

# Performance tests on Waste Crumb rubber and bitumen used in Bitumen mix for the application of flexible pavement

Mr. Pruthvi Raj SR<sup>1</sup>, Mr. Raghavendra S<sup>2</sup>, Mr. Maruthi T<sup>3</sup>

<sup>1,2,3</sup>PG Students, Department of Civil Engineering, U B D T College of Engineering, Davangere, Karnataka, India.

\*\*\*

**Abstract** - The pavement surface in rural area should be strong enough to withstand the heavy loads applied on it. The rough surfaced wheel like bullock carts are travelled on the surface therefore the pavement should be strong enough to avoid the cracks so we have to improve the property of the bitumen to increase the strength of the pavement. The durability of the road surfaces depends largely on the type and quality of bitumen used. Rubber modified bitumen uses stress absorbing membrane that reduce the reflective cracking because of its elastic properties. With fewer cracks there are fewer repairs, so crumb rubber assisting in reducing maintenance cost. Thus the pavement construction with rubber bitumen has long lifespan. The presented article gives special attention to the use of waste crumb rubber for the bituminous mixture and analysis of its stability parameters by making it in to wet mix and dry mix for the flexible pavement into consideration. All the necessary tests are carried as per on IS: 2386 (part IV)-1963. MORT&H (IV-revision) Specifications.

- To study the effect of waste crumb rubber strength and stability characteristics in Bituminous mix
- To analyze the stability of rubber bituminous mix.

### 3. MATERIALS

**3.1. Crumb rubber:** Crumb rubber is actually small pieces of waste tire scrapped from light motor vehicles and whose disposal is a serious menace. The annual available capacity for procured tires retreading is 4.8 million for bus and truck tires and 4.5 million for car and jeep tires. The crumb rubber is made by shredding scrap tire, which is a particular material free of fibre and steel. The rubber particle is graded and found in many sizes and shapes. The crumb rubber is described or measured by the mesh screen or sieve size through which it passes during the production process. To produce crumb rubber, generally, it is important to reduce the size of the tyres.

**Key Words:** Waste Crumb Rubble, Bitumen, Stability.

### 1. INTRODUCTION

Roadways are considered one of the most important elements of infrastructure and they play an essential role in our daily lives. In road pavement construction, the use of crumb rubber in the modification of bitumen binder is considered as a smart solution for sustainable development by reusing waste materials. And since the abundance and increase of waste tyre disposal is a serious problem that leads to environmental pollution. Crumb rubber obtained from shredding of those scrap tires has been proven to enhance the properties of plain bitumen since the 1840s. It can be used as a cheap and environmentally friendly modification process to minimize the damage of pavement due to increase in service traffic density, axle loading and low maintenance services which has deteriorated and subjected road structures to failure more rapidly. Use of crumb rubber leads to excellent pavement life, driving comfort and low maintenance.

### 2. OBJECTIVES

The major objective of the project is to reduce bitumen content in the mixture, increase bond strength, increase lifespan and reduce the disposal of waste tires. Some of the relative objectives are:

- To study the strength & stability characteristics of bituminous mix for 60/70 grade bitumen.

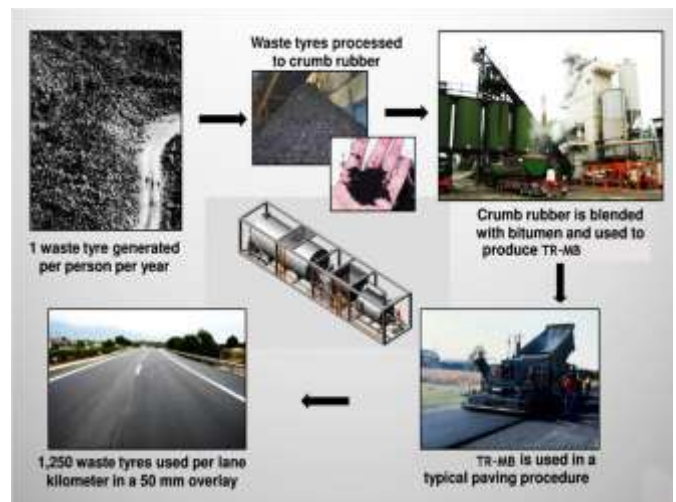


Fig: Crumb rubber production

The possible of this material should be developed for construction of low volume roads in different parts of our country. The necessary specifications should formulate and attempts are to make to maximize the use of waste materials in different layers of the road pavement.

