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Title
Safeguarding buildings against chemical and biological attacks

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Airflow and Pollutant Transport Group

The Airflow and Pollutant Transport Group has been conducting research since 1998 to protect buildings and building occupants from threats posed by airborne chemical, biological, and radiological materials. We use experiments and models to understand aerosol dynamics, whole-building airflows, detailed airflows in large spaces, design and interpretation of sensor networks, and the transport and fate of airborne contaminants. The group applies this knowledge to provide guidance for first responders, building managers, and policymakers seeking to improve occupant safety from chemical, biological, and radiological threats.

The Indoor Environment Department, to which the group belongs, conducts a broad program of research, technology development, and dissemination activities directed toward reducing the energy used for the thermal conditioning and ventilation of buildings, while simultaneously improving the indoor air quality (IAQ), thermal comfort, and health and productivity of building occupants. The Indoor Environment Department has been active at Lawrence Berkeley National Laboratory since 1975.

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Our staff of experimenters, computational fluid dynamicists, airflow simulation experts, data analysts, and building ventilation experts explore the key questions facing building operators, emergency responders, and decision-makers:

- How, where, and how quickly will chemical, biological, or radiological agents move through a given building?
- What is the relationship among outdoor toxic concentrations, indoor concentrations, and health effects?
- What can be done to decrease the vulnerability of building occupants to chemical, biological, or radiological attack?

The APT Group addresses these and other building-related concerns by performing analyses of indoor pollutant dispersion, indoor/outdoor air exchange, and building protection.
Our staff performs a variety of indoor pollutant transport studies, including:
- Experiments to measure air flow and pollutant transport within buildings.
- Computational modeling to predict airflow and to understand what effects the speed and spatial distribution of pollutant transport.
- Developing methods of optimizing sensor networks and interpreting sensor data.
- Developing computer simulations of airflow and dispersion of gases and aerosols in commercial and residential buildings.
- Statistical and uncertainty analyses of data and computer simulations.
- Estimating exposure and health effects from an indoor release under various release scenarios.

In studies of indoor-outdoor air exchange, our research encompasses:
- Experiments to study the infiltration of particles and gases from outdoors into buildings.
- Database compilation and analysis to allow prediction of air exchange rates, by neighborhood, over entire cities.
- Prediction of health effects under various evacuation and shelter-in-place scenarios.

Our staff assists building designers and operators and emergency responders by:
- Providing advice documents and computerized evaluation tools to identify building vulnerabilities related to airflow and pollutant transport, and to recommend improvements.
- Evaluating the relative benefits of various approaches to reducing impacts.
- Examining specific buildings, through simulation or experiment, to determine the effectiveness of airflow modifications that are intended to reduce risks.
- Designing sensor-based monitoring systems to detect and locate unexpected releases of agents in real time, predict dispersion as an event unfolds, and recommend response actions.
- Developing decision-analysis techniques, to determine tradeoffs between corrective responses.
- Providing forensic tools to locate a source, estimate the amount released, and predict the likely areas of contamination.
- Estimating toxic exposures by using computer models of human pharmacokinetics to analyze biomarker measurements.

We conducted a series of experiments in the office building to study how fast a pollutant released in various threat locations would disperse and expose building occupants. We also examined the effectiveness of HVAC controls to contain releases while occupants evacuated the building. Computer models and simulations of the building were developed and used against the field experiments, and applied to determine where to best place air-monitoring sensors to quickly detect and locate an agent.

The figure on the left shows a graphical display of the interconnectivity of zones in the building used in a computer model of the building’s airflows.

The figure below shows the predicted airflow using a coupled CFD and multisite model developed by our group.

Incapacitating
INSIDE FIRST PANEL
INSIDE SECOND PANEL
INSIDE THIRD PANEL
Life Threatening
Discomfort
Measurements
INSIDE FIRST PANEL
INSIDE SECOND PANEL
INSIDE THIRD PANEL

The two figures compare air CFD predictions (left) with detailed experimental data (right). Soil gas concentrations at breathing height in a model structure, demonstrating excellent agreement.

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