Analysis of recycled tire rubber modified bitumen in Albania for quality of the road construction

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Analysis of recycled tire rubber modified bitumen in Albania for quality of the road construction

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Abstract. Over the last decade, air pollution in the Republic of Albania is in a crucial moment and an actual problem that effect on human health. Many of the problems has been noticed in the industrial cities and urban zones where the number of industries and road transport has grown rapidly. One of the largest environmental impacts comes from the landfilled and burning of the waste tires. This problem has made the government to support some companies for building up the recycling industry of the waste tire in Albania. The Recycled Tire Rubber have been used in many fields such as agricultural uses, sport applications, civil engineering, rubber modified asphalt applications etc. Therefore, different parts of the world have used rubber modified asphalts where the benefits were being more widely experienced and recognized. Based on it, our paper will be focused on the asphalt mixtures produced with Recycled Tire Rubber Modified Bitumen's (RTR-MBs). The analysis of penetration, softening point and Marshall Test will be described in this paper. Our proposal can reduce environmental impact from the waste tires and improving the quality of the road constructions in Albania.

1. Introduction

In recent years, air pollution in the Republic of Albania is in a crucial moment and an actual problem that effect on human health. Many of the problems has been noticed in the industrial cities and urban zones where the number of industries and road transport has grown rapidly. Another important sector that increase the environmental impacts comes from the waste tires. Until now many of the tires were just landfilled or buried and only a small part was recycled. This problem for human health has made the government to support some companies for building up the recycling industry of the waste tire in Albania [1].

One of the possible solutions for the use of waste tire rubber is through recycling process and to incorporate it into asphalt for improvement of the quality of road constructions. The use of rubber is of interest to the paving industry because of the additional elasticity imparted to the binder and enhanced safety related to improved roadway skid resistance [2-4]. Tire recycling is one of the most important processes in the industry. There are two most usage methods and technologies for waste tire treatment routes. Firstly has been focused in ambient granulating and the second has been focused in cryogenic grinding with lower temperatures (-87 to -198°C). Due to the economic reasons and widespread method, most of the Albanian pavement industries for possible waste tire treatment routes have been focused in

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the recycling process at ambient temperature. The figure 1 depicts the technology that we have used for the possible waste tire recycling treatment [5].

