Applied Mechanics and Materials Vols. 446-447 (2014) pp 1512-1515

doi:10.4028/www.scientific.net/AMM.446-447.1512

Ways of Using Rubber Crumb from Worn Tires

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Keywords: Tires; rubber crumb; rubber-bitumen; penetration; softening point; particle sizes.

Abstract. In the paper ways of using rubber crumb from worn tires were investigated. Possibilities of preparing Rubber-Bitumen Compounds (RBC) based rubber crumb (RC) from worn tires were studied experimentally. The physico-mechanical characteristics of paving bitumen BND 60/90 modified with rubber crumb and spent engine oil. The structure of rubber crumb was characterized by optical microscopy. Physico-mechanical characteristics of RBC were detrminated by standard methods. It is established that the quantity of entered binders depending on physical and chemical conditions, which was optimal composition of rubber-oil at a ratio of 1:1 and 3:2 and introduction to bitumen in amount of 15-25 wt.%.

Introduction

Well known, crumb rubber is a term usually applied to recycled rubber from automotive and truck scrap tires. During the recycling process steel and fluff is removed leaving tire rubber with a granular consistency. Tires are bulky, they are highly toxic, they do not undergo natural degradation and decay; therefore, they are accumulated in open landfills to occupy considerable ground areas or scattered in ravines, forests, and water bodies to pollute the environment [1, 2]. Worn or spent tires are valuable secondary raw materials, which containing 65–70% rubber, 15–25% technical-grade carbon, and 10–15% high-quality metal. Thus, the efficient processing of scrap tires makes it possible not only to solve environmental problems but also to perform economically rational utilization processes. Now normalization of ecological conditions and rational use of natural resources have become the major state problem of the region [3-5].

In the world, scientists have been offered variety ways of recycling and utilization of rubber crumb from worn tires. A well known method is to burn the rubber waste to produce energy while producing cement. This kind of "recycling" has to be reduced in future. Due to its irreversible network, the different compounds and ingredients the recycling of rubber is not comparable with the recycling of plastics. [6] CR is often used in as troturf as cushioning, where it is sometimes referred to as astro-dirt. CR was used to remove ethylbenzene, toluene and xylene from aqueous solutions at room temperature [7].

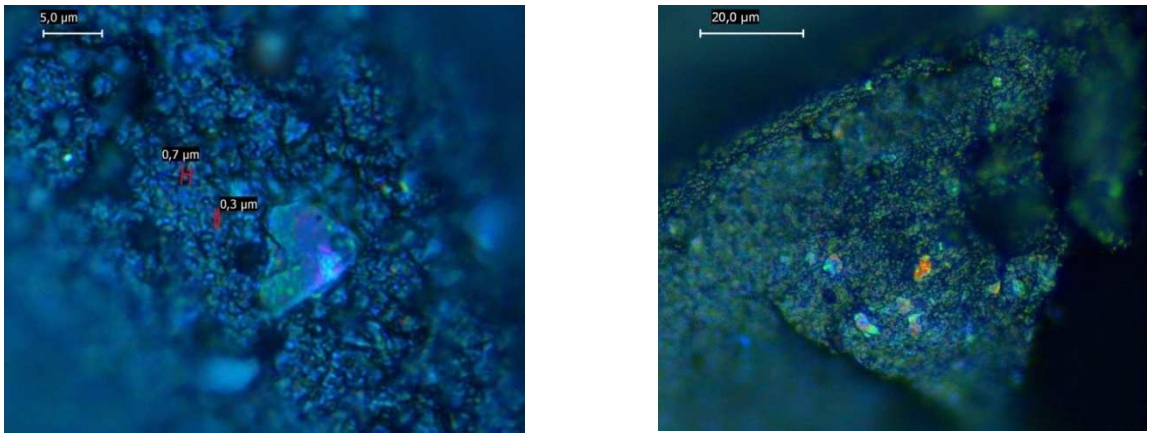
Rubber crumb also goes into the manufacturing of several auto parts such as brake pads, brake shoes and vehicle acoustic insulation. Small percentages of crumb rubber go into manufacturing new tires. A revolutionary nanotechnology process developed by the British group Dena Technology is gearing up worldwide to produce high quality building material as wood-replacement products from used tires. Also uses to paper-replacement materials are investigating [8]. Cut tires are used for the manufacture of drainage tubes, tapes for the protection of cables and pipelines, and soundproof walls along highways and for the protection of downslopes from erosion; Thermal methods for the secondary use of scrap tires are known, in particular, the combustion of tires to generate energy and pyrolysis under conditions of relatively low temperatures to produce light distillate, solid fuel, and metal. In addition, the following technologies are available: the processing of tires to obtain rubber crumbs and powders for the manufacture of polymer mixtures and construction materials and the production of reclaim for the manufacture of rubber mixtures and asphalt-rubber compositions for insulating and roofing materials (soft and hard roofs and roof mastics) [9,10]. One of the ways to

