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Contribution of coal ash used as an additive to concrete to radiation levels

G. Haquin[1] and K. Kovler[2]

[1]Radiation Safety Division, Soreq Nuclear Research Center, Yavne 81800, Israel
[2]Faculty of Civil and Environmental Engineering, Technion – Israel Institute of Technology, Haifa 32000, Israel

Abstract

Recycled industrial by-products containing enhanced concentrations of Natural Occurring Radioactive Materials (NORM) are extensively used in the construction industry. The average ^{226}Ra, ^{232}Th and ^{40}K activity concentrations in the fly ash (FA) produced at power plants in Israel are approximately 150, 130 and 300 Bq/kg, respectively. The major use of FA in Israel is its addition to cement and to concrete, which may increase the activity concentration in the building product.

Concrete containing FA as additive has higher activity concentration of ^{226}Ra, ^{232}Th and their decay products and ^{40}K, than concrete without FA. This higher activity concentration will consequently increase the external radiation exposure of the inhabitants in the room.

The mineralogical characteristics of the FA and of the concrete may influence on the internal radiation exposure of the inhabitants in the room from the radon exhaled from the concrete. Several works and laboratory measurements have found a lower radon emanation rate in concrete containing FA compared to concrete without FA.

Concrete samples containing different concentrations of FA (0 to 150 kg/m^3 of concrete) were prepared both in the laboratory and at the building site, reflecting controlled and normal production processes. Samples using different batches of FA were also prepared.

The radionuclide concentration was determined by gamma spectrometry and the radon emanation coefficient was determined by the closed chamber method, both following the procedures described at Israeli Standard 5098 (IS 5098).

The external and internal exposure were calculated in the center of a standard Residential Protected Room (RPR) constructed with concrete with and without FA, according to the assessment model in the IS 5098. For the external exposure the gamma index (I_γ) of the IS 5098 was used and for the total exposure (internal and external) the total index (I) was used. The average annual external dose was found to be 0.2 mSv (I_γ=0.14) and 0.13 mSv (I_γ=0.09) for concrete with and without FA respectively. The annual total doses are estimated to be 0.74 mSv (I=0.53) and 0.77 mSv (I=0.55) for concrete with and without FA, respectively.

The radon concentration at an RPR constructed with concrete with FA, under conservative living conditions (air change per hour of 0.5 h^{-1}), using the highest

emanation coefficient measured is estimated to be ~30 Bq/m^3. The radon concentration at the same RPR constructed using concrete without FA is estimated to be ~35 Bq/m^3. Those radon concentrations will produce an annual internal dose of 1.0 and 1.2 mSv respectively (using the dose conversion factor of 12 nSv Bq^{-1} h^{-1} m^3 as recommended in the ICRP 2009 statement).