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Investigation of radiation absorption coefficients of lead-zinc mine waste rock mixed heavy concrete at 662–1460 keV energy range

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HIGHLIGHTS

- Lead mine waste was used in heavy weight concrete.
- Lead mine waste as aggregate was replaced by Magnetite, Limonite and Barite at rate of 25%, 50% and 75%.
- Heavy weight concrete samples were prepared in C16/20, C25/30 and C35/45 classes.
- The mineralogical and petrographic properties of the aggregates were described.
- Radiation absorption coefficients were measured for 662–1460 keV energy.

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ABSTRACT

The objective of this study is to observe the radiation shielding efficiency of concrete produced by using the lead wastes that are stored in lead-zinc mines processing of which is not financially viable in the mines they are extracted from that have negative effects on the environment. Within this scope, concretes were produced to be used as radiation shield concretes. The samples were prepared by altering the amounts of heavy aggregates such as lead–zinc mine waste, Magnetite, Limonite, and Barite at 25%, 50%, and 75% ratios, and concrete samples were prepared in C16/20, C25/30, and C35/45 concrete strength grades to determine the effects of these grades on radiation absorption properties. In order to determine the radiation absorption coefficients, absorption coefficients at 662 keV, 1173 keV, 1332 keV, and 1460 keV energy levels from Cs-137, Co-60 and K-40 sources were determined by concrete slabs with dimensions of 20 × 20 × 5 cm.

1. Introduction

Special aggregates utilized in the production of heavy concrete can be natural aggregates with iron ores such as barite, limonite and magnetite, or artificial aggregates that are industrial wastes such as iron and lead particles. The most important difference between heavy concrete and conventional concrete is that the unit masses of heavy concretes are much higher than traditional concretes [1].

While heavy concretes are used to protect structures from sliding and tipping thanks to their weight, they are also used in structures built for protection against nuclear rays emitted from radioactive substances, especially deadly neutron and gamma rays that can penetrate objects [2]. In order to be protected from these radioactive effects, heavy aggregate concrete is the most suitable material [3]. Many studies have been carried out on protective characteristics of heavy concretes against radioactive effects. Studies on heavy aggregates include those on Barite, Colemanite [4,5], Magnetite, Hematite, Geothite, Datolite-Galena, Magnetite-Steel, Limonite-Steel, Serpentine, Limonite and Siderite [6,7,8,9], Heavy metal glasses [10,11].

Today, due to the rapid increase in human population and depletion of available resources, waste management issues such as reducing wastes, evaluating existing wastes as a potential source of raw materials, and recycling of used raw materials have become increasingly important. Usage of industrial wastes is becoming a topic of more and more interest as a means of reduced consumption of natural resources, minimization of environmental pollution and decreasing energy costs. With regards to environment impact, usage of wastes in concrete technology also increases targeted concrete properties aimed at as presented in the literature [12–17]. In addition to environmental issues, wastes create additional costs due to the necessity of storage in many cases. For this

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reason, it is aimed to dispose of various wastes regardless of their contents. Studies are being carried out on the use of wastes in radiation shielding. Researchers have studied radiation shielding using materials such as trommel sieve waste [18], amethyst ore [19], solid waste containing lead [20], open-cell metal foam [21], soils (*Land soil (clay and silt type), hill soil (sand and crust type), beach soil (sand and silt type) and River soil (alluvial type)*), some building materials (*cement, brick, concrete and sand*) and heavy beach minerals (*rutile, zircon, ilmenite and garnet*) [22], barium–borate–fly ash glasses [23], marble [24].

The aim of this study is to investigate the radiation absorption coefficients of composite materials produced with tallow and stored as waste in lead-zinc mines used in radiation shielding instead of heavy aggregate at different energy levels. To our best knowledge, there is no study on the radiation absorption coefficients of concrete samples with lead-zinc mines replaced by heavy weight aggregate at different percentages.

2. Material and method

2.1. Aggregate

The rocks used in the study were lead-zinc mine residues, Magnetite, Limonite, and Barite. The rocks were broken with a jaw crusher and brought to the size of concrete aggregate, then sieved with a sieve and grouped in 0–4, 4–11.2, 11.2–22.4 mm grades. They may be seen in Fig. 1.

