centerline

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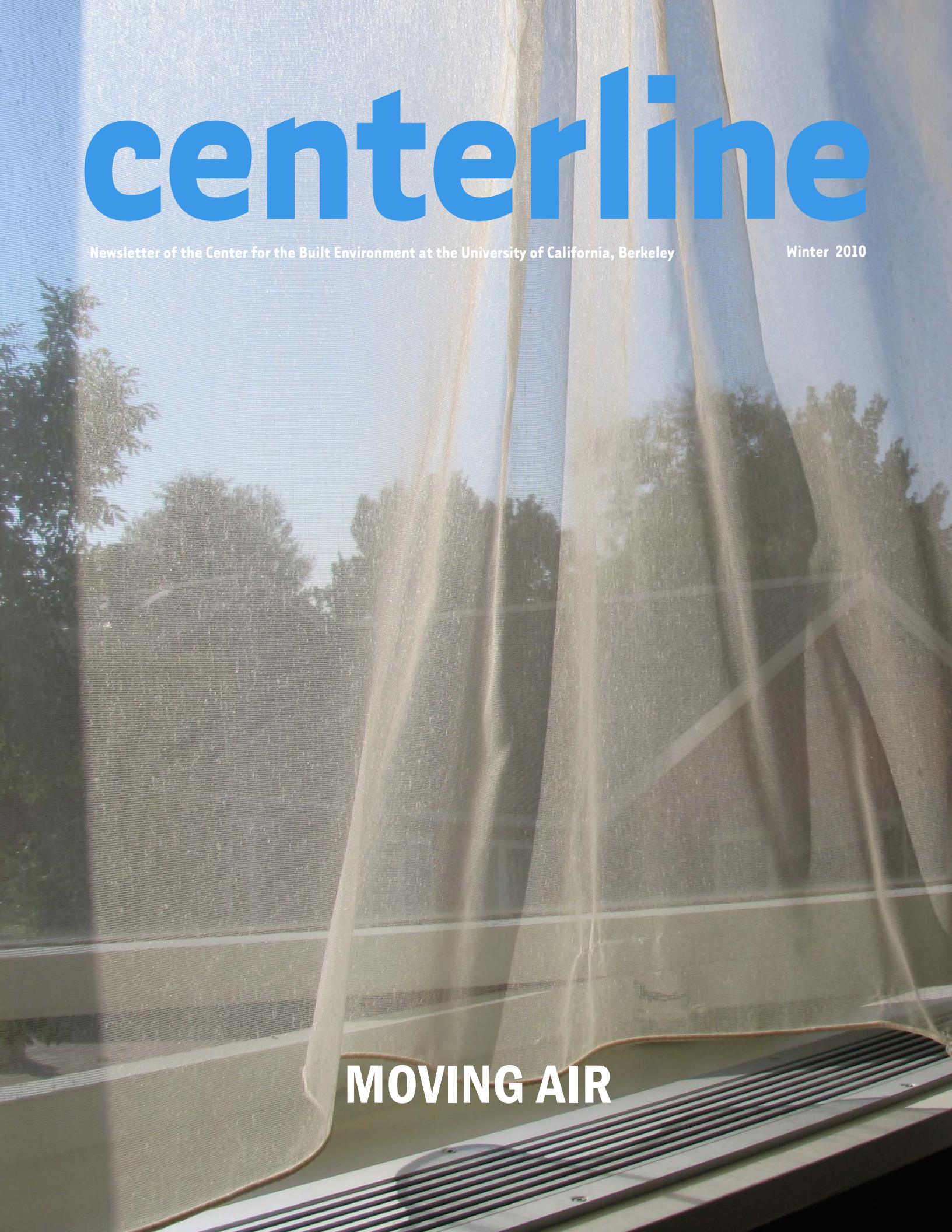

MOVING AIR

Director's Note

Contents

Features

Moving Air: Research on Natural Ventilation Strategies 3

Livable Buildings 2009 8

Project Updates

Kresge Foundation Field Study 10

Facade Survey Research 12

High-Performance Facade Symposium 13

Green Light to Mixed Mode 14

Low-Flow Field Study 15

Back Cover

CBE's Industry Partners

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Dear Industry Partners,

With this edition of *Centerline* we introduce several research projects that we will be conducting in collaboration with partners Arup, Taylor Engineering, Price Industries, and Lawrence Berkeley National Laboratory. Our feature story describes two new projects that take design concepts developed through years of laboratory study, and field test them in occupied buildings. We expect that this work will provide new insight and guidance for the design of naturally ventilated and mixed-mode buildings.

