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Procedia Engineering

Volume 143, 2016, Pages 119–127

Advances in Transportation Geotechnics 3 . The 3rd
International Conference on Transportation Geotechnics
(ICTG 2016)



Improving Quality and Durability of Bitumen and Asphalt Concrete by Modification Using Recycled Polyethylene Based Polymer Composition

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Abstract

Bitumen is a component of asphalt binder that combines gravel, sand and mineral powder in the monolith.

Bitumen performs this function due to adhesive properties and ability to become liquid when heated, and becomes solid when cooling.

At the same thermoplasticity and low strength makes bitumen the most sensitive of all the components of asphalt to the effects of traffic loads and climatic factors.

Softening of bitumen at summer temperatures causes rutting on roads and winter fragility results in the occurrence of low-temperature cracking.

Modification of bitumen by such polymer additives as thermoelastoplastics of SBS type, latex, terpolymers allows improving bitumen properties and increasing asphalt concrete durability. These additives increase cohesive strength and heat resistance of bitumen, impart elasticity to it, improve its behavior at low temperatures.

The main reason that hinders wide application of polymeric modifiers is their high cost. One promising way for solving an issue is partial substitution of expensive modifiers for cheaper plastic waste. In addition, this waste must meet two requirements. Firstly, it should be compatible with bitumen. Secondly, it must provide bitumen with the required positive properties, although maybe not to the extent as special modifiers do.

The conducted research showed that so-called recycled polyethylene resulting from the processing of plastic products (films designed for agricultural works, packaging material etc.) meets these requirements.

Recycled polyethylene increases viscosity, cohesive strength and heat resistance of bitumen.

The conducted studies allowed establishing effective combinations on the basis of recycled polyethylene which ensured significant reduction in the content of expensive special polymer modifiers in bitumen.

Ratio of components in the polymer composition is as follows: recycled polyethylene - from 50 % to 65 %, latex or SBS thermoelastoplastics type - from 30 % to 50 %, plasticizer (industrial oils, oil extracts, etc.) up to 10 %. Rational content is from 3 % to 4 % by weight of bitumen.

The technologies of combining polymer components among themselves and with bitumen were developed.

Modification of bitumen by created polymer compositions improved strength and heat resistance characteristics of asphalt concrete and increased its resistance to cracking.

Technological parameters of modified bitumen based asphalt mixtures preparation and placing were defined.

Modification of asphalt concrete by direct introducing of composite polymer additive in the mix was proposed.

Keywords: recycled polyethylene; bitumen; asphalt concrete; modification

1 Introduction

The durability of asphalt concrete pavements is determined by the duration of their operation while preserving the required performance under traffic loads and weather and climatic factors.

Bitumen produces a decisive impact on the durability of asphalt concrete which due to its bonding ability acts as binding component. When heated, bitumen becomes liquid allowing it to mix with a mixture of crushed stone, sand and filler. When cooled, bitumen becomes hard and turns mixture into a single monolith. However, thermoplastic properties of bitumen are one of the main reasons for the occurrence of deformations and deterioration on the pavement.

So, in summer bitumen softens at elevated temperatures and rutting is formed on the pavement under traffic loads. In winter bitumen becomes hard and brittle. Consequently, at low-temperature compression of asphalt bitumen cracks and transverse cracks occur on the pavement surface. Of all the components of asphalt bitumen is the least durable material and it has no elastic properties. Under the influence of long-term traffic loads stresses are accumulated in bitumen resulting in the occurrence of "fatigue" cracks on the pavement.

One of the most effective ways to increase the durability of asphalt pavements is modification of bitumen by special polymer additives, such as SBS type thermoelastoplastics, latex, terpolymer and others. These additives increase heat resistance of bitumen, impart elasticity to it, improve behavior at low temperatures. Due to this resistance of asphalt pavements to traffic loads impact and adverse weather conditions increases and thus, their service life is prolonged.

The main reason that hinders a wide application of polymer modifiers is their high cost.

One of promising ways for solving this issue is a partial replacement of expensive special modifiers with the cheaper general-purpose polymers or their waste. The main condition for this is imparting modified bitumen the required properties and compliance with current standards.

Among the general-purpose, high density polyethylene and recycled polyethylene – the product of recycling plastic waste polymers have the ability of combining with bitumen.

Given the above, the purpose of the study was to establish the possibility of using these materials as partial substitutes for such additives as latex, thermoelastoplastics and terpolymers, and creating on their basis cheap and effective composite bitumen and asphalt modifier.

2 Research study

At the first stage of creating polymer modifying composition the effect of polyethylene and recycled polyethylene on the properties of bitumen was studied.

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