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POLLUTION REDUCTION OF TIRES WASTE THROUGH INCORPORATION IN THE BITUMEN TO FIGHT AGAINST PAVEMENT RUTTING

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Abstract. *The number of used tires is increasing every year by simply due to increased fleet. The problem of waste is a huge problem both economically and ecologically. In Algeria, the valuation of waste tires in civil engineering is a main consumer sector of used tires.*

This study focuses on waste recycling of used tires in the road sector to reduce pollution due to the latter and secondly to improve the characteristics of asphalt concrete to meet the sustainability criteria. For this we shall modify the asphalt with rubber crumb. Different percentages of rubber crumb (RC) are added to the bitumen to evaluate their influence on modified bitumen behavior. The experiments were performed on 35/50 grade bitumen. The results show a significant improvement on the softening point (SP), penetration and thermal sensitivity (PI).

1 INTRODUCTION

The hydrocarbon mixture is the material chosen for the majority of roads. The bitumen is road material most used. Since bitumen used in asphalt pavements will be a change of the thermo-mechanical state during their service life, it is extremely, important to study their rheological properties under the effect of different temperatures and loads conditions [1].

The problem of waste is a huge problem both economically and ecologically. The desire to preserve the environment by the need for a more pleasant living environment, has emerged towards the middle. As such, the policy on waste is one of the oldest environmental policies. Among the different types of waste materials, rubber wastes represent a significant recoverable deposit. These deposits come from different origins; the main one is used tires. Used tires are relatively inert compounds, they do not pose direct danger to the environment. However, low rate of degradation and low compressibility are many disadvantages to burial. Indeed, these tires remain stable when buried. Their inherent physical properties, as well as soil, garbage, gas, freezing and thawing, causing the return to the tire surface. A few years or decades after burial, the tires end up in proportion to the surface of the discharge [2]. Pneumatic accumulation in addition to their unattractive appearance, also pose a high fire risk if not properly managed. Tire fires are characterized by incomplete combustion producing thick clouds of toxic black smoke and causes the release of toxic oils, generating pollution manifest in different consequences on nature and the environment. Faced number of population growth, developing countries and the increase in traffic, and consequently the increase of tire waste, the problem becomes serious. (Example Figure 1)

Fig 1. Space accumulation of used tires.[3]

This experimental work is an investment to improve the quality of asphalt by the incorporation of crumb rubber bitumen while to reduce the scope of the phenomenon of pollution.

2. DEFINITION OF WASTE

Within the meaning of Law No. 01-19 of 12 December 2001 on the management, control and disposal of waste by waste means: as "any residue of a production process of processing or use, any substance, material or more generally any goods or furniture that abandoned its holder intends to abandon ". [4]

In this experimental work we used the crumb rubber used tires for improving bitumen characteristics to find it for use in the field of public works.

3. MATERIALS AND METHODS

3.1. Materials

3.1.1. Bitumen

The bitumen used in this study is a 35/50 grade bitumen NAFTAL marketed by a subsidiary of the Algerian oil company Sonatrach. Removed from the coating station BenNasser in Souk-Ahras (Algeria). the physical properties of bitumen are summarized in Table 1.

Table 1. Physical Properties of bitumen.

Test	Standard	Results	Specification limits
Penetration (1/10mm)	EN 1426 ASTM D-5	48	**35 - 50**
Softening point (°C)	ASTM D-36 EN 1427	51.7	**50 - 58**
Specific gravity (g/cm^3)	ASTM D-70	1.029	**1 - 1.1**
Ductility (mm)	ASTM D-113	>1000	**> 600**

3.1.2. Additive description

The crumb rubber (PR) used tires is obtained from crushing of the latter, we have used the particle diameter lower than 2.0 mm.

3.2.Methodology

3.2.1.Bitumen-polymer mixture preparation

The bitumen modified with rubber crumb was made using a mechanical stirrer (propeller) at a temperature of 190 ° C ± 5 ° C with a shear rate of 1400 rev / min for 3 hours. Bitumen is preheated up until becoming liquid (190 ° C) and after temperature stabilization additives added slowly. Four modified bitumens are prepared.

The addition percentage is from 3% to 12% with an increase of 3% based on the weight of the bitumen. At the end of change test is executed to penetration and the softening point of all mixtures.

3.2.2. Presentation of materials

The change was made in roads laboratory level Civil Engineering Faculty of USTHB (Algeria), we used it for the following equipment:

- An electric propeller stirrer equipped with a speed variator (High speed = 2200 rev/ min).
- An adjustable heater plate capacity of 400 ° C.
- A thermometer from -50 ° C to 400 ° C.
- A vessel in which the modification is carried out, the latter is equipped with a tight lid to prevent evaporation of bitumen oils during heating.