We are also excited about several new developments here at CBE. We will be conducting a comprehensive field study of the Kresge Foundation Headquarters in Michigan, as described on page 10. We also have begun a long-awaited three-year study of thermal comfort in automobiles, to be conducted in collaboration with General Motors and the U.S. Department of Energy.

We have also teamed up with UC Berkeley's Department of Electrical Engineering and Computer Sciences, and separately with Purdue University, on two proposals for new NSF-sponsored Engineering Research Centers. These NSF-supported centers represent significant levels of funding, and if either of the proposals are approved it will allow us to expand our research in exciting new directions.

We look forward to sharing developments with you, and we welcome your interest and participation.

Sincerely,
Edward Arens

Moving Air:

Improving Design and Standards for Natural Ventilation

Since the 1950s office buildings have been largely designed as sealed and mechanically ventilated environments. The modernist idea of hygienic, uniformly conditioned and brightly illuminated offices may have been a huge improvement over poorly conditioned workplaces of the past, but our nearly universal application of this modernist ideal has produced several negative consequences. For example, studies have shown that symptoms of sick building syndrome are higher in sealed, air conditioned buildings than in buildings with operable windows. The sealed building paradigm is also energy intensive, as cooling and ventilation together now account for approximately one quarter of all electricity use in commercial buildings.

Through the use of traditional natural ventilation strategies such as operable windows, adequate shading and fans, the building industry can potentially capture significant energy savings. However comfort for occupants must be maintained.

In collaboration with several of our industry partners, and with funding from the California Energy Commission PIER Program, CBE will launch several new field studies this spring to study energy and comfort in buildings with natural ventilation, using fans and personal controls to improve occupants' comfort.

Past research has led to more flexibility for designers

Faculty and researchers at CBE have conducted multiple laboratory and field studies on operable windows and natural ventilation, many of which have had far-reaching impacts on standards and practices for the design of buildings and HVAC systems.

CBE research has led to more flexibility in comfort standards, which may enable energy conserving approaches and better comfort for occupants.

Studies completed by CBE in 1998 and 2004 showed that in buildings with operable windows, people are comfortable over a wider range of indoor temperatures than in air-conditioned buildings. These studies led to the development and refinement of an "adaptive" thermal comfort model, which was adopted in the 2004 revision to ASHRAE Standard 55, *Thermal Environmental Conditions for Human Occupancy*. This model acknowledges the adaptive behavior of building occupants over the course of the year, and provides greater flexibility in the design of naturally ventilated buildings, expanding the narrow range of conditions otherwise mandated by Standard 55.

In related studies conducted at CBE and verified by other research, we found that both in air conditioned and naturally ventilated buildings, most occupants prefer to have more air movement, and very few want less. This was found to be true for a range of temperatures, even in many cases with slightly cool temperatures. Responding to these findings, ASHRAE Standard 55 was again modified in 2009 to expand the allowable airspeed range in neutral to warm conditions. This revision now allows building designers to use air

movement to improve both energy and comfort performance. This provides opportunities for energy-efficient systems which have cooling capacity limitations, or that are inherently slow acting such as radiant floors and ceilings.

CBE conducted numerous human subject tests to evaluate the ability of personal control devices to make people comfortable over a wide range of indoor temperatures.

New field study of naturally ventilated buildings

These new opportunities for increasing air movement raise a number of unresolved issues. For example, very little information is available on how airflow from windows or fans affect the comfort of occupants. Because fans are so rarely integrated into offices, there is remarkably little guidance for designers in selecting appropriate sizes and spacing of ceiling fans in offices.

