United States
Environmental Protection
Agency

National Risk Management
Research Laboratory
Research Triangle Park, NC 27711

Research and Development

EPA/600/SR-96/116 November 1996

Project Summary

Large Building HVAC Simulation

L. Gu, M. V. Swami, and V. Vasanth

The report discusses the monitoring and collection of data relating to indoor pressures and radon concentrations under several test conditions in a large school building in Bartow, FL. The Florida Solar Energy Center (FSEC) used an integrated computational software, FSEC 3.0, to simulate heating, ventilation, and air-conditioning (HVAC) system and multizone airflows, indoor pressures, radon transport in the soil, and slab and indoor radon levels in the large building. The simulation was validated by measured data. A limited parametric study shows the influence of outdoor airflow, ambient radon level, and soil radium content on indoor radon levels.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The report represents work performed by the Florida Solar Energy Center (FSEC) for the Environmental Protection Agency (EPA) and the Florida Department of Community Affairs. Although individual tasks were funded separately by the two agencies, the report, for the sake of completeness, represents the combined efforts of all simulation-related tasks.

Project Goals

The primary goal of the project was to establish the potential for using models to analyze radon levels in large buildings. This was done by applying modeling tools developed in earlier work and integrated in the computational platform, FSEC 3.0, and to analyze pressures, airflows, and indoor radon levels in a school building monitored by the EPA and Southern Research Institute (SRI). Simulation results are compared with measured data. Preliminary parametric analysis will be discussed.

Discussion

The effort of the EPA contract is to simulate pressures of indoor and air distribution system airflows of interzone and supply and return, and indoor radon levels in the Polk Life and Learning Center at Bartow, FL, monitored by the EPA and SRI.

First, only the air distribution system of the school building was simulated to obtain and refine the distribution system parameters. This was done by trial and error while adjusting values of the distribution system parameters and comparing the results with a test and balancing report provided by the Associated Air Balance Council. After adjustments, the differences between measured and predicted airflows were less than 5%. Next, a steady-state simulation of the soil/slab composite was carried out, and the results were compared with experimental data. Because of the nature of the boundary conditions over the slab, a three-dimensional discretization was required to correctly model the soil/slab composite. Soil/slab parameters were adjusted by trial and error to obtain a reasonable match between predicted and measured values of pressures and air-

flows. Results of the steady state simulation comparison with measured indoor radon levels agreed to within 6%. Due to a paucity of detailed data, it is important to note that the adjusted material properties may not necessarily represent the true values, and the calibration may not necessarily translate to other cases.

Keeping the adjusted parameters obtained from earlier runs constant, the next step is to compare measured and calculated indoor radon levels for a transient 7-hour period and a typical school day with the system "on" for the first 12 hours and "off" for the remaining 12 hours. Figure 1 compares histories of predicted and measured indoor radon levels in one station (Room 109) for a typical school day. It is evident that while the agreement at the beginning and end of the "on" cycle is good, the model predicts higher radon dilution rates during the "on" cycle than shown by the experiment. However, the model and experiment compare very well during the "off" period. The disparity noted during "on" times appears consistently in all zones. This is a significant cause for concern and is possibly due to two factors: (1) the model assumes well mixed zones, which may not be true in actuality (the ventilation efficiency may not be 100%, leading to different radon levels within a zone, and a single-point measurement may be insufficient); and (2) the ambient radon level may be higher than assumed. Due to the unavailability of data on ambient radon levels during this period, we assumed a constant of 3.5 pCi/L for the simulation. Results of other work for the Florida Radon Research Program show that ambient radon levels may not only be higher than established action levels, but may also vary cyclically during a 24-hour day. Clearly, the model would predict lower rates of dilution and would approach measured values if higher ambient radon levels were used in the simulation. Undoubtedly, these two factors (ventilation efficiency and ambient radon levels) must be investigated further before answering the question definitively.

Next, parametric analysis of the effect of varying outdoor airflow, ambient radon level, and soil radium content was carried out for this specific building. Indoor radon level decreases with increasing outdoor airflow through the air distribution system, due to dilution. When ambient radon level and soil radium content are varied, there appears to be a linear relationship between indoor radon level and ambient or soil radium content. This determination is specific to the building studied and is based on assumptions stated in the report and may not necessarily translate to other similar buildings.

