Proceedings of the 9th International Conference on Civil Structural and Transportation Engineering (ICCSTE 2024)
Chestnut Conference Centre - University of Toronto, Toronto, Canada – June 13-15, 2024
Paper No. 161
DOI: 10.1115/iccste24.161

Impact of Ground Tire Rubber (GTR) on Asphalt Properties and Long-Term Performance

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Abstract **–** The incorporation of ground tire rubber in asphalt mixture has gained significant importance in recent years. Many researchers have realized that adding waste tire rubber into asphalt mixture can improve pavement performance and sustainability by increasing its softening point, viscosity, and flow. Using old car tires, old bicycle tires and other waste tire rubber, will reduce dumping of scrap tires. This study consists of adding ground tire rubber into bitumen as additive to improve the properties and long-term performance of pavement. Penetration testing was used to compare pure bitumen with bitumen containing ground tire rubber. The motive was to provide insights into the effectiveness of tire as a sustainable modifier for asphalt pavement. Our findings will contribute to advancing the understanding of integrating ground tire rubber into asphalt pavement, so that we shall attain more valuable information to help in developing more resilient and environmentally friendly pavements in future. Penetration testing was used to measure the depth to which a standard needle penetrates the asphalt sample to measure the softness or hardness of the bitumen. Bicycle tires were ground into powder and mixed with bitumen, to assess their performance. This finding indicated that ground tire can significantly enhance asphalt durability and sustainability, offering promising insights for the development of resilient and eco-friendly roads.

Keywords**:** Ground Tire Rubber (GTR), Asphalt, Sustainable Pavements, Penetration Test, Durability, Environmental Impact, Pavement Performance

1. Introduction

Asphalt is made up of crushed stone, gravel, sand, and bitumen. Bitumen is a sticky black by-product of petroleum that helps in keeping the aggregates together. Global concern about sustainable development goals (SDGs) coupled with reduction in the disposal of scrap tires has made many researchers in the engineering field to explore innovative materials for asphalt modification. Studies have revealed that there is approximately 4.3% increase in the yearly demand for tires [1]. Tires from waste bicycles were used for this study because it was easy to cut and ground using a bench grinder. Tires potentially improves asphalt properties and at the same time addresses environmental issues. Waste bicycle tires can easily be ground into fine rubber powder using a bench grinder and the powder from it can easily mix with bitumen. To check the presence of these additives in bitumen, a penetrometer test should be conducted. Tire rubber does not melt, and it is difficult to ignite but if it does, the fire and smoke will spread rapidly. It is preferable and environmentally friendly to grind waste tires before mixing with bitumen. The addition of ground tire rubber into bitumen enhances its rheological properties, increases its resistance to permanent deformation, and improves durability of asphalt mixture.

Key objective includes, evaluating how ground tire rubber influences critical asphalt properties such as rutting, cracking, and skid resistance. The long-term durability of pavement modified with ground tire rubber was investigated under diverse environmental conditions. Ultimately, this research aspires to provide comprehensive guidelines and best practices for incorporating ground tire rubber into asphalt pavements, thereby aiding engineers, decision-makers, and the construction industry in creating road infrastructures that are not only durable but also sustainable and cost-effective. Moreso, bicycles are widely used in Japan and there is an increase in waste tire disposal in the country. We can reuse this waste tires on our roads to reduce dumping and minimise the cost of buying new materials during road construction. It should be noted that waste car tires can also be used in this research. Our choice of tire was greatly influenced by the availability of bicycle tires and the presence of the Bench Grinder in the laboratory. It is easy to cut bicycle tires with

scissors, but car tires require more advanced techniques and bigger grinder to turn them into powder rubber that will be suitable for our experiment.

2. Materials

Bicycle tires were collected from bicycle repairer shops in nearby cities in Japan for free. A Bench Grinder was used to turn the tire into ground powder. Bitumen40/50 was used.

2.1. Bench Grinder

We used a Bench Grinder to turn the waste tire rubber into fine rubber. This machine is easy to use in grinding small seizes of tires like that of a bicycle. Safety gloves, nose mask and glasses must be worn before operation this machine. Caution should be taken not to hurt your fingers during grinding the tires manually.

Fig. 1: Bench Grinder

2.2. Standard Bitumen

40/50 standard grade bitumen was used in this study because this grade is suitable for paving roads, airports and other similar projects that require bitumen with superior properties.

Fig. 2: Standard Bitumen 40/50

2.3. Ground Bicycle tires.

Bicycle tires were collected from bicycle repairer shops and cut into smaller seizes then added it into bitumen at 170°C for both to mix but melting of the cut tires was not possible. We later decided to grind the waste rubber using a Bench Grinder shown on fig. 1 above to turn it into fine rubber tire. This fine rubber tire mixed easily with the bitumen. Waste tires should not be burnt because it emits toxic hot smoke that is not suitable for breathing and its harmful to our environment. It is advisable to grind tire rubber if we want to reuse.

