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Enhancement of Road Construction by Using Recycled Tire Rubber Modified Bitumen

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Abstract

Conventional asphalt used in road construction in Albania has faced many problems due to its lower quality and lack of maintenance. Most of the problems come from urban and industrial cities where vehicle usage is very high. The problem has been faced in the first three years after their construction with conventional asphalt due to lower crack resistance and skid resistance. This emerging situation has sparked recent interest from different researchers, companies, and the Albanian government to support improving the quality of road construction. Our research work will be focused on the production of mixture asphalts by using recycled tire rubber modified bitumen (RTR-MBs). Moreover, it will be analysed the physical and mechanical tests, which involve, respectively, penetration tests, softening point tests, and Marshall tests. All the new results will be compared to conventional asphalt.

Keywords: *Road construction; Mixture asphalt; Recycled tire; rubber modified bitumen's; Physical test; Mechanical test.*

INTRODUCTION

During the last decade most of the roads in the republic of Albania have been damaged due to the influence of some important factors. Weather conditions, traffic load and service temperatures were some factors that can affect constructed conventional asphalt in most of the national roads in Albania. Based on it, enhancement of the properties of conventional asphalt can be realized through usage of possible additives or recycled additives that come from waste tires [1-3]. One of the possible solutions for enhancement of the conventional asphalt comes from the recycling process of the waste tire. The use of rubber plays an important role on the road construction industry due to the additional elasticity given to the binder and improved safety in relation to the skid resistance at different roads [1, 4-8]. Moreover, recycling process of the waste tyres can reduce environmental impacts and improve the lifecycle of the roads. Figure 1 depict technological scheme of the recycling process used in most of the companies in Albania [9, 10].

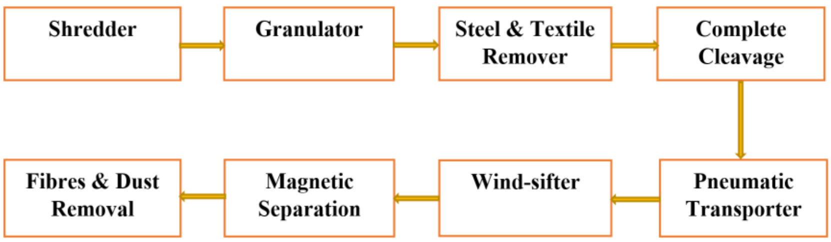


Figure 1. Recycling technological scheme of the waste tires

The above recycling technological scheme shows the whole recycling process where it can be removed all the textile fibre and metallic materials on the waste tires. The size of the waste tires varied from the range of a large size 150 mm to a small size of 50 mm. Due to economical reason, this is the most widespread technology scheme that have been used in most of recycling companies in Albania where all the recycling process should be realized at room temperature. This technology plays an important role for producing crumb rubber that can be used for production of the mixture asphalts.

Our research work will be focused on the production of the mixture asphalts by using Recycled Tire Rubber Modified Bitumen's (RTR-MBs). Moreover, it will be analysed the physical and mechanical test which involve respectively penetration test, softening point test and Marshall test. All the new results will be compared to the conventional asphalt and previous research work [9].

MATERIALS AND EXPERIMENTAL DETAILS

Materials used in this research work were ingredients of waste tires, aggregates and bitumen. Table 1 until 3 depict all the ingredients needs for materials characterizations to produce the mixture asphalts with RTR-MBs.

From the Table 1 it has been seen the aggregate characteristics used in our research work where the filling material can come from broken river gravel or granule of volcanic origin. In has been depicted the measurement types of combined aggregates which contain aggregate granulometry and asphalt percentage.

Table 1. Aggregate characteristics

Sieve size (mm)	Conglomerate % of passing	Binder
0.075	2-6	4-8
0.18	5-11	5-55
0.4	7-20	7-25
2.0	20-40	20-44
5	35-55	30-60
10	50-75	50-80
15	60-85	65-100
25	75-100	100
31.5	100	-
% Of Bitumen	4-5.5	5-6

Table 2 show the whole characteristics that is needed for requested bitumen to produce the mixture asphalt. Furthermore, Table 3 shows chemical composition of the recycled waste tyres that has been used during recycling process at ambient temperature.

