Getting Bituminous Ploymeric Mastic for Sanitation Pavement

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Abstract

Objectives: In this research, the durability of bitumen-polymer mastic is largely determined by low-temperature properties and the provision of proper adhesion with the mineral filler surface to their properties. Methods: It is necessary to change the structure and the properties of materials used for its preparation to increase the service life of the pavement. Besides, poor quality of bitumen leads to capital cost increase on labor-intensive repair works. Results: Polymeric materials are used in road construction to reinforce the base of asphalt concrete pavements. Due to their use, the quality and durability of roads increase significantly. They prevent the displacement of layers and the formation of voids under the asphalt canvas, and this allows to reducing the formation of cracks, ruts, and also to lessen the cost of road pavement repair significantly. This paper presents the results of bitumen modification studies by butadiene, ethylene-propylene, from butyl isoprene. The choice of these polymers is conditioned by the fact that they have the properties desirable for bituminous materials used in road construction for the sealing of asphalt concrete pavement joints, causing increased elastic, plastic, hydrophobic properties and weather ability. Conclusion: The results of important physical-mechanical properties study of a modified polymer containing mastics indicates that the introduction of fillers into bitumen leads to a significant improvement of specifications.

Keywords: Bitumen-Polymer Materials, Physical-Chemical Properties, Polymer Mastic, Road Bitumen

1. Introduction

The use of bitumen-polymer materials which began with road surfaces increased significantly. The paint waterproofing materials, sealants, anti-corrosion coatings, roofing roll and mastic materials appeared1-4. Speaking of polymers, which are used for these purposes, one may state almost for sure that almost all produced industrial polymers produced are tested in compositions with bitumen. The effect of their action is different, but usually if one may obtain a polymer and asphalt mixture, the composition has the fraction of valuable polymer properties: elasticity, decreased flowability at elevated temperatures, fracture toughness, and flexibility at low temperatures. The cost of polymeric road mastics and sealants is high and only occasionally is comparable to the cost of coatings made of bituminous materials. So now terpolymer bituminous compositions are used widely, which managed to combine their commodity costs with improved performance characteristics5,6. The objective of the article

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is to develop the formulations for bitumen-polymer mastics obtaining to repair road pavements.

2. Study Methods

The following polymers were selected to obtain bitumen joint mastics for road construction with improved low temperature and plastic properties: TCPE (copolymer of ethylene) with Mooney viscosity of 36-45, with a relative elongation at break of 400%; BBR (Bromo Butyl rubber) with Mooney viscosity of 38, with a relative elongation at break of 430%; butadiene rubber with a relative elongation at break of 500%; isoprene with Mooney viscosity of 27-36, with a relative elongation at break of 350%. At bitumen modification by polymers, the primary task was the search of rational ways for polymer and bitumen combination, which allows obtaining a homogeneous composition. At a direct introduction of polymer into bitumen, it is often impossible to achieve the desired uniformity, even at high mixing temperatures. The heterogeneity of composition is the cause of mastic elasticity loss, cracking and unprepared use of mastics in construction. In order obtain a uniform composition structure, it is preferable to introduce polymer into bitumen in the form of its solution. At that the process of a binder getting increases, the temperature mode of matching process is reduced, a complete homogeneity of the composition is achieved, and the required fracture toughness is provided. Further, the solvent component should be used having a high flash point. In this work, kerosene and alpha-olefin C26 fraction were used as thinning agents. The bitumen characterized by a softening point of 80 °C, the brittleness of -8 °C, the depth of a needle penetration of 62 mm at 25 °C and the elongation of 4 cm at 25 °C 4 used as a starting bitumen. The solutions of bitumen-polymer compositions with suitable concentrations (10, 20, 30, and 40%) prepared. The process of BPM preparation is the following one: the polymer is mixed with a solvent in predetermined proportions, and the mixture was left at room temperature for a day for polymer swelling. The mixture was vigorously stirred then at the temperature of 130-1400 °C until a complete dissolution is achieved after 1-2 hours of stirring. Then, these solutions were introduced into bitumen at calculated quantities and were stirred at 100 °C until a complete homogeneity to improve the adhesion index; an adhesive additive was used of 2% mass. For finished mastic and asbestos and gaseous elemental sulfur were used as fillers. Thus, adhesive and asbestos were introduced into bitumen-polymer composition followed by vigorous stirring of all compound using a milling stirrer for 1 hour at 130-1400 °C. Then the ready mixture was applied on a conventional coating (base), which is made of solid rectangular cardboard. The drying period of mastic made 24 hours. The composition of bituminous mastics is shown in Figure 1.