Crumb rubber is brought from tires factory in Harihar. It is in the form of black granules and is recycled from used tiers. Crumb rubber is the recycled rubber obtained by mechanical shredding or grinding of tires into small coarse crumb rubber. Tires are composed of several different types of rubber compounds. The major variations are in the synthetic rubber content, natural rubber content, total

rubber hydrocarbon content, and acetone extractable. Ash and carbon black contents are typically similar for different tire rubber compounds.



Crumb rubber and their environmental considerations

Despite the potential uses, approximately 300 million scrap tires are generated annually only in United States, and about 13% of which are discarded in landfills. Europe produced 355 million tires every year, and millions of used tires are illegally dumped or stockpiled. The inadequate disposal of tires could be a potential threat to human health and increase environmental risks. Fortunately, nowadays, waste tires are used for several purposes in civil engineering.

Around 200,000 tons of end-of-life tires (EOL) were collected from all Spanish territory in 2010 for reuse, recycling and energy recovery purposes. In this research work, Crumb Rubber Modified Binder (CRMB) employed in bituminous mixtures uses end-of-life tires, thus, this type of wearing courses could be a profitable use for these waste materials. The use of rubber powder on pavements is justified because it produces benefits in bituminous mixtures. Temperature susceptibility and resistance to permanent deformation are improved by the addition of crumb rubber, since elasticity is increased at operating temperatures of the mixes. Also, asphalt rubber pavements have been demonstrated to have lower maintenance costs, higher skid resistance and better night-time visibility. On the other hand, crumb rubber modified asphalt mixes could assume negative environmental effects. These types of mixtures require a higher temperature to blend, thus, potentially increasing the hazardous emissions in hot-mix plants. Furthermore, crumb rubber asphalt concrete leachates contain organic and metallic contaminants, which are moderately toxic. However, the influence of the contamination is limited since the contaminants are degraded in their transport through nearby soils and ground waters. In short: crumb rubber in bituminous mixtures could not be a panacea, but it prevents the accumulation of tires in landfills. According to the total weight of end-of-life tires collected from all Spanish territory.

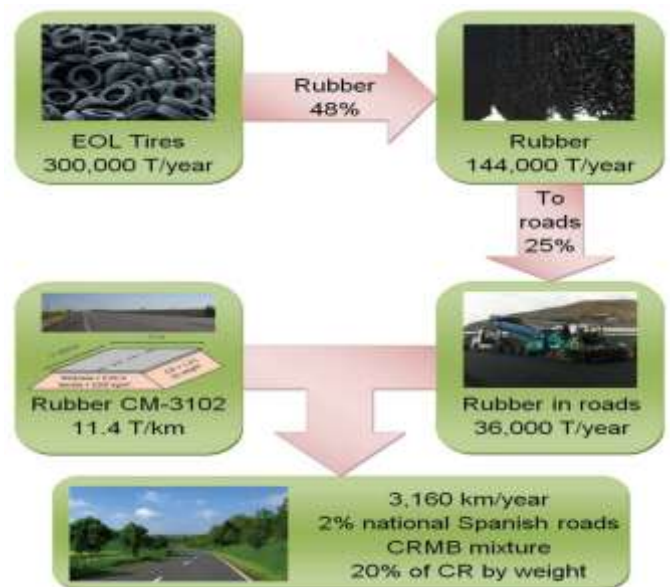


Fig -1: Name of the figure

Annual total length of roads of a gap graded mix with high content of crumb rubber.

3.2. Bitumen:

Bitumen is commonly used binder for flexible road construction. Different grades of bitumen like 30/40, 60/70 and 80/100 are available based on their penetration values. The steady increase in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal, demands improved road characteristics. Any improvement in the property of the binder is the need. The selected bitumen penetration grade for this study is 60/70 usually used as a Paving Grade Bitumen suitable for construction of flexible pavements with superior properties. The bitumen is obtained from a construction site near Ram and co circle.



Fig: Bitumen

4. COLLECTION OF CRUMB RUBBER

Crumb rubber is actually small pieces of waste tire scrapped from light motor vehicles and whose disposal is a serious menace. Crumb rubber is brought from tires factory in Harihar. It is in the form of black granules and is recycled

from used tires. Crumb rubber is the recycled rubber obtained by mechanical shredding or grinding of tires into small coarse crumb rubber. Tires are composed of several different types of rubber compounds. The major variations are in the synthetic rubber content, natural rubber content, total rubber hydrocarbon content, and acetone extractable.

## 5. TYPES OF BITUMEN

When the Bitumen contains some inert materials or minerals, it sometimes called Asphalt. Asphalt found as deposits in the form of natural asphalt or rock asphalt.