improve the quality of the binders is their modification with polymers and rubber crumb [11]. The ability of crumb rubber to improve the mix properties depends on many factors, including the incorporation technology, nature of rubber crumb, size of the rubber particles, and the percentage of rubber in the mix and its reaction time with asphalt [12].

In the paper possibilities of rubber crumb use to road constructions are investigated. Crumb rubber modified bitumen can improve the heat-resistance, the crack-resistance at low temperature and the durability of bitumen. As a result, the pavement quality grows, and its service life becomes a factor of 1.5 - 2 longer [13-15].

Material and Methods

Rubber crumb from spent tires (from Kazakhstan Rubber Recycling LLP (in Astana)) which have two different particle sizes: one of the rubber crumb is activated, particle size less than 0.6mm. The other one is no activated, which particle size between 0.6mm and 1mm. they are showing on the figure 1. These figures were taken in Laboratory of National Nanotechnology of Kazakh National University by Leica DM 6000 M optical microscope on optical reflection.



a b

Fig. 1 Optical microscope images of rubber crumb. a) Particle size less than 0,6 mm (activated), b) Particle size 0,6-1,0 mm (no activated)

At work standard paving bitumen BND 60/90 and spent engine oil from Car service in Almaty city were used. At first, rubber-oil mixture was prepared. Rubber-oil mixtures were prepared by mixing spent engine oil into rubber crumb with a ratio in 5:6, 1:1 and 3:2. After a day it used for preparing rubber-bitumen compounds. Bitumen samples were heated at 160-170 °C and variety content of rubber-oil mixtures were added in bitumen. Deadline of stirring compounds were between 5 and 60 minutes at165-180 °C. Physico-mechanical characteristics of RBC are established by standard methods: softening temperature (S) was determined by the method “Ring and Ball”, depth of needle penetration (P) was determined by penetrometer, extensibility (D) was determined by ductilometer.

Results and Discussion

We tested only rubber crumb modified bitumen, which was heated to 165±5 ºC and 5-10 weight percent of activated crumb rubber was added in to bitumen. It was prepared by stirring for 5 min at 170-180 ºC. But, for the results of analyses on the physico-mechanical characteristics were shown poor indicator, because of lower extensibility. Ductility of rubber modified products was between 7 cm and 11 cm. In fact, all of the samples were mismatch standard requirements of the rubber-bitumen compounds. The dispersion degree and the swelling capacity of crumb rubber in the bitumen have an important effect on improving properties of bitumen.

Aim of improving the physico-mechanical characteristics of RBC was used spent engine oil as additional modifying agent. According to experimental results, physico-mechanical characteristics of

activated rubber modified RBC with 20 wt. % rubber-oil corresponds to grade of paving rubber-bitumen compounds RBC 90/130 and 25 wt% is according to standard RBC 130/200. Physico-mechanical characteristics of rubber-oil mixture (activated rubber crumb: engine oil=3:2) modified bitumen are given in table1.