Table 2. The characteristics that bitumen must meet

Tests	Requested (%)
Penetration at 25⁰C, 1/10 mm	60-80
Softening point, ⁰C	48-55
Elasticity at 5⁰C, cm	> 4
Elasticity at 25⁰C, cm	> 100
Fracture Point, ⁰C	< - 13
Disintegration, %	> 99
Paraffin content, %	> 2
Density at 15⁰C, gr/cm3	> 0.995
Binder with graniles	> 80

Table 3. Chemical composition of the recycled waste tyres

Elements	Mass (%)
Elastomer	50
Carbon black	23
Steel	15
Textile fibre	4
Oxide Zinc	1
Sulphur	1
Additive	6

In this research work wet process asphalt forming has been used for producing of rubber modifying asphalt, see Figure 2.

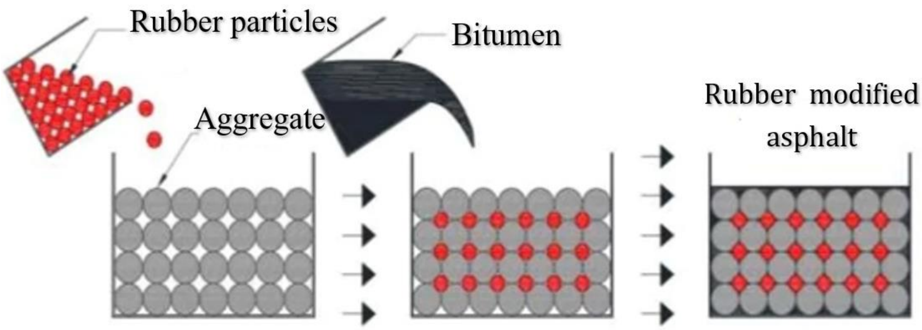


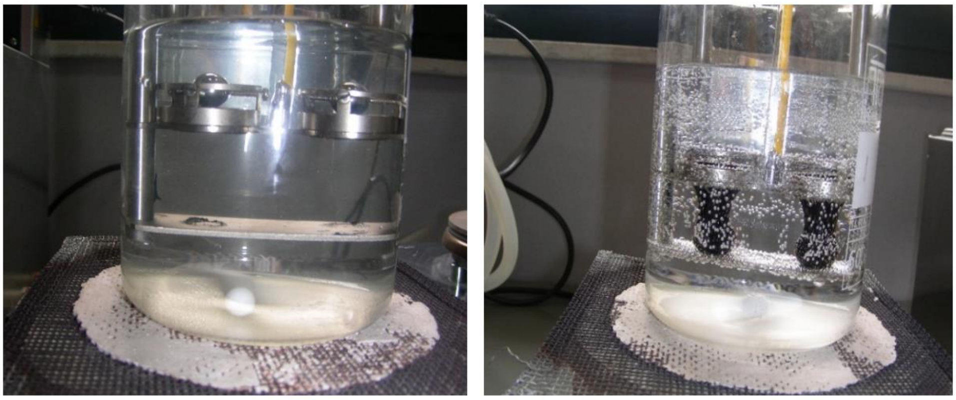
Figure 2. Schematic view of rubber modified asphalt [9]

Bitumen type 50/70 has been used to the whole experimental setup for preparing the asphalt mixture with RTR-MBs. The quantity of RTR-MBs in asphalt mixture setup correspond to 10% where particles size of rubbers was in the range 0.92 until 2.42 and 1 mm to 4 mm. Figure 3 depicts the preparation of the asphalt mixture with RTR-MBs which is heated in a fluid condition and poured into the ring. Cooling process it takes 30 min and is realized at room temperature. Sample preparation has been repeated 4 times and afterward it has been realized inspection services of the asphalt mixture to verify the quality of the samples. Due to it, we have realized softening point test, penetration test and Marshall test by using respectively standards BS EN 1427:2015, ISO 1203:1978 and ASTM D 1559:2004 [11-13].

Figure 3. Preparation of the asphalt mixture with RTR-MBs, ELBA ltd laboratory

Softening Point Test

A softening point test has been realized to determine the softening point of the bitumen and the bitumen's binder from 28 °C until 150 °C. This test can give to us an important information for known the nominal temperature that we need to use for bituminous binder during different usage roads applications. Figure 4 depict the softening point test.



(a) (b)

Figure 4. Softening point test; (a) before and (b) after, ELBA ltd laboratory

For determining the softening point from 28 °C up to 80 °C, a thermometer with a subdivision of 0.20 °C and deionized water have been used. The rest of the measurements have been realized for the temperature range above 80 °C up to 150 °C by using a thermometer with a subdivision of 0.50 °C and glycerol.