3.2.3. Needle penetration and softening point

The pure bitumen penetration value and amended, is measured using the penetrometer according to specification EN 1426, the penetration test performed using a standard needle with a 100g load to measure penetration for 5 seconds. The depth of needle penetration is expressed in increments of 1 / 10mm indicating penetration. The measurement taken at 25 ° C defines the degree of penetration bitumen.
The softening point of the vas deferens tests was carried out using the ring and ball test according to the specification EN 1427. The softening point is the temperature at which the steel ball embedded in a bitumen film producing a 25mm deformation.

3.2.4. Temperature susceptibility

The temperature susceptibility of the bitumen is the value at which the consistency of bitumen changes with the temperature change, is a very important property of the bitumen. The amelioration of the temperature susceptibility with PR was investigated with a calculating penetration index (PI).

For PI, the temperature susceptibility for the binders is measured by calculating the PI using the penetration at 25 °C and softening point results.

Penetration index is calculated using an equation, shows as follows:

$$PI = \frac{1952 - 500 * \log(Pen_{25}) - 20 * SP}{50 * \log(Pen_{25}) - SP - 120}$$

Where Pen is the penetration test at 25 °C and S.P is the softening point [5].

4. RESULTS AND DISCUSSION

The test results are presented as graphs and table show the evaluation of the influence of the rubber crumb on improving the characteristics of the bitumen. (0% the mixture is bitumen by reference).

Table 2. Basic Properties of bitumen and bitumen modified.

Asphalt	Softening point (°C)	Penetration (1/10mm)	Penetration index
A	51.7	48	-0.88
A-3% PR	57.5	30	-0.61
A-6% PR	76.6	20	1.75
A-9% PR	70	24	1.14

A-12% PR	65.9	26	0.64

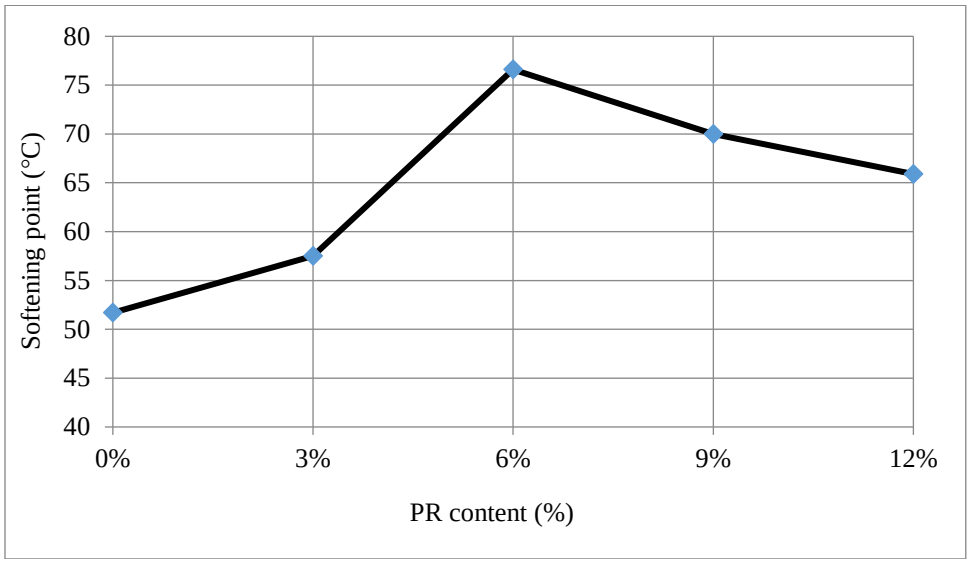

Fig 2. The softening point variation as a function of PR content (%)

Softening point of the results based on the PR content are shown in Figure 2. From these results, it is noted that: Incorporation of PR in the bitumen has a positive influence on the softening point values with an increase for all blends compared with the reference bitumen (0%). The greater softening point value is obtained by mixing modified to 6% PR with an improvement of 48.1%.

