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# Use of Waste Tier in Construction of Bitumen Road- A Review

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***Abstract:*** *This paper is based on the review study on waste tier generation, Its environmental problem, and its use in construction of the bitumen road. The growth rate of population which depends upon on vehicles is the backbone of economic development of any country. India is the second fast growing automobile industry in the world. In today's era, solid waste management is the thrust area. On the other side, the traffic intensity is also increasing. As a result amount of waste tires is also increasing. The increasing in consumption of waste tire has created many problems such as increasing landfill space, environmental pollution and causing health hazards to living being. Parallel to this is tremendous increasing of roads construction as a result of heavy traffic on roads. This study reviews regarding the use of crumb rubber (waste tires in powder form) in bitumen using the wet process. The study focuses on the crumb rubber as a replacement to the total weight of bitumen. using of crumb rubber when in the reinforcement of asphalt is considered as a smart solution for sustainable development by reusing waste materials, and crumb rubber modifier (CRM) could be an alternative polymer material for improving hot mix asphalt performance properties. This paper is a critical review on the use of crumb rubber in reinforcement of asphalt pavement will be presented and discussed. this paper is a review on the effects of CRM on the stiffness, rutting, and fatigue resistance of road pavement construction.*
***Keywords:*** *Crumb Rubber, Asphalt Concrete, Tire.*

## I. Introduction

The rapid growth rate of population of India has resulted in an overall count of around 1.35 billion people which represents almost 17.85% of the world's total population. This huge crowd is creating serious impact on environmental assets and resources of the nation. Such growths not only demand resources for sustenance but also need good infrastructure for mobility, which adds huge amount of non-biodegradable solid wastes in the ecosystem. According to a GOI report, "National Highways Development Project, road network of India is growing at an annual rate of 4% since 1951 while the vehicles are increasing at a much faster rate of around 12% per annum. Because of this higher rate of increment of vehicles on the roads as compared to the rate of construction of roads, have resulted in the formation of transverse and longitudinal cracks, potholes and subgrade. At the same time as the traffic on road increase generation of the waste tire also increase. Considering the large amount of material recycled from tires, this material should become the subject of worldwide research study on its utilization potential. So it became very necessary to search new potential uses of recycled tires in construction, attention is focused primarily on their use in asphalt mixtures, which are applied to different structural layers of road pavement. The experimental road section at Mala Ida (Slovakia, Kosice region) consists of asphalt concrete along with the addition of crumb rubber. The studied asphalt mixture was developed within the project "NFP 26220220051 Development of progressive technologies for utilization of selected waste materials like rubber and plastic in road construction engineering, supported by the European Union structural funds" at the Department of Geotechnics and Traffic Engineering, Technical University of Kosice.

After the asphalt mixture went through laboratory testing, an experimental road section was constructed. The original surface layer of this road was replaced with asphalt mixture with addition of crumb rubber. Crumb rubber is an elastic material and its behavior could improve classic asphalt mixtures in loaded roadways. Asphalt mixtures can be modified with crushed rubber in different ways. Properties of asphalt mixtures with added rubber have been monitored using wet as well as dry methods. The wet method is based on mixing crushed rubber and asphalt binder at elevated temperature, and the final product is asphalt rubber binder. The dry method involves replacement of part of the aggregate with crumb rubber. The wet method for asphalt rubber pavement composition can be used in preparation for this study. The rubber content can be chosen with regard to the aggregate and binder content.

Natural asphalt is a naturally occurring hydrocarbon mineral that is high in asphaltense and high in the Nitrogen. When crumb rubber added to asphalt it dramatically increases the asphalt's viscosity, lowering penetration while increasing the softening point. The crumb rubber is first chemically treated and then is used to rapidly blend into asphalt. The elasticity and softening point of the asphalt increasing after addition of rubber it also gives the additional binding strength,. Carbon present in rubber acts as an anti-oxidant and prevents asphalt from ageing and oxidization.

