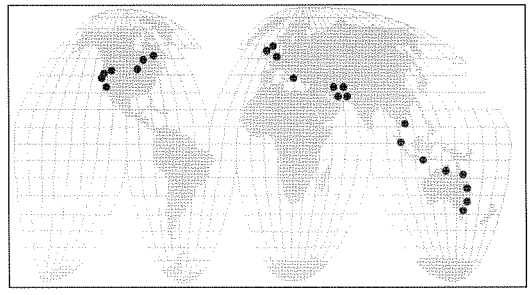
Design for Comfort

PLACE RESEARCH AWARD

Researchers: Gail Brager, Professor of Architecture, University of California, Berkeley; Richard de Dear, Professor of Environmental and Life Sciences at Macquarie University, Sydney.

Sponsor: American Society of Heating, Refrigerating and Air-Conditioning Engineers

Re-evaluation of thermal comfort research demonstrates that workers in naturally ventilated buildings are satisfied with a wider range of climatic conditions.



Locations of research studies whose data was re-evaluated for this project.

Graphic: Gail S. Brager

Climate is one of the most critical ways in which people experience place, and it is no coincidence that an appropriate response to climate has formed an expressive feature of almost every great building tradition.

For example, the lifestyles of people who live in tropical regions have for many years inspired distinctive climate-responsive architecture. Using such devices as covered porches, high ceilings, fans and large open windows, tropical buildings were able to provide a sense of comfort, delight and connection to environment and culture. Other architectural features were designed to maintain comfort in cold climates.

In the modern era, however, advances in mechanical heating and cooling have largely undone this connection between place and built form; the pleasures of such place-based design have been eclipsed by sealed structures. This is especially evident in the design of modern office buildings, where the relation of exterior form to place has become almost entirely cosmetic. Workers inside these buildings may find it impossible to tell if they are in Anchorage or Riyadh.

A major link in the chain of events that severed place-based ties between architectural form and climate was the establishment of universal standards for thermal comfort. These standards, derived entirely from laboratory tests, are published by agencies such as ASHRAE and ISO.[1]

Today, in nearly all but residential-scale buildings, designers wishing to employ natural strategies for thermal control must collaborate with engineers whose professional obligation is to adhere to these one-size-fits-all standards.[2] While engineer and designer may agree that natural strategies are more healthy, energy-efficient and aesthetically pleasing, engineers often have no choice but to veto natural approaches because they cannot consistently maintain the same performance as artificial mechanical systems.

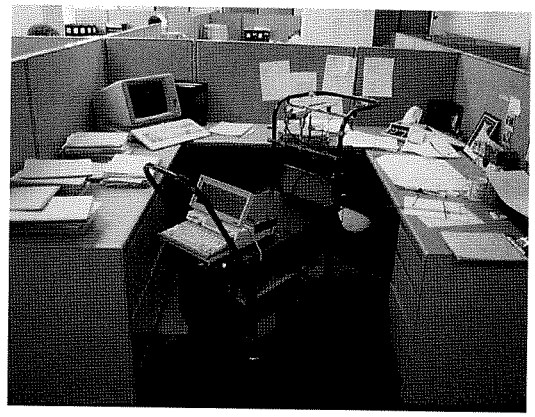
This research sought to break the dominance of universal thermal comfort standards and to facilitate a return to a more person-centered approach to building design and environmental control that is healthier, better connected to place and more sustainable. The project was directed by Richard de Dear, Professor of Environmental and Life Sciences at Macquarie University, Sydney, and Gail S. Brager, Professor of Archi-

tecture at the University of California, Berkeley, and was sponsored by ASHRAE.

The project's initial assumptions were that strict reliance on laboratory-based standards ignores important cultural and social differences in what makes people comfortable, and that the standards discourage design innovations that might allow people to have a greater degree of interaction with, and connection to, their environment. The study proposed that people who had control over their thermal comfort would be more comfortable in a wider variety of conditions than people who were forced to accede to a single climatological setting that they could not control.

The research focused specifically on workers' experiences in office buildings. The researchers assembled a database from existing thermal comfort field experiments involving 21,000 observations in 160 buildings on four continents. The extensive sampling was needed to attain the level of scientific rigor required to propose modifications to thermal comfort standards. Data included information about the buildings and their occupants, the indoor and outdoor climate, and opportunities for personal control (such as operable windows, curtains or blinds, local heaters or fans, etc.), as well as responses to questionnaires about thermal conditions and preferences.

