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EXPERIMENTAL STUDY ON PASSIVE SUB-SLAB DEPRESSURISATION SYSTEM

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Topic: Radon, prevention in new buildings, experimental study, natural soil depressurisation System.

Abstract

It appears that Soil Depressurisation System (S.D.S.) is one of the most efficient solutions to prevent buildings against radon from ground. Currently theses systems are mainly used with a fan which enables to extract mechanically air from basement to under pressurise it. On the principle, other way to obtain a depressurisation is to use natural thermal forces and wind effect. But the ability and the efficiency of this technique is not properly characterised.

In an experimental house, a one year follow up of a passive sub-slab depressurisation system has been carried out in order to analyse the natural running of such a system during time. A specific sump has been installed under basement and different parameters have been measured: wind (velocity and direction), external temperature, extract flow from basement, basement depressurisation, internal temperature and ground air temperature. An alternative have also been tested using a more efficient static extractor than basic one, to extract flow naturally from basement.

This paper presents first experimental results an analysis of the one year follow up. It appears that such a passive system could run efficiently a significant part of the year if it is properly dimensioned, and mainly during cold conditions, where it is more necessary to have a good protection against radon.

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Introduction

Radon is a radioactive gas which comes from the degradation of uranium and radium present in variable quantity in the earth crust and whose solid descendants can settle in the lung. Radon is one of the pathogenic agents of the lung cancer. It tends to accumulate in closed spaces, which justifies vigilance in the buildings. In France, few thousands of annual cases of lung cancer are thus attributed by the epidemiologists to radon exposure into buildings. In these conditions, it is necessary to maintain As Low As Reasonable Achievable the radon concentration into indoor environment.

The presence of radon into buildings results from many parameters. The main source of radon in building is generally the ground under basement. Its entry into building is mainly due to convective forces due to pressure difference between the soil beneath the ground floor and the inhabited volume. This pressure difference is due to temperature difference between indoors and outdoors. It induces an air flow from ground porosity to the indoor environment via basement air leakages. So that, the intensity of radon source in a building is generally growing up with temperature difference.

The principles developed on different techniques consist in diluting the radon concentration in inhabited volume and to prevent radon incoming from the ground. In practice, from the various possible configurations for existing buildings, many alternatives techniques calling upon these two combined principles are used. The taking into account of these techniques for the new buildings, as of the design of the building, makes it possible to ensure good system effectiveness with a marginal cost.

The principle of reduction of the entry of radon in the buildings the most effective is the Soil Depressurisation System (S.D.S.) under the building in order to prevent the convective air flow from the ground and loaded with radon towards the building (EPA, 1993; Scivyer, 1993 2001 and 2007; Collignan & al, 2003; Allison & al, 2008). However, this system is generally installed with an extract fan which enables to maintain a constant depressurisation beneath building. It is sometimes mentioned that this depressurisation could be obtained naturally using natural thermal forces and wind effect. But the ability and the efficiency of this technique is not properly characterised and needs to be tested.

In this context, the aim of this study is to test in an experimental dwelling the ability of a natural sub-slab depressurisation system to maintain depressurisation along the year.

Description of the experimental dwelling

An experimental dwelling called MARIA (Riberon, 2002) has recently been built in order to study indoor air quality in housing sector. It is a dwelling with one living room and four bedrooms on two levels.

Photo 1: Experimental dwelling MARIA

During its construction, basement has been prepared to be depressurised. For that purpose, a 40 centimetre thick gravel layer with a membrane under a concrete ground floor have been installed. Two sumps, one centred and one decentred have been put on gravel layer to have the ability to test these two configurations (figure 1). Surface of soil is around 80 m².