## II. Literature Review

R. A. Khan and A. Shalaby, (2002) [1] Author concluded that The thermal conductivity of the tire shreds is five times lower than the thermal conductivity of clay with a dry density of 1500 Kg/m3 and moisture content of 25 percent. Frost penetration in the tire shred embankment is larger than in the natural ground because of the low water content and presence of large voids in tire shreds and the difference in snow cover. It was observed that the surface deflection of the tire shred embankment is 15 to 25 mm, under 21000 Kg axle load. An average rebound of 11 mm and irrecoverable displacement of 7 mm were recorded after two passes of load. The elastic modulus of the tire shreds is proportional to the bulk density of the shreds. Non-linear elastic isotropic analysis gives a conservative estimate of the deflection of the tire shred embankments as compared to the linear elastic analysis. The design of road embankments with large-size tire shred layers can be made using the non-linear elastic analysis model presented in this paper. Large size tire shreds can be an economical alternative compared to the small size tire shreds in the construction of the tire shred embankment.

Justo et al (2002)[2]**,** Author have done the research work in the Centre lab for Transportation Engineering of Bangalore University on the possible use of the processed plastic bags as an additive material in bituminous concrete mixes. This properties of the modified bitumen were compared with ordinary bitumen. In the research it was observed that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic additive, up to 12 % by weight. Due to this the life of the pavement surfacing course using the modified bitumen is also expected to increase substantially with comparison to the use of ordinary bitumen method.

Rokade S (2012) [3] He conclude in study that on the use of LDPE (Low Density Polyethylene) and CRMB (crumb rubber modified bitumen) reveals that the Marshal Stability value, which is the strength parameter of SDBC has shown that it is increasing trend and the maximum values have increased by about 25 % by addition of LDPE and CRMB. The density of the mix has also increased in both the cases of LDPE and CRMB when compared with 60/70 grade bitumen. This will provide more stable and durable mix for the flexible pavements. The serviceability and resistance of road surface to moisture will also be better when compared to the conventional method of construction. The values of other parameters i.e Air Voids (Vv) , Voids in mineral aggregate (VMA) , Voids filled with bitumen(VFB)in both the cases LDPE and CRMB have found out to be within required specifications. This study not only constructively utilizes the waste plastic and tires in road construction industry but it has also effectively enhanced the important parameters which will ultimately have better and long living roads. From the results it is observed that the Marshal Stability Value are increased from 8% to 10% Crumb Rubber and then it is decreased i.e 10% of Crumb Rubber of the weight of bitumen is the optimum dose for getting enhanced strength characteristics of SDBC(Semi Dense Bituminous Concrete) mix. The bulk density of the sample also shows increasing trend from 8% to 12. The values of other parameters are also within the required specification limits.

Davide Lo Presti. (2013) [4] The author believes that the widespread use of the RTR-MBs technologies within the road pavement industry is advisable. In fact the several benefits provided to the asphalt pavement performance, and to the overall sustainability of the infrastructure, are so evident that it is strongly advised to consider RTR-MBs technologies as a first option to the binders currently used in road pavements. Companies, road authorities, etc. have to evaluate if it is convenient to use the High Viscosity wet process technology, which proved widely to provide several benefits, in particular it allows highway designers to reduce pavement layer thickness due to the proven properties of rubberized bitumen, but presents some challenges as: the need for suitable blending and mixing equipment, the cost of such equipment and the degree of difficulty in preparing asphalt mix design. The other option is to choose the wet process-No-Agitation technology which solves several issues but leads to asphalts pavements. On the other hand, asphalts obtained by using High Viscosity RTR-MBs (Recycled Tire Rubber Modified Bitumen emulsions)have more performance history since this process started over in 1960s and they have been used successfully with many applications. With regards to asphalt mixtures, High Viscosity RTR-MB technology is very successful when used with Open- Graded surface courses, where the high air void content of the mix allows an aggregate coating with a much thicker film (36 lm) of high RTR content modified bitumen's (about 20%) which leads to an asphalt mix with significantly high binder content (about 7–9%) and with widely proven reduced oxidation, increased durability and increased resistance to reflective cracking. All these benefits are reduced when High Viscosity RTR-MBs is used for Dense-Graded hot mix projects since the dense gradation cannot adequately accommodate the rubber particle size, film thickness is reduced (9 micron) as well as acceptable binder content (about 5%) and the RTR-MBs needs to be produced with much lower rubber content (about 10%). The use of special equipment is not anymore justified by the significant benefits of a thicker coating, therefore in the case of Dense-Graded asphalt mixes the No-Agitation RTR-MBs are the most suitable. On this regard, they are more likely to compete with polymer modified bitumen rather than High Viscosity RTR-MB. No-Agitation RTR-MBs have been successfully used for a much wider range of products as for instance chips seal applications, open graded and gap graded mixes and emulsions.