Among its many findings, the project demonstrated that while universal standards do produce comfort in situations where centralized climate control is the only option, occupants were quick to complain when temperatures deviated from the narrow, constant conditions to which they were accustomed. In contrast, occupants of naturally ventilated buildings were comfortable across a wider range of temperatures that more closely reflected the patterns of the outdoor climate.



Top: **Operable windows on the facade of a San Francisco building, an example of how ventilation strategies affect architectural character**
Photo: **Chris Benton**

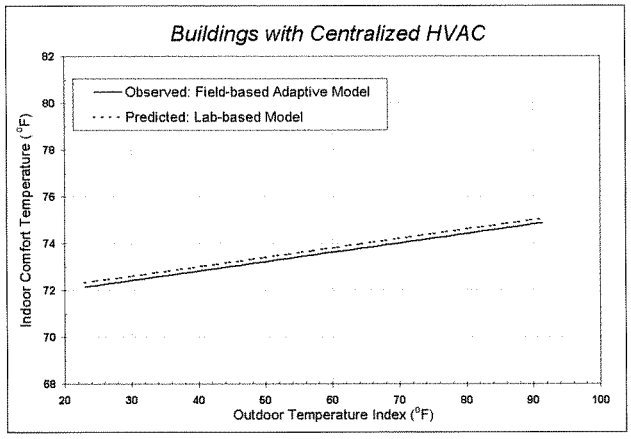
Above: **Instruments for measuring thermal conditions in work environments**
Photo: **Gail S. Brager**

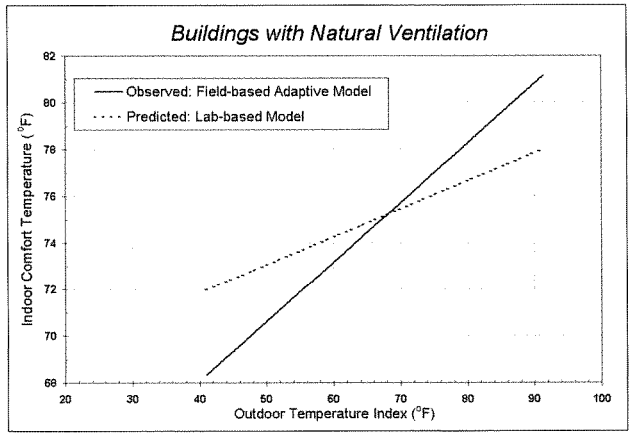
By comparing observed and predicted comfort responses, the researchers were able to explain these results both in terms of behavioral adjustment (the extent to which people are able to modify their clothing, open windows, turn on fans, etc.), and psychological adaptation (comfort in the naturally ventilated buildings was derived, in part, from local climactic expectations and higher levels of perceived control).

This research represents a fundamental shift of view in terms of the relationship between people and their thermal environment. The central premise is that people can be instrumental in creating their own thermal preferences through interactions with the environment, modifications of behavior and changes in

expectations. This approach considers people active agents, rather than passive recipients, of optimized conditions. Such a view is critical to re-establishing place-based values for thermal design.

As a result, ASHRAE has acknowledged that its existing standards may not be applicable across all building types, climates and populations, and the organization is considering ways to incorporate this research into the next round of standard revisions. One outcome could be the establishment of an alternative standard for naturally ventilated buildings, which would link recommended indoor temperatures to the climactic context of place. This would free heating and cooling engineers to collaborate with architects in the design of new, innovative, natural systems.





Charts comparing user preferences in climate-controlled and naturally ventilated buildings. The data compares preferences predicted by standard models and the preferences people actually expressed in surveys. Workers in naturally ventilated buildings reported being satisfied in a wider range of temperatures. Also, the standard model did a better job of predicting preferences in climate-controlled buildings than in natually ventilated buildings.

Graphics: **Gail S. Brager**

Jury Comments

GANTT: It is very big. In the hundreds of buildings that I have designed, the most common complaint after "The roof leaks" is, "We are not comfortable." A lot of what engineers adhere to are these ASHRAE standards, and this research suggests that we have to look for ways to make buildings more comfortable.

