Pleasure and Performance*

G.Z. BROWN

Professor, University of Oregon, Eugene, OR, U.S.A.

ABSTRACT: Ideas about what constitutes thermal and visual comfort have evolved in tandem with the development of building elements and technologies that supply heat, cooling, ventilation, and lighting. Standards have narrowed, driven as much by social status as technological change. This keynote suggests that the integration of passive bioclimatic strategies such as daylighting, passive heating and cooling can provide intense sensory and mental pleasure while optimizing both the building's heating, cooling, lighting and the occupants' performances.

In the 20th century, mechanical and electrical systems became able to heat, cool, light, and ventilate buildings regardless of their envelopes. This independence gave architects the freedom to sculpturally shape building form and select materials more for their experiential than for their performative qualities. At the same time, experimental data quantified the temperature and relative humidity at which people were most comfortable, given assumptions about their clothing and activities. By the second half of the 20th century, the technological and social status goal of a comfort zone with unvarying temperature and relative humidity was established.

Architects thus began to design buildings (especially those with large floor plates) that depended on mechanical and electrical systems, and comfort became the domain of engineers. While architects created buildings that provided pleasure through variations in form and facade transparencies, engineers designed systems that kept these buildings within a narrow temperature range regardless of orientation or glazing area, using electric lights to reduce glare resulting from the contrast between the window wall and the back of the room.

The problem with this approach was that the building's design exacerbated its heating, cooling, ventilating, and lighting loads, and its systems gobbled energy to offset these loads. While this wasn't a serious concern at the time (nuclear plants were expected to produce electrical energy "too cheap to meter"), we can no longer afford such architecture—not when we know that buildings use 36% of total energy and 70% of electricity in the U.S. and that the production of energy is the primary cause of climate change.

While energy use is not the only measure of sustainability, it is a good indicator of our ability to design sustainable buildings. Energy use is a complex interwoven web that touches almost all aspects of building design. If we can solve the problem of excess energy use, we can solve other sustainability problems as well. At the root of the problem is the way architects think about and design buildings. Most people have a predilection for either humanistic or scientific thinking, and our educational systems reinforce this split. Design courses are dominated by humanistic thinking, while performance issues are covered in science-based technical courses. This results in an emphasis on *either* the humanistic *or* the performative aspects of buildings—not both—a way of thinking then carried into practice.

Architects must strive to be as fluent in scientific thinking as they are in humanistic thinking if they wish to create buildings whose sustainable features are an integral part of the design, buildings that provide both pleasure and performance. A building that achieves broad architectural purpose and sustainable performance is elegant and, at its best, inspirational. *Elegant* is a useful term to describe the combination because its meaning implies both architectural purpose—richness of design—and the scientific goal of precision, neatness, and simplicity.

The climate, building occupants, and site/building design determine a building's heating, cooling, ventilating, and lighting loads, which are acted on by the systems that use energy. Our first response to a societal need to use less energy has been to increase the efficiency of the mechanical and electrical systems that meet these loads. If we double their efficiency, a building will use one half the energy, but the cost of its systems will increase. However, if we first reduce the loads—the demands for energy—by 50%, the systems can be smaller, cost less, and still be twice as efficient. Total energy use would be 75% less; the building would cost less to build and to operate. If we wish to achieve energy and resource performance goals such as carbon neutrality, load reduction is the critical first step.

When used elegantly, sun, wind, and light can provide intense sensory and mental pleasure while reducing a building's heating, cooling, and lighting loads. Building occupants can sensorily experience many load reduction strategies. For example, cross-ventilation is sensible as a fresh cooling breeze and visible as an artifact—an open window. Cooling provided by mechanical systems is less directly registered by our senses. Ducts are usually not visible as artifacts, and being cool is different from the feeling of being cooled.

Two load reduction strategies that afford a rich sensory experiences and have wide application are daylighting and night ventilation of mass. What makes daylighting pleasurable are the ways in which it connects us to the dynamics of the natural world—for example, how the light in a room changes from lighted floor plane to lighted ceiling plane as snow blankets the ground outside.

Windows are multivalent; they provide views in and out, ventilation, sitting places, and modulation of walls—all potential sources of sensory pleasure. By comparison, luminaires are single purpose, provide less varied sensory input, and therefore have less potential for pleasure. But daylighting saves energy only when it replaces electric light use. Daylighting is complex and fraught with potential problems. There are performance conflicts: For example, the required glazing area can increase heating and cooling loads and cause glare. And there are conflicts with architectural purpose because the need for light can greatly influence building form and organization, openings placement, room depth, and reflectivity. Since the performance of a window is directly related to its physical characteristics but our experience of a window is only indirectly related and is filtered through our perceptions and modified by our knowledge of windows, it is useful to think of the window as having two aspects: its aperture and its architectural setting. The aperture defines the window's performance, and the aperture plus the setting determine one's experience. This makes it possible to design windows that provide both sensual pleasure and sustainable performance.

