Influence of Ventilation on Radon Concentration in a Study Case in Spain

Pilar Linares-Alemparte[1*], Sonia García-Ortega[1]

1 Eduardo Torroja Institute for construction sciences-CSIC
4, Serrano Galvache St.
Madrid, Spain
plinares@ietcc.csic.es

ABSTRACT

Radon gas is a well-known building´s pollutant which can affect negatively people´s health (WHO, 2009). Radon´s source is the soil underneath buildings. Radon moves from the soil to the buildings by advection through cracks and joints, and diffusion through porous materials. Once radon enters buildings it can accumulate in lower areas due to lack of ventilation. Ventilation is one of the main ways to prevent radon from accumulating in enclosed spaces in the case of moderate radon concentrations up to 600 Bq/m^3 (Collignan, 2008).

This paper presents the research that has been conducted in a building with moderate levels of radon, using precisely ventilation to reduce these levels. The building is placed in a granitic area at the North of Madrid (Spain) with a high presence of radon (García-Talavera, 2013). The results show how even little ventilation can lower radon concentration up to acceptable levels.

KEYWORDS

Ventilation. Radon, Case, Spain

1 INTRODUCTION

One of the objectives of the research project: *Proyecto Radón Cero (Proyecto Radón Cero,* 2018), is the study of the efficiency of ventilation as a way to mitigate moderate indoor radon concentration in an existing building.

Moderate levels of radon concentration were measured in an existing building so it was chosen to perform the corresponding tests The methodology conducted in the research is based on the study of the existing building (initial measurement of radon concentration, building elements, airtightness), proposal of mitigation solution, final measurement of radon concentration and analysis of results.

2. STUDY OF THE EXISTING BUILDING

2.1. Description

The case study is a social centre that belongs to the City Council of Torrelodones, Madrid (Spain). The building is placed above granite rock which is common in the area.

The studied rooms are the kitchen and the fireplace room (Fig. 1). The kitchen presents a high level of airtightness whereas the fireplace room does not due to the chimney, the configuration of windows and an opening above the door to the corridor.

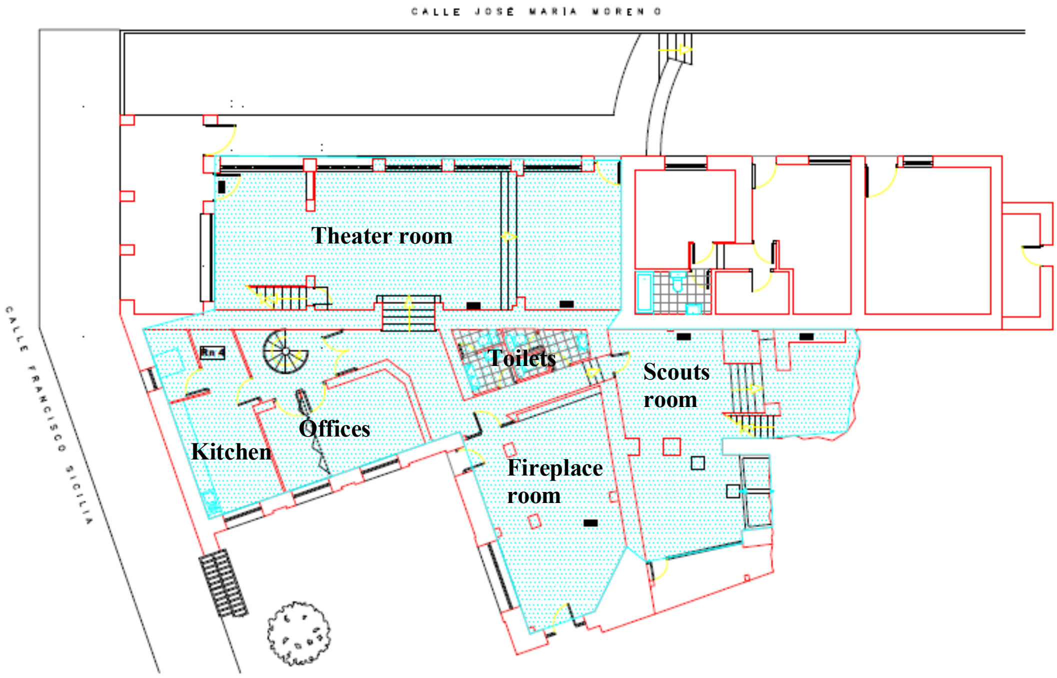

Fig. 1 Ground floor.