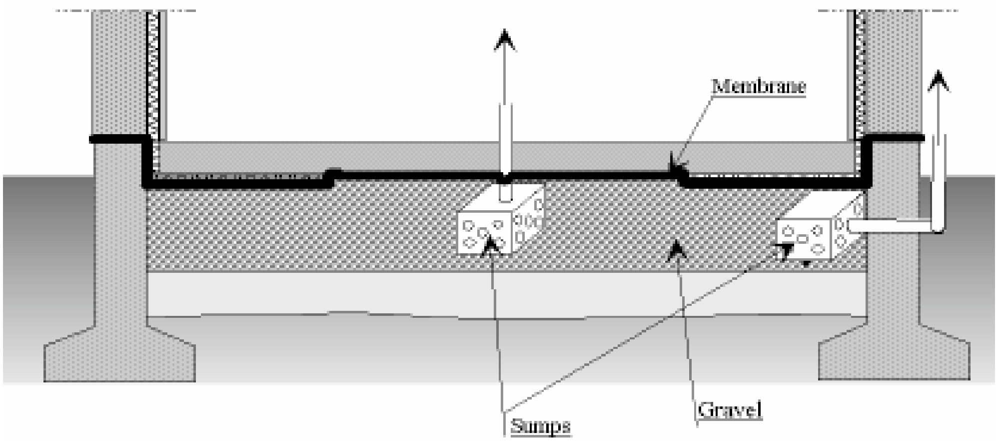

Figure 1: Soil Depressurisation System (S.D.S.) installed on basement of MARIA dwelling.

Ten different holes have been managed through concrete floor to measure pressure difference between gravel layer and the inhabited volume.

In previous works undertaken, basement permeability characterisation has been realised with a variable velocity fan enabling to exhaust air from the gravel layer via the sump. Pressure differences induced were measured with manometer at the ten different holes. It is worth noting that pressure field into basement generated by the exhaust flow is homogeneous on the gravel layer (figure 2).

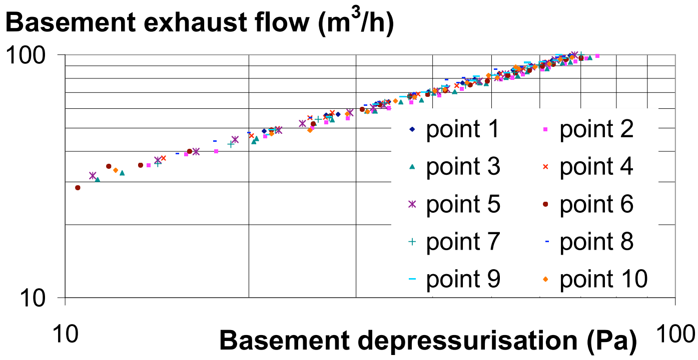

Figure 2: Basement permeability characterisation

Other study previously undertaken have shown the ability of a mechanical ventilation exhaust system commonly used in France to generate air renewal into dwelling, to be connected to the S.D.S. to generate sufficient depressurisation in the basement and to ensure simultaneously adequate exhaust flow in the dwelling (Collignan & al, 2004).

For the present study it has been needed to create a specific sump with a larger diameter of 200 mm for the extraction in order to be able to used natural forces for the extraction reducing linear pressure losses along duct (photo 2).

Photo 2: Installing new sump for natural depressurisation

Protocol

A one year follow up of the passive sub-slab depressurisation system has been carried out in order to analyse the natural running of such a system during time. Different parameters have been measured each minute along the year: wind (velocity and direction), external temperature, extract flow from basement measuring duct air velocity, basement depressurisation, internal temperature and duct air temperature (figure 3).