Caveats

It is crucial to note that the nature of the work performed here is exploratory, primarily to establish the potential of using models to analyze large buildings and to identify the essential areas for experiment and simulation to complement each other in providing an accurate, yet cost efficient, strategy to study radon in large buildings. This objective was substantially achieved through a preliminary simulation of airflows and pressures in a school building monitored. Since only a limited set of experimental data were available, several assumptions were made to successfully complete the simulations. The results presented in this report should, therefore, be viewed in light of the assumptions stated and applied only to the specific problem analyzed. The result should in no way be construed to represent generalizations for large buildings. The report concludes with a list of areas that need further attention.

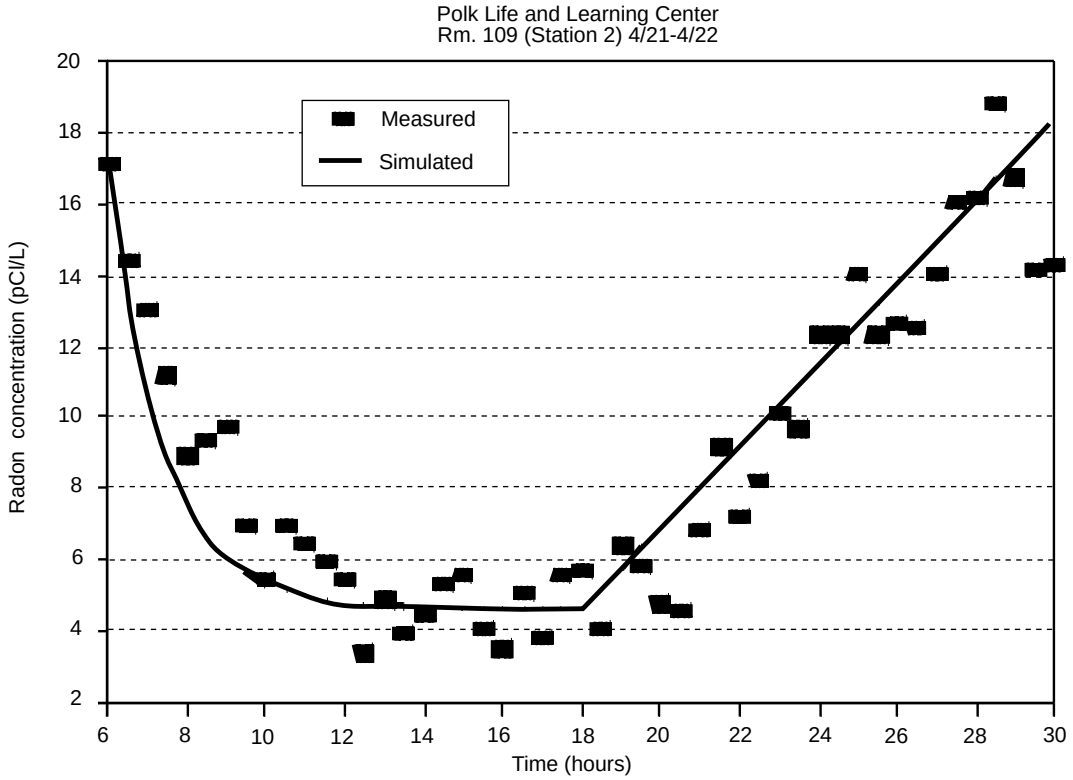

Figure 1. Predicted/measured indoor radon levels.

L. Gu, M. V. Swami, and V. Vasanth are with the Florida Solar Energy Center, Cape Canaveral, FL 32920.
***Marc Y. Menetrez** is the EPA Project Officer (see below).*
The complete report, entitled "Large Building HVAC Simulation," (Order No. PB97-104715; Cost: $21.50, subject to change) will be available only from
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at
Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35

Official Business
Penalty for Private Use
$300

EPA/600/SR-96/116