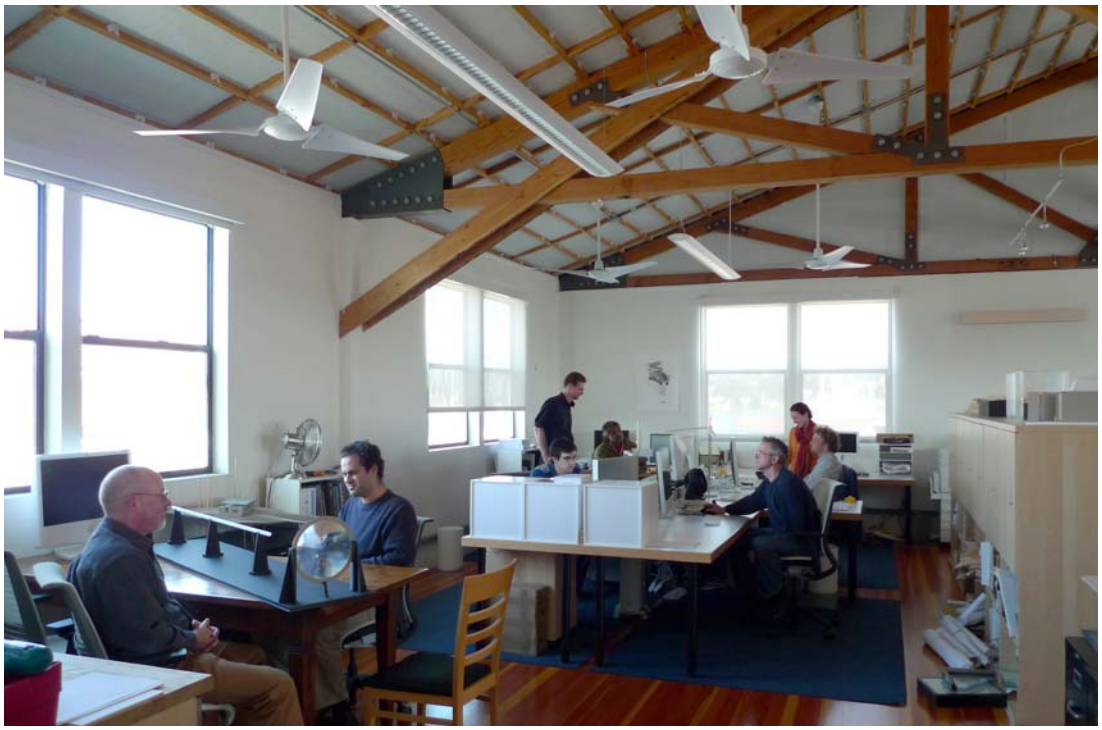
Lacking a longitudinal study of comfort in a fan-cooled office space, a number of questions remain: How do occupants set the fan speeds at varying temperatures? What is their comfort over the course of the entire workday, during hot summer afternoons, or over the entire year? How do they rate indoor environmental quality in comparison to people in air conditioned spaces?

In collaboration with Arup, UC San Diego, and Lawrence Berkeley National Laboratory (LBNL), this spring we will begin a detailed field study that will begin to answer these questions. This study is planned for a naturally ventilated design firm's office in Alameda, California, in which a number of ceiling fans are installed. Through detailed observation and analysis, we expect to generate information which will provide valuable guidelines for architects and system designers.

The research plan includes a number of related activities. The primary focus will be to conduct surveys of occupants, monitor environmental conditions in the space, and monitor occupants' use of windows and ceiling fans, especially during the warmest times of year. We will document indoor environmental conditions using desk-top monitoring devices for recording air and radiant temperatures, airspeed, humidity, and CO_2. We will also monitor indoor air velocity and temperature profiles using CBE's "commissioning cart." An outdoor weather station will measure the ambient air temperature, wind speed and direction, and solar radiation.

The lack of data on naturally ventilated buildings leaves many unanswered questions.

To accurately gauge occupants' comfort, we will survey them multiple times each day, using 'right-now' surveys to document comfort at a specific point in time, in order to compare responses with physical conditions in the space. We will also



Beginning this spring, CBE will study the effectiveness of fans and personal control devices this naturally ventilated office space in Alameda, CA. Image: Loisos + Ubbelohde

provide the occupants with personal environmental conditioning (PEC) systems that provide individual control, and we will monitor the use of these devices as well. (More information on PECs is below.) The study will document different seasons, and will capture different modes of operation—natural ventilation alone, operation with ceiling fans, and ceiling fans combined with PECs.

The second focus for this research will be to study the impacts of natural ventilation on indoor air quality. In contrast to buildings with sealed windows and mechanical ventilation, naturally ventilated buildings may increase occupant's exposures to some types of outdoor air pollutants such as particles and ozone. With this work, to be led by William Fisk, the Head of the Indoor Environment Department at LBNL, we will record indoor and outdoor concentrations of ozone and particles in three office buildings, while also collecting information on occupants' use of windows. The resulting data will be used to determine indoor-to-outdoor concentration ratios for ozone and particles, and their relationship to the use of windows. This data will allow us to compare against data from typical air conditioned office buildings.

Prototyping and testing personal environmental conditioning systems

In conjunction with our study on natural ventilation, we are also developing a new generation of personal environmental conditioning (PEC) devices. Based on previous findings from comfort and energy modeling research, we believe that using low-power PEC devices, and allowing ambient temperatures to fluctuate beyond current standards, can provide both a high level of comfort for occupants and overall building energy savings.

