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Research Article

Analytical quantification of airflows from soil through building substructures

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Abstract

Soil gas pollutants (VOCs, radon, ...) have long been known to intrude into buildings through various openings, e.g., cracks and gaps in the foundations. As yet no model has been developed which can quantify this rate of flow whilst taking into account various substructure configurations. This is due to the complex phenomena that need to be consider and particularly to the difficulty in estimating pollutant flows at soil-building interfaces. In this paper analytical models have been developed to quantify these flows. The models have been developed for some typical substructure configurations: slab-on-grade, basement and crawlspace. The inputs of these models include particularly the foundation wall depth and the slab permeability. The analytical models have been compared to existing analytical models for one of the configurations. Moreover a 2-D finite element model has been used for numerical comparison. The models are presented as pressure-flow relationships and can be integrated into risk assessment tools in order to study the impact of soil gas pollutants on indoor air quality.

Keywords

analytical model,
airflow,
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Indoor/Outdoor Airflow and Air Quality

1 Introduction

The pollutants from soil, (e.g., radon, hydrocarbons from underground fuel spills, volatile organic compounds and chlorinated organics associated with landfills or contaminated groundwater), enter buildings mainly by convective transport through various leakages (e.g., cracks, openings around pipes, ducts through the foundation and permeability of the floor slabs). Screening tools for the risk assessment that calculate transfer of soil gas to the indoor air include large amounts of uncertainty (Provoost et al. 2010), this is due particularly to the difficulty in estimating the flux of pollutants at soil-building interfaces. Gas transport from soil into buildings occurs by a combination of diffusion and convection. In this paper, diffusion has been neglected. The convective transport of radon and/or soil gas contaminants into houses is due to small pressure differences between the indoor and outdoor environments created by various phenomena (i.e., the stack effect, wind interaction with the building shell, heating, ventilation and air-conditioning systems) (Nazaroff 1992). Some analytical models have been developed to quantify the gas flow entry rate from the soil into the buildings by pressure-driven flow (Mowris and Fisk 1988; Nazaroff 1988; Abdelouhab et al. 2010). Mowris and Fisk (1988) developed an analytical model that quantifies radon flow entering into buildings. In their work, they modelled the gas flow between the soil and the basement using an analogy with the conduction of heat from a horizontal cylinder buried in a semi infinite medium. In the model developed by Nazaroff (1988) an electrical analogy has been used, the path of radon from the soil into the basement is idealized as a flow entering into buried cylinder. Yao et al. (2011) proposed an improvement on the Nazaroff's model (1988) by assuming that only half of the hypothetical buried cylinder is available for receiving flow from the soil into basement. These analytical models do not enable to quantify the air flow entering into all commonly encountered building substructures. In fact, these analytical models treat two building substructures, basement and slab-on-grade with peripheral crack. Existing analytical models assume that the soil gas from soil enters into buildings only by the peripheral crack. They do not consider the following substructures

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