figure 2.
5. Test Performed
  5.1. Impact Value

It is used to evaluate the toughness of stone or the resistance of aggregate under sudden impacts load. Coated of waste plastic over the aggregates reduces the voids and the air cavities present in aggregates. The aggregate were subjected to 15 blows with a hammer of weight 14kg and the crushed aggregate were sieved on 2026mm sieve. The aggregate value is the percentage of fine to the total weight of the sample. The aggregate impact value should not exceed 30% for the use of wearing course of pavements. Maximum permissible values are 35% for bituminous macadam and 40% for water bound macadam. The plastic coated aggregate were subjected to the test and the results.

The test sample consists of aggregates sized 10.0 mm 12.5 mm. Aggregates may be dried by heating at 100-110°C for a period of 4 hours and cooled. Sieve the material through 12.5 mm and 10.0mm IS sieves. The aggregates passing through 12.5mm sieve and retained on 10.0mm sieve comprises the test material, see table 2 and figure 3.

| Aggregate Impact Value | Classification                  |
|------------------------|----------------------------------|
| < 20%                  | Exceptionally Strong             |
| 10 – 20 %              | Strong                           |
| 20 – 30 %              | Satisfactory for road surfacing  |
| >35%                   | Weak for road surfacing          |

Table 2: Aggregate Characterization

Figure 3: Impact Value Test Apparatus
Table 3: Impact Value Results at different Plastic content

| Aggregate   | Plastic content | Impact Value |
|-------------|-----------------|--------------|
| Coated Aggregate | 3%            | 12.75%       |
| Coated Aggregate | 5%            | 10.88%       |
| Coated Aggregate | 7%            | 7.29%        |

After mix different percentage (3%, 5%, 8%) of waste plastic with hot aggregate then testing result obtained, see Table 2.

5.2 Moisture Absorption Test

A known quantity of plastics coated aggregate was taken. It was then immersed in water for 24 hours. Then the aggregate was dried using dry clothes and the weight was determined. The water absorbed by the aggregate was determined from the weight difference. The test were repeated with different percentage of plastic coated aggregate and plain aggregate for comparison of results, see Table 4.

Table 4: Moisture Absorption Test Result at Different Plastic Content

| Aggregate          | Plastic content | Moisture |
|--------------------|-----------------|----------|
| Without coated     | 0%              | 5%       |
| Coated aggregate   | 3%              | 2%       |
| Coated aggregate   | 5%              | 1%       |
| Coated aggregate   | 7%              | 0.50%    |

5.3 Marshall Stability Value for coated aggregate

Marshal stability test is the basic study on the stability of the mix with application of load. The procedure consists of determination of properties of mix, Marshal stability and flow analysis and determination of optimum bitumen content. The aggregate were coated with plastic waste described. The plastic coated aggregate mix with different percentage 3% 5% 7% of the total quantity of bitumen. The mixture transferred to the mould it compacted with 75 blows on the either side. The specimens were prepared. Varying the percentage of plastic waste and by varying bitumen quantity. The specimens were tested. The voids present in the mix also play important role in deciding the performance of the mix.

Marshall Stability Value (kN), Flow Value (mm) and Marshall quotient (kN/mm) were obtained for plain aggregate bituminous mixes and polymer coated aggregate bituminous mixes of varied compositions, see Table 5

Table 5: Marshall Stability Value at Different Plastic Propotions

| Bitumen content | Plastic content | Marshall value |
|-----------------|-----------------|----------------|
| 5%              | 3%              | 13%            |
| 5%              | 5%              | 15%            |
| 5%              | 7%              | 16%            |
6. Conclusion

Engineering Possessions of rutting is one of the problematic issues for flexible pavement, and needs to be researcher’s research in new methods and find modification technique. Waste Material has different origins and sources that can be used in prevention of rutting techniques. Industrial garbage dump are most popular source which waste materials can be produced. Researcher try to find an economic waste materials for large project that can be impact on budget of project of road construction. Polythene bags or packaging bags is one of the economic and waste materials that is use on road construction. Use of waste polymeric waste materials in road construction is the best sustainable option for disposal of non-biodegradable plastic waste.

After performed tests and seeing result for waste polythene bags, water bottles, cold drink bottles and thin film with aggregate mix sample give good result as compare without mix plastic of aggregate. Using different percentage of waste 3% 5% 7% and analysis result good, best as this percentage and this waste material have high softening point. Use of this waste plastic material with aggregate and it increase the bond strength aggregate to aggregate and provide good resistance of rutting in pavements

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