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A REVIEW ON SHREDDED TYRE RUBBER MIXED WITH BITUMINOUS MIX FOR ROAD ASPHALT MIXTURES

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Abstract

Now a day's construction cost of road materials are quit increasing day by day so its necessity of time is to use the low cost materials or wastage to optimize the cost of road construction. Rate of increase of Tyre waste of automobiles is a big issue, so the tyre waste of automobile vehicles are easily available and shredding of rubber is also done in a very low cost to obtained the shredded crumb rubber. Now the aim of this study is to reduce the scrap tyre waste by using it in bituminous mix for flexible pavement, somehow it may also reduce the today's cost of road construction. The idea behind this study is that the shredded crumb rubber is added in different proportions (10%, 15% & 20%) in a bituminous mix to prepare a Crumb Rubber Bituminous mix (CRBM). Further the strength and stability characteristics (Marshal Stability test) of this Crumb Rubber Bituminous mix is determined and anlysed. Mixing temperatures of 155°C and 150°C were adopted for modified binders (CRBM) and 80/100 neat binder respectively. Five different binder contents were chosen for testing, they are 4.5, 5.0, 5.5, 6.0 & 6.5% by weight of aggregate.

Keywords: *Shredded crumb rubber, Crumb Rubber Bituminous mix (CRBM), Marshal Stability test.*

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1. INTRODUCTION

Roads are considered one of the most important aspects of infrastructure and play an important role in our daily lives. In road masonry construction, the use of latex rubber for bituminous binder conversion is recognized as a viable sustainable development solution for waste recycling. In addition, the amount and increase in landfill disposal of waste tires is a major problem that leads to environmental pollution. Rubber debris found in discarded tire disposals has been shown to improve the performance of 1840s transparent bitumen. It can be used as an inexpensive and environmentally friendly conversion system to reduce road damage caused by increased numbers of service vehicles, stress on axles, and low-end maintenance services that quickly brought road construction to a halt. Using waste rubber results in better road conditions, a better ride, and less maintenance.

A major problem with crumb rubber mix mixtures made by both dry and wet processes is the lack of cohesion. This is mainly due to poor interaction between crumb rubber and bitumen. This reduces moisture resistance, causes spalling of the aggregate, and reduces the pavement's load-bearing capacity. A major drawback of incorporating rubber crumbs into bitumen mixtures is that becomes unstable when mixed with bitumen. particle size of the granules, method of obtaining the rubber granules, percentage of the rubber granules added to the mixture, composition of the rubber granules, degree of penetration, etc.). bitumen softening point, bitumen composition, etc.) and mixture properties (mixing time and type, temperature, etc.). As a result, there are a great many variables in manufacturing crumb rubber mix mixtures, which also means that the results are highly sensitive when the process is applied.

Regarding wet processes, there are many studies and experiments showing the influence of the aforementioned variables, resulting in a set of reference values for the optimum properties (size, composition, etc.) of crumb rubber. , type, etc.), mixing temperature and time, bitumen properties [31–33]. Research studies have also been conducted in recent years to determine the effect of such variables on the properties of dry process asphalt mixtures, with the aim of promoting the use of dry process. As a result, studies on the effect of decay time (the time required for crumb rubber to interact with bitumen to obtain optimal properties) are currently underway.

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Bitumen is often used as a raw material for flexible road construction. Different bitumen brands such as 30/40, 60/70, 80/100 are available depending on the starting price. The ever-increasing service life of vehicles in the commercial vehicle sector, with their large daily and seasonal variations, necessitates improved traffic signage. Improved binder materials are a prerequisite. The preferred range of bitumen permeability in this study was 60/70, which is commonly used as a paving grade bitumen suitable for the construction of flexible corridors with high-rise structures.

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Imports waste rubber from tire factories. It has the shape of a black mouse and is also used by used tiers.Crum rubber is reclaimed rubber obtained by mechanically crushing or pulverizing small cracked rubber tires. Tires are made from a variety of rubber chemicals. The main variations are rubber content, natural rubber content, total rubber hydrocarbon content, and acetone extraction. Ash and carbon content are generally similar for various rubber tire compounds.

In addition to the potential uses, approximately 300 million tons of tires are produced annually in the United States alone, of which approximately 13% end up in landfills in Europe, and 355 million tires are produced annually, with hundreds of Thousands of used tires are discarded. illegally disposed of or maintained; Proper disposal of tires can be very dangerous to human health and increase environmental hazards. Fortunately, tire waste is used for many technical purposes these days.

In 2010, around 200,000 tonnes of end-of-life tires (EOL) were collected across Spain for reuse, recycling and energy recovery. In this study, the crumb rubber modified binder (CRUMB RUBBER MIXB) used in the bituminous mixture uses scrap tires, so this type of wear course could be a viable application for these wastes. The use of rubber powder on roads is justified as it provides advantages in bituminous mixtures. The addition of crumb rubber improves temperature sensitivity and permanent set resistance as it increases the compound's elasticity at operating temperatures.

