

Utilization of Waste Materials in Flexible Pavement Construction

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Abstract - Due to increase in population, urbanization, development activities, and the quantity of plastic waste, municipal solid waste and tires are increasing day by day. This waste is disposed by land filling and incineration, which are hazardous and not eco-friendly. The aim of project is to analyze & study how the waste material will be effectively utilized in construction of pavement as a binder material for replacing the content of bitumen. Plastic & tires are cheap in cost and not environmentally friendly. The physical properties of bitumen mix at variation of 10 to 40% of waste plastic (PET) and 10 to 40% of waste rubber is examined by simultaneously combining both plastic and rubber equally from 5 to 20%. According to this research we find optimum percentage of waste plastic, rubber & both combination of (plastic + rubber) is 30%, has given better finish, stability, binding property, resistance to water and durability & Due to use of waste materials, the cost reduction is up to 25 % when compare to ordinary bitumen.

Keywords :- (Flexible Pavement, Environmentally Friendly, Marshall Stability, Plastic, Tires, Waste.)

1. INTRODUCTION

In a recent scenario, a world without roads, cars, motorcycles, trucks is almost unimaginable. India encompasses a road network of over 5,603,293 kilometers as on 31 March 2016. The second largest road network in the world. As on 31 March 2016, 62.6 % of Indian roads were paved. Only 40% of Indian roads are flexible pavements. Rest 22.5% of roads are rigid pavements. Indian roads are primarily bitumen-based macadamized roads. Due to extreme climatic conditions and a steady increase in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature demands improved road characteristics. The entire road infrastructure with its diversity of transport concepts now has a prominent position in our civilization. The question is thus not so much whether or not there'll still be a road infrastructure within the future, however, rather how can a society read these quality facilities in say 20 or 30 years' time. Comparing the road infrastructure and suggests that of transport of these days with those of 40 years past, it becomes clear within the next forty years' time everything can once more look a lot different to how it looks today. Societies area unit perpetually developing and, consequently thus area unit people's requirements regarding the use, structure and design of the road infrastructure – not simply roads in urban areas (urban roads), but also the motorways (inter-urban roads) between the major cities. It is conjointly quite conceivable that the longer term construction and style of infrastructure constructions like bridges and tunnels are

be subject to completely different needs. In view of the long time span of 10 to 15 years between planning infrastructure facilities and its actual completion, followed by an operational period of at least 25 years, more clarity of these future needs, demands and requirements becomes essential in order to make the right choices for tomorrow. Making the longer term a lot of acknowledgeable and tangible reveals the gaps of information and indicates which new technologies can need to be developed to meet the future demands and needs. Besides generic developments like shortage of clean environment, space and energy, spotting and extrapolating the social and economic trends and technical advances offer starting-points for forming a more realistic image of the longer term and therefore the associated desires and demands associated with road transport. 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. In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It conjointly helps to boost the strength of the road. But its resistance towards water is poor. Use of plastic and rubber leads to excellent pavement life, driving comfort and low maintenance. Scientists and engineers are constantly searching on different methods to improve the performance of bituminous pavements. A common methodology to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with organic artificial polymers like rubber and plastics. Polymer and crumb rubber can be used as a binder with respect to aggregate and bitumen in construction of flexible pavement. This paper aims at proposing a method of disposal of plastic and tire waste by using them on the surface course of the pavement. The Main objective of this study are safe and productive disposal of wastes - plastic and tire, study of index properties and suitability of waste-bituminous mix on surface course of the pavement.

1.1 Objectives

- 1 To study the physical properties of bitumen & crumb rubber, bitumen & PET, both rubber & PET mixed bitumen & at the various percentage.
- 2 To find out an optimum percentage of waste materials in the bituminous mix
- 3 To improve the properties of bituminous mix & to provide the solution for disposal in a useful way.
- 4 To increase the Marshall Stability value.

2. LITREATURE REVIEW

2.1 Review: 1

S. Rajesekaran, Dr. R. Vasudevan, Dr. Samuvel Paulraj has been studied "Reuse of Waste Plastic Coated Aggregate-Bitumen Mix Composite for Road Application-Green method" (2013).