Using detailed EnergyPlus simulations, we have found that allowing the indoor ambient temperature to vary by even a few degrees can result in large energy savings. A building can conditioned less intensely and less often, and the number of hours in which it is in economizer mode (i.e., using outside air alone for conditioning) is increased. Although the savings

vary by climate zone, we learned that for each degree (C) of temperature the thermostat is raised, cooling energy is reduced by 7-15%. If we widen the thermostat dead-band (the temperature range between heating and cooling thermostat settings) as part of an energy-saving strategy, giving occupants personal control of their environments goes a long way to keeping them comfortable.

Individual control of the environment in offices is not a new concept. In the late 1980s Johnson Controls patented and marketed its Personal Environmental Module (PEM), consisting of miniature fan towers mounted on a desk, a fan assembly below the desk, a radiant heating panel, and a small control panel. The devices were designed to work with the underfloor air distribution systems that also were new at the time. Our research group conducted both field and laboratory studies of the effectiveness of the PEM product, and found that they increased occupant satisfaction across all categories tested. However the devices were not widely adopted, and were ultimately discontinued by the manufacturer. (Although the PEMs were not a commercial success, the quest for personal control continues *ad hoc*. Walking through a typical office, it is not uncommon to see fans and heaters that employees have brought in to make themselves more comfortable.)

For the design of the ideal PEC system, we can draw upon previous research conducted at CBE. In a multi-year laboratory study funded by the National Renewable Energy Laboratory (NREL) in 2000, we determined that the most likely sources of thermal discomfort in a workplace are from cold hands and feet, or from feeling too warm around the head and/or "breathing zone." This study formed the Ph.D. dissertation of Research Specialist Hui Zhang who now leads CBE's comfort research.

Graduate student researcher David Fannon works on the first generation prototype for the low-energy desktop fan.

From this understanding of hot and cold perception, we hypothesized that the most effective PEC devices would allow people to warm their hands and feet, and adjust cooling air around their heads. In 2005 we began a series of human subject tests to study this hypothesis in detail. We found that with a low-energy PEC system, people could be comfortable in temperatures

ranging from 64°F (18°C) to 86°F (30°C). We also learned that if people were temporarily away from the PEC devices, and performed activities that increased their metabolism to the point where they felt warm, they could immediately feel comfortable again once they were back in their workstations and able to use the PEC devices to cool themselves.

The devices that were tested in this study had been designed to use minimal amounts of energy, as our goal was to demonstrate that overall building energy use could be reduced with PEC systems. Energy modeling confirmed that the additional electrical use of the PEC devices, even under aggressive use, was tiny compared to the building energy savings from increasing the temperature dead bands.

The PEC devices used in CBE's laboratory study, while effective for the purposes of the test, were mockups suitable only for a laboratory setting. We are now involved in the next step of our PEC research, creating robust, high-quality PEC devices for use in large-scale demonstrations, and appropriate for a professional workplace. With funding from the CEC's PIER program, we are developing several low-energy (4 watt) desktop fan prototypes that will include an occupancy sensor to further reduce energy use when a workplace is vacant. These fans will be deployed in the Alameda field study described above, and in other study sites as well. We are also working on the design of a compact, low-energy foot warming device to be used under cool weather conditions. We plan to oversee the manufacture of an initial quantity of both devices for implementation in a larger field study, and we are in discussion with Rumsey Engineers and the U.S. General Services Administration to identify a research site in a prominent naturally ventilated building.

The field implementations of the PEC concept represent a major milestone in this line of inquiry, and will take concepts developed in a laboratory setting and test them in actual occupied offices. We are eager to share the results of these studies, and we hope that our findings can provide much needed guidance to designers, manufacturers and building owners.

References

Draft or Breeze? Preferences for Air Movement in Office Buildings and Schools from the ASHRAE Database

This paper from Healthy Buildings 2009 describes building occupants' preferences for air movement at different interior temperatures.
http://escholarship.org/uc/item/99q2f4cf

A Standard for Elevated Air Speed in Neutral and Warm Environments

This article from *ASHRAE Journal* describes the new Standard 55.
http://escholarship.org/uc/item/6d94f90b

Comfort, Perceived Air Quality, and Work Performance in a Low-Power Task-Ambient Conditioning System

This article describes the comfort and perceived air quality with our personal environmental conditioning system.
http://escholarship.org/uc/item/8x95h9w7

Occupant Satisfaction in Mixed-Mode Buildings

An examination of occupant survey results, showing high occupant satisfaction in mixed-mode buildings.