Basically, RTR-MBs cannot be used wherever conventional asphalt mixes or asphalt surface treatments are needed. The lower viscosity of No-Agitation RTR-MB implies the usage of less binder per unit area (5–6% binder content) indicating less performance life than if High-Viscosity RTR-MB is used (8–10% binder content). In fact, the ability to inject more binder in the mix translates to better fatigue and reflective cracking performance.

Tomas Ucol- Ganiron J. (2013) [5] Author concluded that Gradation of the asphalt mixture with scrap tire is lower in percentage retained 4.76 mm sieve than the conventional one for both marshall and immersion-compression tests. It was observed that bulk specific gravity of the design mixture has a lower result than the conventional for Marshall Test. Since scrap tire is not so hard as the crushed-stone aggregates, the Marshall stability values of the asphalt-aggregate-tire mixes were consistently lower as compare to control mixes without any scrap tire. It was also found that the tire which is cubical in shapes tend to absorb some of the energy imparted to compact a sample resulting in a weaker aggregate structure than a mix with no tire in it. For Marshall test The stability of the design mixture is twice lower than the conventional one, and constitutes a lower value in terms of flow. The density of the design mixture is lesser than the conventional. The stability of the mixture of asphalt depends on the grading of the aggregates, temperature and size of scrap waste tire. The advantages of scrap waste tires are: it mitigates roads noise and lessen the number of waste tires. In terms of Marshall Test, the longer rate of curing, the higher stability acquires. For Immersion-Compression test, the rate of curing by maximum 4 days will give the maximum value for water resistance for the road surface.

R S Deshmukh (2015) [6] The Author concluded that, Strength of the road increased & Better soundness property. Better resistance to water & water stagnation. No stripping & have no potholes. Increased binding & better bonding of the mix. Optimum content of waste rubber tires to be used is between the range of 5% to 20%. Modifies the flexibility of sub surface layer Problem like thermal cracking and permanent deformation are reduce in hot temperature region after addition of waste tires as rubber aggregate.

Manoj Sharma. et al. (2016) [7] Author concluded that the basic reason for using RTR-MB's is that it provides significantly improved engineering properties over conventional paving grade bitumen. The most important benefit is to withstand against the high climate, as generally in many parts of north India temperature reaches 40-60 $^0$c. In these temperature RTR-MB's shows physical and rheological properties significantly different than those of neat paving grade bitumen likewise reduced several properties like fatigue, rutting, reflection cracking, and improved oxidation resistance, aging and better chip retention due to thicker binder films with additional increased viscosity that permit greater film thickness in mixed pave without bleeding and excessive drain down. It also shows that greater values of the elasticity and resilience especially at high temperature. This method proves to be very useful in Indian as the availability of waste rubber is in abundant and there is also no need of any special arrangement to prepare them for the use in road construction.