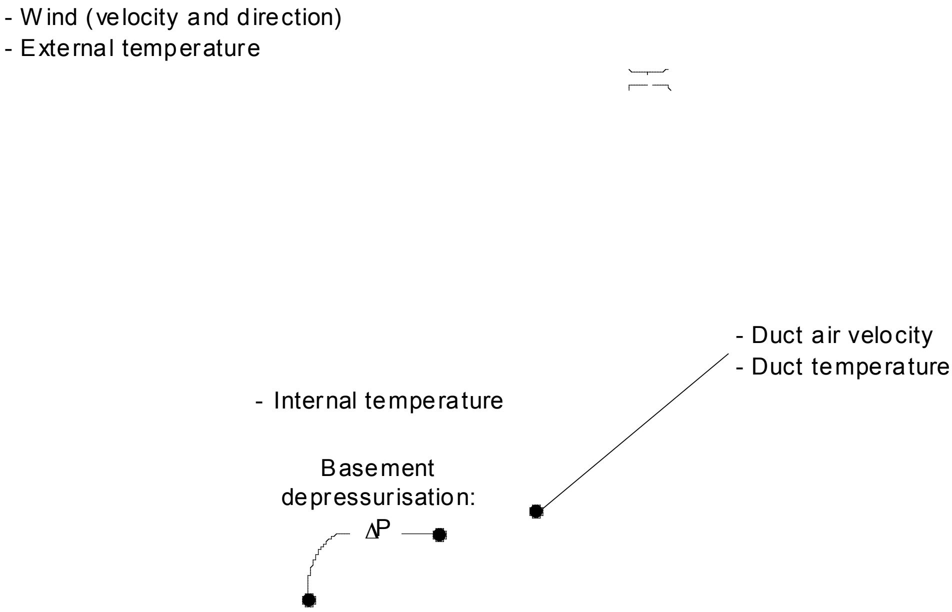

Figure 3: Parameters measured during follow up

An alternative have also been tested using a more efficient static extractor than basic one, to extract flow naturally from basement. Specific shape of this static extractor enables to enhance depressurisation at the exhaust of the duct, ameliorating extract flow from basement in wind presence. Basic extractor had been installed from July 2007 until February 2008 and static extractor from March 2008 until June 2008.

Photo 3: Basic extractor and static extractor

Results

Results obtained consist on an important data base of different parameters measured each minute along the year. At first, data have been averaged with a time step of 15 minutes. Figure 4 shows an example of results obtained referring to the evolution of basement extract flow and basement depressurisation along time during a month.

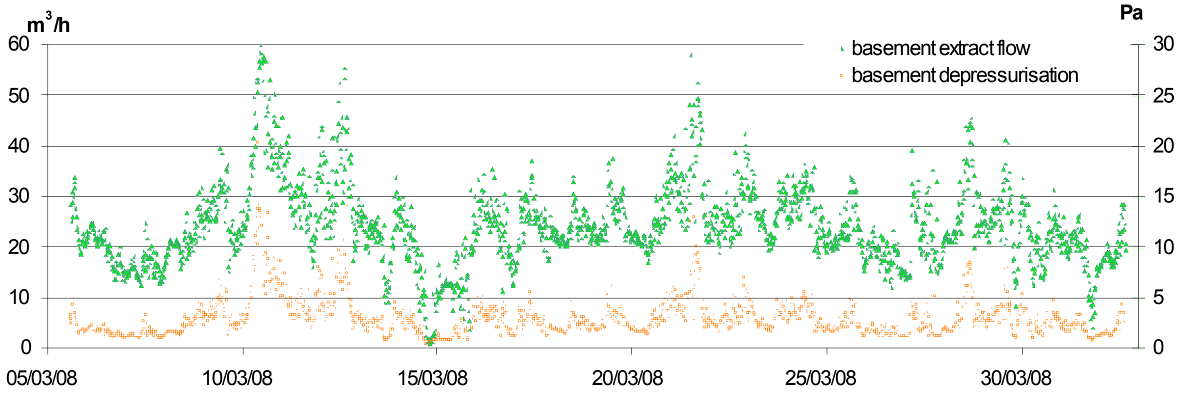

Figure 4: Evolution of basement extract flow and basement depressurisation during time

Figure 5 shows characterisation of basement permeability obtained naturally with natural S.D.S. and compared with characterisation obtained mechanically.

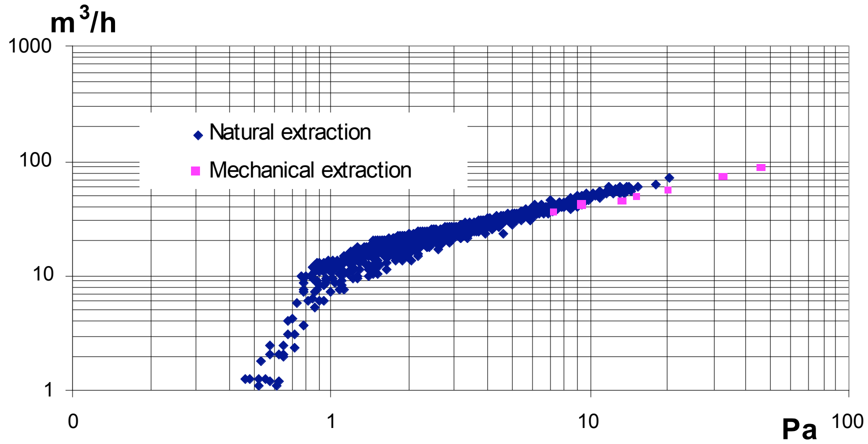

Figure 5: Comparison of basement depressurisation function of basement extract flow for natural and mechanical extraction

Based on these results, running of natural S.D.S. has been studied along the year. Figure 6 shows percentage of running time of the system along year above three thresholds of extract flow from basement: 13.5 m^3/h, 19 m^3/h and 23 m^3/h which correspond respectively to around 1 Pa, 2 Pa and 3 Pa of basement depressurisation. Figure 7 shows Monthly averaged temperature difference between air duct and external air and monthly averaged wind force along year.