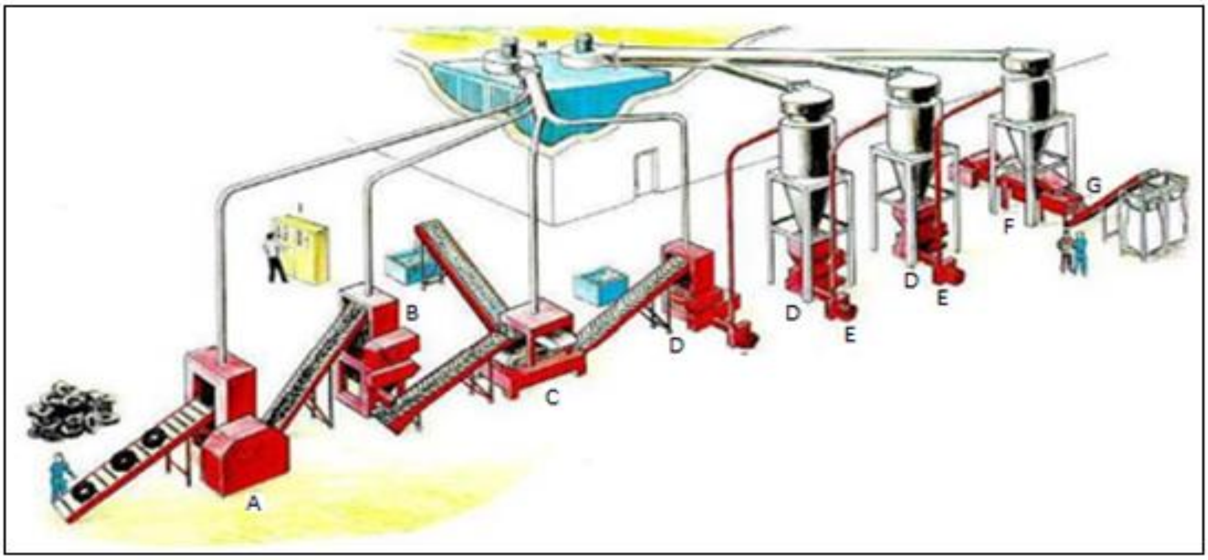

Figure 1. Recycling Technology of the waste tire, A) preliminary shredder, B) granulator, C) steel separation and textile fibres remover, D) complete cleavage, E) pneumatic transportation, F) wind-sifter, G) secondary magnetic separation and H) fibres and dust removal [5]

The size of the tire shreds may range from as large as 460 mm to as small as 25 mm, with most particles within the 100 mm to 200 mm range, while the tire chips range from 76 mm down to approximately 13 mm. Through the recycling technology we can remove metallic and textile materials from tire rubber. By further reducing the size of shreds and chips, it is possible to produce Ground and Crumb Rubber, also known as size-reduced rubber, which are suitable to be re-used in the asphalt industry [6, 7]. Afterward the tire rubber will be mixed with asphalt for usage of road construction.

The aim of this research work will be focused on the asphalt mixtures produced with Recycled Tire Rubber Modified Bitumen's (RTR-MBs). The analysis of penetration, softening point and Marshall Test will be described briefly in this paper. Our proposal can reduce environmental impact from the waste tires and improving the quality of the road constructions in Albania such as resistance to permanent deformation (rutting) and fatigue cracking.

2. Materials and test methods

Tire recycling is one of the most important processes in the industry [1-6]. Table 1 shows the materials characterization of the waste tire that is used in recycling process.

Table 1. Materials characterization of the waste tire.

Ingredients	Percentage (%)
Elastomers	48
Carbons	21
Metals	17
Textile fibres	5
Zn-oxide	1
Sulphur	1
Additive	7

The figure 2 and 3 depicts respectively the various stages of rubber tire and the Scanning Electron Microscope (SEM) image after recycling process of our waste tire.

Figure 2. Recycle rubber from waste tire.

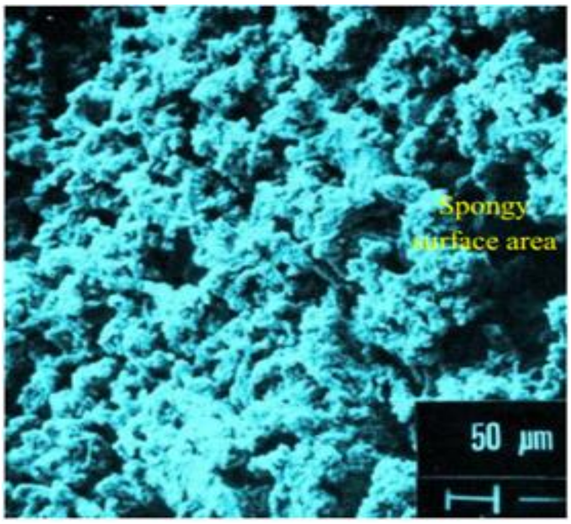

Figure 3. SEM micrograph of waste rubber powder [1, 8].

Tire rubber was grounded into three sizes after removing the steel and textile fibres. The particle size of the rubbers would influence in the performance of the rubber modified asphalt. Non-regular sizes of the rubbers having a specific area of greater than regular size were preferable to react with bitumen through wet process asphalt forming at high temperature.

Furthermore, the SEM image have shown irregular shape of the ambient rubber particles which play an important role as a good binder between waste rubber powder and asphalt. Based on it, the wet process asphalt forming has been used to produce rubber modified asphalts as can be seen in figure 4.