Fig. 3: Ground Bicycle Tire Rubber

3. Gaps and Future Research

Further research needs to be carried out to discover other easy techniques to process large-scale applications of ground tire rubber or advanced additives and researchers need to conduct comprehensive studies to compare the long-term environmental risk with roads life cycle by using such innovative technology.

4. Methodology

The approach in this experiment was a combination of laboratory testing, and performance modelling. Penetration test was used to understand the degree of hardness when ground tire rubber is added into bitumen in different percentages.

4.1. Penetration Test.

Penetration test is a good method for classifying bitumen according to its penetration value. This test is used to measure the nature of bitumen weather it is soft bitumen (higher penetration) which are good to be used in cold weather to avoid cracking or it is hard bitumen (lower penetration) good in hot weather, to avoid it to get too soft when subjected to heating [2]. Penetration test was used in this study to verify the effect of adding rubber into bitumen. In this study, 0%,10% ,20%and 30% of rubber of the total weight of bitumen was used. It was observed that, the penetration of bitumen containing tire rubber reduced as the amount of tire rubber was increased. Mbereyaho et al. Conducted similar research using different seizes of tires (No. 16–20, No. 20–50, and No. 50–200) and observed that, the binder containing 16-20 grinded tire rubber had the highest value of penetration [3], [4]. Similarly, our experiment showed that bitumen with 0% ,10% and 20% of rubber tire had higher penetration than bitumen with 30% of added ground tire rubber. Penetration reduced as the percentage of tire rubber was increased. 30% of rubber had the lowest penetration result and 0% of rubber had the highest penetration result Fig4 below shows samples used for this test and fig 6 shows the results obtained.

Fig. 4: samples with and without rubber

Fig. 5: Penetration Test.

5. Results and Discussion

The addition of ground bicycle tire rubber in bitumen resulted to significant improvements of its hardness and deformation resistance. The modified bitumen demonstrated reduced penetration depth, giving us the idea that modified bitumen can make pavements last longer than standard bitumen without additives [5]. Visually, it was seen that bitumen with rubber tires had more air bubbles than bitumen without rubber tire. This indicated changes in material properties due to the rubber addition. In this experiment, both samples with rubber and without rubber had air bubbles but samples with rubber had more of it. To disappear the bubbles, we used a burner and heated the surface of the bitumen gently. The Penetration test results revealed that the addition of 30% ground rubber had best result. The more waste bicycle tire rubber was increased the higher the ductility of the asphalt. This result indicates that adding grinded tires into bitumen increases rutting resistance.

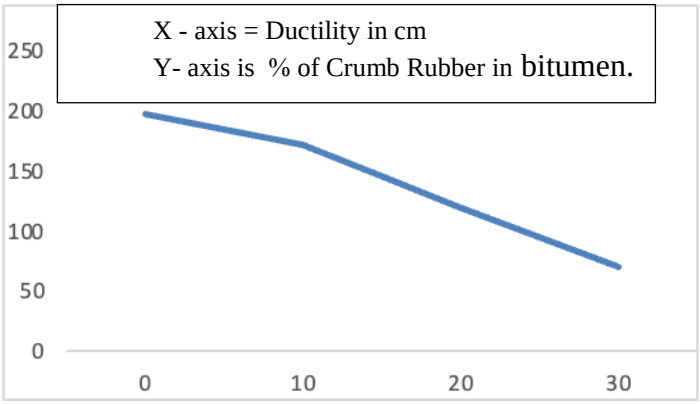

Fig. 6: Penetration Test with varying percentage of rubber

6. Conclusion

The findings of this study show that incorporating ground tire rubber into asphalt mixtures reduces penetration, ductility, and significantly enhances the durability and sustainability of pavement. This research provides valuable insights into the importance of waste tire rubber as a sustainable asphalt modifier, contributing to the development of more resilient and environmentally friendly road infrastructures. Future work should focus on further refining the integration methods and conducting long-term field evaluations to fully understand the benefits of Ground Tire Rubber - modified asphalt. We tested the addition of 0%,10%,20% and 30% of ground waste bicycle tire rubber into bitumen and the results from

Penetration test showed that 30% had lesser penetration meaning it was more resistant. This kind of bitumen is suitable in hot weather.

6. Acknowledgements

I express my heartfelt gratitude to Professor Yoshitaka Kajita of Tokai University for his exceptional supervision and guidance. I also want to thank Japan International Corporation Agency (JICA) for their invaluable support, and Mr Akira Nomoto of Gaert Laboratory, Japan, for his technical assistance during my experiment.

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