- **Cut back Bitumen:** It defined as the bitumen, the viscosity of which has reduced by volatile diluents. A suitable solvent mixed to reduce viscosity.
- **Bitumen Emulsion:** Bitumen suspended in finely divided condition in aqueous medium 60% bitumen and 40% water.
- **Bituminous Primers:** Mixing of penetration bitumen with petroleum distillate.
- **Modified Bitumen:** Blend of bitumen with waste plastics or crumb rubber.

### 5.1. Advantages and Disadvantages of bitumen

The following are some of the advantages of the bitumen.

- **Cohesive Property:** Good cohesive and adhesive property.
- **Repellent Property:** Water repellent property.
- **Nature:** It is its thermoplastic nature (stiff when cold, liquid when hot), that makes bitumen so useful.

The following are some of the disadvantages of the bitumen:

- **Temperature Effect:** At high temperature, bleeding of road occur reducing performance of road.
- **Oxidation Effect:** Due to oxidation bitumen may led to cracking & crazing phenomenon.
- **Water Effect:** Due to water, bitumen strips off from the aggregate forming pothole on roads as being water repellent material and reduces life of roads.
- **High Cost:** Being petroleum product it costs much higher.

## 6. TESTS ON BITUMEN

### 1. Specific gravity test

The density of a bitumen binder is a fundamental property frequently used as an aid in classifying the binders for use in paving jobs. The specific gravity is greatly influenced by the chemical composition of binder. The specific gravity is define by ISI as the ratio of the mass of a given volume of the bituminous material to the mass of an equal volume of water, the temperature of both being specified at 27°C ±0.1°C. The specific gravity test is conducted based on IS: 1202-1980.

### 2. Penetration index test

The consistency of the bitumen is determined by penetration test which is a very simply test. The penetration test determines the consistency of bituminous materials for the purpose of grading them, by measuring the depth to which a standard needle will penetrate vertically under specified condition of standard load, duration and temperature. The penetration test is conducted based on IS: 1203-1978

### 3. Softening point test

This test conducted using Ring and ball apparatus. The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test. Bitumen suddenly does not change from solid to liquid state, but as temperature increases, it gradually becomes softer until it flows readily. The temperature at which substance attains a particular degree of softening under specified condition of test is called softening point. The softening point testis conducted based on IS: 1205-1978.

### 4. Ductility index test

The ductility of a bituminous material measured by the distance in cm to which it will elongate before breaking when a standard briquette specimen of the material is pulled apart at a specified speed and a specified temperature. The ductility test is conducted based on IS: 1208-1979

### 5. Flash and Fire point test

Flash and fire point test is a safety test conducted on a bituminous material so that it gives an indication of the critical temperature at and above where precaution should be taken to eliminate fire hazards during its applications.

Flash point of a material is the lowest temperature at which the vapor of substance momentarily takes fire in the form of a flash under specified conditions of test. Fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test. Flash and Fire point test is conducted based on IS: 1209-1981.

### 6. Viscosity Test

Viscosity is defined as inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. The degree of fluidity at the application of temperature greatly influences the ability of bituminous material to spread, penetrate in to the voids and also coat the aggregates and hence affects the strength characteristics of the resulting paving mixes. Viscosity test is conducted based on IS: 1206-1978.



S l	Name of test	Requirement as per IS: 73-2006	As per test
	Characteristics	Grade 60/70	-----
1	Specific Gravity	0.98-1.3	1.01
2	Penetration test	80-100	85
3	Softening point °C	Should be minimum 47 ° C	53.5° C
	Flash point ° C	Should be minimum 220 ° C	160 ° C
5	Fire Point	<260	210 O C
6	Ductility @ 27 °C	Should be minimum 75 cm	105 cm.
7	Viscosity Test	.....	120sec onds

Table: Test results on bitumen

### 6.1. Marshall Stability test:

The Marshall stability testing machine has strain controlled loading unit to move the base plate at the rate of 51mm per minute. The test head and dial gauge is set to measure the vertical deformation of the specimen during loading as shown in the Fig. No.4.4.



### 6.2. Modification of Rubber Bituminous mix

Modification of Bitumen is done by two ways, they are;

1. Wet mix process
2. Dry mix process

#### Wet mix process

Waste tire is ground and made into powder, about 10%, 15%, 20% and 30% mixed with bitumen. Crumb rubber increases the melting point of bitumen and makes the road retain its flexibility during winter resulting in its long life. By mixing rubber with bitumen the ability of the bitumen to with stand

high temperature increases. The rubber waste melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5° C but when Rubber is mixed, it remains stable even at 55°C. The vigorous tests at the laboratory level proved that the bituminous concrete mixes prepared using the treated bitumen binder fulfilled all the specified Marshall mix design criteria for surface course of road pavement. There was a substantial increase in Marshall stability value of the mix, of the order 1 to 2 times higher value in comparison with untreated or ordinary bitumen. Another important observation was that the bituminous mixes prepared using the treated binder could with stand the adverse soaking conditions under water for longer duration.

