Modification of Asphalt By Rubber Crumbs

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Abstract

Health aspects enforced to ponder a study on asphalt which incorporate rubber crumbs to increase strength and flexibility of asphalt. Disposal of waste tires is a menace and it's a serious problem globally because it is not easily biodegradable as these tires consume large spaces, open burning cause serious problems. By the use of rubber tires, this scrap is utilized efficiently and reduces the cost of asphalt to produce economical system. The asphalt is absorbed by the rubber particles which swells at high temperature allowing greater concentration of liquid asphalt. The partial replacement of crumb rubber in asphalt is 5%, 10%, 15% and 20% (D_{05}, D_{10}, D_{15}, D_{20}). The analysis of incorporated asphalt was done in hot mix asphalt. The generated results showed that the value for resilient modulus and creep stiffness is more as compared to the conventional asphalt and in the accumulated strain the values are much lesser which is a positive approach.

Keywords: Biodegradable, Liquid Asphalt, Conventional Asphalt

1. INTRODUCTION

The disposal of waste material is one of the most serious environmental concerns globally. There is no difference of opinion that the increasing piles of tires are creating environmental issues. For that matter there must be a way to dispose-off these tires. These tires have potential risks to environment and health. As far as their disposal is concerned landfill disposal is problematic or undesirable because it consumes

large amount of valuable space as the rubber tires are not easily biodegradable as their decomposition time is indeterminate [1]. It is for this reason that tires have been banned from disposal in landfills in the European Union [2]. Open air burning is risk to health because it's an uncontrolled process and contains hazards level of chemicals such as carbon monoxide, polycyclic aromatic hydrocarbons and difficult to extinguish, and clean up. After this process, organic compounds rest in the soil and can cause environmental issues including soil, air and water pollution. There are various ways to get rid from these tires and utilization of these wastes material for the purpose of benefit as well as the reduction of environmental pollution. Recycled rubber is defined as recyclable, vulcanized rubber that has been processed to give particulates or other forms of different shapes, and size distributions [3]. By the use of this crumbs of rubber flexibility and strength of asphalt increases. Asphalt-Rubber is a blend of asphalt cement, reclaimed tire rubber and certain additives where the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles [4].

Recycling is phenomenon in which wastes materials are used in raw form either fully or partially for the manufacturing of the required products. Asphalt is sensitive to temperature variations, in hot summer days softening of asphalt takes place because of that rutting and surface deformation produces. Asphalt acts as a brittle material in cold temperature and subjected to tensile thermal cracking. There are various methods for the modification of asphalt like air blowing, flux oil, crumb rubber derived from scrap tires etc. [5]. The purpose of crumb rubber is not only to utilize the scrap tires rather these tires have also good engineering properties like resistance to freeze and thaw and reduces cracking. Modification of this asphalt by the use of crumbed rubber will be more temperature stable, increases asphalt film thickness and reduces the cost as well.

Early studies pertaining to the use of scrap tires started in the mid of 1980's after a number of major stockpiles fire [6]. Engineers all around the world tried to incorporate the use of rubber tires in asphalt since the 1950's.Until 1960's the discovered formulation was unsuccessful, Charles H. MacDonald was first thought of asphalt rubber. Hanson in 1984 performed different experiments involved incorporation of natural rubber with bitumen. While in late 1960's MacDonald and co-workers developed results in terms of performance enhancement. This so called wet process was developed by McDonald with 14-20wt. % ambient ground tire rubber swallowed to asphalt and after mixing at 175-220℃ for 45 minutes. For the sake of increment of workability the gel was added some aromatic kerosene fraction. 20% more liquid asphalt is required rather than used in a conventional hot mix pavement but in some other cases 40-60% more asphalt is used which accounts for the increase in cost and performance [7]. In the late 1980's, scrap rubber in asphalt cement was suggested as a solution to this environment solid waste problem. In asphalt cement, the use of scrap tire rubber as an additive over the past 25 years [8].

2. Research Objective

The main objective of the research project is to use asphalt with crumb rubber that provides flexibility and strength to asphalt. The use of crumb rubber was 5%, 10%, 15% and20% and represented as D_{05}, D_{10}, D_{15} and D_{20} respectively. Where D denotes the asphalt mixture and subscript designates the percentage.

3. Experimental investigation

3.1 Selection of materials

There is a broad category of course particulate material used in construction as in asphalt concrete. Aggregate selection is important for the construction of pavement. The aggregates were taken from

Sargodha pull-111 quarry (Mughal crusher). The gradation of fine and coarse aggregate is according to National Highway Authority (NHA) class-A gradation.

1. Sieve Analysis

It is the practice to access the particle size distribution (gradation) of granular material. The gradation of fine and coarse aggregate is according to NHA class-A gradation is given in Table-1.

