



# Radon Exhalation from Concrete Containing Fly Ash: Laboratory and *In-Situ* Measurements

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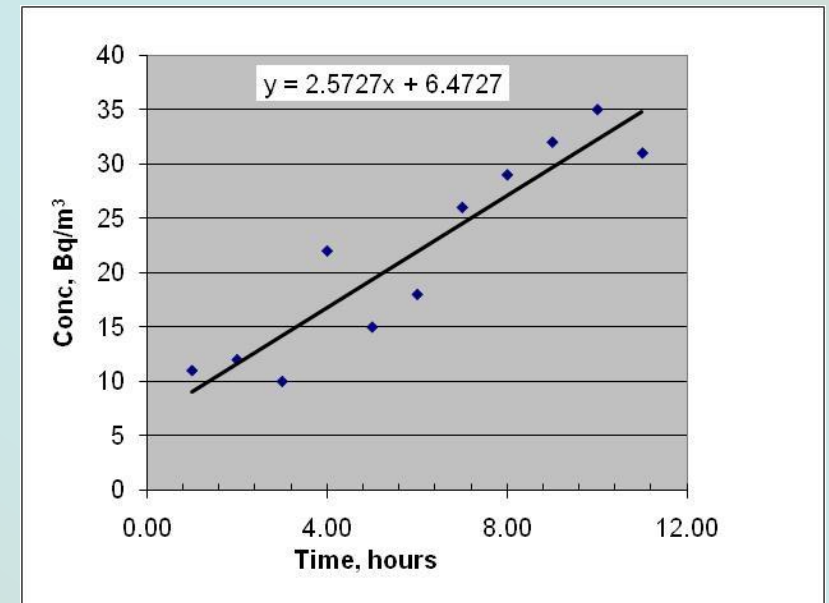
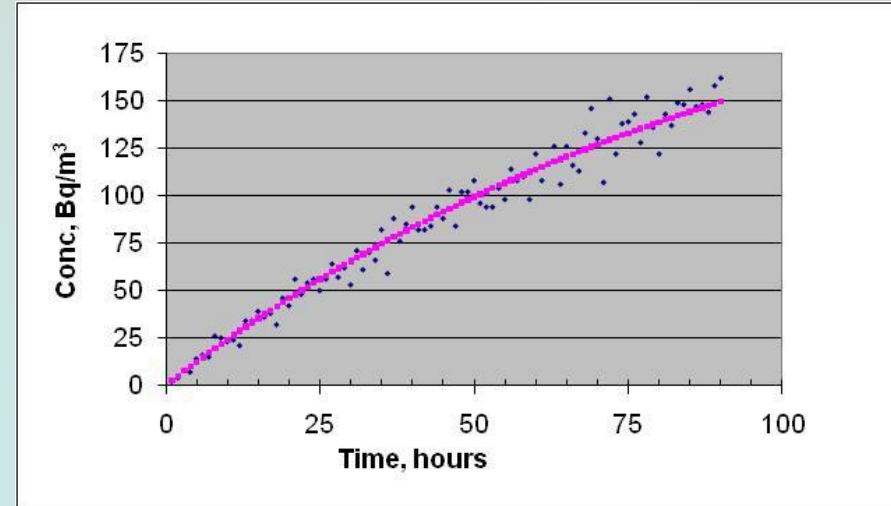
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# Introduction