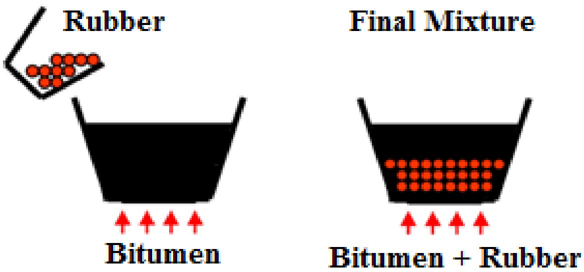

Figure 4. Schematic view of Rubber modified asphalts [1, 8].

The quantity of the Recycled Tire Rubber (RTR) in the sample mixture of the asphalt was 10%. Particles size of the rubbers varied from 0.85 mm to 2.36 mm and 1 mm to 4 mm. The fine rubber is blended with hot bitumen to produce a 'rubberised bitumen' binder through wet process. The modification of this material is carried out to reinforce the bitumen properties through the physical-chemical coupling between bitumen and rubber at high temperatures. The bitumen type 50/70 were used as neat bitumen for preparing all the experimental setup that is need to mixes this material with recycled wasted tires. In preparation, the modified asphalt was heated to a fluid condition and poured into the ring where afterward allowed to cool down at room temperature for approximately 30 min. The sample quantity should be equal to fill 4 rings for repeatability measurements. The figure 5, 6 and 7 depicts conventional physical properties of RTR-MBs respectively including penetration at room temperature, softening point and Marshall which were tested and briefly described in accordance with standards ISO 1203, EN 1427 and ASTM D 1559 respectively [9-11] All the test methods and measurement results have been realized at accredited laboratory called ELBA ltb.

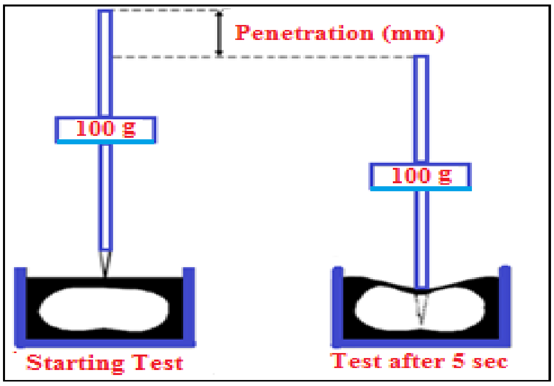

Figure 5. Schematic view of penetration test.

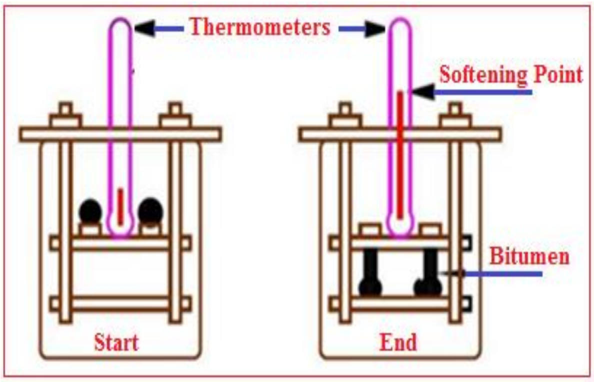

Figure 6. Schematic view of softening point test.

Figure 7. Marshall Testing Device with modified asphalt sample.

2.1. Penetration test
In this test we have examined the consistency of a modified bitumen sample by determining the distance to the tenth of a millimetre that standard needle will penetrate vertically in the bitumen sample under known standard conditions such as load, temperature and time. The penetration test has been realised in the temperature 25°C where the weight of 100 g was applied at both sides. Based on it we have measured the bitumen hardness through the depth of which standard loaded needle that can penetrate vertically for 5 seconds.