http://www.cbe.berkeley.edu/research/pdf_files/Brager2008-OccSatisfaction-MM.pdf

Operable Windows, Personal Control and Occupant Comfort

Results of a detailed field study in a naturally ventilated building.
http://escholarship.org/uc/item/60q9596r

Livable Buildings 2009

Livable Buildings Awards 2009 Acknowledge Diverse Project Types

A zero-electricity school, a design studio interior, and an energy-efficient remodel of a '70s era university building were recognized in CBE's 2009 Livable Buildings Award last December. A panel of seven CBE industry partners selected Chartwell School of Seaside, Calif., to be the top award winner, and identified as honorable mentions Cohos Evamy's Toronto Studio and the William Robinson Technology Building at Norfolk State University.

These projects were selected from among several projects that met the minimum qualifications for the award by showing high levels of occupant satisfaction as determined by CBE's Occupant IEQ Survey. Projects must rank in the top 50 percent in occupant satisfaction in areas such as air quality, lighting, acoustics and thermal comfort, and must place in the top 25 percent for overall building satisfaction. This year a total of nine projects met this standard out of over 90 that used the survey, and six of these finalists applied for the award program. (The finalists included three elementary schools, as CBE conducted close to 60 surveys in 2009 as part of an IEQ study in K-12 schools.)

Chartwell School, designed by EHDD Architects and Taylor Engineering, was singled out by the program judges for its high occupant satisfaction scores, its ambitious energy goals, passive design strategies, and its overall design quality. The project was designed to be net-zero in electricity use, and the project team has worked in close collaboration with the facility managers to monitor and improve energy consumption. (This was described in *Centerline*, Summer 2008, pages 7-8.)

Peter Alspach, an award competition judge and engineer with the global

Exterior view of multi-purpose room at Chartwell School. Image: Michael David Rose

Cohos Evamy Toronto Studio. Image: Tom Arban

Reading area at Chartwell School. Image: Michael David Rose

Robinson Building at NSU.
Image: Steve Maylone

firm, Arup, praised the Chartwell team's ambitious energy goals, and cited the project's value to others attempting net-zero or evaluating existing buildings for efficiency.

Scott Shell, Principal and Director of Sustainability at EHDD, explains that "CBE's work and the survey has really been a powerful influence in our work. The results for the many projects surveyed have taught us to pay close attention to acoustics, as well as the other issues that are so clearly articulated."

The school had already received substantial recognition, including the AIA's list of Top Ten Green Projects for 2009, and in 2007 it became the first school in California to earn LEED Platinum status.

Livable Building honorable mentions go to the Cohos Evamy Toronto Studio and the renovated William P. Robinson Building at Norfolk State University in Norfolk, Va. Contest judge Sandy Mendler, a principal with Mithun, gave kudos to the Cohos Evamy workspace for its comprehensive green design strategies. The office is located in a transit-friendly high rise, uses 44% less electricity for lighting and plug loads than average office building, and uses 59% less water. The firm has made waste reduction a part of the office culture, and currently diverts over 60% of operational waste from landfill. In addition, each meeting room has individual temperature and ventilation controls, and zone-by-zone controls regulate thermal comfort.

The William P. Robinson Sr. Technology Building is the first building at Norfolk State University campus to earn LEED certification. Jurors noted that the Robinson Building can be seen as a positive example of blending sustainability into the renovation of a large number of now-aging and ready-for-renovation '70s era buildings. Kevin Powell, Director of Research for the U.S. General Services Administration and one of the program judges, remarked that the "greenest building is the one you don't build."

Details about the award-winning projects and their CBE survey results are online at http://www.cbe.berkeley.edu/livablebuildings

Project Updates

CBE will lead Comprehensive Field Study of Kresge Foundation Headquarters

Representatives of the Kresge Foundation last fall invited CBE to conduct an intensive field study of their headquarters, a complex of LEED-Platinum buildings in Troy, Mich. Environmental conservation is one of the foundation's core programs, and Kresge hopes to disseminate the results of its building evaluation widely for the benefit of green building professionals. Kregse's specific objectives are to determine to what degree design goals are being met in terms of energy, water, landscape, stormwater management, finance, and indoor environmental quality.

The Kresge Foundation Headquarters consists of a new office building and renovated stone barn and farmhouse.

The headquarters, completed in 2006, includes a renovated barn and farmhouse, and a modern office building that incorporates multiple energy and water conserving strategies, including underfloor air distribution and geothermal heating and cooling. The project also includes innovative stormwater management, a green roof, and native landscaping, all of which will be evaluated in the field study.