Prof. S. B. Patil. et al. (2016) [8] Author concluded that Rubberized bitumen is used extensively in California, Arizona and Texas in the USA, in several countries of Western Europe, and in South Africa. It is also used to a lesser parts of Canada and in a dozen more states in the USA. Its benefits are many which including reduced long-term road maintenance and expense, significant noise reductions, improved traction and reduced accident rates in wet road conditions. Rubberized bitumen is a less expensive application when used as a thin top course over failed pavement that would otherwise need replacement. It is less expensive to maintain per lane-kilometer in years 6 through 15 of pavement life over conventional pavements, and the same in years 1 through 5. Rubber bitumen makes urban environments more habitable as it significantly reduces noise as opposed to concrete pavements, and also is quieter than bituminous pavements;. It significantly improves wet surface traffic safety. It creates less of a "heat island" effect than with concrete pavement at surface. In an Open Grade Friction Course it provides better surface road drainage. It is a hugely beneficial use for post-consumer waste tire materials, using about 1,000 waste passenger tires per lane mile.

H.T. Tai Nguyen et al. (2017) [9] Author concluded that the dry process, CR is used in hot mix asphalt as a replacement for parts of coarse and fine aggregate, resulting in a preference for gap gradations, and aggregate does not appear in the dimensions of the added CR. Furthermore, the work of designing a gradation curve of aggregate corresponding to the added rubber powder is quite complicated because the melting of fine CR particles will occur at high temperatures. For example, the chunk rubber process could consume CR up to 12% by weight of the mixture. They have concluded after conducting various test on the bitumen sample like The CR contributes to the significant improvement in the Marshall stability and rutting resistance of asphalt concrete. The optimal CR content in mixtures of dense gradation and SMA gradation are 1.5% and 2%, respectively. And At the optimal content of CR, the rutting resistance of dry process asphalt mixtures is as good as that of SBS (Styrene-Butadiene- Stryrene). and CR modified asphalt mixtures using wet process. Therefore, CR modified asphalt mixtures using dry process can be used in flexible pavement to mitigate rutting distress and, on the other hand, promote the recycling of waste tires, contributing to the protection of environment.

Olga Frolova et al. (2017) [10] The paper was created in order to demonstrate the possibilities for reducing car noise levels by using low-noise asphalt pavement. asphalt mixture with the addition of crumb rubber from used tires showed good acoustic properties. Roughness of the mixtures was studied in in-situ conditions, on the wearing course of the experimental section (with crumb rubber) and the SMA (Stone Mastic Asphalt) section three years after the mixtures were laid. According to the results shown in this figure, the roughness of the CR mixture was lower than that of the SMA mixture. In recent studies it is find out that the use of crumb rubber modified binders produced higher stiffness modulus than the same binder without crumb rubber on mixtures sampled and compacted in the laboratory. According to the results, roughness could be potentially responsible for the higher sound emissions of SMA pavement. In order to achieve noise mitigation in overall noise emissions due to this surface property lower roughness values would be necessary. One of the aims of this work was to find out the existence of a good correlation between tire/pavement sound levels and the roughness surface characteristics in an in-service asphalt mixture with crumb rubber content.

Nitu H. Deshmukh Et al.(2017) [11] Author conducted the test which were done for normal bitumen and modified bitumen with 0%, 8%, 10%, 12%, and 14% of rubber waste content. From the result of the test, the penetration value for normal bitumen was 69 mm. The penetration value decreased with the increased amount of the rubber crumb waste added. Lower penetration value prove that grade of asphalt is harder, giving additional strength to the road and reduces water damage. Softening Point Test was done for normal bitumen and modified bitumen with 0%, 8%, 10%, 12%, and 14% of rubber waste content. From the result of test, the softening point for normal bitumen was 42.75˚c. Softening Point increased with the increased amount of the rubber waste added. The result showed that the bitumen becomes less susceptible to temperature changes as the content of rubber waste increased. Ductility test was done for both normal bitumen and modified bitumen with 0%, 8%, 10%, 12%, and 14% of rubber waste content. The result found that the rubber waste added will harden the bitumen. The bitumen becomes more viscous and harden, which would be useful to obtain stiffer bitumen asphalt.

