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Incorporting Tire Dust in Roadworks

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Abstract: ***In this study the changes that are incurred in the properties of bitumen upon adding scrap tire dust in it are investigated. The basic properties of bitumen are Ductility, Softening Point and Penetration Value. These values change depending on the grade of bitumen. The objective of this study is to determine the rate of change of basic bituminous properties and other key properties such as Marshall Stability and Flow Rate of Dense Bituminous Macadam due to addition of scrap tire dust in bitumen. Crumb Rubber Modified Bitumen is acquired by adding certain amount of tire dust in bitumen, in this study 10% and 30% of bitumen is replaced with scrap tire dust and their properties are compared with the properties of pure bitumen. Modifying bitumen with scrap tire dust increases the stability, flow rate, penetration value and softening point which makes it more resistant to loading and temperature. Incorporating scrap tire dust in roadworks also helps in reducing the overall volume of waste tires. Scrap tires are often a breeding place for mosquitoes as tires contain huge concentration of carbon. Burning of tires leads to even greater hazards. So, through modifying bitumen with tire dust we can prevent harm to environment and enhance the properties of Bitumen.***

Keywords: Discarded Truck Tires, scrap tire dust, reusing waste tires instead of burning, enhancing properties of bitumen, Crumb Rubber Modified Bitumen

I. INTRODUCTION

In India, bituminous roads are preferred form most part of the vast road network. The roads should last for as long as possible as redoing the entire network of roads in shorter intervals would lead to consumption of more and more materials. On the other hand, discarded truck and car tires are an accumulating problem that need to be addressed before they impact the environment. Tires in general are concentrated with carbon and they emit harmful gases such as Carbon monoxide when burned which causes lung diseases. In order to prevent the burning of tires they can be grinded into dust and be incorporated in road works which strengthens the road. In this study the properties of bitumen are investigated after adding the scrap tire dust in 10 and 30 percentages and their results are compared with pure bitumen test results. This allows us to determine the credibility of Crumb Rubber modified bitumen in Indian Road Works.

II. DISCARDED TIRES AND THEIR IMPACT ON ENVIRONMENT

Vehicle Tires are primarily made of Natural Rubber which is concentrated with carbon and Burning of worn out tires produces harmful gases such as Carbon Monoxide (CO), Nitric oxide (NO) and Sulphur Dioxide (SO2). All these gases are liable to cause lung cancer and various respiratory problems to both humans and cattle. Unlike plastic there aren't many ways to recycle rubber tires. So, in order to control the increasing number of discarded tires necessary measures should be taken to reduce their volume. One way to reduce the volume of discarded tires is to grind them into dust by using heavy machinery. The rubber tire dust which is produced by grinding scrap tires is called as Crumb Rubber Dust and it can be used to enhance the properties of bitumen and make pavement surface stronger.

III. METHODOLOGY

1) *Materials Required:* Scrap Tire Dust and Bitumen. Lab apparatus such as Softening Point test apparatus (Beaker, water heater brass ring & steel ball), Ductility test apparatus (ductility testing machine and brass ductility moulds) and Penetration test apparatus (penetrometer and canisters) are also required.
2) *Making of Crumb Rubber Modified Bitumen (CRMB):* The wet process of making CRMB is used in this paper. In order to make CRMB by wet process, rubber dust of required proportion is directly added to bitumen and they are heated. In this test 10%CRMB and 30%CRMB are made, which means 10 grams of 100 grams of bitumen is replaced with tire dust and 30 grams of 100 grams of bitumen is replaced with tire dust. Both are done by wet process of making CRMB.

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3) *Properties of Aggregate:* In order to determine the flow rate and stability of Dense Bituminous Macadam (DBM) should be casted. In order to cast DBMs, optimum content of bitumen should be added to the coarse aggregate. The properties of aggregate used in casting DBM such as Abrasion, Impact Value and Specific Gravity should be known. These properties are also determined by conducting experimental tests. The tests on aggregate to determine their properties were conducted as per IS:2386 part-4.