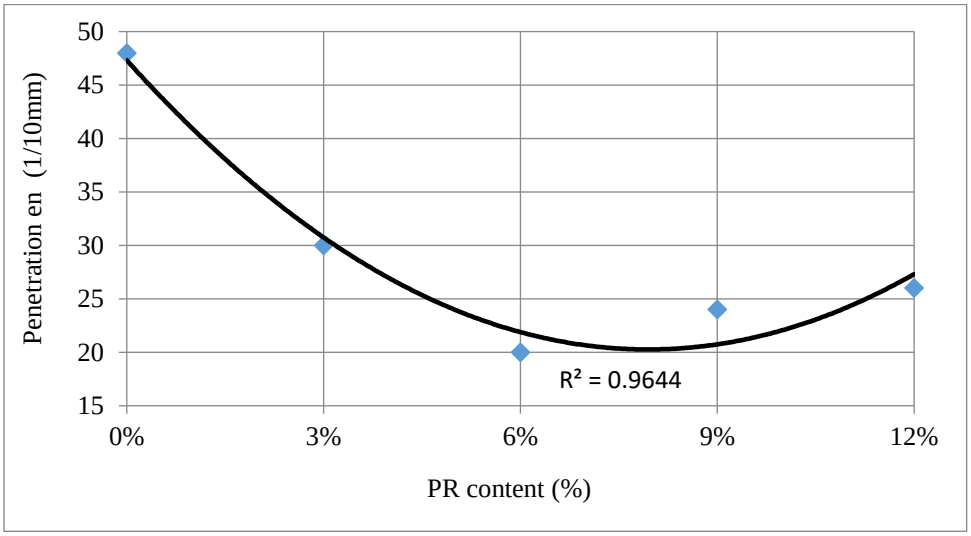

Fig 3. The variation of the penetration depending PR content.

The above curve (Figure 3) shows the variation in the penetration according to PR content. There has been a severe decline in the value of penetration with increasing PR content up to 6% when it reaches 20 (1 / 10mm), and after a significant increase but still a significant improvement over the reference bitumen. The value of

the correlation coefficient expresses the quality of the adjustment. Indeed, the R^2 correlation coefficient obtained is greater than 0.96 and is very close to 1, which demonstrates that there is very good correlation between the results.

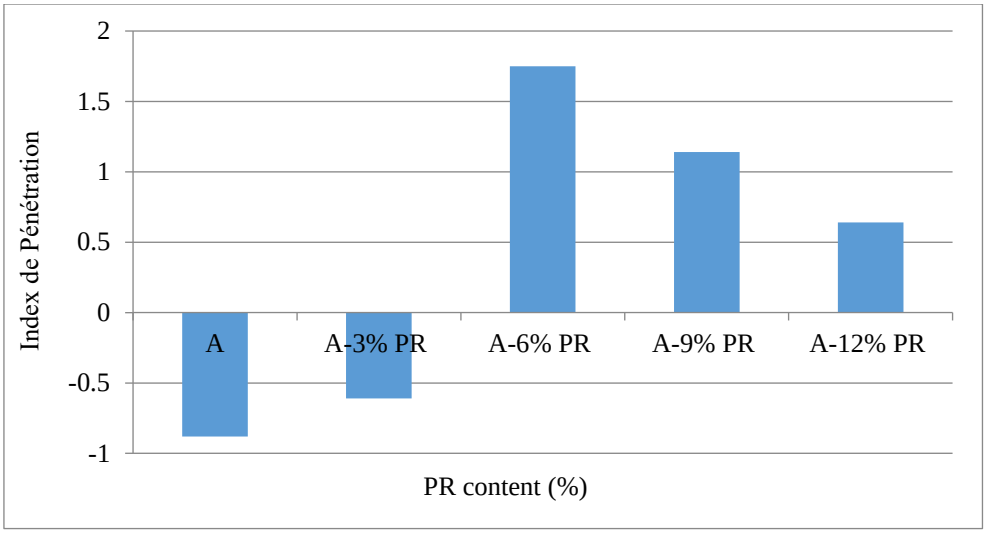

Fig 4. The variation of the penetration index based PC content.

The values of the penetration index (PI) were calculated for the control bitumen and different mixtures of bitumens, the results are presented in Figure 4. Continuous improvement with increasing PR content up to 6% after a slight decrease while remaining in the area of good results. Bitumen consistency has really improved especially 6% PR, following the decrease in the value of penetration and softening point increase.

4.1. Synthesis

A clear improvement of bitumen characteristics is noted following the addition of PR, the best performance is recorded to the content of 6% with PR:

- An increase in the softening point value of 48.1%.
- A decrease in the penetration value of 58.3%.
- The consistency of the bitumen that represented by the penetration index is improved by the incorporation of PC with attractive decrease in thermal susceptibility value.

5.CONCLUSION

By the introduction of the law on waste management, waste disposal has become mandatory. The addition of rubber crumb to a positive effect on the properties of the bitumen, the penetration value decreases, also reduces the sensitivity to temperature and the value of point ramoulissement improved. The results obtained by the tests indicate that the optimum percentage of PR 6% by weight of bitumen. The use of tire crumb rubber used as bitumen modifier is a considerable gain, firstly it reduces waste and protects the environment against pollution and secondly, it improves the bitumen characteristics and Consequently bituminous concrete and road durability.

According to other studies, the experimental results show that the modified bitumens, by their lower thermal susceptibility, exhibit better performance than conventional bitumens, both vis-a-vis resistance to rutting than cracking by fatigue. What gives us meaning in our results, as an improvement that fight against diseases of asphalt pavements.

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