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Gamma-ray attenuation coefficients and transmission thickness of high consistency heavyweight concrete containing mineral admixture

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Abstract

In the study, high consistency heavyweight concrete mixtures containing barite aggregate were produced by using some common mineral admixtures (viscosity modifier, silica fume and fly ash) at various water/binder ratios and binder contents. Gamma-ray linear attenuation coefficients of the concrete mixtures were determined by using gamma sources of ^{137}Cs and ^{60}Co in NaI(Tl) gamma spectrometry system. The relationship between specimen thickness and transmission of the rays was constituted by emphasizing their mean free path, half-value layer, and tenth-value layer. Moreover, experimental mass attenuation coefficients of the concrete specimens were determined and compared with theoretical mass attenuation coefficients calculated by XCOM software depending on elemental fractions of these concrete in equivalent energies (662 keV, 1173 keV and 1332 keV). As a result, the replacement of the aforementioned admixtures with ordinary cement negatively affected the linear attenuation coefficients of the heavyweight concrete. A relative change of up to 25% was observed between the least and the highest attenuation thickness values at a certain gamma-ray transmission. A good regression relationship has been established between density and linear attenuation coefficients, density and mean free path, and density and half- or tenth-value layers of the heavyweight concrete. Theoretical (XCOM) mass attenuation coefficients were found similar to the experimental mass attenuation coefficients of the heavyweight concretes. Although there is a good linear regression relation between the theoretical and experimental mass attenuation coefficients at 662 keV energy of gamma rays, the relations were disappeared at 1173 and 1332 keV energies of gamma rays.