Shubham Bansal et al (2017) [12] Discarded waste materials like crushed plastic bottles, thrown away polythene bags and used rubber tires were the minor constituents of the binder along with bitumen as major constituent. Shredded plastic waste, having particle size around 650 microns with specific gravity 1.18 was used in the binder mix. All binders were divided into three series namely A, B and C. Series A and B represents the binary mixes i.e., Bitumen (B) + Plastic (P) and Bitumen (B) + Rubber (R) respectively while Series C is the tertiary mix with varying proportion of plastic and rubber both in bitumen. All the mixes having varying percentages of binder constituents are represented as Bitumen Mix (BM) as illustrated in table 1. Penetration test, Ductility test, Softening Point test and Specific gravity test were performed to analyze the physicochemical properties of various binders.

**Fig.1-Crumb Rubber**

***Mixing:*** Shredded plastic and rubber was mixed with bitumen at a temperature range between 200ºC to 220ºCin pre-determined proportions. Plastic replacement in the binder was in the order of 4%, 6%, 8% and 10%, while the rubber replacement was 5%, 10% and 15%.

***Binder testing:*** Physicochemical properties of binders were tested under Indian Standard test conditions. Results of the tests performed on non-modified bitumen and modified bitumen has been shown in Table 1.

**Table. 1: Physical Properties of Binders (**CM – Control Mix , B – Bitumen, P – Plastic, R –Rubber, BM - Bitumen Mix).

| **Serial No.** | **Composition** | **Penetration (25°C, 100g, 5sec)** | **Ductility (25°C)** | **Softening Point** | **Specific Gravity (27°C)** | **Viscosity (135°C)** |
|---|---|---|---|---|---|---|
| ***Test Method*** | | ***ASTM: D5-97*** | ***ASTM: D113*** | ***ASTM: D36*** | ***ASTM: D70*** | ***ASTM: D2170*** |
| **Units** | | mm | cm | °C | ----- | cST |
| ***CM** | **100% B** | 67 | 82 | 51.2 | 1.02 | 274 |
| **Series A** | | | | | | |
| BM1 | 96% B + 4% P | 64.5 | 79 | 53.5 | 1.05 | 304 |
| BM2 | 94% B + 6% P | 63 | 74 | 54.5 | 1.07 | 327 |
| BM3 | *92% B + 8% P* | ***59.5*** | ***71*** | ***56*** | ***1.09*** | ***350*** |
| BM4 | 90% B + 10% P | 56.5 | 69 | 59 | 1.12 | 385 |
| **Series B** | | | | | | |
| BM5 | 95% B + 5% R | 61 | 73 | 55.8 | 1.01 | 338 |
| *BM6* | *90% B + 10% R* | ***57*** | ***69*** | ***57*** | ***1.03*** | ***412*** |
| BM7 | 85% B + 15% R | 49 | 59 | 59.5 | 1.07 | 433 |
| **Series C** | | | | | | |
| BM8 | 91% B + 4% P + 5% R | 63 | 70 | 56.8 | 1.04 | 357 |
| *BM9* | *84% B + 6% P + 10% R* | ***59*** | ***62*** | ***60*** | ***1.07*** | ***477*** |
| BM10 | 77% B + 8% P + 15% R | 56 | 54 | 62 | 1.14 | 495 |
| **Specified Limits (BIS -73: 2006)* | *Pure Bitumen* | *60-70* | *> 75* | *40 - 55* | *> 0.99* | *>150* |

