



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

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Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge
Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn
Ba	L	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb
Ra	A											
L	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er

Introduction

- ❖ Fly Ash (FA) contain higher activity concentration of ^{226}Ra , ^{232}Th and their decay products and ^{40}K , than common aggregates or sand. Thus, its use in concrete will enhance their activity concentration.
- ❖ This higher activity combined with the mineralogical characteristics of FA may influence on the radiation exposure of the population in buildings.
- ❖ The results of a survey of different mixtures of concrete containing FA is presented.

Survey method

- ❖ Concrete samples having 0, 75 and 120 kg/m³ of FA from different sources were examined.
- ❖ The FA was produced at different power plants
- ❖ Cement, sand and aggregates were from the same source for all mixtures
- ❖ The radionuclide content and the Rn emanation were determined according to IS 5098 procedures.

Exposure calculation

- ❖ The calculation of the population potential exposure were based on the IS 5098 principles
- ❖ Standard room at normal living conditions
- ❖ Calculation of gamma index

$$\frac{C_K}{A_K(\rho d)} + \frac{C_{Ra}}{A_{Ra}(\rho d)} + \frac{C_{Th}}{A_{Th}(\rho d)} \leq I_\gamma = 0.4 \equiv 0.44 mSv/y$$

- ❖ Calculation of total index

$$\frac{C_K}{A_K(\rho d)} + \frac{C_{Ra}}{A_{Ra}(\rho d)} (1 - \varepsilon) + \frac{C_{Th}}{A_{Th}(\rho d)} + \frac{\varepsilon \cdot C_{Ra}}{A_{Rn}(\rho d)} \leq I = 1 \equiv 1.1 mSv/y$$

Radionuclide activity concentration

Material	FA [kg/m ³]	⁴⁰ K [Bq/kg]	²³² Th [Bq/kg]	²²⁶ Ra [Bq/kg]
Cement		110.7	22.9	70.8
Sand		74.8	7.8	9.2
Aggregate		33.6	1.5	40.6
Concrete	0	43.3	5.4	37.2
Concrete	75	59.6 (49-67.2)	9.9 (7.2-14.5)	33.2 (31-37.5)
Concrete	120	64.9 (48.4-85.6)	11.2 (7.5-19.5)	37.7 (33.6-42.4)

Radon emanation coefficient

FA type	FA [kg/m ³]	²²² Rn [%]	SD
	0	10.4	0.4
IA	75	13.1	1.1
IA	120	11.1	0.7
SH	75	13.0	0.2
SH	120	12.2	0.2
AH	75	12.2	2.0
AH	120	11.1	1.2
RH	75	11.0	0.3
RH	120	9.3	0.7
CH	75	11.7	0.4
CH	120	8.7	0.3

Exposure calculation

FA type	FA [kg/m ³]	E_{γ} [mSv/y]	E_{tot} [mSv/y]
	0	0.17	0.66
IA	75	0.15	0.67
IA	120	0.18	0.73
SH	75	0.21	0.83
SH	120	0.25	0.91
AH	75	0.17	0.66
AH	120	0.19	0.83
RH	75	0.18	0.67
RH	120	0.21	0.70
CH	75	0.17	0.64
CH	120	0.18	0.57

Previous results

- ❖ Concrete samples with 0 – 150 kg/m³ of FA were tested in the lab according to IS 5098 procedures.
- ❖ The ²²⁶Ra, ²³²Th and ⁴⁰K activities concentration were enhanced proportionally with increasing FA content
- ❖ A decrease in Rn emanation was found in concrete with FA.
- ❖ The rate of the Rn emanation decrease was not proportional to the ²²⁶Ra activity concentration.

Conclusions

- ❖ Sixty Concrete samples containing 0, 75 and 120 kg/m³ FA from different sources were examined.
- ❖ The activity concentration of ²³²Th and ⁴⁰K increased by 100% and 50% respectively for the highest FA content.
- ❖ No change was found in the ²²⁶Ra activity concentration, in contrary to previous results
- ❖ The Rn emanation decreased by 14% when increasing FA from 75 to 120 kg/m³, a smaller rate than previously seen.

Conclusions ...

- ❖ The total average exposure in concrete with FA ranges from **0.69 to 0.75 mSv/y** for 75 and 120 kg/m³ FA respectively.
- ❖ The average gamma exposure was 0.18-0.20 mSv/y respectively.
- ❖ No significant difference was found in the exposure from concrete with and without FA (0.66 and 0.17 respectively)

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