Abstract

The construction sector shows a very high demand for natural resources, mainly aggregates and mineral binders. The sources of these raw materials are limited, which, combined with their significant use, cause their stocks to decline rapidly. This creates the need to use raw materials from other sources which meet the basic requirements. In line with the idea of a circular economy, recycled raw materials or waste resulting from industrial processes would be the best for this purpose. Such an approach of management of natural resources, recycling and the use of waste may allow for securing reserves of natural resources and improving the ecological balance of the world. On this basis, a mixture bound with a mineral binder was proposed, consisting of three industrial wastes: unburnt coal mining slate, shredded rubber wastes and fly ash.

The management of rubber waste, mainly from the automotive industry, is a problem on a global scale. It is estimated that around 1 billion used car tires are added to the world annually. Rubber wastes do not have an aggressive influence on the natural environment, but due to their flammability, their storage sites can be dangerous. Due to the characteristics of irreversible chemical processes occurring in vulcanizates, the raw material recycling of rubber waste is very complicated and expensive. Hence, the most frequently chosen methods of reducing the amount of this waste in landfills are energy, product and material recycling.

Unburnt coal mining slate is mining waste accompanying the extraction of hard coal. Their management is a local problem occurring mainly in the Upper Silesian Basin. It is estimated that about 37 million tons of this waste are added each year. Current activities accompanying attempts to abandon coal-fired power generation will result in a constant decrease in the annual increase in this waste. However, it is still necessary to remember about very large amounts of it lying on the existing heaps.

Fly ash is a waste generated by the production of electricity from fossil fuels. In construction, they have been used for a long time as a substitute for mineral binders or as an additive to improve the workability and reaction of pozzolanic concrete mixtures. The mixture consisting of these three wastes, bound with the binder CEM I cement, can be used in road engineering construction, as a construction material or to strengthen the ground. Its use will allow the disposal of large amounts of waste. The paper presents an analysis of laboratory tests of physical and mechanical parameters of "Unburnt coal mining – shredded rubber wastes – fly ash – cement" mixtures.

Results and their analyses were preceded by a literature review, which presented the characteristics and recognition of the physical and mechanical properties of each of the components as well as the influence of rubber waste on the mixtures bound with the binder. Due to the local nature of the problem of coal waste management, the review of the literature on the influence of rubber waste on mixtures bound with binder mainly refers to their use in concrete mixtures.

The research on physical and mechanical properties was performed in two stages. Tests of mixtures of a very similar scope were carried out, in which the unchanged content of fly ash and cement, as well as the additives of 5, 10 and 15% of shredded rubber waste, were used in relation to the weight of unburnt coal mining slate. The scope of the tests included the control of mass water absorption and the height of capillary rise of water, strength tests after 7 and 28 days of sample care, and testing under cyclic loading conditions.

In stage 1, an unburnt coal mining slate with grain size 0/31.5 mm from Bielsko-Biała (no. 1) was used for the preparation of mixtures, and in stage 2 unburnt coal mining slate with decarburization grain size 0/31.5 mm produced at the Haldex Plant (no. 2) was used. The use of two coal mining slates from different places made it possible to check whether the proposed mixture would have similar properties, regardless of the properties of the base material.

In the cyclic loading study included in stage 2, the DIC ARAMIS 3D measurement system was used to determine the deformability of the mixtures under load. The presented results allowed to determine the effect of using rubber waste on the reduction of mass water absorption and the amount of water capillary rise in the mixture, as well as the impact on the reduction of the compressive strength value and increase of the deformability of the tested mixtures. The results of the cyclic loading indicated that the additives of shredded rubber waste improve the fatigue life of the mixture by reducing the reduction in the value of the elastic modulus caused by the cyclic loading of the samples.

The obtained results for two different unburnt coal mining slates confirmed the effectiveness of their use in "Unburnt coal mining slate – shredded rubber wastes – fly ash – cement" mixtures.

Konrad Walotek, 13.04.2022