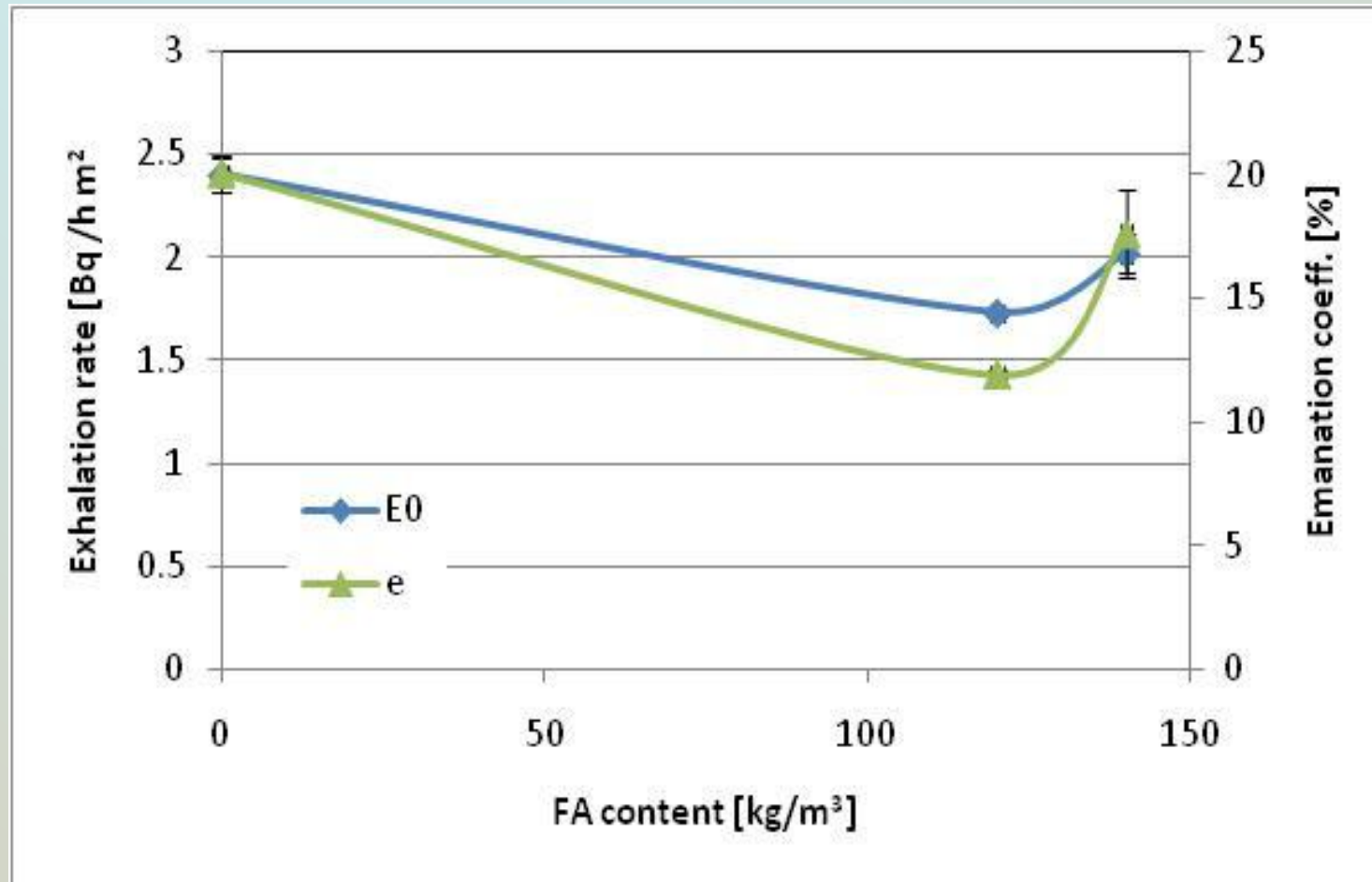
- ❖ Most building materials contain natural radionuclides from the  $^{238}\text{U}$  and  $^{232}\text{Th}$  decay chains and  $^{40}\text{K}$ .
- ❖ The increase of  $^{226}\text{Ra}$  activity concentration, the mineralogical characteristics of the FA and of the concrete may influence on the radon exhalation rate.
- ❖ Previous laboratory studies showed decrease in Rn release in concrete containing FA
- ❖ In-situ measurements of Rn exhalation rate were not reported
- ❖ This study investigate and quantify that influence and correlates between *in-situ* and laboratory measurements