2.2. Radon concentration

During 2016 and 2017 radon concentration integrated measurements were carried out using trace detectors CR-39 with the collaboration of *Universidad de Cantabria*. These measurements revealed that some areas presented moderate radon concentrations (Table 1).

Table 1. Radon concentration (Bq/m^3)

	Period of time	
Room	**01/03-05/04/2016**	**19/09/2016 - 27/01/2017**
Theater room	677 ± 55	471 ± 37
Scouts room	78 ± 26	304 ± 29

3. PROPOSAL OF RADON MITIGATION SOLUTION

In order to reduce the moderate levels of radon concentration, a mechanical ventilation system with heat recovery was designed and installed in the building.

The system consists of mechanical extraction in wet rooms and corridor, and mechanical supply in the habitable rooms (Fig. 2). It can provide air flows up to 400 m^3/h and be programmed hourly and daily.

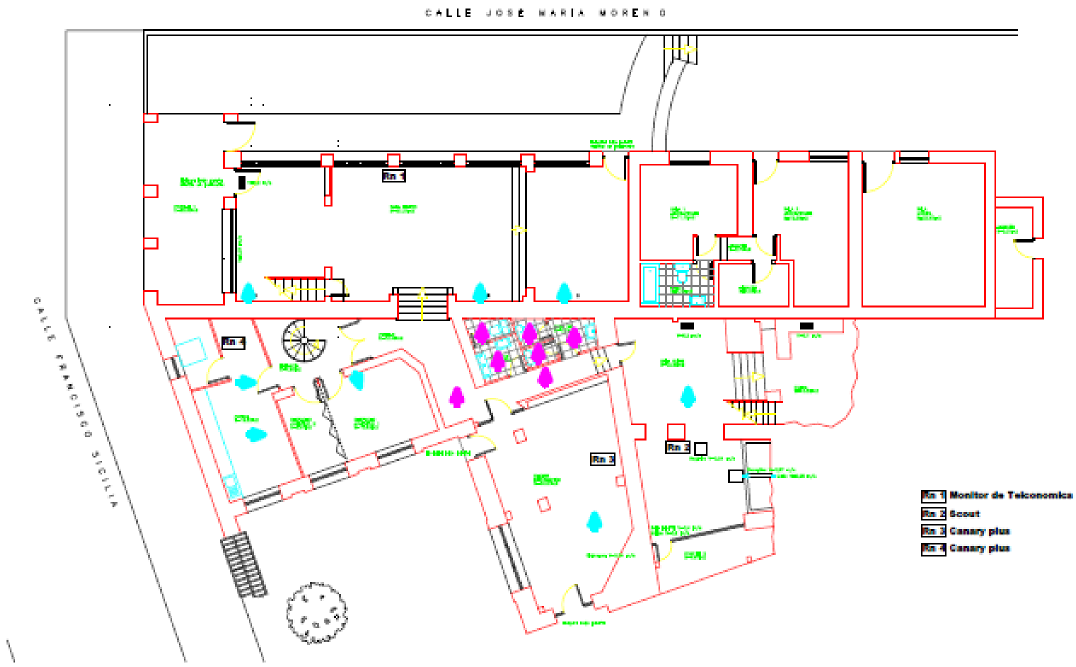

Fig. 2. Air inlets (blue) and outlets (pink).