Figure 1. Chemical composition of samples of bitumen-polymer mastic.

3. Study Results and their Discussion

The samples of bitumen-polymer materials shown in Figure 1 were tested for such performance properties as water resistance, water absorption, flexibility, brittleness temperature, the softening temperature of the coating composition, adhesion, and elongation. The specifications of bitumen-polymer mastics are presented in Table 1. The increase of basic physical and mechanical characteristics in bituminous mastic samples is conditioned primarily by the increased cohesive and adhesive strength of a mineral (filler) and an organic portion of a composite material with the introduction of polymers. In its turn, the increase of mastic softening temperature containing polymers at the amount of more than 2%, can be explained by bitumen-polymer composition viscosity increase due to the development of highly structured dimensional polymer network which significantly impedes the wetting of mineral particles. The study results concerning obtained bitumen-polymer mastic samples showed a significant increase in their heat resistance, coupled with excellent low-temperature indicators. All samples pass a flexibility test at the temperature of (-15) - (-20) °C on the rod with the diameter of 25 mm.
The study of mastic brittleness temperature showed that the use of asbestos increases brittleness temperature by 2 °C, which allows to use them as a road surface, characterized by a high fracture toughness, particularly during winter periods. The results of basic physical-mechanical properties study concerning modified polymer containing bitumen mastics suggest that the introduction of fillers into bitumen leads to a significant improvement of specifications. Water resistance of obtained samples is an absolute one; the water absorption of the samples with a binder is 2-3 times lower than in the original bitumen. The elongation values of obtained mastics specimens with various adhesives is reduced by 2-4 times. One of the biggest challenges during the creation of a composite material for the rehabilitation of a roadway is the development of mastics, equally well opposed to the formation of shear deformation at high operating temperatures and the formation of cracking at low temperatures, i.e. the temperatures with a low-temperature sensitivity ratio. The result of obtained mastic samples study revealed that the filler content increase in bitumen-polymer composition naturally reduces this figure. It was found that the samples containing terpolymer of ethylene in a binder have the highest thermal stability. The compositions with isoprene are less thermally stable. The result of thermal stability ratio kinetics decrease study at the changes of filler content showed that the least change occurs at the asbestos content increase in bitumen, which indicates its lower temperature sensitivity.

### Table1. Specifications of bitumen-polymer mastic

| Indicators                                      | Original bitumen | Our samples (№/№) |
|------------------------------------------------|------------------|--------------------|
| Water permeability                             |                  | Absolute           |
| Water absorption for 24 h, %                   | 0,20             | 0,09               |
|                                                | 0,10             | 0,15               |
|                                                | 0,02             | 0,02               |
|                                                | 0,02             | 0,02               |
|                                                | 0,05             | 0,07               |
|                                                | 0,08             | 0,30               |
| Brittleness temperature, °C                    | -25              | -18                |
|                                                | -18              | -19                |
|                                                | -25              | -20                |
|                                                | -20              | -20,5              |
|                                                | -19,5            | -20                |
|                                                | -17              | -18,5              |
| The softening temperature of a binder, °C     | 84               | 65                 |
|                                                | 60               | 70                 |
|                                                | 120              | 115                |
|                                                | 99               | 80                 |
|                                                | 75               | 70                 |
|                                                | 85               |                    |
| Adhesion (adhesiveness to an applied base surface) | 3                | 3                  |
|                                                | 3                | 3                  |
|                                                | 2                | 2                  |
|                                                | 2                | 2                  |
|                                                | 3                | 3                  |
|                                                | 3                | 3                  |
| Elongation at 25°C, cm                         | 26               | 6                  |
|                                                | 4                | 10                 |
|                                                | 25               | 24,5               |
|                                                | 24,5             | 24,5               |
|                                                | 15               | 13                 |
|                                                | 9                | 10                 |

### 4. Conclusions

The analysis of study results indicates that there were significant changes in physical-chemical properties of bitumen-polymer materials, namely, at the increase of the ternary ethylene polymer content in bitumen-polymer materials the softening temperature increased and, in comparison with the known analogs of mastics the obtained results surpass them. However, the introduction of polymer solutions did not allow achieving the desired result fully concerning adhesive properties.

### 5. Summary

The durability of bitumen-polymer mastic is largely determined by not only by low-temperature properties but also by the provision of proper adhesion with the mineral filler surface to their properties. It was found that the modification of bitumen only by polymers does not enhance the adhesion of a binder with a stone material surface.

### 6. Conflict of Interest

The author confirms that the presented data do not contain any conflict of interest.
7. Acknowledgment

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