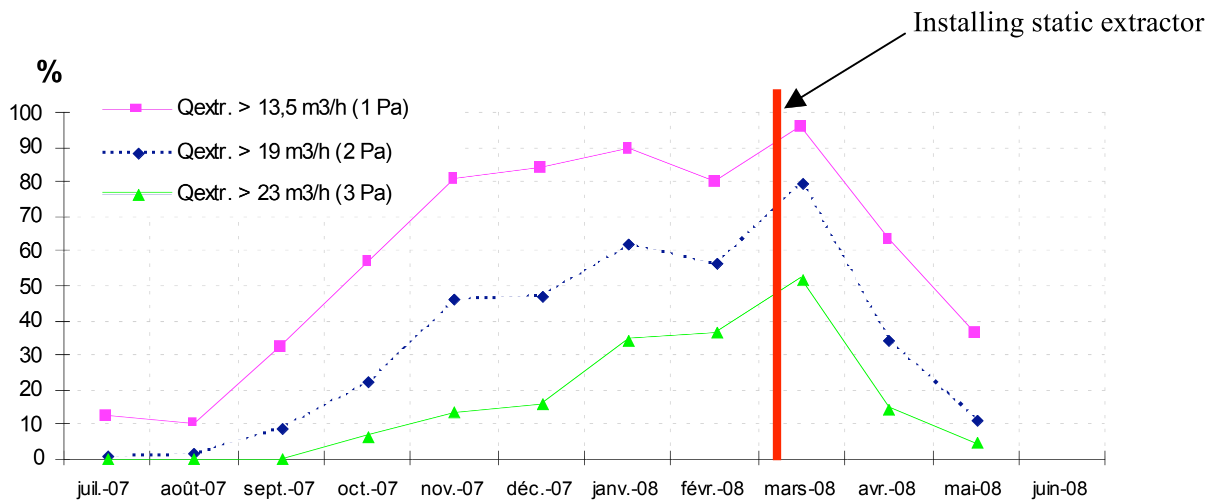

Figure 6: Percentage of running time of the system along year above three thresholds.

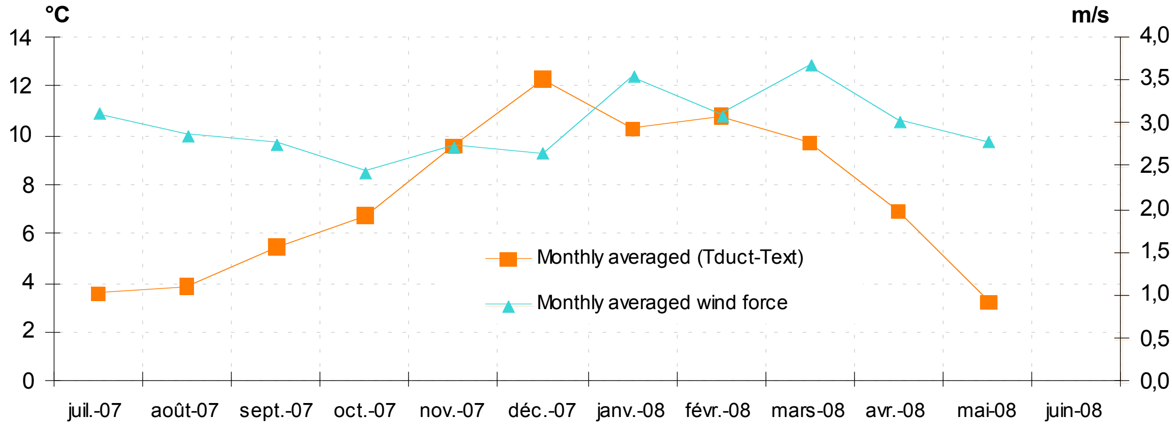

Figure 7: Monthly averaged temperature difference between air duct and external air and monthly averaged wind force along year.

In order to analyse the impact of static extractor, figure 8 shows a comparison of extract flow from basement function of wind velocity for natural S.D.S. with static extractor and with basic extractor. To isolate the impact of wind, these running points are considered when temperature difference between air duct and external air is below 4°C.