# Laboratory measurements of radon exhalation

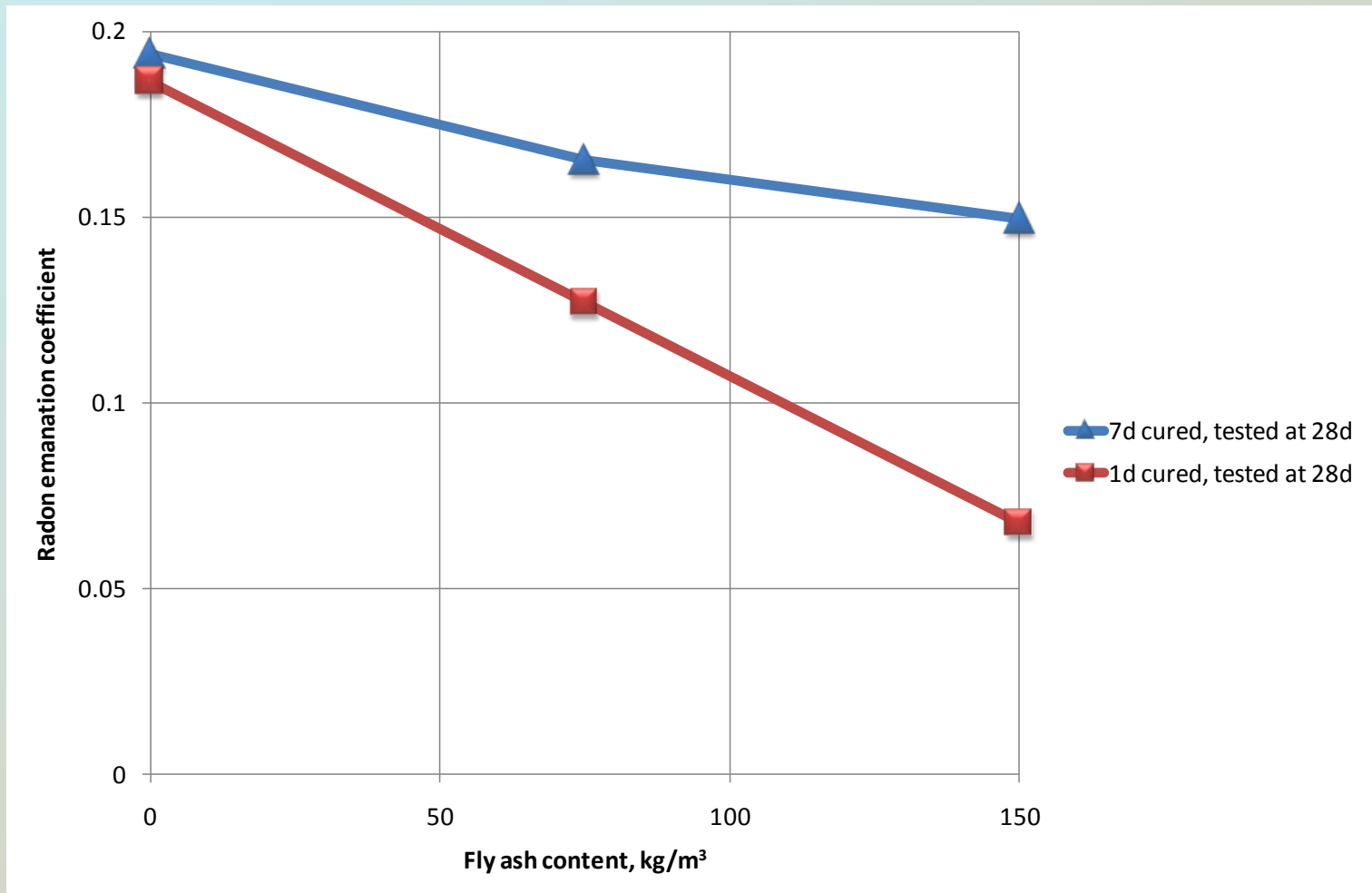
- ❖ Concrete samples containing 0, 120 and 140 kg of FA per m<sup>3</sup> of concrete
- ❖ The average <sup>226</sup>Ra activity concentrations are: 27.1, 33.1 and 36.8 Bq/kg respectively.
- ❖ The free exhalation rate was measured by the close chamber method (IS 5098) for uncoated samples of 10 cm x 10 cm x 20 cm using a continuous radon monitor.
- ❖ The average free Rn exhalation was calculated fitting a non-linear regression of the Rn ingrowths curve and using the slope of the beginning of the Rn ingrowths.