Table-1: Aggregate Gradation of NHA Class- A

Sr. No.	Sieve Sizes mm(inch)	JMF Limits (%age Passing)	Blend Grading (%age Passing)
1	19 mm (3/4 inch)	100	100
2	12.67mm (1/2 inch)	75-89	77.5
3	9.5mm (3/8 inch)	66-77	68.1
4	4.75mm (No.4)	41-55	53.4
5	2.36mm (No.8)	22-30	28.2
6	0.3mm (No.50)	6-14	10.7
7	0.075mm (No.200)	4.6-6.6	5.7

3.2 Sample preparation

The step after selection and sieve analysis according to NHA is to prepare sample 15 conventional sample were prepared without crumb rubber. There are two important steps for sample preparation. One is mixing and other is Marshall Compactor. The crumb of size ranging from 0.60 mm to 0.75 mm heated at 150℃. Bitumen get heated at 150℃ and then crumb rubber partially replaced at a rate of 5%, 10%, 15% and 20% by mass with the wet process at a low speed for % minutes. In mixing all aggregates were mixed in a correct proportion and temperature and after pouring in a clean container place it in the stove for heating (140̊ C). That was all in the first step, while in the next step i.e. (Marshall Compactor) usually bituminous concrete mix is designed. The test is extensively used in routine test program for paving. This test tries to achieve the optimum binder content for traffic intensity and aggregate mix type. When the sample is compacted from the Marshall Compactor test it was taken out from the mould and before going to Marshall Stability test it was placed for water bath at a maintained temperature of 60̊ C for 30-40minutes as shown in Fig-I.Graphical representation of the stability of the conventional sample and %age of bitumen illustrated in Fig-II. Facts revealed that the optimum bitumen content (OBC) of the conventional sample is 4.5%.

Fig-I Sample preparation and heating

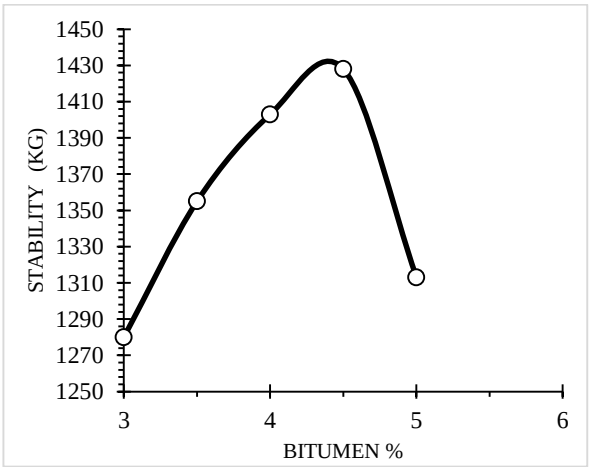

Fig II: Stability ~ Bitumen

4. Results and Discussions

Marshall Stability test was performed on the Hot Mix Asphalt (HMA) to analyze the resistance to plastic flow resistance bituminous cylindrical specimens and universal testing machine designed to transmit energy to the HMA specimens using high pressure air acting on double sided piston (actuator)**.**

4.1 Marshall Stability Test

This test was done to find the Marshall stability of bituminous mixture as per ASTM D 1559. To acquire the results for Marshall Stability of bituminous mixture, we used Marshall Stability apparatus, balance and water bath. The test was performed on all mixes of HMA as shown in Table2 which shows the results of stability of the conventional sample and %age of bitumen.

Table-2: Stability of the conventional sample

Bitumen (%age)	Stability (kg)
3	1280
3.5	1355
4	1403
4.5	1428
5	1313

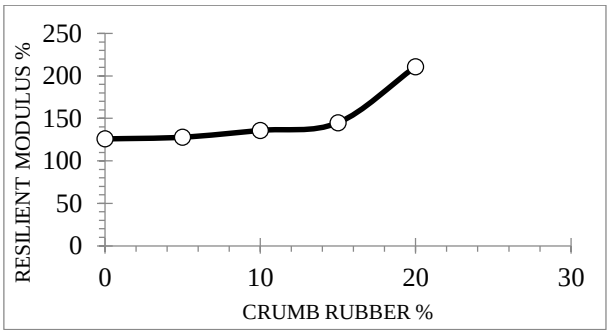

Figure 3: Resilient Modulus ~ Crumb Rubber

4.2 Compressive Strength

Almost all over the world, the most important property which has to be achieved is compressive strength. While, in this case the Universal Testing Machine (UTM) was used to determine the compressive strength of conventional samples. Repeated load uniaxial strain test was performed on the cores by using UTM. The test was performed at 100 kpa loading stress with a loading pulse period 2000 ms and pulse width of 1000 ms at a constant temperature of 40℃ for each sample.