The chemical analysis of the aggregates is shown in Table 1.

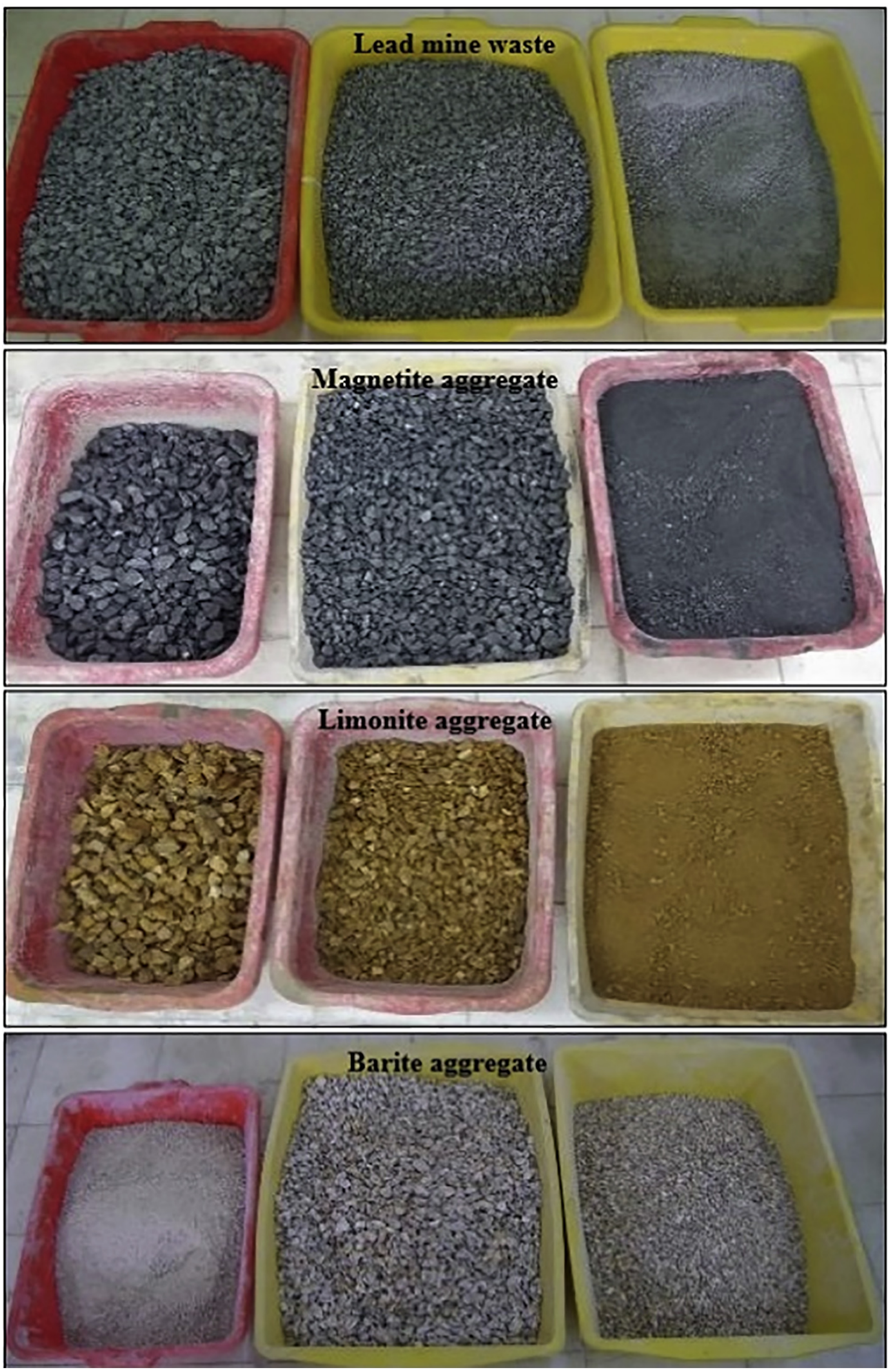

Fig. 1. Crushed aggregate in jaw broken and separated in classes.