Night ventilation is a cooling load reduction strategy. At night drawn in air cools the building's thermal mass, which then absorbs heat the next day. Like daylighting, this strategy also influences building design. It requires mass area equal to twice the floor area, ventilation pathways through the building, and large secure openings. Making these openings secure can be an opportunity for using decorative patterns that are a source of pleasure, for example, the grille work of Louis Sullivan.

Night ventilation can also provide aromatic pleasures. For example, side-by-side identical classrooms at the University of Oregon were tested—one with night ventilation of mass and one without. When faculty toured first the non-ventilated classroom and then the night-ventilated classroom in the morning, their comments centered not on the fact that the night-ventilated room was cooler but that it smelled fresh, recalling the pleasure of teaching outside under a tree. A night ventilation strategy can meet the entire cooling load for many building types in several climates, eliminating the need for mechanical cooling and lowing initial costs.

To realize both architectural purpose and sustainable performance, architects and engineers need to modify the way they design buildings. For example:

- Because load reduction strategies using sun, wind, and light are more architectural (affecting building form, organization, and materials) than mechanical/electrical systems, these strategies need to be integral in programming and concept development phases.
- As building loads are reduced dramatically, systems can be eliminated or significantly downsized and the savings used to increase the sustainable attributes of the building and the pleasure afforded by them.
- To insure high levels of energy performance, design responsibility should be organized by performance area (such as lighting) rather than by discipline (such as electrical engineering).

A synthesis of climate, use, design, and systems is crucial to achieving elegance of architectural purpose and sustainable performance. Of the four topical areas, use is often the catalyst for synthesis. After all, buildings don't use most of their energy on their own, people do.

The comfort standards used to determine thermostat set points are probably the most important determinant of building energy use and the least expensive to change to improve performance. The "comfort zone" is usually defined as ranging from 67° F to 81° F, depending on relative humidity. However, designating this range "the comfort zone" is problematic because it suggests that outside of it we would be uncomfortable. In fact we can be comfortable at a higher temperature with air movement and at a lower temperature with a warmer radiant field. And variation in temperature can be a source of pleasure like standing on a cold night next to a masonry wall that has been warmed all day in the sun. Allowing variation in temperature means that a load reduction strategy such as night ventilation can take advantage of the cooler radiant field it produces to ensure comfort when air temperatures are above 80° F.

Thermostat set points for individual buildings are often based on asking occupants or owners what air temperature they would like rather than whether they are comfortable in various environmental conditions. People are not very good at judging absolute standards like temperature. Researchers from the Energy Studies in Buildings Laboratory at the University of Oregon recently occupied a "comfort chamber" where every fifteen minutes they estimated the air temperature and noted if they were warm, cool, etc. Of the forty-two estimates, only three closely identified the air temperature. Building users know when they are comfortable, but they don't know why—comfort is a function of too many variables. Furthermore, our bodies' temperature sensors measure rate of heat loss or gain not temperature, which is why metal feels cooler than wood when they are at the same temperature. Asking people what temperature they want their building to be limits the opportunity for saving energy as well as the pleasure of variation.

A classroom at Mt. Angel, Oregon uses daylighting and night ventilation strategies to realize both sustainable performance and architectural purpose in ways that elicit pleasure. The project used an integrated design approach to create a classroom that performs 62% better than Oregon Energy Code requirements at no increase in first cost. The envelope's high resistance to heat flow meant that the mechanical cooling system could be eliminated and only night ventilation of mass and ceiling fans would be needed for comfort.

Horizontal roof openings were preferred for daylighting because in an overcast climate they let in more light per square foot than any other orientation. However, horizontal openings are vulnerable to heat gain from the high summer sun, and large openings can create a too bright area under them. To resolve this problem, we developed a top light reflector that uses photo-controlled louvers within the skylight to keep the light level within the desired limits, preventing excess heat gain while keeping the skylight large enough to daylight the room almost all the time the sun is up. The reflector redirects the light to the sides of the room, thereby eliminating glare directly under the skylight.

The daylighting strategy not only affords visual comfort and an even distribution of light for occupants, it also makes the ceiling and walls luminous, bathing the room in light and allowing the placement of a central window to view the Mt. Angel landscape. More than 100 teachers and administrators visited the prototype classroom. Before they entered the room they were asked to imagine the classroom they currently taught in and to tell us which they would prefer to teach in the following year—their existing room or the prototype. None voiced a preference for an existing classroom.

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