cutting the cost

HAVE YOU EVER WALKED through an office building during summer and noticed this scene? In one office, the occupant has his/her jacket off and shirt sleeves rolled up with a small fan perched on the desk blowing on high. In the office next door, the occupant has on a sweater and a space heater at his/her feet trying to keep warm. It's a scenario that plays itself out in offices across America and has done so since the 1970s, when office buildings became more energy efficient.

Conventional wisdom among engineers has said that office buildings should reach a temperature of between 72 and 75 degrees Fahrenheit. Dip below 70 and the space heaters come out. Rise above 75 and complaints to building management increase. To achieve this optimum temperature, powerful, centralized air conditioners pump out 55-degree air through overhead vents into the room.

It's an approach that has worked—up to a point. But it's an approach with drawbacks. As evidenced from the above scenario, people are more comfortable at a wider range of temperatures. Also, from a cost standpoint, it takes a lot of power to cool air to 55 degrees.

Today, engineers are questioning the conventional wisdom. If you provide people with options to control their environment, they ask, will they be able to accept a wider range of temperatures? If air is fresh, not recirculated, will people feel better? Can you reduce or even eliminate the need for conditioned air? Can you save energy while at the same time make people more comfortable?

These are tantalizing questions, and, fortunately for hapless office workers, there's an answer that's gaining attention in the United States: a strategy called adaptive comfort.

the principles of adaptive comfort

"Adaptive comfort is a strategy that has gained attention as engineers have begun to understand that people are able to accept a wider range of temperatures for thermal comfort due to perceptions of their environment," says Joe McCabe, Carter & Burgess mechanical engineer. "The conditions that influence this perception of comfort include control, air movement and air freshness."

Adaptive comfort systems provide increased individual control over the environment, displacement ventilation and increased natural ventilation; these principles work together. Operable windows draw in

adaptive comfort strategies keep building occupants cool while reducing energy usage and saving money

fresh air while providing a measure of control and improving air flow.

Control provides both psychological and physical comfort, says McCabe. "When people have an opportunity to control their environment by opening a window or turning on a fan, they are more easily thermally satisfied than if they have no control."

Air that is moving is more comfortable than static air because it helps the body cool itself. "When you're in an air conditioned room and the air is moving around you, you feel good," says Carter & Burgess' vice president Rick McGee. "But as soon as the air turns off, you start feeling warm, even though the room is at the temperature called for. In adaptive comfort, the air never shuts off. You've always got air moving across your body. You're able to adapt to a higher temperature because the air movement over your body allows the natural ventilation system in your body to work."

Fresh air also increases the perception of comfort, perhaps in part by decreasing the amount of carbon dioxide in the air. (Think of how stuffy the recirculated air in an airplane cabin feels at the end of a flight.)

Buildings designed according to the principles of adaptive comfort sometimes rely entirely on natural ventilation for heating and/or cooling. Others might use adaptive comfort strategies while also incorporating conventional heating and/or cooling systems.

The primary advantage of the technology is energy

Northern Arizona University College of Business Administration Building
Flagstaff, Arizona
One organization that has turned to adaptive comfort is Northern Arizona University (NAU). For its new College of Business Administration building, set to open in January 2006, NAU wanted an innovative, flexible, energy-efficient building that would set a standard for sustainability and comfort.

savings. "If you can keep occupants comfortable in a wider temperature range, you can satisfy thermal load conditions with less energy," says McCabe.

In buildings operating with only natural ventilation, primary energy costs come from fans. Buildings can be designed to maximize natural air flow through convection—for example, vents at the tops of buildings can take advantage of the tendency of heat to rise—but fans are generally needed to keep air moving.

Even in mixed-mode buildings that include some mechanical heating and cooling, energy costs can be reduced by supplying air at higher temperatures than with conventional systems. For example, air might be conditioned to 65 degrees rather than 55 degrees.

"That ten degrees saves a lot in energy costs—particularly over time," says McGee.

Adaptive comfort is still relatively new in the United States; the concept has been implemented in Europe more widely. However, as the green building movement has gained momentum in the United States, building owners interested in sustainable design have turned to the adaptive comfort model.

The increase in interest is reflected in a 2004 ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) standard for naturally ventilated buildings. The standard, derived from research of 160 buildings in four continents, determined the comfortable temperature range in a building, dependent on the mean monthly outdoor air temperature. This range allows for indoor temperatures from 78 to 86 degrees when outside air is 90 degrees; the temperature range extends from 73 to 82 degrees when outside temperature is 77 degrees. (The ASHRAE standard for buildings cooled with mechanical systems establishes a much narrower temperature range that is less affected by conditions outside.)

sustainability at NAU

One organization that has turned to adaptive comfort is Northern Arizona University (NAU), located in Flagstaff, Arizona. For its new College of Business Administration building, set to open in January 2006, NAU wanted an innovative, flexible, energy-efficient building that would set a standard for sustainability and comfort.