Waste plastics both by domestic and industrial sectors can be used in the production of asphalt mix. Waste plastic, mainly used for packing are made up of polyethylene, polypropylene, polystyrene this softening varies between 110°C-140°C and they do not produce any toxic gases during heating but the softened plastics have tendency to form a film like structure over the aggregate when they sprayed over the hot aggregate @ 160°C. this PCA bitumen mix showed improved binding property and less wetting property and it also showed higher Marshall stability value in the range of 18-20KN and load bearing capacity of the road is increased by 100%. The roads laid since 2002 using PCA bitumen mixes are performing well. This added more value to the dry process as this process helps to dispose 80 percentage of waste polymers usefully by an eco-friendly method and also it reduced the cost to around Rs.3000/km of single lane road as on date.

2.2 Review: 2

H. K. Sharma, has conducted experiment on "Utilization of Waste Plastic in Construction of Pavement" (2014).

He found that Waste plastics - as binder and modifier at 130°C using Thermo gravimetric analysis 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 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.

2.3 Review: 3

D R. Manju, Sathya.S, Sheema.K has been studied on "use of plastic waste bituminous pavement" (2017).

This paper reveals that the utilization of waste plastic in bituminous mix enhances its properties and strength. Titanium Di-oxide is used as smoke absorbent material, which will absorb the smoke from vehicle. Addition of waste plastic in construction reduces the plastic shrinkage and drying shrinkage. Dry process is carried out for mixing process. The plastic pavements can withstand heavy traffic and are durable than flexible pavements. The stability of modified bitumen (10% bitumen replaced by plastic) is higher than the nominal bitumen. The use of plastic will reduce the bitumen content by 10% increases the strength

and performance of the road. The smoke absorbent material (titanium dioxide) by 10% of polymer content can reduce vehicular pollution. Thus the use of waste plastic improves the abrasion and slip resistance of bitumen pavement [2].

2.4 Review: 4

Vishal Rasal, L Nokfho K, P.M.Wale, Mrunalini Kasar, Anjali Thorat, Raunak Solanki, Ishan Dharmadikari, has been studied on "Experimental Study on Modified Bituminous Mix Using Waste High Density Polyethylene and Crumb Rubber" (2018).

This paper presents an effort taken to produce modified bituminous mix and coated aggregates. Aggregate were coated with 6, 8, 10% of High density polyethylene (HDPE) and 8, 10, 12% of crumb rubber and were mixed with bitumen. Different molds are prepared with different combination and compared with conventional bitumen mix by conducting Marshall Stability test to check its strength, flow value and stability value. The dense based macadam (DBM) mix was designed for Marshall Stability test using VG30 grade. Dry process (polymer coating of aggregates) is more useful as compared to wet process (adding polymer in the binder) for the manufacturing modified mixtures, as it can accommodate higher amount of waste plastic as modifier and results most stable mixture. Penetration values and softening points of plain bitumen can be improved by modifying it with addition of crumb rubber. Optimum percentage of rubber was found to be 8% and 10% of HDPE gives more satisfied results comparing to conventional bitumen. Use of waste plastic in construction of bituminous road helps to improve strength, life of road, resistance to temperature and water

3 MATERIALS USED

3.1 BITUMEN

Ordinary Bitumen of 50/70 grade is used.



Fig -1: Bitumen

3.2 COARSE AGGREGATES

Aggregates which possess sufficient strength, hardness, and toughness are chosen, keeping in view the availability and economic consideration. A sets of aggregates were chosen, one set for trial and error testing's which may have passing 12.5mm and retaining 10mm. Another set may have actual gradation of aggregates specified by IRC.



Fig -2: Aggregates

3.3 PLASTIC

A plastic is a material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow. And Types of plastics are thermosets, elastomers, and thermoplastics. Waste plastics –as binder and modifier at 130°C Thermogravimetric 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 a binder like bitumen to enhance their binding property. This may be an honest modifier for the bitumen, used for road construction.

3.3.1 Polyethylene terephthalate:

Bottles made of polyethylene terephthalate can be used to make lower grade products, such as carpets. To make a food grade plastic, bottles need to be hydrolyzed down to monomers, which are purified and then re-polymerized to make new PET. PET is sometime recycled and tends to be both durable and flexible. It can withstand temperature of 80° c continuously and 95° c for short time. The use of PET will not only strengthen the pavement but also increases its durability. PET comprises of house hold polythene and soft drink bottles that can be collected from local dump sites.



