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FEATURE

NIST Software Provides Powerful Tool to Assess Design, Airflow, Contaminant Exposures, and Other Building Issues

When engineers needed to analyze issues related to upcoming modifications at the World Trade Center in New York City they used a little-known software program to simulate airflows and smoke transport in the 116-floor complex.

Other engineers with the US Department of Energy (DOE) used the same software program at DOE's giant Savannah River (Aiken, South Carolina) nuclear facility. It helped them determine the limitations of their existing ventilation system and identify the extensive changes to the duct system needed to support proposed renovations.

Although your design projects or system management tasks are probably not as complicated, you can still use the same CONTAMW multizone indoor air quality (IAQ) and ventilation-analysis software program, which might make your work easier and your results more effective. The CONTAMW program is highly flexible and easy to operate, according to Stuart Dols, who converted it from a DOS program to the Microsoft Windows (95, 98, and NT) world. The program can help you determine if your building ventilation rates are adequate, how the rates vary over time, and how that ventilation is distributed. You can use them to help assess: the IAQ performance of buildings before they are constructed; the impacts of various ventilation system designs and choices of building materials; and different IAQ-control technologies. You'll like the program's price, too: you can download CONTAMW free from the National Institute of Standards and Technology (NIST) Web site (www.bfrl.nist.gov/863/contam/).

Once you've got the program, you can plug in your building or design data to predict or analyze:

- Airflows — including infiltration, exfiltration, and room-to-room airflows in mechanically driven systems; wind pressures affecting your building envelope; and the effects of differences in indoor and outdoor air temperatures.
- Concentrations of indoor contaminants — how they're dispersed by airflows; how they're transformed by chemical and radio-chemical processes; whether they're absorbed and desorbed by building materials, deposited to building surfaces, or generated by a variety of source mechanisms.
- Contaminant exposures to occupants — predicted exposures to airborne contaminants for risk assessment.

Since NIST made the CONTAMW program available on its Web site in June 2000, more than 200 site visitors from Asia, Africa, Europe, the Middle East, and North America have downloaded it. NIST engineers ask CONTAMW users to notify them by e-mail when they download the program in order to be able to receive future upgrades to the program and hope that users will keep them posted on their successes and failures with CONTAMW.

Why NIST Developed CONTAMW

"NIST originally developed the program for researchers to investigate ventilation rates, or more specifically, infiltration rates for multizone structures," explains Dols, a mechanical engineer for the Building and Fire Research Laboratory, Indoor Air Quality and Ventilation Group at NIST, a division of the US Department of Commerce. "Since then, NIST added contaminant-modeling capabilities to attack contaminant-migration issues and questions about occupant exposure. We want to get it into the hands of building designers, architects, and people who maintain buildings, so they can apply multizone modeling to their real-world applications such as building design, renovation, and forensics. CONTAMW can help you analyze IAQ problems, so building managers and others can use it to simulate the problem their building has and then determine what actions would remedy it. They can draw a simplified schematic floor plan of their buildings, including the ductwork, and provide the airflow rates the system was designed to provide or, alternatively, airflow rates as measured. They can then review the contaminant levels and air balances. If they need to correct them, they can use CONTAMW to determine how by modeling adjustments within the program."

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Perhaps you want to simulate a time history of contaminant concentrations in your building. You can, for example, have CONTAMW provide the concentration of contaminants in your building every five minutes for a day or for any time interval you wish. You can also use the program to simulate occupants with certain inhalation rates and move those occupants through the building. The program would calculate the amount of contaminants each occupant is exposed to along with the potential dose. You can plot the results within the program or export them to a spreadsheet or other data-analysis program you've developed for further analysis. For example, you can compare the exposure results to contaminant-exposure guidelines such as those in the appendices of American Society of Heating, Refrigerating and Air Conditioning Engineers Standard 62-1999.

You could also use the system to model airflow in elevator shafts, chimneys, plumbing and wire chases, or overall building pressurization, Dols says. "People have looked at an as-built scenario versus design scenarios, modeled what they could do to improve their design, and tested whether changes would cause adverse effects. In other cases, fire-science engineers, who design smoke-management systems, use CONTAMW to determine how to best design a building to vent smoke in case of a fire." While this was not the originally intended use of its modeling capability, it may be the most significant use of CONTAMW to date, Dols tells ***IEQS***.

Employing CONTAMW to tackle these and other projects and problems might save substantial time and produce better solutions, because the program eliminates much of the guesswork. Obviously, this could save users and their clients considerable cash. Dols emphasizes, however, that inputting high-quality data is crucial to using CONTAMW successfully.

Limitations of CONTAMW

As versatile and powerful as CONTAMW is, it has its limitations. You could never validate a predictive model 100% due to the plethora of different scenarios from all the inputs, such as leakage and contaminant sources, Dols cautions. "But you can validate different pieces and specific cases. Again, the important thing is that you have to choose the input data carefully."