2.2. Softening point test
Through this test we have determined the softening point for bitumen and bituminous binders in the range of 28°C to 150°C. Firstly, we have used deionized water and a thermometer with subdivision of 0.2°C for determining softening points between 28°C and 80°C. Secondly, we have used glycerol and a thermometer with subdivision of 0.5°C for determining softening points above 80°C up to 150°C. Through the test analysis of the softening point we can understand the temperature up to which a bituminous binder should be heated for different road use applications.

2.3. Marshall test
In this test we have determined the stability and flow analysis of the modified asphalt in comparison of the normal asphalt. The stability of the modified asphalt has been defined as a maximum load carried

by a compacted sample at a standard test temperature of 60°C. The flow has been measured as the deformation in units of 0.25 mm between no load and maximum load carried by the sample during stability test. Based on the ASTM Standard [11] we have prepared about 1200 g aggregates blended in the desired proportions which has been measured and heated in the oven to the mixing temperature. The mixing of asphalt was conducted at the temperature of about 165°C for 50/70 grade of bitumen. The effective impact loading has been applied on all specimens using a standard compactor hammer of 50 blows on both sides of samples. After the sample cooled down, they were extracted from the metallic molds by using hydraulic sample extractor in the lab [12]. Afterward, the sample were heated to 60 ±1°C either in a water bath for 40 minutes. The specimens were removed from the water bath and place in testing machine. The modified asphalt sample were tested carefully through calibrated Marshall Testing Device [13,14].

3. Results

Addition of plastic rubber to the asphaltic bond, regardless of the method used for obtaining the final product, makes it possible to reinforce the properties of the asphalts which are as follows. The results of the penetration, softening point test for asphalt and modified asphalts are shown in the figure 8 and 9.

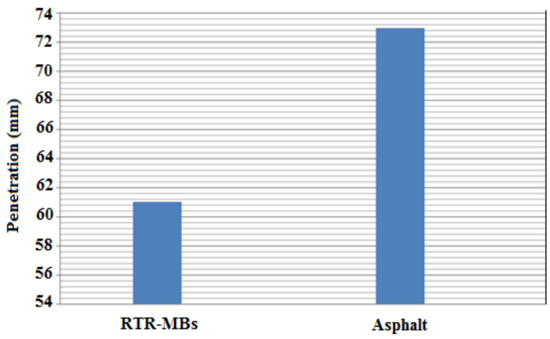

Figure 8. Results of penetration test.

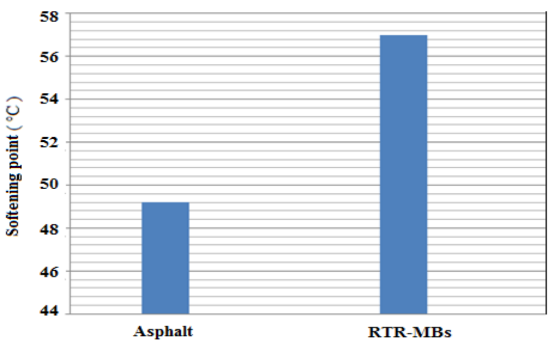

Figure 9. Results of softening point test.

From the above results of the figure 8 we have concluded that the value of penetration is significantly reduced in reinforced asphalt material such as RTR-MBs. This phenomenon appears as a consequence of the absorption of soft fractions from the reinforcing material (rubber) by the diffusion process. The absorption of these fractions causes the order fractions to remain in the bituminous material, i.e those fractions that cannot diffuse inside the reinforcing material, raise the viscosity rate which made penetration more difficult. In the figure 9 we have seen a significant increase of the asphalt softening point as reinforced with rubber modified asphalt compared to the normal asphalt. These changes were present due to the interaction between bitumen and rubber particles. The increase of the asphalt softening point creates the conditions suitable for the use of this material as propagating material in hot climate locations by improving also the quality of the road constructions.

The table 2 depicts the stability and flow analysis for normal asphalt and modified asphalt from plastic material such as recycled waste tire.