Fig -3: PET Bottle

3.3 CRUMB RUBBER

Crumb rubber is actually small pieces of waste tire scrapped from light motor vehicles and whose disposal is a serious menace. The crumb rubber is created by shredding scrap tire, which is a particular material free of fiber and steel. Bitumen-rubber is manufactured by adding graded

crumbed rubber to hot bitumen which contains a quantity of heavy extender oil. The rubber never completely dissolves in the bitumen and the product is therefore classed as a non-homogenous binder. Special manufacturing equipment is needed to manufacture this extremely viscous material.



Fig -4: Crumb rubber

4. METHODOLOGY AND TESTING

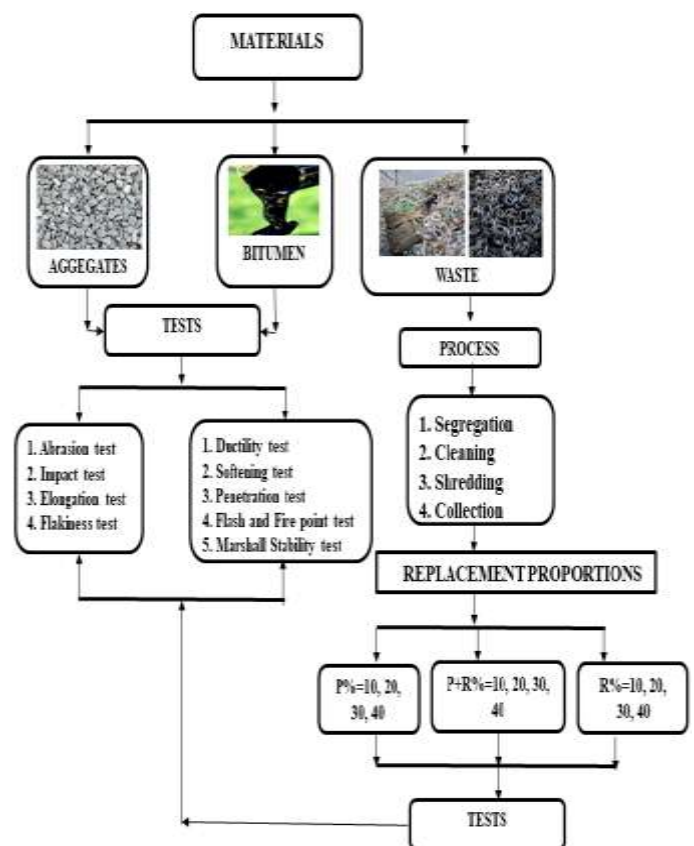


CHART –Methodology

5. RESULTS AND DISCUSSION

MARSHAL STABILITY TEST

5.1 Mix Design

- Desired grading of mix is selected from the recommended gradation for the particular type of pavement layer by IRC.

- Sieve analysis is carried out on the samples of aggregate collected and the proportion in which they should be mixed to obtain desired gradation (by any one of the methods such as graphical method or trial method).
- The maximum permissible size of coarse aggregates for the preparation of Marshall Stability test specimen is 25 mm (but we are using 12.5 mm downsize).
- The present project is carried out for the top most layer of surface course.

The compacted specimen should have a thickness of 63.5mm. At least 3 specimens should be prepared for different bitumen content.



Fig -5: Heating of Aggregates Fig -6: Mixing of Bitumen



Fig -7: Demolded Specimens Fig -8: Molds in Water bath



Fig - 9: Marshall Stability Test

5.2 EXPERIMENTAL OBSERVATIONS

The Marshall Stability Test is conducted and the readings were tabulated. For the readings obtained the following graphs are plotted against Bitumen and various parameters

- Plastic replacement.
- Rubber replacement
- Plastic and rubber replacement

a) PLASTIC REPLACEMENT

Plastic is replaced with bitumen in various proportions like 10%, 20%, 30%, & 40% Marshall Stability test where carried out for every replacement of plastic proportions and note down the readings respectively.