**Table 2. Stability-Flow and Volumetric analysis results of BC samples for non-modified and modified mixes.**

| ***Test Method*** | **Composition** | **Marshall Stability (60°C)** | **Marshall Flow (60°C)** | **Bulk Density** | **Air Voids** | **Voids in mineral aggregate** |
|---|---|---|---|---|---|---|
| | | ***ASTM: D1559*** | ***ASTM: D1559*** | ***ASTM: D2726*** | ***ASTM: D3203*** | ***ASTM: D1559*** |
| Units | | kN | mm | g/cc | % | % |
| *CM | 100% B | 9.06 | 3.8 | 2.320 | 3.72 | 12.07 |
| **Series A** | | | | | | |
| BM1 | 96% B + 4% P | 9.21 | 2.56 | 2.299 | 4.23 | 12.82 |
| BM2 | 94% B + 6% P | 9.91 | 2.64 | 2.318 | 4.28 | 12.93 |
| *BM3* | *92% B + 8% P* | ***10.54*** | ***3.35*** | ***2.362*** | ***4.31*** | ***13.11*** |
| BM4 | 90% B + 10% P | 10.01 | 3.79 | 2.271 | 4.77 | 13.66 |
| **Series B** | | | | | | |
| BM5 | 95% B + 5% R | 10.45 | 2.84 | 2.281 | 4.01 | 12.92 |
| *BM6* | *90% B + 10% R* | ***13.10*** | ***3.7*** | ***2.328*** | ***4.27*** | ***13.53*** |
| BM7 | 85% B + 15% R | 8.75 | 5.25 | 2.242 | 4.52 | 13.34 |
| **Series C** | | | | | | |
| BM8 | 91% B + 4% P + 5% R | 11.40 | 3.4 | 2.288 | 4.32 | 13.43 |
| *BM9* | *84% B + 6% P + 10% R* | ***13.89*** | ***3.9*** | ***2.331*** | ***4.69*** | ***14.181*** |
| BM10 | 77% B + 8% P + 15% R | 10.21 | 4.6 | 2.304 | 5.09 | 14.322 |
| **Specified Limits (MORTH)* | *Bituminous Concrete Mix (Grade 2)* | *>9* | *2 - 4* | - | *3-6* | *>12* |

**Table 3:** Cost comparison of Bituminous Concrete mix with and without additives.

| | Composition | Bitumen Cost | BC layer thickness / length | Cost Reduction |
|---|---|---|---|---|
| ***Code used*** | ***IRC 37:2012*** | | | |
| **Units** | | **lakhs** | **50 mm/1km** | **%** |
| CM | 100% B | 7.092 | 50 mm/1km | - |
| **Series A** | | | | |
| BM1 | 96% B + 4% P | 6.746 | 50 mm/1km | 4.88 |
| BM2 | 94% B + 6% P | 6.661 | 50 mm/1km | 6.077 |
| ***BM3*** | ***92% B + 8% P*** | ***6.643*** | ***50 mm/1km*** | ***6.331*** |
| BM4 | 90% B + 10% P | 6.248 | 50 mm/1km | 11.90 |
| **Series B** | | | | |
| BM5 | 95% B + 5% R | 6.624 | 50 mm/1km | 6.599 |
| ***BM6*** | ***90% B + 10% R*** | ***6.404*** | ***50 mm/1km*** | ***9.70*** |
| BM7 | 85% B + 15% R | 5.825 | 50 mm/1km | 17.86 |
| **Series C** | | | | |
| BM8 | 91% B + 4% P + 5% R | 6.365 | 50 mm/1km | 10.25 |
| ***BM9*** | ***84% B + 6% P + 10% R*** | ***5.985*** | ***50 mm/1km*** | ***15.61*** |
| BM10 | 77% B + 8% P + 15% R | 5.423 | 50 mm/1km | 23.53 |

## III. Conclusion

Rubber waste which is the major challenge for the environmental can be reduce by re using it to the bitumen road construction. All the above authors have concluded that the use of waste tires in road can be improve it near about all the parameter of the bitumen road. Shubham Bansal et al. have written in his research work that the Marshall Stability result for Bitumen (B)+ Plastic(P) + Rubber(R). Author have also proved that for BM10 77% B + 8% P + 15% R cost will reduce up to 23.53% which can reduce overall cost of the project. Thus if we use the waste rubber tires in this way it will no more be the waste and also the environment will be protected.

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