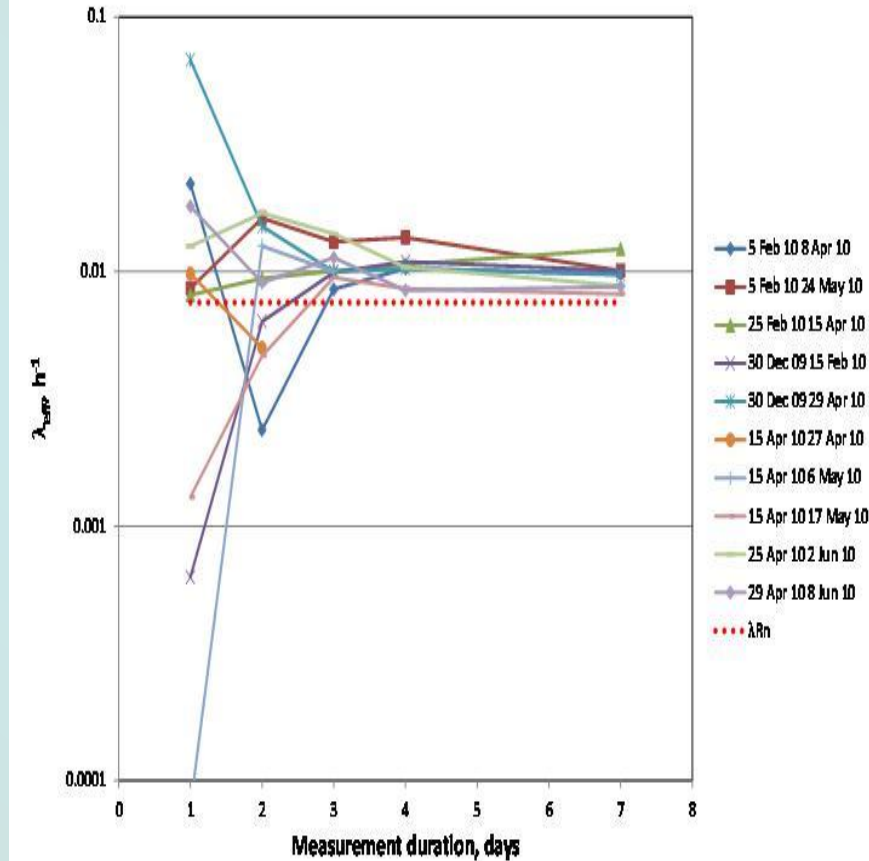
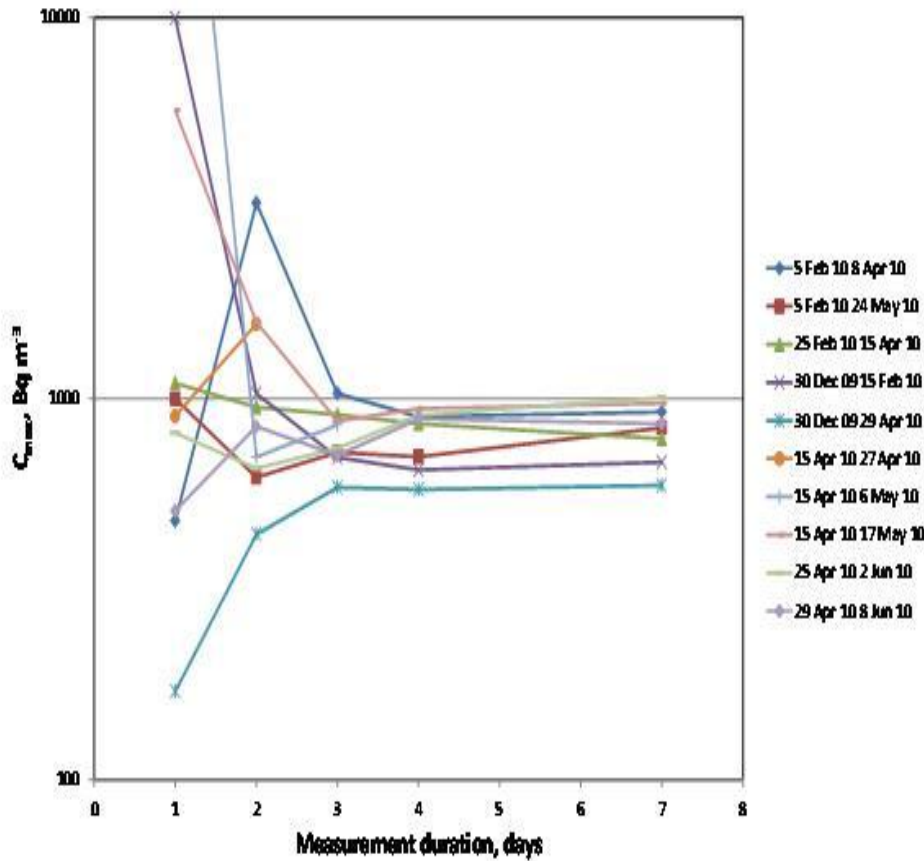
# FA influence on Rn exhalation in lab measurements