Table -1: Marshal Stability Test for plastic replacement

PLASTIC%	Stability KN	Flow value mm
Bitumen	34.14	5.5
10	36.18	6
20	42.18	5
30	54.53	4
40	49.43	4.6



Chart -1: Stability Graph for plastic replacement

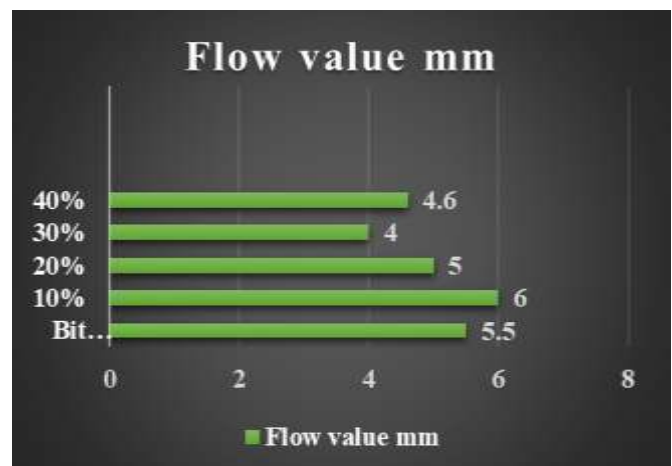


Chart -2: Flow Graph for plastic replacement

b) RUBBER REPLACEMENT

Rubber is replaced with bitumen in various proportions like 10%, 20%, 30%, & 40% Marshall Stability test where carried out for every replacement of rubber proportions and note down the readings respectively.

Table -2: Marshal Stability Test for rubber replacement

RUBBER%	Stability KN	Flow value mm
Bitumen	34.14	5.5
10	36.69	4
20	43.32	3.5
30	57.08	2.6
40	49.94	3

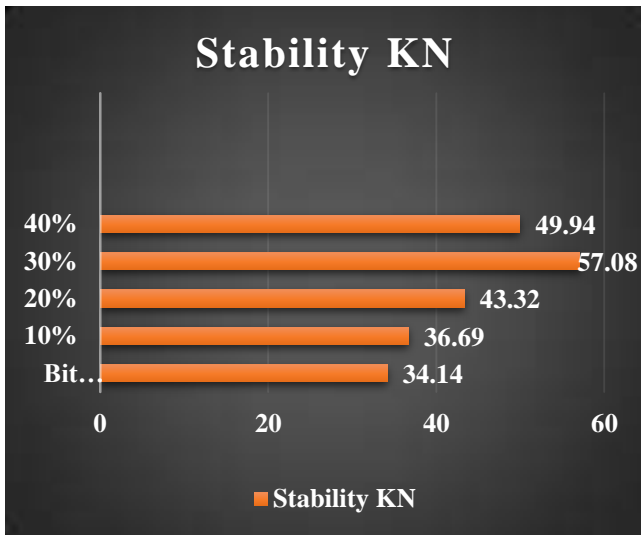


Chart -3: Stability Graph for rubber replacement

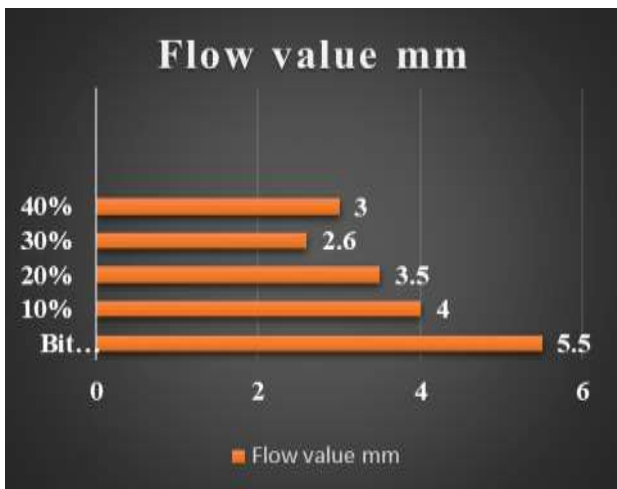


Chart -4: Flow Graph for rubber replacement

c) PLASTIC & RUBBER REPLACEMENT

Plastic and Rubber is replaced with bitumen in various proportions like 10 % (5%P+5%R), 20 % (10%P+10%R), 30 % (15%P+15%R), & 40 % (20%P+20%R), Marshall Stability test where carried out for every replacement of plastic rubber proportions and note down the readings respectively.