VERNEZ-MOUDON: On the down side, I don't see any comprehensive paper on how the standards should be changed. What is the next step, how do you implement it? That would be the missing link.

ZEISEL: The problem with doing really excellent research is that it takes a lifetime and a lot of money. These researchers have taken their lives and done that. It's not exciting, it's not cross-disciplinary. But it's the only way you get this kind of stuff done.

VERNEZ-MOUDON: For once you have pretty standard engineering research that has a high-level goal; it's not just trying to crank numbers. I like the findings, which are quite interesting, that people prefer and can adjust to places that they can modify. The results may seem obvious to us, but this research proves them. We could also highlight the fact that this researcher is working from the bottom up to change an institution that is very hard to change.

So it's very interesting because it is using traditional research methods for non-traditional advocacy. This is presenting long-term framework; it is not point of intervention research.

ZEISEL: It says that ASHRAE's standards don't work for different cultures—that you want a standard that takes culture into account. And when you can open the windows, you feel better about the temperature.

VERNEZ-MOUDON: It attacks a significant problem, which is controlled environment within buildings.

GANTT: Do we know enough about the data itself to give this an award?

ZEISEL: They never asked anybody a question. They are doing secondary analysis using other people's research.

GANTT: What about places? Is it a place?

VERNEZ-MOUDON: The comfort issue is essential to place. This is a way of reaching out to people who are really constraining in a bad way the place-making process.

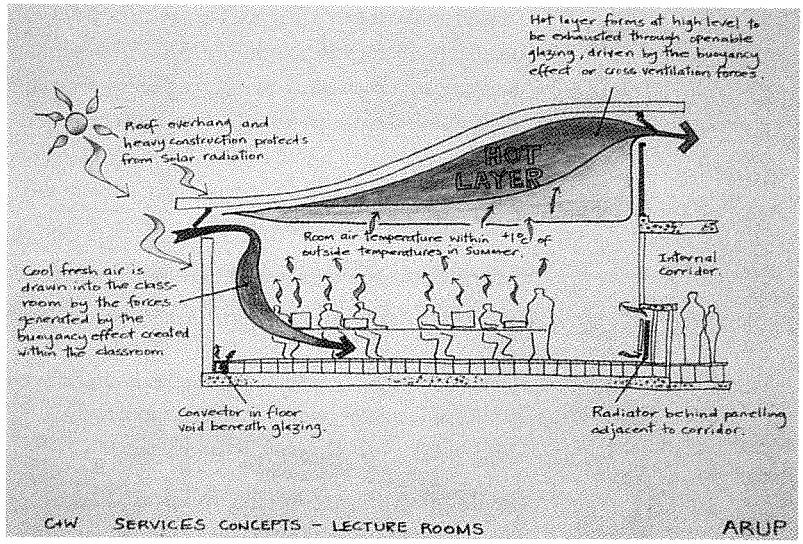
Notes

1. ASHRAE is the American Society of Heating, Refrigerating and Air-Conditioning Engineers, an international society with more than 75,000 members. Its scope also includes aspects of human response and energy-efficient building design.

   ASHRAE issued its first comfort standard in 1938. It was replaced in 1966 by "Standard 55: Thermal Environmental Conditions for Human Occupancy." Standard 55 was subsequently revised in 1974, 1981 and 1992. The standard is currently in its next round of revisions, which will include the results of this research.

   ASHRAE's standards have been adopted by many countries and serve as the model for standards developed in parallel by ISO, the International Standards Organization.

2. The standards specify combinations of environmental and personal factors that will produce thermal conditions that occupants will find acceptable. To apply the standards, designers must use information about local temperature, thermal radiation, humidity and air speed, and make assumptions about the type of activity and clothing levels appropriate for the occupancy. There is no direct distinction made for the type of building involved, cultural preferences or outdoor climate.



Cable and Wireless College
Coventry, England, 1993

Design: **MacCormac Jamieson Prichard**
Photos: **Ove Arup and Partners**

The wave-shaped roof of this building was strongly influenced by the requirements of buoyancy-driven natural ventilation in a deep-plan space. Air enters through low windows on the south, rises above the occupied zone as it is warmed by the heat gains from people and equipment in the classrooms, and is exhausted through high-level eaves on the north.