Another issue with CONTAMW is that the program can create contaminant sources in every zone in a building but can handle only trace contaminants. Therefore, you must understand the program's limitations when you use CONTAMW to address nontrace contaminants such as smoke or moist air. Furthermore, its macro-model simulations assume the air in each room is well mixed. This "big picture" provides a single temperature, contaminant, and pressure for each room. CONTAMW does not perform computational fluid dynamics (CFD) to break down single rooms into multiple zones and provide temperatures, contaminants, airflows, and pressures on a "microscopic" level. CFD modeling is well established but is not yet practical to use to analyze an entire building, Dols says.

Finally, NIST cautions that CONTAMW should only supplement the judgment of users knowledgeable in airflow and contaminant dispersal in buildings. A NIST disclaimer adds, "The calculations [in CONTAMW's prototype methodology] are based upon a simplified model of the complexity of real buildings. These simplifications must be understood and considered by the user." NIST takes no responsibility for the program's use or the results it provides.

Despite these limitations and cautions, CONTAMW clearly is a valuable tool in qualified hands. Looking ahead, Dols says that NIST engineers hope to increase that value by adding capabilities to handle heat transfer and nontrace contaminants and to provide a more direct method of addressing natural ventilation design issues. He says these upgrades hinge on future budgeting and policy priorities.

Web Site to Feature CONTAMW Projects

Dols says NIST has plans to soon establish a Web site aimed at facilitating the application of multizone modeling with CONTAMW. The site will detail the design analysis of the World Trade Center complex in New York City. At the October 2000 meeting of the Committee on Indoor Air Quality at the US Environmental Protection Agency in Washington, DC, Dols cited the World Trade Center project to colleagues from several US federal agencies. To illustrate CONTAMW's power to his listeners, he revealed that it took the program only two seconds to simulate the airflow and pressures

for all 3,000 zones used to model the trade center complex.

"CONTAMW's capabilities are continually being applied in new ways by creative engineers, so it is hard to say what the limits of its applications are," Dols tells ***IEQS*** enthusiastically. "We're hoping that after we set up our new Web site, engineers will submit case studies of what they've been able to accomplish with it." As more and more examples appear on the NIST Web site, they in turn should stimulate an even wider expression of CONTAMW capabilities among the user community. Dols says NIST hasn't yet determined an address for the new Web site, but once it is active, it will be linked to the current CONTAMW site.

For more information, contact W. Stuart Dols, mechanical engineer, Indoor Air Quality & Ventilation Group, Building and Fire Research Library, National Institute of Standards and Technology, 100 Bureau Drive, Stop 8633, Building 226, Room A313, Gaithersburg, MD 20899-8633. Tel: (301) 975-5860; Fax: (301) 975-4409; E-mail: wsdols@nist.gov.

PRACTICAL RESEARCH BRIEFS

A Review: Studies on the Association of Ventilation Rates and CO_2 Levels with Health and Other Human Outcomes

Ventilation rates under 10 liters per second (l/s) per person are consistently associated with statistically significant worsening of one or more adverse health or perceived air quality outcomes in nonresidential and nonindustrial buildings. That is what researchers from three highly regarded institutions concluded after they reviewed the findings of 20 studies of ventilation rates and 21 studies of carbon dioxide (CO_2) levels performed between 1986 and 1999. The ventilation studies estimated relative risks of 1.5-2 for respiratory illnesses and 1.1-6 for "sick building syndrome" (SBS) symptoms at low ventilation rates compared to high ventilation rates. A relative risk of 1.0 designates no increased risk while 2.0 would specify twice the risk. Overall, the 41 studies included some 60,000 occupants of more than 750 offices, schools, nursing homes, daycare centers, and other nonresidential buildings in Europe, Scandinavia, Japan, and the US. Since only 5 of these studies took place in hot, humid climates, the review results primarily apply to temperate and cool climates.

Some ventilation studies in the review found further significant decreases in SBS symptoms or significant improvements in perceived air quality as ventilation rates increased from 10 l/s to 20 l/s per person. About half of the CO_2 studies indicated that the risk of SBS symptoms continued to diminish as CO_2 levels declined below 800 parts per million (ppm).

Olli Seppänen (professor at Helsinki University of Technology, Laboratory for Heating, Ventilating and Air Conditioning in Espoo, Finland) teamed with William Fisk (staff scientist, Lawrence Berkeley National Laboratory, Indoor Environment Department, Environmental Energy Technologies Division, Berkeley, California) and Mark Mendell (epidemiologist at the Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, Ohio) to perform the review. They reported their results in "Association of Ventilation Rates and CO_2 Concentrations with Health and Other Responses in Commercial and Institutional Buildings" in December 1999.

Objectives of Review

When they began their review, the researchers wished to answer several questions about the association of ventilation rates with human health and other human responses in commercial and institutional buildings, such as:

1. Does the magnitude of ventilation rate (or CO_2 concentration) within the normally encountered range affect human health and other human responses?
2. Can a no-effect threshold value for ventilation rate (or CO_2 concentration) be found above or below which the prevalence of negative outcomes does not change measurably?

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