Penetration Test

Penetration test has been realized at room temperature and the weight of 100 g has been applied at both sides, see Figure 5.

Figure 5. Penetration test, ELBA ltd laboratory

Through a penetration test, it has been measured the modified bitumen hardness where the standard needle will penetrate vertically in the bitumen sample by using a constant load of 100 g at room temperature.

Marshall Test

Marshall test has been used to determine stability and flow analysis of the asphalt mixture with RTR-BMs. Figure 6 depict Marshall test of the asphalt mixture with RTR-BMs.

Figure 6. Marshall test view, ELBA ltd laboratory

In experimental setup, the maximum applied load to the sample that has been realized at 60 °C standard test temperature can give to us information for stability of the asphalt mixture with RTR-MBs. Afterward, flow analysis has been realized from the deformation in units of 0.25 mm between no load and maximum load carried by the asphalt mixture with RTR-MBs sample during the stability test. ASTM standard has been used to prepared 1200 g aggregate blended in the desired proportions and asphalt mixture with RTR-MBs was realized at temperature 165 °C for bitumen grade 50/70. A standard compactor hammer of 50 blows has been applied in sample where continuously the sample it cooled down by extracting from metallic moulds and heating again for 40 minutes at 60 °C in a water bath. Marshall testing machine has been calibrating for ensuring the quality of our measurement results of the mixture asphalt with RTR-MBs [14-16].

EXPERIMENTAL RESULTS

Figures 7 to 9 depict all the experimental results of the new asphalt mixtures with RTR-MBs in comparison to conventional asphalt and previous modified asphalt [9]. The softening point test and penetrations test results are shown respectively in Figure 7 and Figure 8.