# Influence of curing period on Rn



# Minimum measurement period

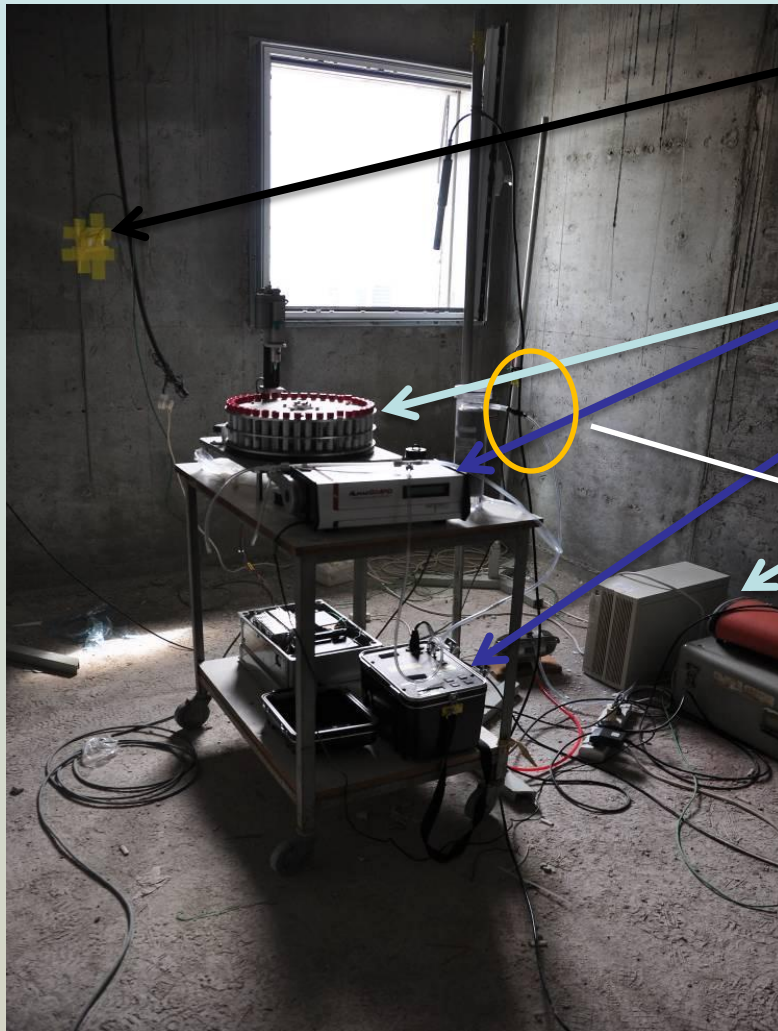


# *In-situ* measurements of Rn exhalation

- ❖ Residential Protected Rooms (RPR) were constructed using 3 different concrete mixtures
- ❖ The free wall exhalation rate was determined under sealed conditions of the RPR.
- ❖ The ventilation rate at several living conditions in RPR was determined by two independent methods:
  - ❖ decay of  $SF_6$  concentration with time
  - ❖ calculation of the ventilation rate from the ingrowth curve of the radon concentration in the room



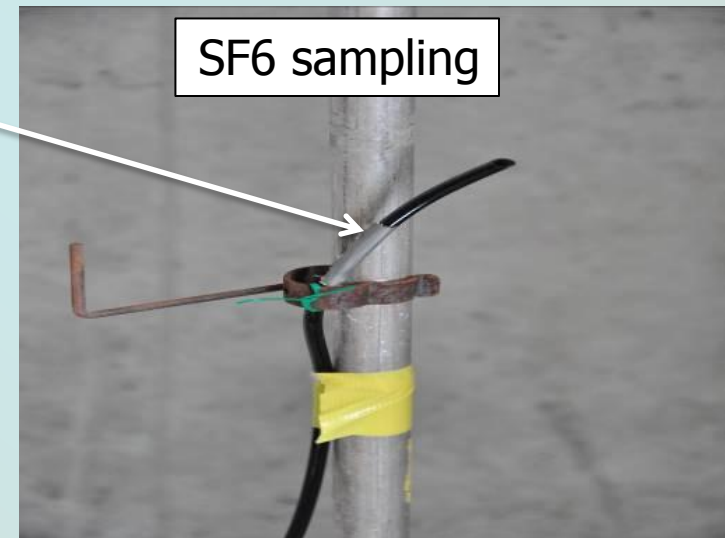
# In-situ measurements of Rn and ventilation rate