For the study CBE plans to use two of its sophisticated tools for evaluating buildings in operation—its occupant IEQ survey and building "commissioning cart." The survey tool has been used in over 500 buildings to evaluate building performance from the building occupants' point of view, and has a unique database of building occupant responses valuable for benchmarking. CBE's commissioning cart, originally developed for measuring indoor climate at the New York Times building, allows our research staff to measure indoor environmental conditions in detail, and to assess the operation of building systems. Together, these tools can provide a comprehensive overview of a building's performance, both subjective and objective.

To respond to the broad scope required by Kresge, Research Specialist John Goins put together an interdisciplinary team to assist with financial, landscape, and site water aspects of the project. José Almiñana of Andropogon Associates will lead the stormwater and landscape portions of the scope. Michele Adams, of Meliora Environmental Design, will conduct water quality tests and other site water evaluations, and Peter Morris with of Davis Langdon will conduce financial analysis of the project's green features. John Goins notes that the Kresge field study is an opportunity for CBE to expand the scope of its post-occupancy evaluation work through collaboration with experts in sustainable landscape,

CBE's field study will evaluate the project's use of native landscaping and stormwater management system. Arch: Valerio Dewalt Train. Images: Kresge Foundation.

site water management, and green building finance. "This is an interesting project with a number of green strategies, and this project team will help us to study all aspects of the building and the site," he says.

The field study is also being used by CBE as a test case for a new performance measurement protocol (PMP) being developed by the USGBC and ASHRAE. This tool is being developed to provide a standardized and consistent method for measuring the energy, water, and IEQ performance of commercial buildings. Our research staff in now reviewing the PMP in the context of this field study, currently in a 90% draft form.

The field study team began its work in earnest in January, and will conduct its first site visit during the first week of March. Additional site visits will be made in the spring and summer. A draft report is due this summer, with a final report due at the end of 2010.

More information on the Kresge Foundation and its headquarters is at http://www.kresge.org/index.php/headquarters/index/

New Occupant Survey Module for Advanced Facades

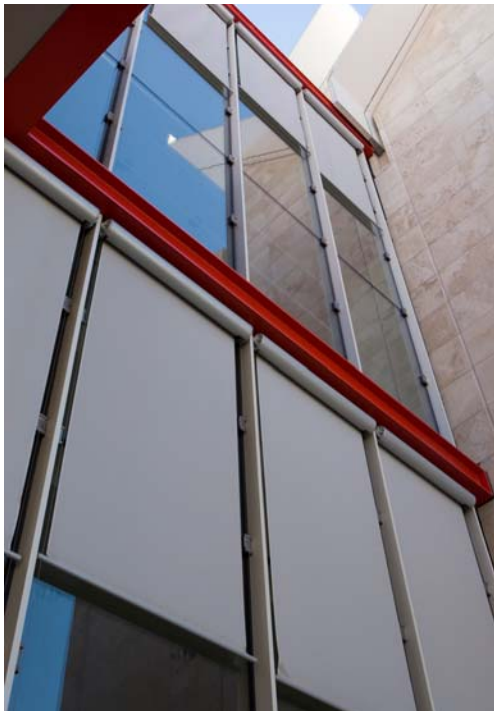
Today's high-performance glazing products allow architects to explore new design possibilities, using highly transparent facades and extending glazing over large areas of a building. While these facades can be aesthetically striking, exactly how occupants respond to such facade designs has not been well studied. In an effort to better understand the relationship between facade and occupant, CBE recently created a new facade module for the CBE occupant IEQ survey. The survey module was completed last fall, and a version of it was pilot tested at the Orinda City Hall in Northern California last December.

The new module will allow building managers, project designers and researchers to drill down and better understand facade impacts on daylighting, visual comfort, and view. A number of branching questions (additional questions which appear only if the survey-taker is dissatisfied with some aspect of the environment) will drill down to identify causes of glare and other sources of discomfort.