4) *Tests on Bitumen:*

a) Softening Point Test:

- Aim: To determine the softening point of bitumen sample
- Apparatus: Beaker, Steel ball, Brass Ring to contain bitumen sample, water-bath and thermometer
- Procedure: The beaker is filled with water and the brass ring is placed in the softening point apparatus which is submerged in the beaker. Once the power is turned on the water starts heating and the steel balls which is placed on top of the brass ring with sample slowly starts to soften and drop on the metal plate that is 0.5cm below the ring. A thermometer is also placed in the beaker to note the temperature of the boiling water. The temperature at which the softened bitumen sample touches the bottom plate of the apparatus is recorded. This point is called as the softening point of bitumen. Note that the experiment should be repeated at least 2 times for final value.

b) Ductility Test:

- Aim: To determine the ductility of bitumen sample
- Apparatus: Ductility Testing Machine, Ductility Moulds made of brass, Glycerin
- Procedure: The ductility moulds are washed with glycerin to prevent sticking of bitumen. After that hot bitumen (or CRMB) is poured into the mould. Note that the temperature for heating bitumen should not exceed 170˚C. After 30 minutes the mould with sample are put in a water-bath for 24 hours. Finally, the moulds are put in the ductility testing machine and the experiment is started. The distance at which the sample separates into two is recorded. This length is known as ductility of bitumen. Note that the average of three values is noted as the final reading.

c) Penetration Test:

- Aim: To determine the penetration value of bitumen sample.
- Apparatus: Penetrometer, Steel Canisters to hold 100 grams of bitumen sample
- Procedure: 100 grams of hot bitumen is firstly filled into steel canisters. These canisters are put in water bath such that the water level is up to the brim of the canister but does not pour into it. After a while the canister is ready for testing and it is placed under the penetrometer. The penetration needle is released into the sample and retracted back after 5 seconds. The reading on the dial of penetrometer is noted and the same process is repeated at 10mm away from the initial penetration point at least two more times. The average penetration value of all three points is considered as the penetration value of the sample. Note that the three points at which the readings are recorded should form a triangle in the canister.

d) Marshall Stability Test:

- Aim: to determine the stability(KN) and flow-rate(mm) of DBM made with aggregate and bitumen.
- Apparatus: Marshall Apparatus, Cylindrical mould of 7.5cm height and 10cm diameter, collar, compaction pedestal, breaking head, weighing machine and Sample Extractor
- Procedure: Firstly, optimum bitumen content should be weighed and the required proportion of tire dust should be added (if testing for CRMB). 1200 grams of hot aggregate (170˚C) should be added to hot bitumen (160˚C) and mixed. Then the mixture (also known as DBM mix) should be poured into the cylindrical mould which is readily fitted to the compaction pedestal. 75 blows are given on each side of the mould and it is left to dry for 1 day. Then the DBM is extracted from the cylindrical mould using bitumen extractor. Finally, the acquired DBM is placed in the breaking head and tested in the Marshall apparatus for stability and flow rate. NOTE that three DBM moulds are to be casted and their average stability and flow rate are to be considered.

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IV. ANALYSIS AND RESULTS

1) Properties of Aggregate:

After conducting Los Angele's Abrasion test, Impact Value test and Specific Gravity test on Aggregate as per IS:2386 part-4 their results are observed to be 23.83%, 17.03% and 2.54 respectively. All the acquired results on aggregate tests satisfy the requirements of aggregate in pavement surface as per IS:2386 part-4.

2) Tests on Bitumen:

a) Softening Point Test:

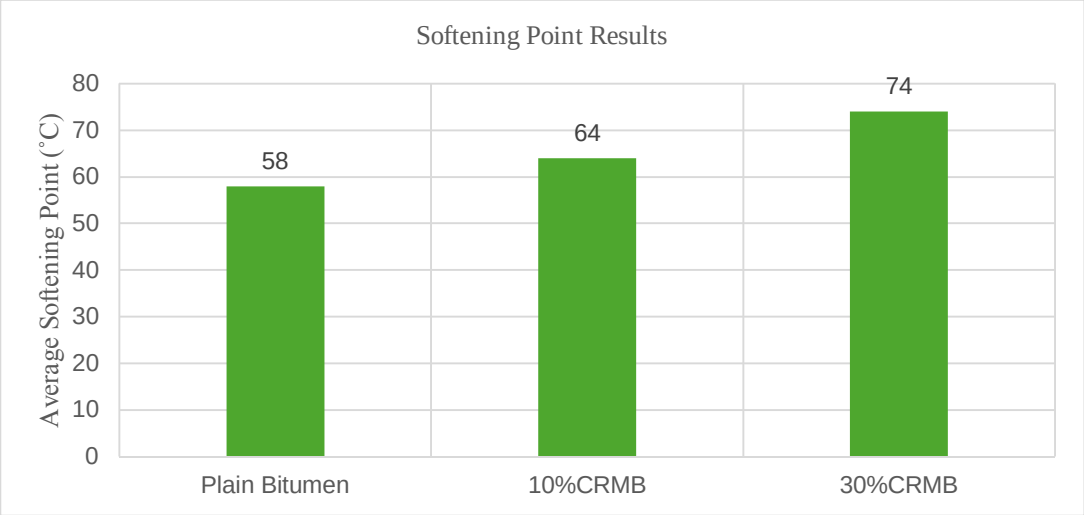


Figure 1: Results for Softening Point test on Pure Bitumen, 10%CRMB and 30%CRMB

In this study, the softening point test results of pure bitumen, 10%CRMB and 30%CRMB are observed to be 58˚C, 64˚C and 74˚C respectively. This indicates that the softening point of bitumen increases with the increase in Tire Dust addition.

b) Ductility Test:

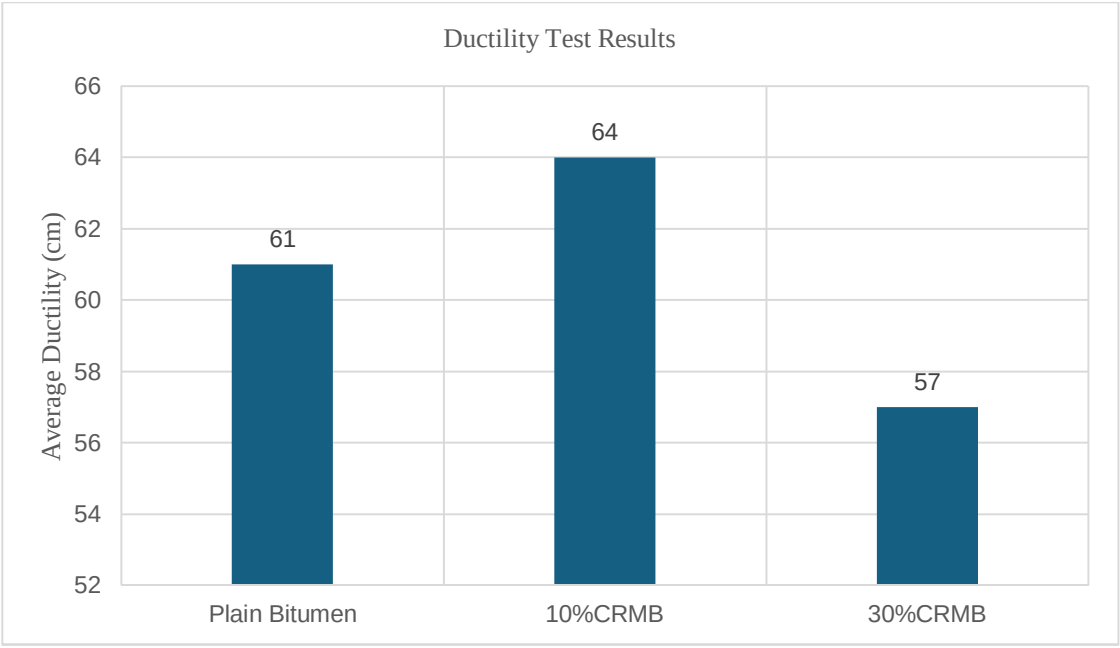


Figure 2: Results for Ductility Test on Pure Bitumen, 10%CRMB and 20%CRMB

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In this study, the ductility test results of pure bitumen, 10%CRMB and 30%CRMB are observed to be 61cm, 64cm and 57cm respectively. This indicates that the excess addition of rubber dust leads to decrease in ductility. 10%CRMB displayed the highest ductility value.