Temp

CRM

SF<sub>6</sub>



# In-situ and Lab results

Measurements under sealed ( $\lambda_{\text{eff}} = 10^{-3} - 10^{-4} \text{ h}^{-1}$ ) and closed conditions ( $\lambda_{\text{eff}} \sim 0.15 \text{ h}^{-1}$ ) gave similar results (8.1 and 8.4 Bq/m<sup>2</sup>h respectively).

FA content [kg/m <sup>3</sup> ]	$E_{0\text{wall,av}}$ [Bq/m <sup>2</sup> h]	SD	Range [Bq/m <sup>2</sup> h]	$E_{0,av}$ [Bq/m <sup>2</sup> h]	$E_{0w}/E_{0,av}$
0	7.90	17%	4.4-9.4	6.51	1.21
120	8.12	14%	4.9-10.3	8.93	0.91
140	7.86	20%	5.5-11.7	7.58	1.04

# Ventilation rate measurements

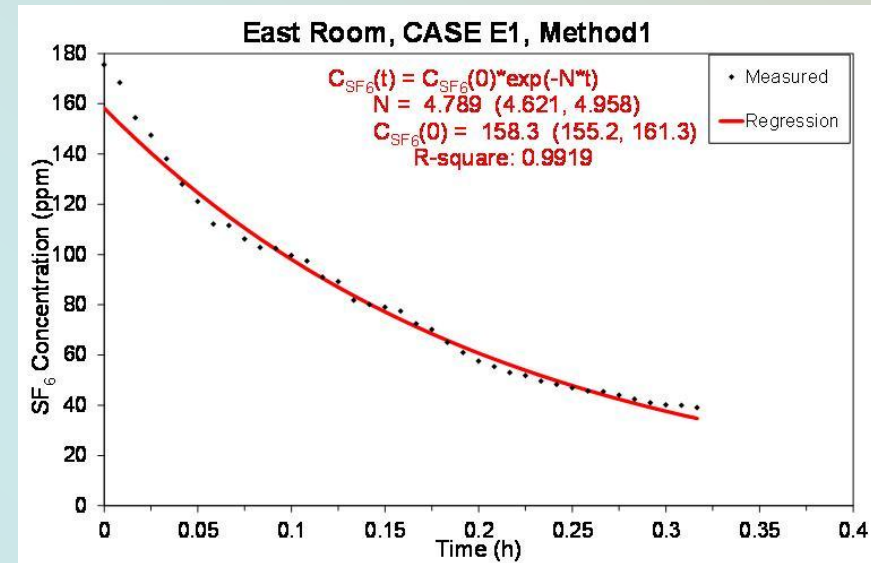
❖ Ventilation rate under several living conditions from sealed DSS to open door and window.

❖ Sealed DSS room

❖  $\lambda_{\text{eff}} \sim 10^{-3} - 10^{-4} \text{ h}^{-1}$

❖ Conservative living conditions  $\lambda_{\text{eff}} \sim 0.15 \text{ h}^{-1}$

❖ Open door and windows  $\lambda_{\text{eff}} \sim 25 - 50 \text{ h}^{-1}$



# Conclusions

- Laboratory measurements showed that Rn exhalation tend to decrease as FA increase
- At *In-situ* Rn measurements no clear influence was found
- The ventilation rate during In-situ measurement does not influence on the wall exhalation rate
- The most conservative living condition ventilation rate was  $\sim 0.15 \text{ h}^{-1}$
- The minimal measurement period is 4 days
- The measurement conditions and the calculation method are the major factors influencing on the uncertainty ( $\sim 30\%$ )

# Acknowledgment

- The work was jointly supported by the Ministry of Construction and Housing and the National Coal Ash Board.
- The authors are thankful to Mr. Zakhar Prilutsky and Zohar Yungrais for the assistance conducting the *in-situ* and laboratory tests