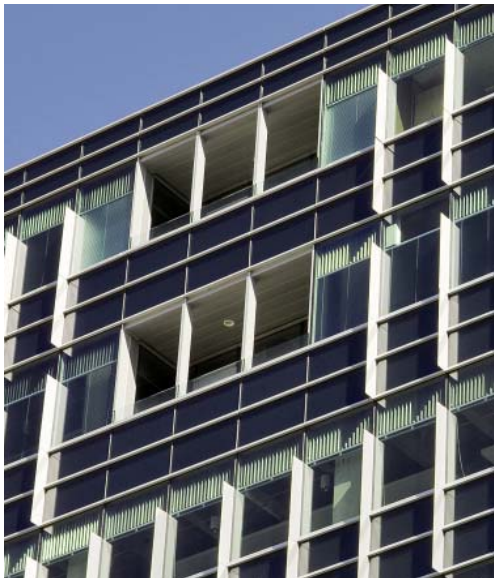
Given the importance of shading in highly transparent facades, and the complexity of designing an appropriate system, we have included a number of questions on the effectiveness of shading systems. This survey tool will help us to understand how frequently blinds or shades are down, why occupants adjust shading, and how satisfied they are with the shading in terms of daylighting, thermal comfort, view, and control. We include versions of the survey for both manual and automated shading, which will allow us to study the full range of facade and shading types.

Last fall we also met with McClintock Facades and Nysan Solar Control to plan for the implementation of the new survey in a number of buildings with interesting and advanced facade systems. We are also planning to create other new survey tools to study facades in exhibit and museum spaces. Because Nysan manufactures a number of movable shading systems, we will work with them to create additional surveys to document operations and maintenance of such advanced systems.

We also hope to implement the facade survey in collaboration with CBE industry partners and other firms, and we will make the module available online for review soon. If you would like to see a copy of the survey, or are interested in implementing the survey on a project, please e-mail graduate student researcher Krystyna Zelenay at kzelenay@berkeley.edu for more information.



Los Angeles County Museum of Art. Arch: Renzo Piano Bldg. Workshop. Image: Nysan



Denver US Environmental Protection Agency Headquarters. Arch: ZGF Architects. Image: Robert Canfield.

Building Facades Symposium: Integrating Comfort and Energy Performance

One of the essential components in the design, engineering and operation of ultra-low energy buildings is the building envelope. Innovative approaches to facade design are common in Northern European buildings where air conditioning is used selectively. As we push for higher performance in sustainable buildings, there is much value to be gained by exchanging conceptual and technical knowledge between North American and European professionals.

On April 21st, the PG&E Pacific Energy Center, Lawrence Berkeley National Laboratory (LBNL), and the Center for the Built Environment (CBE) are sponsoring a full day symposium to generate dialogue between North American professionals and researchers and leading experts from Europe.

The symposium will host leading practitioners from Europe and a panel of local design experts who will discuss case studies, performance, and applications of integrated facade design in North America. Although the final list of presenters and panelists is pending, confirmed presenters include:

Andrew Kiel is an associate at Sauerbruch Hutton Architects in Berlin whose projects include the Federal Environmental Agency (Umweltbundesamt) in Dessau (pictured), the GSW office tower in Berlin, and a new headquarters building for KfW in Frankfurt.

Federal Environmental Agency, Dessau, Germany
Arch: Sauerbruch Hutton. Photo: Mark Perepelitza

Thomas Auer is a managing director of Transsolar of Stuttgart, Germany. Transsolar is a climate and energy consulting firm who have collaborated with Sauerbruch Hutton and other leading European and North American architects in developing the design and energy concepts for high-performance buildings.

Mikkel Kragh is an associate and facade engineer at Arup. In the past year Mikkel transferred from Arup's London office to Milan Italy. He is currently also chairman of the UK-based Society of Facade Engineering.

Steve Selkowitz is head of LBNL's Building Technologies Department. LBNL is an international leader in glass, window and shading systems research, and daylighting including components and systems that support net-zero energy buildings.

Seating for the event is limited, but unlimited remote participation will be available via web-cast. (Seating will be allocated between CBE industry partners, LBNL facade technical advisory committee members, and the general public.)

Giving a Green Light to Mixed-Mode Buildings

Despite growing use of operable windows for natural ventilation, few commercial buildings can completely forego mechanical cooling and ventilation. Managing the effects of operable windows in mixed-mode buildings (those that combine mechanical systems and operable windows) is a challenge that is far from resolved.

Feedback-based informational controls, which indicate to occupants when conditions are appropriate to open and close windows, are increasingly popular. These systems come in many forms including lighted signs, red/green indicator lights, and email notifications. The popularity of these systems stems from the fact that informational devices allow a system to provide the amenity of occupant control, reduce costs, and give designers flexibility in building layout and thermal zoning. The catch is that the design relies on occupant behavior to manage a building's energy savings potential. This challenge forms the basis for a new CBE study that asks occupants how actively they respond to such signaling devices, how well they understand the intent, and how often they follow the feedback provided.