c) Penetration Value:

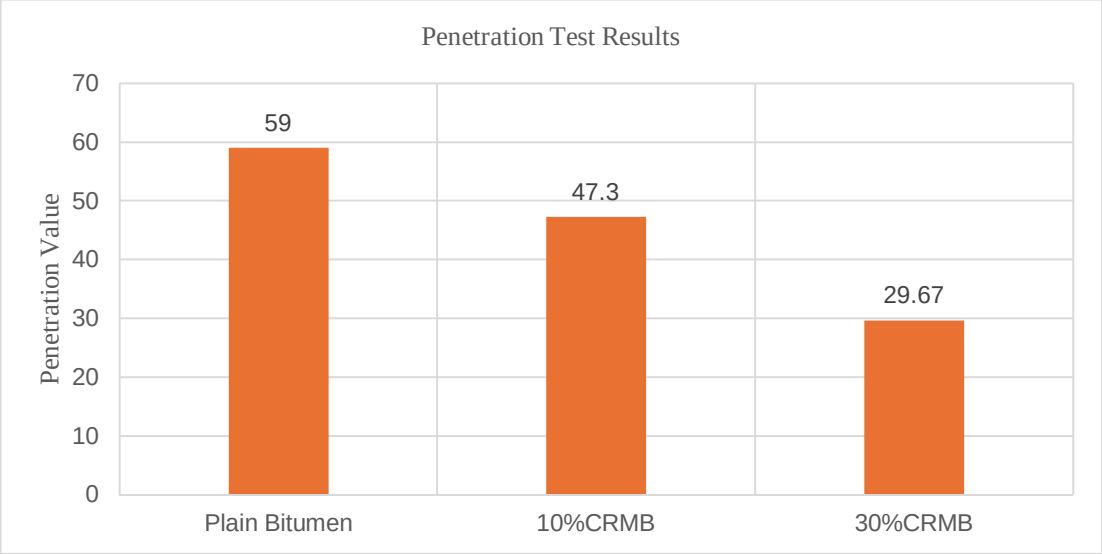


Figure 3: Results for Penetration Test on Pure Bitumen, 10%CRMB and 30%CRMB

In this study, the penetration test results of pure bitumen, 10%CRMB and 30%CRMB are observed to be 5.9mm, 47.3mm and 2.67mm respectively. The penetration Value of bitumen is observed to improve with addition of scrap tire dust in bitumen. This indicates that road deformations are less likely to occur.

3) Marshall test:

a) Stability:

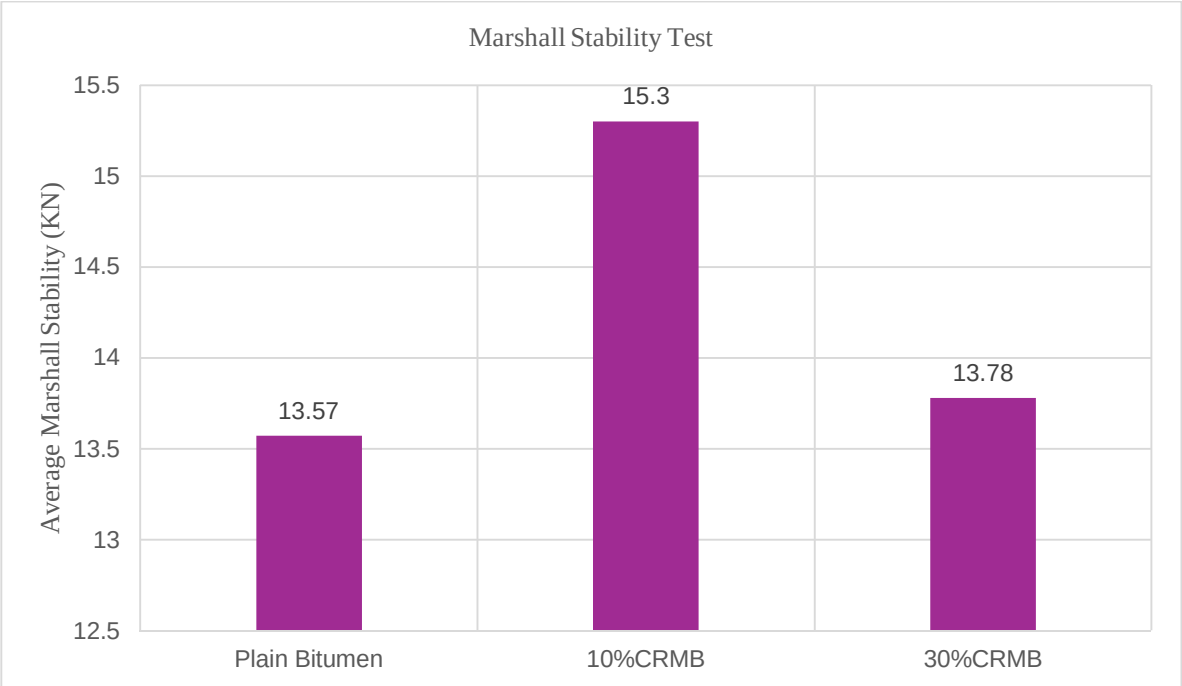


Figure 4: Results for Average Marshall Stability in DBM samples

In this study, the penetration test results of pure bitumen, 10%CRMB and 30%CRMB are observed to be 13.57KN, 15.3KN and 13.78KN respectively. A sharp rise in stability is observed for 10%CRMB. However, upon adding 30% tire dust in bitumen the stability reverted back to plain bitumen's stability.

b) Flow Rate:

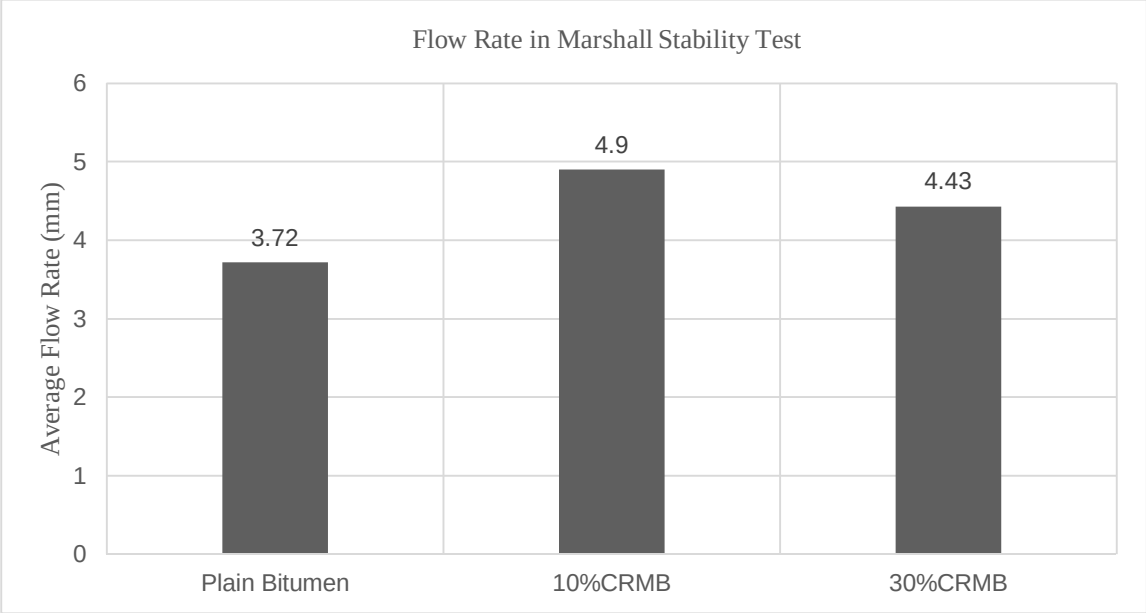


Figure 5: Results for Average Flow rate in DBM samples

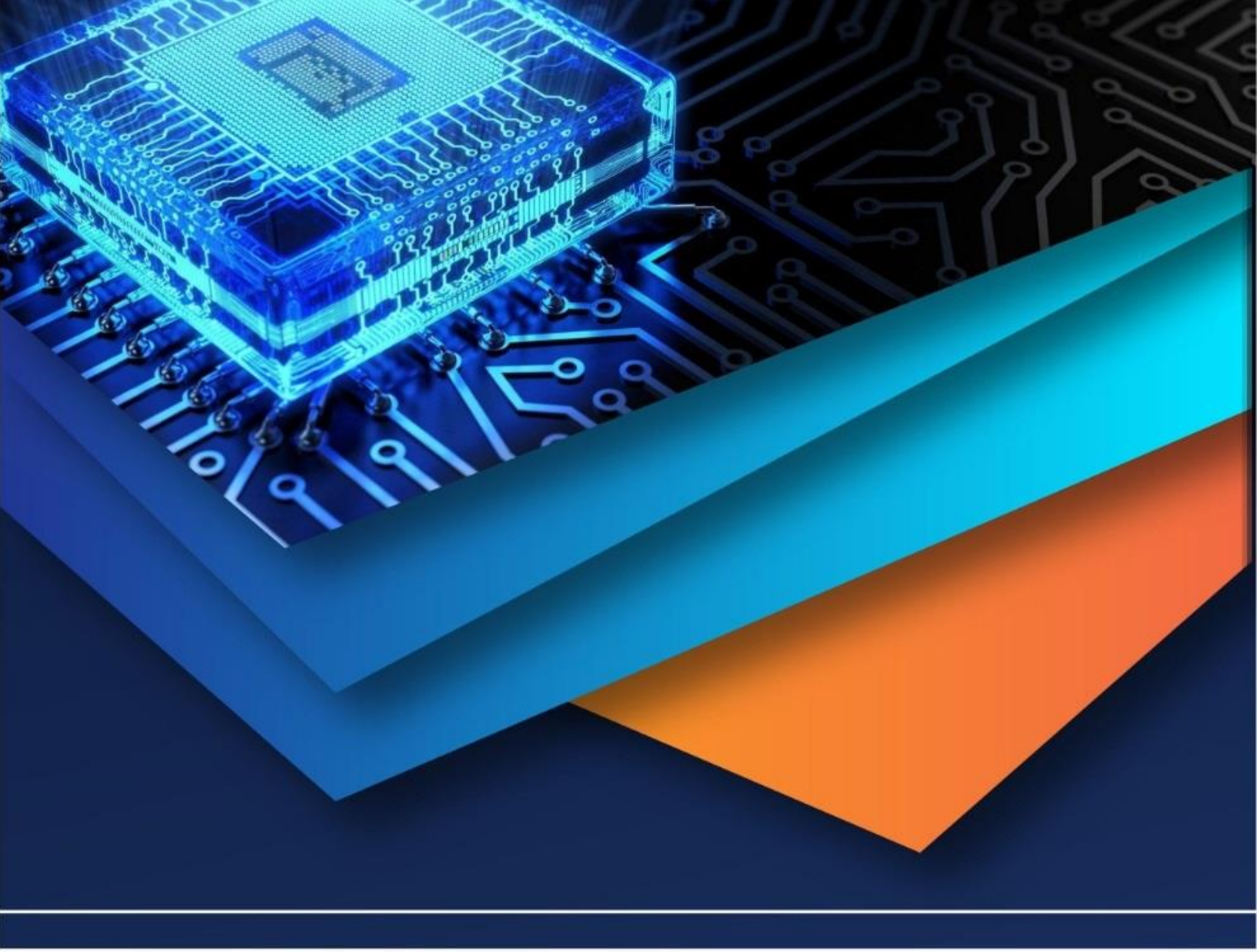
V. CONCLUSION

Based on the observations of the above test results we can conclude that incorporating scrap tire dust in bitumen will enhance the properties of bitumen and make it more durable towards temperature and loads. Crumb rubber modified bitumen has potential for further investigation and can be used in Indian roadworks. It is observed to be more durable than pure bitumen and can enhance the roadways of India. Road deformations such as rutting and cracking are unlikely to occur. Incorporating CRMB in roadworks allows us to consume the abundant waste tires that keep increasing on a daily basis and prevent many environmental hazards.

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