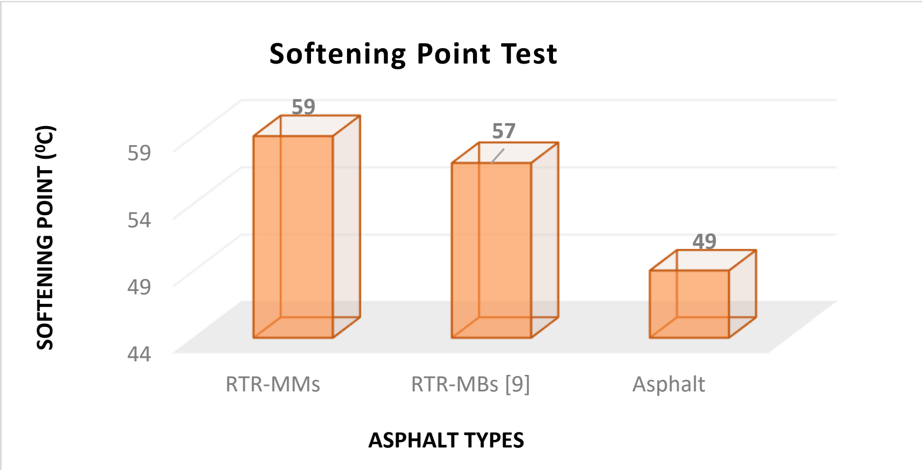


Figure 7. Softening point test results

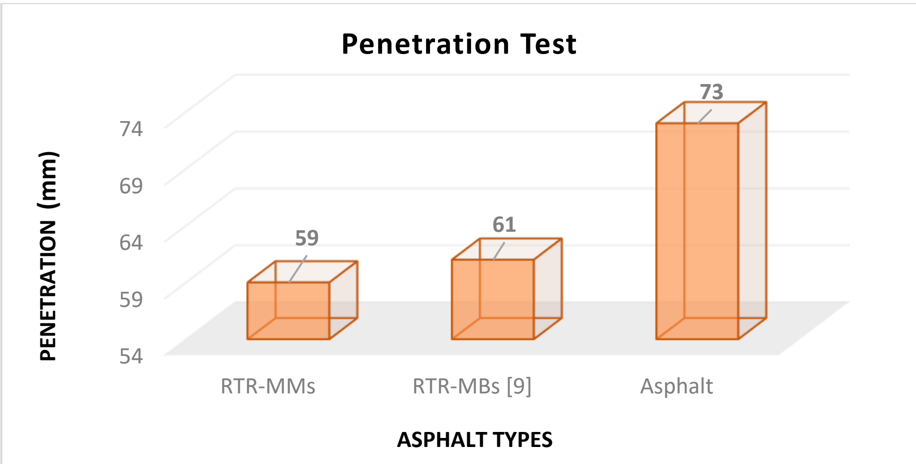


Figure 8. Penetration test results

The experimental results of the softening point in mixture asphalt with RTR-MBs has been improved in comparison to the convectional asphalt and previous modified asphalt with RTR-MBs [9] as can be seen in Figure 7. This improvement comes from the interaction of the bitumen with new ingredients of rubber particles. These results can make asphalt mixture with RTR-MBs to use in road contractions in hot located area of Albania such as south part. In case of penetrations test at Figure 8 it has been seen that our new experimental results depict the value of penetration is significantly reduced in asphalt mixture with RTR-MBs in comparison to the convectional asphalt and previous modified asphalt with RTR-MBs [9]. This has been done due to a consequence of the absorption of soft fractions from asphalt mixture with RTR-MBs by the diffusion process.

Marshall stability and flow analysis results are shown in the Table 4. It has been seen improvement results of the new mixture asphalt with RTR-MBs in comparison to the convectional asphalt and previous modified asphalt with RTR-MBs [9]. All the new experimental results fulfil the standard requirements.

Table 4. Experimental results of Marshall stability and density, ELBA ltd laboratory

Samples	Marshall Stability (kN)	Marshall Density (mm)	Porosity (%)
Asphalt	10.13	2.96	2.71
RTR-MBs [9]	12.32	4.61	3.42
RTR-MBs	12.71	4.71	3.48

Figure 9 depicts cracks level during the last decade. It has been seen that our new experimental results were improved in comparison to the convectional asphalt and previous modified asphalt with RTR-MBs [9].

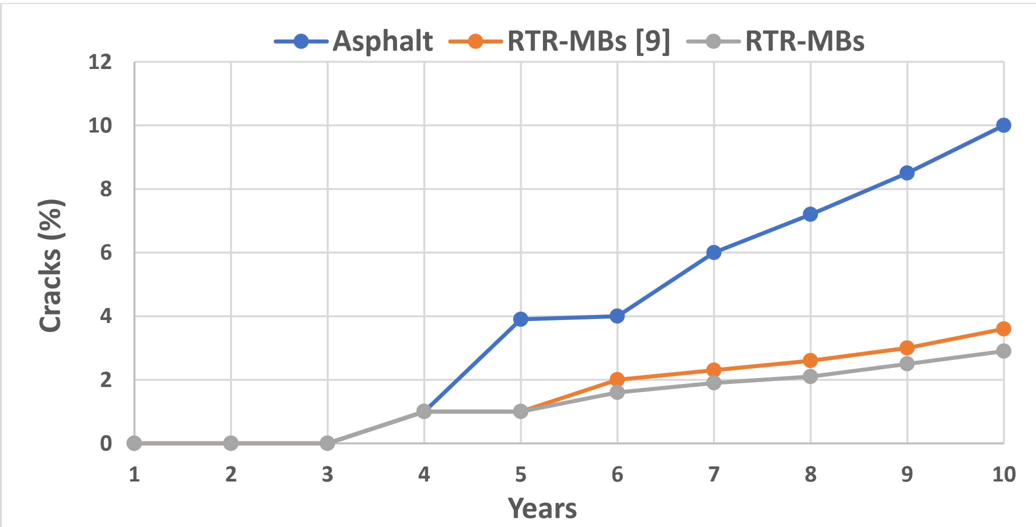


Figure 9. Comparisons crack levels for 3 different types of asphalts

The experimental results of crack levels for 3 different types it has shown enhancement of the quality of road asphalts by reducing the crack level during the last decade.

CONCLUSION

This research investigated the enhancement of the quality of road construction by using asphalt mixtures with RTR-MBs. The experimental results of the softening point have shown enhancement starting from 49 °C in conventional asphalt up to 59 °C in asphalt mixtures with RTR-MBs. Another enhancement of the properties of asphalt has been seen in penetration test results for conventional asphalt up to asphalt mixtures with RTR-MBs, where the results decreased from 73 mm to 59 mm. Marshall stability and density have been enhanced, where the results of the new asphalt mixture with RTR-MBs correspond respectively to 12.7 kN and 4.71 mm. Furthermore, the crack level during the last decade has decreased 3.4 times since the end of the ten years from conventional asphalt to asphalt mixture with RTR-MBs. All the results have fulfilled the requirements of the international standards.

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CONFLICT OF INTERESTS

The authors would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

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