4. MEASUREMENT OF RADON CONCENTRATION AND RESULTS

After the installation of the mechanical ventilation system, radon concentration was continuously monitored with different levels of ventilation using Canary Pro by Corentium detectors to assess the efficiency on the reduction of radon concentration.

Tables and figures were made to analyse the results. In the tables, values below 300 Bq/m^3 have been marked in green, from 300 to 400 in yellow, from 400 to 500 in orange and above 500 in red. 300 Bq/m^3 is the Spanish reference level for indoor radon concentration.

4.1 Initial test: 75 m^3/h

A short test with 75 m^3/h ventilation flow was performed in November (Table 2) to calibrate the ventilation flow needed for the tests.

Table 2. Average radon concentration (Bq/m^3) without ventilation and with 75 m^3/h constant flow

Room	No ventilation	Constant ventilation 75 m^3/h
Fireplace room	566	547
Kitchen	437	370

It was observed a marginal change in the radon concentration in the fireplace room, however it was relevant in the kitchen, perhaps because of the higher level of air tightness of the envelope of the latter room.

1.1 Constant ventilation flow: 350 m^3/h

Further research was conducted with an increased level of ventilation such as 350 m^3/h, which was scheduled alternating periods of time with and without ventilation. This was performed during several months (from February to December) to take into account the effect on the radon concentration of climatic and seasonal variations. Doors and windows were kept closed most of the time to facilitate concentration of radon.

Figure 3 shows the variations of radon concentration from 5 March to 30 August 2018, and Table 3 the average values for each period of time as well as the global ones to take into account the climatic and seasonal conditions. The period of time from 3 to 20 June was not included in this study because a different type of ventilation was tested.

Table 3. Average radon concentration (Bq/m^3)

	Fireplace room		Kitchen	
Period of time	**No ventilation**	**Constant ventilation 350 m^3/h**	**No ventilation**	**Constant ventilation 350 m^3/h**
05-19/03	171		81	
20/03-24/04		168		68
25/04-02/05	258		245	
03-16/05 [(1)]		206		66
17/05-03/06	414		196	
20/06-01/07		341		63
02-17/07	473		319	
18/07-01/08		351		62
02-13/08	543		207	
14-30/08		469		44
Total	372	307	209	60
Reduction (%)	17.4		71	

[(1)] An accidental disconnection of the system occurred at an unknown time within this period of time.

On 5 June 2018, the opening above the doorway to the fireplace room was covered. This may explain the increase of radon concentration in this room after this date (with and without ventilation) due to the reduction of air exchange with the corridor.

