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Radiation Shielding Properties of Shotcrete

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Shotcrete is a concrete spraying of concrete or mortar that may be accomplished through either a dry- or wet-mix process. It is made of normal weight aggregates which have a density of approximately 2323 kg/m^3. For the most part, shotcrete is used in underground excavations in rock and repair work in constructions. In this study, linear attenuation coefficient (μ, cm^{-1}) was measured for shotcrete produced with dry mix process. Measurements were carried out by gamma spectrometry containing NaI(Tl) detector and multichannel analyzer.

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1. Introduction

Modern development of science and technology is accompanied by creation of a variety of new materials for both common and special construction use [1]. Shotcrete is a concrete spraying of concrete or mortar that may be accomplished through either a dry- or wet-mix process. In the dry-mix process, water and liquid admixtures are added at the end of the nozzle to the rest of the materials. Air pressure is used to convey the dry mix through the hose to the nozzle, where water is added. The nozzle man determines the amount of water added to the mix at the nozzle [2]. It is made of normal weight aggregates which have a density of approximately 2323 kg/m^3. For the most part, shotcrete is used in underground excavations in rock and repair work in constructions.

Radiation is either ionizing or non-ionizing, depending on how it affects matter. When gamma radiation is incident on a finite thickness of material, there exists some probability that the radiation will interact in the material and be attenuated. If the material thickness is measured in cm, then μ is called linear attenuation coefficient (μ, cm^{-1}) having dimensions "per cm". Linear attenuation coefficients, however, depend on the density (ρ) of the shielding material. The density does not have a unique value but depends on the physical state of the material, for example in the case of concrete, on its moisture content [3].

In this study, linear attenuation coefficient (μ, cm^{-1}) was measured for shotcrete produced with dry mix process. Measurements were carried out by gamma spectrometry containing NaI(Tl) detector and multichannel analyzer (MCA).

2. Experimental details

For producing shotcrete concrete aggregate was obtained from Kartaş Gravel Plants in Isparta, Turkey. The maximum particle size of aggregate was kept constant at 8 mm in all mixtures. Fine and coarse aggregates were separated into two size fractions, 0–3 mm fine aggregates (FA) and 3–8 mm coarse aggregates (CA) and distribution of aggregate percentage 30% coarse to 70% fine was determined in the study. Due to dry mixture method was selected during the application to prevent the formation of dust and clogging of hose, 4 percent part of the aggregate amount was humidified silt and clay content ratios of aggregate was kept as low as possible.

The ordinary Portland cement (OPC) was obtained at Göltaş Cement Factory in Isparta. Mixing calculations were done according to Turkish Standards in Concrete mix design. The calculations were made on concrete mixture according to Turkish Standards. Water to cement ratio (W/C) was kept constant between approximately 0.35 to 0.50 percent by the operator at the end of the hose. Powder Sigunit AL-N which is suitable as a dry mixture and significantly reduces the amount of rebound and provide better adhesion in injection system. Additive materials were used up to seven percent of the cement dosage. Network water (W) was used as mix water. Dry mix sprayed concrete application in accordance with the current Turkish code TS 11747 square-edged wood panel 45 cm were prepared [4]. 10 cm thick dry mix shotcrete was applied to test panels. The panels were cured, while maintaining suitable conditions. After curing period for determining the linear attenuation coefficient of shotcrete 10 cm diameter core samples were taken from panels. Core samples are shown in Fig. 1.

Radiation measurements were conducted on three different thicknesses of shotcrete samples. The linear attenuation coefficients of concrete samples have been measured using the gamma spectrometer system containing NaI(Tl) detector coupled to a digital spectrum analyzer (DSPEC LF) which was a full featured 16k multichannel analyzer on advanced digital signal processing techniques, and were recorded on the MAESTRO-32 gamma spectroscopy software. The measurements have been per-

Fig. 1. Core samples.

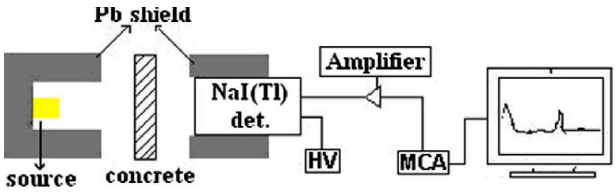

Fig. 2. Schematic view of the experimental setup.

formed at 1173 and 1332 keV which was obtained from ^{60}Co radioactive sources. The schematic arrangement of the experimental setup used in the present study is shown in Fig. 2.

The photon attenuation coefficients have been evaluated comparing I and I_0, which are the measured count rates in detector, respectively, with and without the absorber of thickness x (cm):

$$I = I_0 \, \mathrm{e}^{-\mu x}. \tag{1}$$

3. Results and discussion

The linear attenuation coefficients (μ) for concretes have been measured at the photon energies of 511 and 1275 keV. The obtained results are displayed in Fig. 3.

It is clearly seen from this figure that the linear attenuation coefficients decreased with the increasing photon energy.

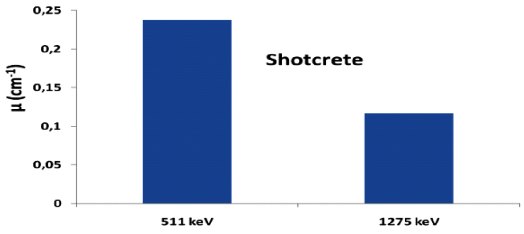

Fig. 3. Measured linear attenuation coefficients.

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