4.3 Resilient Modulus

Resilient modulus (Mr) based on recoverable strain. It is ratio of stress and recoverable strain. It is important for the design purpose, because it supports the load which ultimately, shows the strength of soil. Mr is directly related to the load spreading ability of a material and its relationship between stress and strain and shows how much a material will deform under the load. ASTM D 4123 shows the response of pavement in terms of dynamic stresses and the corresponding strains. The Resilient Modulus for rubber Modified Samples at 40°C is given in Fig III. It was observed that Mr for 20% CR is higher than that of conventional and other percentages of rubber.

4.4 Creep Stiffness

Creep deformation is “time-dependent” deformation. It is the ability of a material to withstand a constant weight or force at elevated temperature. Creep is the tendency of a solid material to slowly move or deform permanently under the influence of stresses. It is more severe in those materials that are subjected to heat for long periods or near the melting point. It occurs as a result of long term exposure to levels of

stress that are below the yield strength of the material. It is directly proportional to temperature as temperature increases, creep also increases. Deformation rate is a function of structural loads, exposure temperature, exposure time, and applied stresses. Depending on the magnitude of applied stresses, the deformation may become greater, that a material no more perform its function. It doesn't occur suddenly on the application of stress.

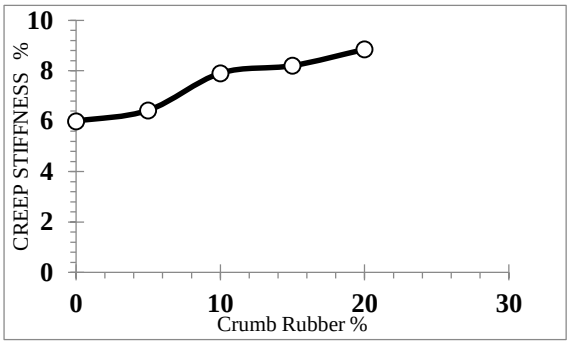

Table IV: Creep Stiffness		
Rubber (%age)	Creep Stiffness (MPa)	Remarks
0	5.999	No Effect
5	6.432	Positive
10	7.904	Positive
15	8.203	Positive
20	8.849	Positive

Fig IV: Creep Stiffness ~ Crumb Rubber

4.5 Accumulated Strain

The strain accumulated over the load increments applied over the surface of the road.It is a measure of permanent deformation which is also called rutting's. Conventional samples have higher values of accumulated strain, so it is high susceptible to rutting. With the replacement of 20% CR modified sample highest resistance to Rutting will takes place.

Table V: Accumulated Strain

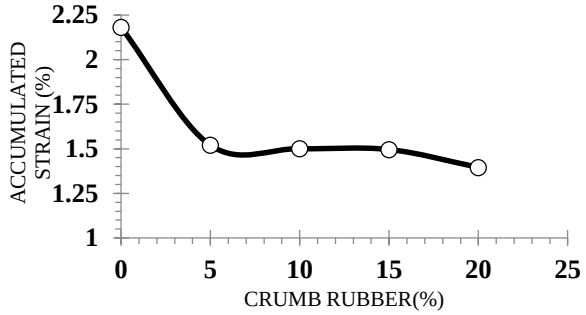

Table V: Accumulated Strain		
Rubber (%age)	Accumulated Strain (MPa)	Remarks
0	2.181	No Effect
5	1.520	Positive
10	1.501	Positive
15	1.496	Positive
20	1.396	Positive

4.6 Resilient Strain

Resilient Strain is the strain which is used in resilient modulus. A material's resilient modulus is actually an estimate of its modulus of elasticity (E).

5. Conclusion

Output of compression test and marshal stability test shows that the efficiency of road increased by using the rubber crumbs in HMA. A high value of resilient modulus and creep stiffness was observed and it's a positive sign while the accumulated strain and resilient strain decreased with the increase in percentage of rubber crumb which is a positive sign. Strain Reduction is a positive effect and an achievement due to incorporation of rubber crumbs from 5% to 20% in the conventional samples. Economy is always a factor which is in consideration whenever doing a project. Raw tires also effect environment badly in many ways, the burning tires exhale carbon and this carbon reacts with oxygen to produce harmful gasses which

are very injurious to health. When it got used in asphalt, it reduces the amount of pile stocks and raw tires which are just covering some area for no gain.

6. References

[1]Technical guidelines for the environmentally sound management of used and waste pneumatic tyres (UNEP/CHW.10/1): *Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal Tenth meeting*, Cartagena, Colombia, 17–21 October 2011

[2] *Directive 1999/31/EC* refers to the deposition of tyres in landfills and supports this paragraph.

[3] ASTM D 5603-01 *Rubber Compounding Materials-Recycled Vulcanizate Particulate Rubber*

[4] ASTM D6114 *Asphalt rubber* / ASTM D8-88

[5] *Advantages of Using Recycled Tire Rubber in Asphalt Mark Belshe*, P.E.Rubber Pavements Association (RPA).