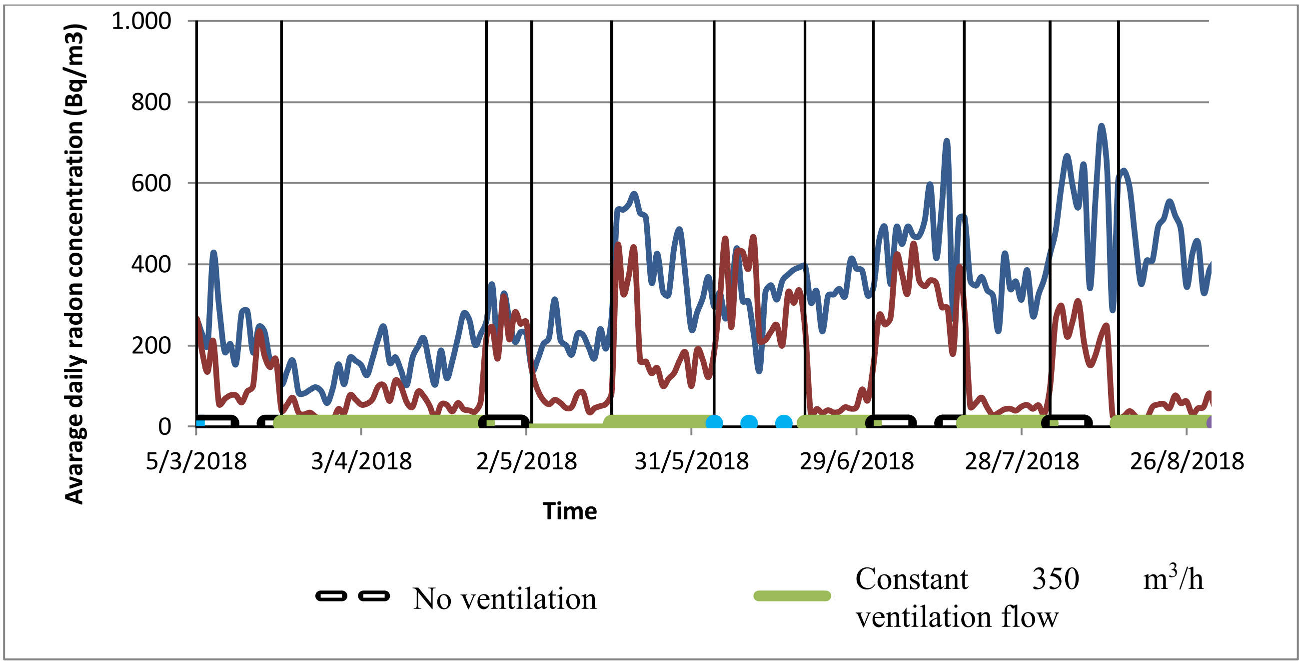

Fig. 3. Average daily radon concentration levels (Bq/m^3) in fire place room (blue) and kitchen (red)

It was observed that the radon concentration is always lower with ventilation in each period of time, and consequently the total value of radon concentration is lower as well.

The total reduction of the radon concentration is 17% in the fire place room and 71% in the kitchen. The bigger reduction in the kitchen could be explained because of the airtightness of this room that is probably contributing to create a pressurization that prevents radon gas from penetrating from soil.

1.2 Constant ventilation flow: 200 m^3/h

With the aim to optimize the ventilation flow able to reduce the radon concentration, a further test was performed with a lower ventilation flow of 200 m^3/h from 2 October to the end of December. Figure 4 and table 4 show the results.

Table 4. Average radon concentration (Bq/m^3)

	Fireplace room		Kitchen	
Period of time	**No ventilation**	**Constant ventilation 200 m^3/h**	**No ventilation**	**Constant ventilation 200 m^3/h**
02-17/10		341		140
18-30/10	495		359	
31/10-15/11[(1)]		338		260
16/11-02/12		390		364
03-21/12	329		364	
Total	412	356	361	254
Reduction (%)	13.5		30	

[(1)] An accidental disconnection of the system occurred at an unknown time within this period of time.