Table 1 Physico-mechanical characteristics of RBC with activated rubber crumb (R:O=3:2)

Names of indicators	Base bitumen	RBC 10 wt%	RBC 15 wt%	RBC 20 wt%	RBC 25 wt%	Method of testing
Penetration at 25°C, 0.1mm	78	75	130	109	150	Standard 11501
Softening point,[°C]	47	58	47	55	46	Standard 11506
Ductility at 25°C, [cm]	96	19	31	17	25	Standard 11505
Standard accordance		RBC 60/90	-	RBC 90/130	RBC 130/200	-

The table1 is showing physico-mechanical characteristics of RBC with 10 wt. % rubber-oil corresponds to grade of paving rubber-bitumen compounds RBC 60/90. Then RBC with 20 wt. % according to standard RBC 90/130 and 25 wt. % rubber-oil corresponds to grade of paving rubber-bitumen compounds RBC 130/200. Whereas the 15 wt% crumb modified sample mismatch any standard of RBC.

No activated rubber crumb modified bitumen was investigated same method and same experimental conditions with activated rubber-crumb modified samples. There are kindred phenomena, too: poor indicators, lower extensibility. Prepared samples were mismatch standard requirements of the rubber-bitumen compounds. At experimental work was used spent engine oil with no activated rubber crumb. When we use no activated rubber crumb (06-1) in ratio R:O=1:1 only one composition is a according to standard RBC 60/90. Physico-mechanical characteristics of rubber-bitumen compounds with no activated (06-1) rubber crumb (rubber:engine oil=3:2) are presented in table 2.

Table 2 Physico-mechanical characteristics of RBC with no activated rubber crumb (R:O=3:2)

Names of indicators	Base bitumen	RBC 10 wt%	RBC 15 wt%	RBC 20 wt%	RBC 25 wt%	Method of testing
Penetration at 25°C, 0.1mm	78	87	160	195	108	Standard 11501
Softening point, [°C]	47	53	45	45	52	Standard 11506
Ductility at 25°C, [cm]	96	17	20	18	13	Standard 11505
Standard accordance		RBC 60/90	RBC 130/200	RBC 130/200	-	-

We can see from the table 2 the sample of RBC added 10 wt. %rubber-oil mixtures are according to standard RBC 60/90, with 15 wt. % and with 20 wt. % rubber-oil modified bitumen corresponds to grade of paving rubber-bitumen compounds RBC 130/200. Thus, all the tabulated results are allows knowing in ratio 3:2 rubber-oil mixture modified bitumen better than ratio of 1:1.

The experimental results showed that the addition of crumb rubber in the bitumen increases the softening point of RBC slowly decreases, otherwise extensibility of RBC isn't more changing in any content of rubber-oil mixture. According to experiment, with increasing content of rubber-oil mixture in bitumen, the penetration of rubber-bitumen compounds were increased. It means the bitumen starts to harden. The properties of crumb rubber modified bitumens, including the RC and crumb rubber with spent engine oil in ratio 1:1, are summarized in Table 3.

Table 3 Properties Comparison of activated Crumb Rubber Modified Bitumens

Kind of modifier	Penetration	Softening point(25)	Ductility
Base bitumen	78	47	96
Rubber crumb, 10 wt.%	52	57	7
Rubber-oil ixture, 20 wt.%	126	50	26,5

By comparison, the properties of modified bitumen with the rubber-oil mixture are best, because of it is according to standard mark RBC 90/130. Its penetration and ductility is highest, while softening point decrease. And RC modified bitumen due to poor extensibility (7 cm) were mismatch standard requirements of the rubber-bitumen compounds. It can be describe elasticity properties of engine oil for preparing modified bitumen based rubber crumb.

Summary

In the study production of rubber-bitumen compounds based on spent rubber items and spent engine oil were investigated. It is established that the quantity of entered binders depending on physical and chemical conditions, which was optimal composition of rubber-oil at a ratio 3:2 and introduction to bitumen in amount of 15-25 wt.%. It is improving to physic-mechanical characteristics of rubber modified bitumen.

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