"We knew early on we wanted a building that incorporated sustainable design principles that made sense from a business point of view," says Mason Gerety, dean of the College of Business Administration. "NAU is an environmentally focused campus in general, with sustainability as a critical goal. But green for green's sake doesn't make business sense. We wanted to do things in a sustainable way that had associated cost savings."

NAU didn't go looking for an adaptive comfort system—the University simply set out to build the most sustainable building possible. It decided at the beginning to seek LEED (Leadership in Energy and Environmental Design) certification from the U.S. Green Building Council. The highly regarded LEED system provides points toward certification based on energy use and sustainability of a building's systems.

When the adaptive comfort approach was presented to University staff, they were initially skeptical. "The largest piece of risk-taking was the concept of adaptive comfort," says Gerety. "I think that's one of the biggest barriers we had to cross."

At one time, NAU considered a 100 percent natural ventilation approach. Unlike much of Arizona, Flagstaff has mild summers with temperatures normally in the 70s and 80s. However, concern over abundant sunshine and the potential solar heat gain at a 7,000-foot altitude led to the decision to design a mixed-mode building that would include a mechanical cooling system. (Heat for the building was most cost-effectively supplied through the University's centralized hot-water system; the heating system for the building is relatively conventional.)

The building can operate in two cooling modes: natural ventilation or mechanical cooling. In natural ventilation mode, cool air is circulated through an under-floor air distribution system. Each floor of the building contains a concrete slab, with the actual floor raised above it. At night, the desert's cold air is drawn into the building and circulated over the slab. During the day, as air moves through the building, these slabs cool the air around them.

In classrooms and offices, numerous adjustable vents for individual control are a part of the under-floor distribution system. Rooms also contain numerous operable windows. To pull warm air out of the building, each floor opens to a central atrium. Vents at the top of the atrium help draw hot air up and out of the structure.

If the air inside the building gets too warm, the mechanical system kicks in. Air conditioners cool air and circulate it through the under-floor system. Warm air rises to the top of each room, where it is pulled out through vents. Since air is entering the room from below, not above, it only needs to be chilled to 65 degrees, not the 55 degrees of conventional systems.

"Sixty-five degrees is optimal because you're directly supplying it to the occupied zone of the room as opposed to the ceiling space," says McCabe. "You don't have to worry about cooling air that's three feet above someone's head. This allows you to downsize your equipment and use less energy."

The mechanical system pulls in 100 percent fresh air without any recirculation when outside temperatures allow. This further reduces the size of air handling equipment while helping occupants feel comfortable.

An energy management system monitors temperature conditions inside and outside and enables optimal energy savings. When the system senses that natural ventilation is failing to keep the building comfortable, the system switches to mechanical cooling mode.

"We had to develop a way to let building users know when this was happening," says McCabe. "The system sends out an e-mail to all workstations in the building, telling them we're going to mechanical mode and to close their windows. We also installed a system of lights in the atrium that alerts occupants as to what stage the building is in."

sustainability as an educational strategy

Adaptive comfort wasn't the only element used in designing the College of Business Administration Building with sustainable systems. The building also uses natural lighting as much as possible to reduce energy costs.

"There's a good deal of daylighting utilized in the building," says Gerety. "The large central atrium has skylights as well as clerestory windows, and all of the classrooms have windows. The idea was to light the interior of the building using a minimum amount of artificial lighting."

Water use in the building takes advantage of a reclaimed water system available through the City of Flagstaff. A separate piping system in the building supplies non-potable water for bathrooms and outdoor irrigation.

NAU's goal going into the project was to achieve a 25-percent savings in energy consumption, says Carter & Burgess' Daniel Perez, who is serving as project manager, as well as overseeing construction administration. "We achieved 30 to 35 percent, which gives the University nearly $1 million in utility savings over 15 years."

While significant for the University, the benefits of adaptive comfort and sustainable design go beyond energy costs. Studies have shown that people working in natural light with fresh air are more productive; students also learn more in these environments.

Further, the innovation and flexibility of the design reflects the character of the NAU College of Business Administration and encourages creative, team-based problem solving.

"This building fits our program," says Gerety. "Until now, innovation in our program has been hampered by our architecture. This building fits the mission of our college."

In fact, the NAU College of Business Administration has already begun its educational mission by teaching its engineers that comfort isn't limited to a three-degree range. ■

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