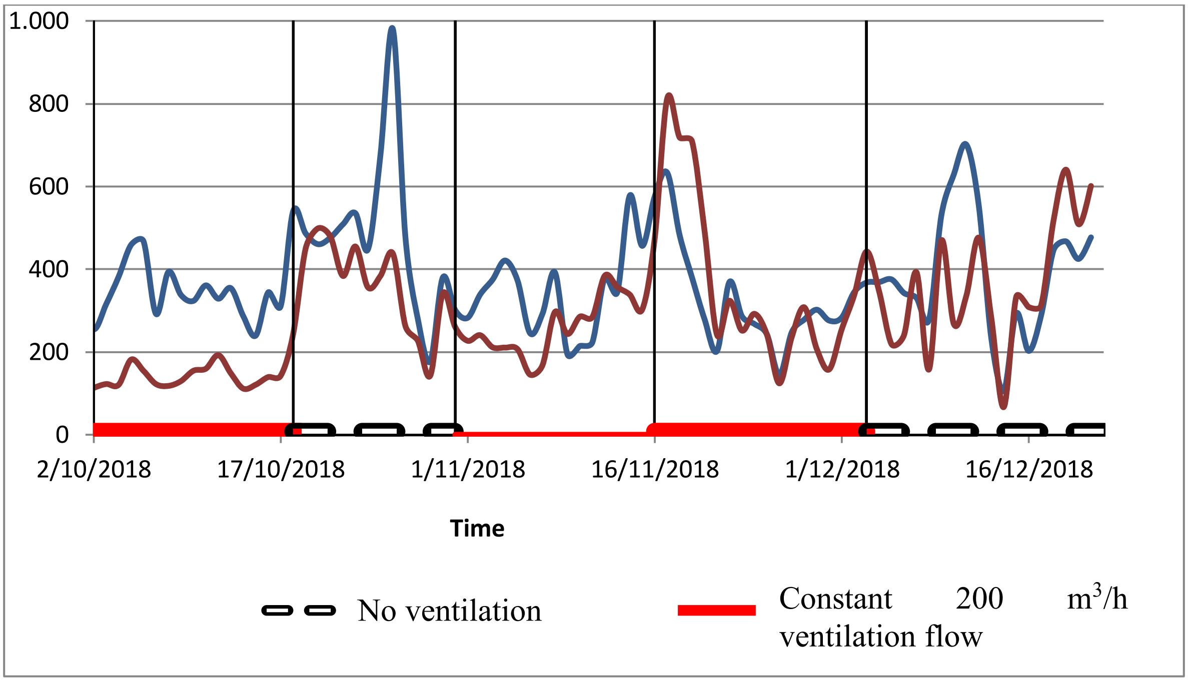

Fig. 4. Average daily radon concentration levels (Bq/m^3) in fire place room (blue) and kitchen (red)

It was observed that the radon concentration is always lower with ventilation in each period of time, and consequently the total value of radon concentration is lower as well. Although in this case the difference between both situations is not as remarkable than with 350 m^3/h, as expected.

The total reduction of the radon concentration is 13.5% in the fire place room and 30% in the kitchen. Even with a smaller ventilation flow, the kitchen keeps providing the better results due to its higher airtightness and the pressurization.

It is worth remarking that in both cases (350 and 200 m^3/h) total values related to constant ventilation include the periods when an accidental disconnection of the system is believed to have occurred, so it is quite likely that these values are higher than expected.

5 CONCLUSIONS

Mechanical ventilation system helped reducing moderate levels of indoor radon in an existing building. Two ventilation rates were tried: 200 and 350 m^3/h. With 350 m^3/h, reductions of 17% and 71% were achieved in the fire place room and in the kitchen, respectively. With 200 m^3/h, reductions of 13.5% and 30% were achieved in the fire place room and in the kitchen, respectively. The reduction was more efficient with a higher ventilation rate, as expected.

Rooms in which the mitigation was conducted where submitted to air supply, whereas extraction was performed in adjacent wet rooms. This air supply was particularly efficient in the kitchen, because of its airtightness that helped to create a pressurization preventing radon from entering the building from the soil.

In the fire place room pressurization was not achieved, so it was more efficient to have a less airtight room, ventilating to other parts of the building.

Ventilation could be used to reduce moderate radon concentration, but it is important:

- to achieve a minimum airtightness of the building,
- to assess the energy performance of the building with the increased ventilation level and to use systems that improve it like heat recovery.

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7 REFERENCES

WHO (2009). *Handbook on indoor radon, a public health perspective*.

Collignan, B. (2008). *Le radon dans les bârtiments. Guide pou la remédiation dans les constructions existantes et la prevention dans les constructions neuves.* CSTB

García-Talavera, M. et al. (2013). Mapping radon-prone areas using Č-radiation dose rate and geological information. *Journal of radiological protection*, 33 (3), 605-20.

Proyecto radon cero (2018): Optimizacion de soluciones constructivas frente a la inmision de gas radon en edificios y desarrollo de metodologias de diseño de soluciones (BIA2014-58887-R) - Zero radon: optimization of building solutions against radon gas and development of solutions design methods https://proyectoradoncero.ietcc.csic.es/