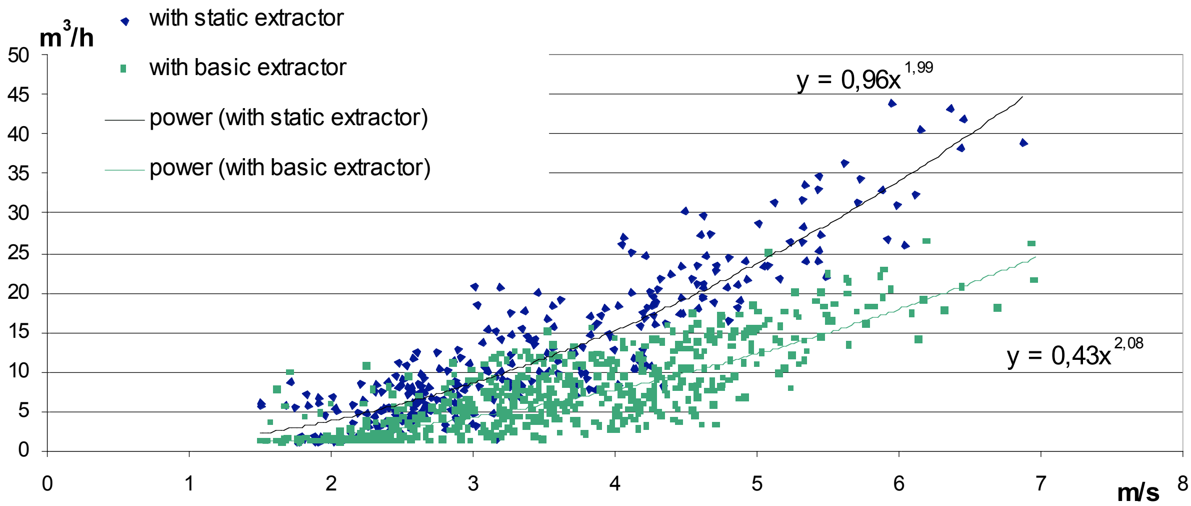

Figure 8: Comparison of extract flow from basement function of wind velocity for system with static extractor and with basic extractor (temperature difference < 4°C).

Analysis

At first, a high variability of running is observed along the year and even during a day. This is due to the fact that natural forces which make possible the extraction of air from basement are highly variables: temperature difference between air duct and external air and wind force. However, it is seen on figure 6 that percentage of running along year could be significant and mainly in winter season. This is an interesting result because the main cause of radon entrance in a dwelling without prevention against radon is the convective flux due to pressure difference between the dwelling and ground below, which is due to stack effect and this effect is stronger in winter season. In summer season, natural S.D.S. running is very weak but radon convective source is also weak.

It is seen in figure 6 that running is better in March than in February. This could be explained by the installation of the static extractor at the beginning of March. Figure 8 shows the impact of this static extractor on extract flow from basement in comparison to basic extractor. At first, it is noted, that for each extractor, a relative dispersion of experimental points is observed. This could be due to the fact that wind measurements are made with meteorological station installed on CSTB site but wind "seen" by extractor at roof level of the dwelling could be different and more fluctuant due to obstacles around the dwelling (trees, other buildings). These obstacles could modify wind velocity at roof level in comparison with wind velocity at meteorological station. However, positive impact of static extractor on extract flow from basement is clearly seen on this figure. It can be noted, that for significant wind forces (above 3 m/s) extract flow with static extractor is twice the value of extract flow with basic extractor.

Conclusion

A one year follow up of a Natural Soil Depressurisation System has been undertaken in an experimental dwelling on CSTB site. The experimental dwelling has been adapted in order to conduct this experimental study. This paper shows a first analysis of results obtained.

It appears that natural running of S.D.S. is highly variable along the year but percentage of running could be significant and mainly during winter season. This is an interesting result because preventive solution is mainly needed during this period to fight against radon entrance due to convective fluxes between ground and inhabited volume.

During this follow up, two different static extractors have been used: a basic one and other with shape optimised to benefit of the impact of wind on extraction flow. It has been seen that with optimised static extractor, flow from basement is around twice the value than flow obtained with basic extractor.

In perspective, it is planed to study hybrid solutions for basement depressurisation using a stato mechanical extractor, which means to use natural forces when sufficient and fan assistance when needed in order to have sufficient basement depressurisation along the year.

Acknowledgments

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