#### Dry mix process

For the flexible pavement, hot stone aggregate (170°C) mixed with rubber powder in proportion like 2.5%, 5%, 7.5% etc., and then blended with hot bitumen (160°C) and the mix used for road laying. The aggregate is chosen based on its strength, porosity and moisture absorption capacity as per IS coding. The bitumen chosen based on its binding property, penetration value and its elastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness. The coating of rubber decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement. It is to note here that stones with less than 2% porosity only allowed by the specification.

### 7. ADVANTAGES AND DISADVANTAGES OF CRUMB RUBBER BITUMINOUS MIX

#### Advantages

The advantages of modified bitumen can include one or more of the following for road works.

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

### Disadvantages

- The Burning of crumb rubber creates health hazards and also air pollution some precautions should be taken while conducting this process.
- Toxics present in the co-mingled rubber will start leaching.
- It is opined that first rain will trigger the leaching. As the rubber constituent in the pavement will merely form sticky layer.

### 8. CONCLUSIONS

The properties of bitumen such as softening point, flash point, fire point increases with addition of the waste Crumb rubber. Ductility value decreases with increase in percentage of modifier. The optimum dose of the fiber found to be 10 percent based on performance grade 60/70. From the Marshall Test results, it is concluded that the Marshall Stability value increases up to 5%, then on increase in bitumen content Marshall Stability value decreases. So the optimum binder content found to be 5%. From an environmental and economic stand point, the use of waste Rubber, as a bitumen-modifying agent may contribute to solving a waste disposal problem and to improving the quality of pavements.

The properties of bitumen can be enhanced by adding small amounts of the modifier called Crumb rubber. Therefore, modified bituminous mix can bring real benefits to highway construction, maintenance, in terms of better and longer lasting roads, and savings in total road life costing.

### 9. ACKNOWLEDGMENTS

We are grateful to our beloved Principal Dr. K S SRIDHAR, who always been thriving for enhancement and excellence for collage, department facilities and student welfare which a student desires.

We deeply indebted to Head of the Dept. DR. K. KRISHNEGOWDA and PG Coordinator Dr.H R PRABAKARA for his moral support and encouragement.

### 10. REFERENCES

- [1] Angela Farina, Mariachiara Zanett, Ezio Santagata, Gianandrea Blengini and Michele Lanotte, "Life Cycle Assessment Of Road Pavements Containing Crumb Rubber From End-Of-Life Tires".
- [2] Athira R Prasad and Dr Sowmya N J, "Bituminous Modification with Waste Plastic and Crumb Rubber" IOSR Journal of Mechanical and Civil Engineering, Volume 12, Issue 3, May - Jun. 2015, PP 108-115.
- [3] Bala Raju Teppala, Prof. C.B. Mishra , Dinesh Kumar, "Experimental Assessment of Properties of Crumb Rubber

Modified Bitumen Mix With and Without Application of Nano-technology Additive", Vol. 3, Issue 10, October 2014.

[4] Mohammed Islamuddin Faraz, Utkars Jain, "Effect of Crumb Rubber Material on Concrete Mix", SSRG International Journal of Civil Engineering – volume 2 Issue 4 April 2015.

[5] Mohammed H. Al-maamori, Muntadher Mohammed Hussen, "Use Of Crumb Rubber As A Way To Improve Performance Grade For Asphalt Cement", Vol. 5 No. 1 January 2014. RYRYRFHvVVVVol5 No. 1L: 2223-9553, ISSN: 2223-9944

[6] Nabin Rana Magar, "A Study On the Performance of Crumb Rubber", International Journal of Engineering Trends and Technology (IJETT) – Volume 14 Number 2 – Aug 2014.

[7] Niraj D. Bariya, "Use of Waste Rubber Tyres in Construction of Bituminous Road – An Overview", International Journal of Application or Innovation in Engineering & Management (IJAEM) Volume 2, Issue 7, July 2013.

[8] Nuha S. Mashaan, Asim Hassan Ali, "An overview of crumb rubber modified asphalt", International Journal of the Physical Sciences Vol. 7(2), pp. 166 - 170, 9 January, 2012.

[9] S. Shankar and C.S.R.K, "Prasad Evaluation of Rutting Potential for Crumb Rubber Modified bitumen in Asphaltic mixes", National Institute of Technology, Transportation Division, Department of Civil Engineering, 2009.