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Recent Work

Title

Safeguarding buildings against chemical and biological attacks

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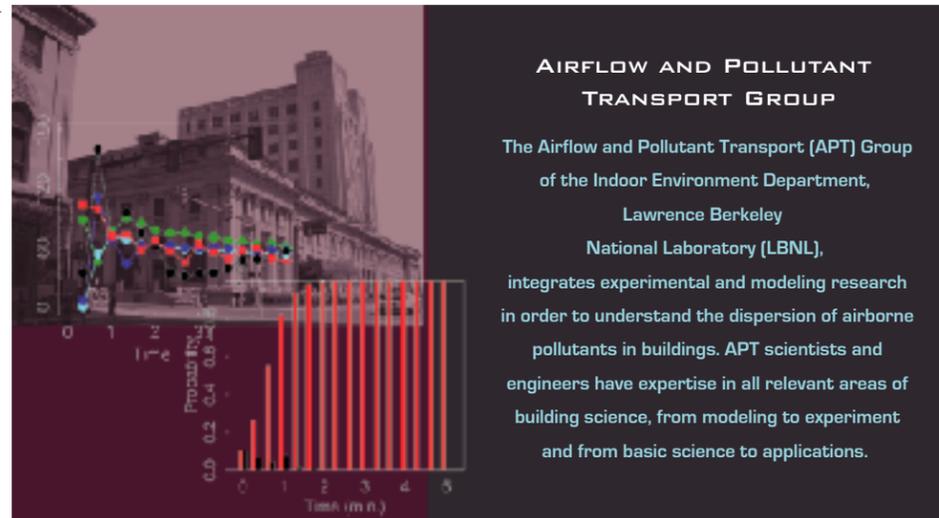https://escholarship.org/uc/item/8sc7n7vw

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COVER

SAFEGUARDING BUILDINGS AGAINST CHEMICAL AND BIOLOGICAL ATTACKS

AIRFLOW AND POLLUTANT TRANSPORT GROUP

BERKELEY LAB
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

2004

INSIDE FLAP

AIRFLOW AND POLLUTANT TRANSPORT GROUP

The Airflow and Pollutant Transport (APT) Group of the Indoor Environment Department, Lawrence Berkeley National Laboratory (LBNL), integrates experimental and modeling research in order to understand the dispersion of airborne pollutants in buildings. APT scientists and engineers have expertise in all relevant areas of building science, from modeling to experiment and from basic science to applications.

Our staff of experimenters, computational fluid dynamicists, airflow simulation experts, data analysts, and building ventilation experts explores 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.

$$\frac{\partial \mathbf{V}}{\partial t} = -(\mathbf{V} \cdot \nabla)\mathbf{V} - \frac{1}{\rho}\nabla P + \frac{\mathcal{F}}{\rho} + \nu\nabla^2\mathbf{V}$$

BACK COVER

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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http://securebuildings.lbl.gov

http://buildingairflow.lbl.gov

INDOOR ENVIRONMENT DEPARTMENT

BERKELEY LAB
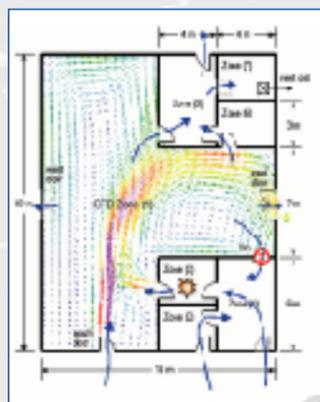ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Indoor Pollutant Dispersion

How, where, and how quickly will chemical, biological, or radiological agents move through a given building? Airborne material will be carried around the building by airflows. In most commercial buildings, these flows are driven primarily by the building's ventilation system, but natural convection can also be important.

Indoor-Outdoor Air Exchange

What is the relationship among outdoor toxic concentrations, indoor concentrations, and health effects? If a toxic release occurs outdoors, indoor concentrations will be much lower than outdoors for a long time, since buildings only slowly take in outside air. Eventually, though, indoor concentrations will rise and the building will become contaminated.