Table-3: Marshal Stability Test for plastic & rubber replacement

PLASTIC %+RUBBER%	Stability KN	Flow value mm
Bitumen	34.14	5.5
5+5	49.43	2.5
10+10	56.07	2.3
15+15	70.84	2
20+20	38.73	3.5

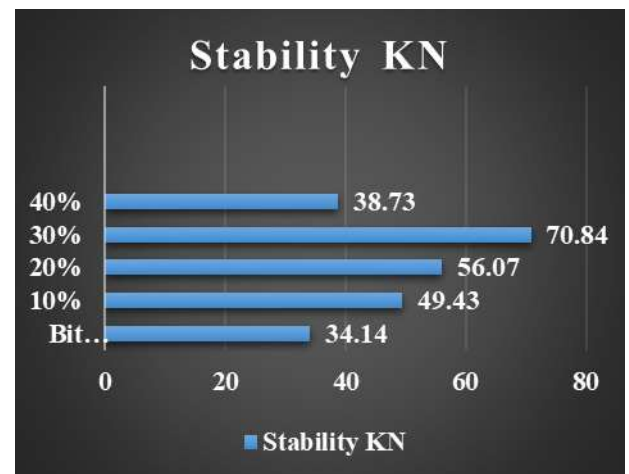


Chart -5: Stability Graph for plastic & rubber replacement

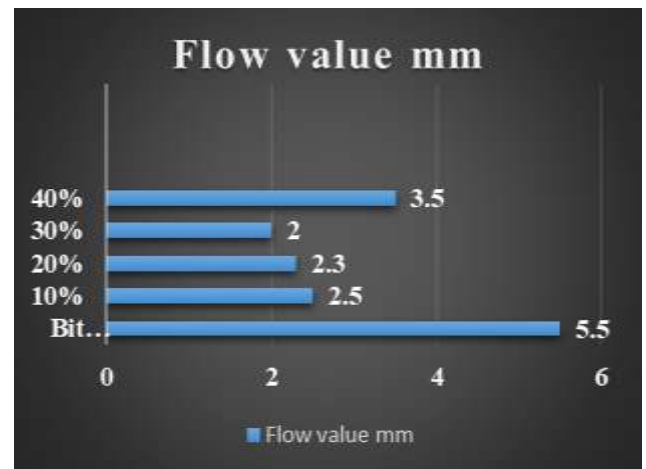


Chart -6: Flow Graph for plastic & rubber replacement

7. Estimation and Comparison

Material Needed	Plain Bitumen Process	Plastic-Bitumen road	Rubber-Bitumen road	Plastic & Rubber-Bitumen road
50/70 Bitumen	1000 kg	700kg	700kg	700kg
Waste	-----	300	300	150P+150R
Cost Rs.	35000	27000	26300	.26900
Cost Reduced	NIL	Rs. 7500	Rs. 8700	Rs. 8100
Cost Reduction in %	0%	21.5%	25%	24%
Stability kN	34.14	54.53	57.08	70.08
Stability Increased By	0 times	1.6 times	1.68 times	2 times
Flow Value Decreased By	0 times	0.72 times	0.47 times	0.36 times

8. CONCLUSIONS

1. The graphs plotted against various content of bitumen and properties of behavior of marshal stability molds, shows good results at 30% of waste content. Hence we can conclude that among 10%, 20%, 30% and 40%, 30% is the optimum.
2. The waste added in the bituminous mixes can increase the stability and density of the mix which is designed for the surface course.
3. It is found that, the stability is increased twice, when compared to the normal bituminous mix i.e. with adding waste materials.
4. We found that, the flow value is decreased 0.36 times, when compare to the normal bituminous mix i.e. with addition waste materials.
5. The thickness of the pavement layer may be reduced to half of normal thickness which results in economy of cost by reducing quantity of aggregate, bitumen and by achieving the work in less duration of time with better quality.
6. Due to use of waste materials the cost reduction is up to 25 % when compare to ordinary bitumen.

SCOPE OF FUTURE STUDIES

1. The studies can be carried out for other grades of bitumen.
2. Other waste materials like LDPE, HDPE, fibers, glass powder etc. can be taken for replacing with bitumen.
3. SEM imaging (Scan Electronic Microscopic).

4. Other tests like flow test, water content test, viscosity test, deflection test (Benkelman beam method, rebound deflection method) can be carried out.

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- a) **IS 2386:1963**- For Aggregates test
 - b) **IS 73:2013** – For Paving Bitumen (local)
 - c) **IRC 37:2012**- For Flexible Pavements
 - d) **SP 20**-Mix Design of Waste Materials
 - e) **MORTH 500**