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Radon exhalation from concrete containing coal fly ash – laboratory and *in-situ* measurements

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Abstract

The increase of ^{226}Ra activity concentration, the mineralogical characteristics of the fly ash (FA) and of the concrete may influence on the radon exhalation rate and consequently on the radon exposure of the public.

The Israeli Standard 5098 (IS 5098) "Content of natural radioactive elements in building products" limits the content of natural radionuclides as well as the radon emanation from concrete.

A study was conducted to investigate and quantify the influence of FA content in concrete and to find a correlation between *in-situ* and laboratory measurements.

Concrete samples containing different contents of FA in concrete (0, 120 and 140 kg/m^3) were prepared in the concrete plant from the same mixes used in the construction of Residential Protected Rooms (RPR). In the second mixture FA with a moderate content of ^{226}Ra (~100 Bq/kg) was used, while in the third mix - with an elevated content (~200 Bq/kg).

The free exhalation rate ($E_{0,av}$) and the concrete emanation coefficient (ε) were measured according to IS 5098 standard procedure by the closed chamber method.
The *in-situ* free wall exhalation rate ($E_{0,w}$) was determined under sealed conditions of the RPR by monitoring the radon concentration ingrowths in the air volume of the room. The values of $E_{0,av}$ and $E_{0,w}$ are summarized in Table 1.

Table 1: Exhalation rates from concrete as measured in the laboratory and *in-situ*

FA content [kg/m^3]	$E_{0,w}$ [Bq/m^{2}h]	Range of $E_{0,w}$ [Bq/m^{2}h]	$E_{0,av}$ [Bq/m^{2}h]	$E_{0w}/E_{0,av}$	ε (%)
0	7.90±17%	4.4-9.4	6.51	1.21	20.0
120	8.12±14%	4.9-10.3	8.93	0.91	11.9
140	7.86±20%	5.5-11.7	7.58	1.04	17.6

Emanation coefficient measured in laboratory samples tends to decrease in concrete containing FA, while for the *in-situ* measurements no clear influence of the FA content on $E_{0,w}$ was found.

$E_{0,w}$ measured *in-situ* was not influenced by the effective radon decay ($\lambda_{eff}=\lambda_{Rn}+\lambda_v$) in the RPR during the measurement. Measurements under sealed ($\lambda_{eff} = 10^{-3}–10^{-4}$ h^{-1}) and closed conditions (λ_{eff} ~ 0.15 h^{-1}) gave similar results (8.1 and 8.4 Bq/m^{2}h respectively).

The uncertainty of the measurement (*in-situ* and laboratory) was assessed to be ~25%. It is concluded that the measurement conditions and the calculation method are the major factors influencing the uncertainty.

The calculated radon concentration under conservative living conditions ($\lambda_v \sim 0.5\ h^{-1}$) in a RPR is estimated to be ~ 30 Bq/m^3.