Building Protection

What can be done to decrease the vulnerability of building occupants to chemical, biological, or radiological attack? Building ventilation system design and operation, emergency response capabilities and training, and other factors all come into play in reducing the severity of an attack.
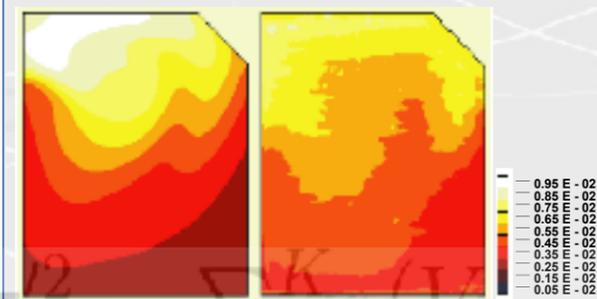

Our staff performs a variety of indoor pollutant transport studies, including:

- Experiments to measure airflow and pollutant transport within buildings.
- Computational modeling to predict airflow and to understand what affects 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.

The figure below shows the predicted airflow using a coupled CFD and multizone model developed by our group. Computational Fluid Dynamics (CFD) predicts the flow in large indoor spaces. These predictions are coupled to airflows in the rest of the building, driven by wind, buoyancy, and ventilation systems.

The two figures compare our CFD predictions (left) with detailed experimental data (right), for tracer gas concentration at breathing height in a model atrium, demonstrating excellent agreement.
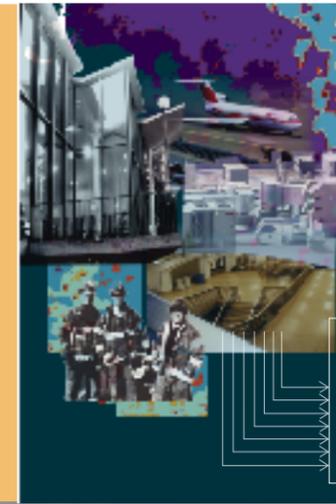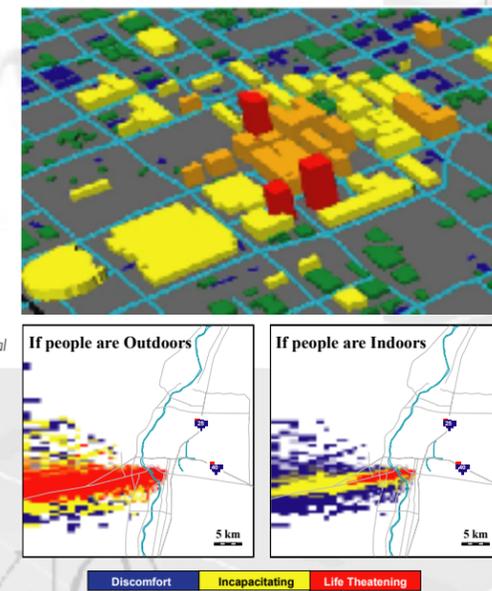

0.95 E - 02
0.85 E - 02
0.75 E - 02
0.65 E - 02
0.55 E - 02
0.45 E - 02
0.35 E - 02
0.25 E - 02
0.15 E - 02
0.05 E - 02

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.

Sheltering indoors can significantly reduce the harm caused by an outdoor toxic plume. Shown here are the predicted health effects of a hypothetical large-scale chlorine gas release in Albuquerque if the population were outdoors, and if they sheltered indoors. Since city centers can be targeted intentionally, and are of specific concern during a release, we study and develop models to predict the effectiveness of sheltering-in-place for both commercial and residential buildings. Such models guide first responders, and are useful to building managers and occupants.

If people are Outdoors   **If people are Indoors**

5 km   5 km

Discomfort   Incapacitating   Life Theatening

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-analyses 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 this 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 minimize exposures while occupants evacuated the building. Computer models and simulations of the building were developed and tested 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.