Examples of devices used to give occupants information about use of windows. Left, Orinda City Hall, and right, Kirsch Center for Environmental Studies.

We have identified close to 20 mixed-mode buildings that combine informational controls with operable windows. The strategy has been included in several well known green buildings from the '90s, such as the Hewlett Foundation in Menlo Park, Calif., and the CBF Merrill Environmental Center in Annapolis, Md. More recently we see window operation feedback implemented in some of the newest green buildings, including the Yale School of Forestry's Kroon Hall, the City Hall in Orinda, Calif., and in several renovation projects at the University of Washington, and in four new buildings under construction at Stanford University. The system was also installed during a recent renovation at UC Berkeley's Boalt Hall.

At their best, informational controls can lead to greater occupant engagement, reigniting the modern office worker's connection to daily and seasonal cycles. In NBBJ's architectural offices in Seattle, for example, the "first green light of spring" has been cause for spontaneous cheer. On the other hand, people may resent getting direction on something as simple as operating windows, and such direction may reduce the satisfaction that comes from personal control of one's environment.

Two pilot surveys we've conducted show that the degree to which people obey the red/green light system is highly consistent within a single building, but highly variable between buildings. Although this result is preliminary, it suggests that the design of the system, and/or how it is introduced to occupants, may be important factors in influencing occupants' operation of windows.

Collaborative Research with Taylor and Price will Study Low-Flow VAV Strategies

Our feature article in this edition of *Centerline* discusses ways to use higher rates of airflow to save energy while keeping occupants comfortable in warm seasons. However when air movement is not used for providing comfort (as is the case in most commercial buildings), reducing zone minimum airflow rate can be an effective energy-conserving strategy. Working in collaboration with Taylor Engineering and Price Industries, we are planning two studies to evaluate this concept.

Typical overhead variable air volume (VAV) designs use zone minimum airflow rates of 30-50% of the maximum rate due to concerns about controller stability, uniformity of temperatures, and ventilation. However under low-load conditions, when airflow is not required for heating or cooling, this level of airflow consumes excessive fan energy, and provides arguably little benefit in terms of indoor environmental quality.

A number of studies show that minimum airflow can be reduced below manufacturers' specifications, resulting in significant energy savings without adverse loss of control. Simulations done by Taylor Engineering show that reducing minimum flows in a typical office building from 30% to 20% can save approximately 10% in total energy use. Multiplied across the millions of square feet of commercial space served by VAV boxes, the potential economic and environmental benefits are tremendous. In addition, these savings can be achieved both in new construction and in existing buildings through low-cost control system re-programming.

Taylor Engineering has been successful in implementing this strategy in a number of buildings. Although the potential for energy savings is significant, there are gaps in the research on occupant comfort and ventilation effectiveness at low flows, especially with less than 25% flow, and in heating applications. (Rates as low as 10% provide acceptable ventilation for air quality purposes.)

Two planned research studies will examine the energy and indoor environmental conditions under such low flow operation. If this mode of operation can be demonstrated to be successful, there are significant implications for energy savings in existing buildings.

For the first of these projects, funded by CEC's PIER Program, we will conduct an intervention study of low flow operation in a corporate campus consisting of seven buildings. We will program a sequence of periods with high and low minimum rates, using daily and weekly schedules to provide us with a robust dataset covering various weather patterns, occupancy conditions, and other variables. We will monitor the cooling, heating, and fan energy use in detail while simultaneously monitoring zone VAV trends during and after the intervention. CBE will use its occupant IEQ survey both before and during the intervention to study the effect on the building occupants. Jeff Stein and Gwelen Paliaga of Taylor Engineering will collaborate with CBE on this research, and we expect to report on this work this summer.

We have also submitted a proposal to ASHRAE to study ten or more buildings that are operating with low minimum VAV airflow set points of less than 30%, and which represent different climates. We will implement occupant IEQ surveys, including "right now" surveys that ask occupants questions about their perceptions of the indoor environment at a given time. We will also monitor air temperatures, CO_2 and VOC levels to determine the distributions of these parameters among the occupants, both near and far from diffusers. These physical measurements will help us to explain the subjective survey results. We will also conduct a series of laboratory tests of diffuser performance under low-flow conditions, in collaboration with Julian Rimmer and Brad Tully of Price Industries, using Price's test chamber. This proposal is currently pending approval by ASHRAE.

centerline
Winter 2010

Industry Partners at the Center for the Built Environment

CBE's research is supported and guided by CBE's consortium of industry partners, a diverse group of leaders in the building industry. The Center's membership includes the following firms and organizations:

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- Mahlum Architects
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