Table 2. Stability and flow analysis of normal asphalt and modified asphalt (RTR-MBs).

Samples	Marshall Stability (60°C)	Marshall Flow (60°C)	Mixing Temperature
Test Method	ASTM: D1559	ASTM: D1559	
Units	kN	mm	°C
Asphalt	10.13	2.96	100 - 170
RTR-MBs	12.32	4.61	165
Remarks	*ok: criteria fulfilled*	*ok: within range*	*ok: within range*

The testing of the recycled tire rubber modified bitumen showed that stability and flow value throughout the mixing temperatures fulfil the standard requirements. Furthermore, we have investigated asphalt and modified asphalt the crack levels during the last ten years as can be seen in the figure 10. The results have shown that the cracks level during the years were lower in rubber modified asphalt than conventional asphalt.

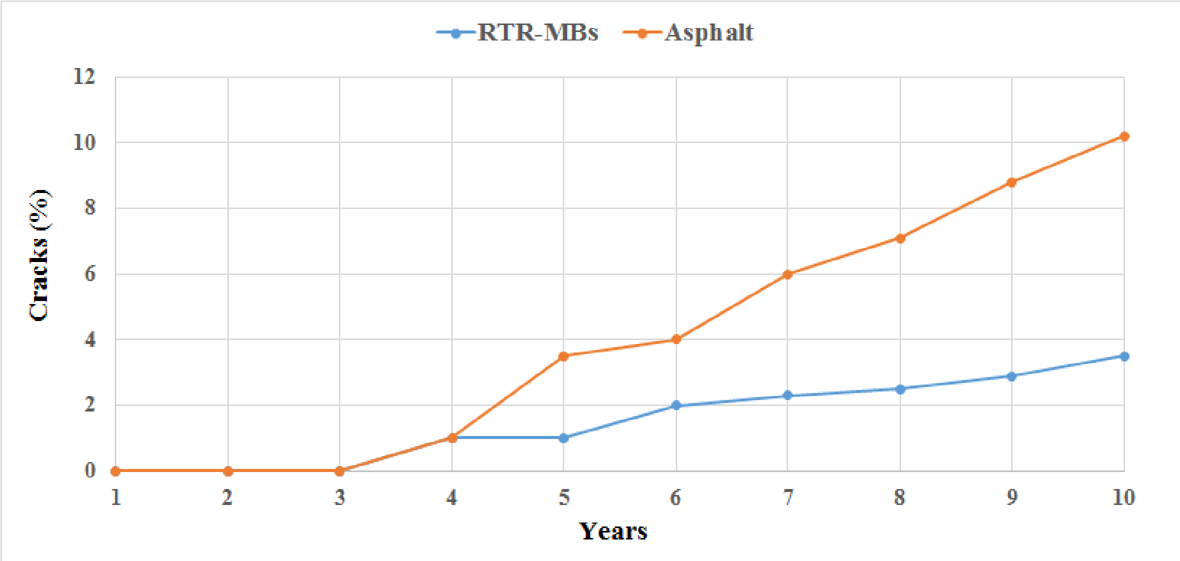

Figure 10. Comparisons of the cracks level during ten years for RTR-MBs and conventional asphalt.

4. Conclusions

The analysis of penetration, softening point and Marshall Test of Recycled Tire Rubber Modified Bitumen's has been briefly described. The results of the penetration test have shown the improvement of the properties of asphalt by decreasing the results from 73 mm for conventional asphalt to 61 mm for RTR-MBs. The results of softening point have been increased from 49°C for conventional asphalt to 57°C for RTR-MBs. Also, the cracks level for RTR-MBs has been decreased approximately three times in the end of the ten years by comparing with normal asphalt. All the mentioned results were in accordance to the international results. This proposal have shown that rubber modified asphalts will improve the quality of the road constructions in Albania and reducing environmental impact by using recycling process.

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