Advantages of crumb rubber bituminous mix modified bitumen can include following for road works:

1. Lower susceptibility to daily & seasonal temperature variations.
2. Higher resistance to deformation at elevated pavement temperature.
3. Better age resistance properties.
4. Higher fatigue life of mixes.
5. Better adhesion between aggregates & binder.
6. Prevention of cracking & reflective cracking.
7. Overall improved performance in extreme climatic conditions & under heavy traffic conditions.

2. LITERATURE REVIEW

R. A. Khan et. al. (2002) 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.

F.Moreno rt. al.(2011): The use of crumb rubber modifiers (CRUMB RUBBER MIXs) in bituminous mixtures produced using dry processes is less prevalent than in wet processes. Still, this method has the following advantages: B. Potential consumption of large amounts of rubber granules leading to significant savings in energy and natural resources. This survey research contributes to the advancement and sophistication of the dry process by analyzing the effect of pulping time (contact time between rubber granules and bitumen) and rubber granule compounding amount on compounding design characteristics. Investigations have shown that pulping time does not affect the selection of optimal binder content or mixture compaction. In contrast, the digestion time was found to affect the mechanical performance of the mixture. In this respect, an increase in the amount of rubber granules contributed to a corresponding increase in the required amount of bitumen, which also led to a decrease in compressibility of the mixture. This study showed that a crumb rubber content of less than 1% of the total mix weight and a pulping time of 90 minutes gave the best results.

Justo et. al. (2002) 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) He conclude in study that on the use of LDPE (Low Density Polyethylene) and CRUMB RUBBER MIXB (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 CRUMB RUBBER MIXB. The density of the mix has also increased in both the cases of LDPE and CRUMB RUBBER MIXB 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 CRUMB RUBBER MIXB 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) 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) 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) 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) 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) 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) 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) 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) 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) 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.

Neto et al.: found that CR obtained by cryogenic process has a smoother surface than CR produced by the grinding rubber at ambient temperature. The latter process interacts to a lesser extent with the binder, resulting in AR with a lower viscosity compared to CR obtained at ambient temperature. With the aim of presenting a brief overview of the research efforts carried out worldwide on asphalt rubber, the authors evaluated the studies published to date. This analysis was based on the Scopus search engine (www.scopus.com). This tool was used to find the required information in the existing database by using a keyword search in the title, the abstract or the keywords of the document. Since the database provides information on documents published on asphalt rubber starting from 1930, the search was made between 1930 and 2018.

Navarro et al.: investigated the thermo rheological behavior of bitumens modified with 9 wt.% crumb tire rubber at in-service and handling temperatures. They concluded that the addition of ground tire rubber to bitumen increased both the linear visco-elastic modulus and the viscosity at high in-service temperatures. Additionally, the use of rubber-particle sizes less than 0.35 mm and high shear rates during manufacturing operations was highly recommended.

Cao W.: In this study has been reported that the addition of recycled tire rubber to asphalt mixtures using a dry process can improve the engineering properties of asphalt mixtures, and the rubber content has a significant effect on the performance with respect to resistance to permanent deformation and cracking.

Ching WC, et al.: In this study various comparison of different processes were made, like compared to the wet process, the dry process has been a far less popular method for crumb-rubber-modified (CRM) asphalt production. This is due to problems regarding the compatibility of mixtures. In a study investigating the effects of different sizes of crumb-rubber modifier on high-temperature susceptibility, it was concluded that by using 10% CR (by total weight of bitumen) in the wet processes, the mixtures modified with 0.15 mm CR exhibited the best effect on a dense-graded mixture, whereas mixtures modified with 0.60-mm CR exhibited the best effect on an open-graded mixture of porous asphalt.

Xiao et al.: concluded that the addition of crumb rubber was helpful in increasing the voids in mineral aggregate in Superpave mix design and improving the rutting resistance of asphalt mixtures regardless of rubber size and type.

Adhikari B et al.: Asphalt-rubber binder results from the chemical reaction of a mixture of liquid asphalt binder with 5–22% crumb rubber obtained from used tires and added to liquid asphalt. Asphalt-rubber is mixed and applied to roads mainly using either of two techniques: the dry and wet processes. In a dry process, crumb rubber is used as a part of the aggregate in the hot mixture to replace some of the solid fraction. In a wet process, crumb rubber is added to the asphalt cement mixture

3. CONCLUSION

The low cost materials or wastage to optimize the cost of road construction. Rate of increase of Tyre waste of automobiles is a big issue, so the tyre waste of automobile vehicles are easily available and shredding of rub-ber is also done in a very low cost to obtained the shredded crumb rubber. Now the aim of this study is to re-duce the scrap tyre waste by using it in bituminous mix for flexible pavement, somehow it may also reduces the today's cost of road construction. The idea behind this study is that the shredded crumb rubber is added in different proportions (10%, 15% & 20%) in a bituminous mix to prepare a Crumb Rubber Bituminous mix (CRBM). Further the strength and stability characteristics (Marshal Stability test) of this Crumb Rubber Bi-tuminous mix is determined and anlysed. Mixing temperatures of 155°C and 150°C were adopted for modified binders (CRBM) and 80/100 neat binder respectively. Five different binder contents were chosen for testing, they are 4.5, 5.0, 5.5, 6.0 & 6.5% by weight of aggregate..

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