DESIGN systems

The enclosure systems have a direct impact on the thermal and visual comfort of a building's occupants. Enclosure systems also have a major impact on energy usage. The enclosure systems must create thermal comfort by making appropriate responses to local microclimates. Enclosure systems also play a strong role in creating the indoor visual environment through daylighting and views.

Enclosure

CMU's Intelligent Workplace features operable exterior shading devices, operable windows and high-performance glass.

Photo: Bob Kobet

For more information see *References and Resources*
- *General Sustainability*

Thermal Comfort

The purpose of the enclosure system is to create a comfortable thermal environment. This is accomplished by regulating air temperature, radiant heat loss or gain, solar heat gain, relative humidity and air movement. There are many factors that should be considered when designing for thermal comfort.

Recognize climatic concerns of the region. In Pennsylvania, enclosure systems must recognize the wide temperature variations and precipitation typical of our four distinct seasons. A "rain screen" system incorporates an exterior finish material with a full drainage cavity ventilated to the exterior to keep out moisture. A pressure-equalized metal or glass curtainwall or a vented masonry cavity is preferred to single wythe masonry or unvented exterior insulation systems.

Acknowledge impact of the orientation on the building. The enclosure on each side of the building has to deal with different conditions based on its exposure to sun and wind. Southern facades must accommodate a large swing in temperatures from day to night. East and west facades must be suitable for shorter periods of sun exposure, but at angles that are more difficult to control. The northern face of an enclosure does not usually endure temperature extremes, but often must address the predominant winds of the region.

Within a single building, there may need to be multiple responses to enclosure based on the microclimate. For instance, the insulating R-values of a wall system might need to be increased or decreased depending on its location in the building. The west and south facades, which in some cases can experience temperature swings of 70 degrees or more, should be made of materials and detailed to allow for expansion and contraction, the migration of moisture and maintenance for harsh weathering conditions. The use of computer modeling can reveal the performance of each building enclosure element. This, in turn, enables the designer to optimize the building's performance.

Configure the envelope to deal with the conditions created by different orientations. Light shelves and exterior shading devices on the south face of a building can be used to increase light penetration and decrease thermal loading of the envelope. Light shelves can have many configurations, including a single shelf or multiple shelves. Some manufacturers have standardized sizes and configurations for ready application.

Daylighting from overhead can create a dramatic area to work and meet people, such as at the Buchart Horn building.

Photo: Bob Kobet

The west and east sides of a building can also be configured with vertical fins, deep recesses or other articulation to decrease the impact of low sun angles on the building's thermal loading. Often, off-the-shelf elements can be configured to provide this benefit without custom products or systems. Finally, be aware of the R-value of the enclosure relative to the varying microclimates. Large expanses of wall or window with a low R-value can create uncomfortable radiant losses or gains for occupants.

Use the envelope enclosure to minimize conditioning loads. Many green buildings that provide daylighting and access to operable windows have greater perimeter areas and are "envelope-dominated loadings." It is especially important that envelope-dominated buildings be sited well, with their enclosure system "tuned" to the different microclimates and orientations. By using appropriate enclosure materials, external shading devices, reflective roof or wall colors and high-performance glazing, the envelope design can play a large role in minimizing space conditioning loads.

Additional savings can be achieved by allowing for passive conditioning and through the use of dynamic enclosures. Dynamic, or operable, enclosures can include things as familiar as operable windows to miniblinds to moveable exterior light shelves. Some systems are best controlled automatically, based on changes in the environment or on thermal loading. Other elements should be user controlled, an important step in creating occupant comfort.

Understand how the enclosure's materials work as a system. For this, it is important to know the basic physics that affect the enclosure -- temperature, moisture movement and air movement.

Temperature. Elements within a wall, roof or floor should be designed to include adequate insulation to ensure thermal comfort. This is especially important where the occupants will be close to or touching the envelope, such as at a wall or floor. Radiant and conductive heat losses caused by inadequate insulation can overwhelm even the best designed mechanical system. Avoid thermal bridging, or heat transferred across or through enclosure elements, by examining enclosure details and designing for thermal breaks.

Moisture movement. The effects of moisture migration are not often felt by occupants directly, but can greatly affect the longevity of an enclosure system and the entire building. Because warmer air can hold more moisture than colder air, there is a constant movement of water vapor between areas of different temperatures on the inside and outside of a wall system. In a poorly designed enclosure system, uncontrolled vapor can condense within the wall or roof and eventually cause deterioration. Enclosure systems must include a vapor barrier on the warm side of the enclosure (the interior side in Pennsylvania).

Exterior moisture migration from rain or capillary action can be a problem. Enclosure systems must provide for the removal of moisture that penetrates the exterior skin of a building. For example, brick cavity walls include a cavity for drainage and flashing and weep holes as a standard detail. All enclosure systems should be detailed with ways for water to exit the system harmlessly.

The Intelligent Workplace at Carnegie Mellon University has a dynamic thermal envelope with movable sunscreens, passive ridge vents and other technologies.

Photo: Bob Kobet

Enclosure cont.

The new DEP headquarters employs exterior and interior light shelves to bring light deeper into the space.

Photos: Bob Kobet

Air movement. Finally, elements within an enclosure system must be arranged to limit air infiltration and exfiltration. Without an effective air barrier, uncontrolled infiltration of warm or cool air can cause occupant discomfort through convective heat loss and gain. It also can carry water vapor into the enclosure system, where it can condense. Areas of solid material such as sheets of glass, sheathing, etc., are effective air barriers. Areas where materials make transitions or turn corners should be detailed carefully to avoid unwanted infiltration.

Visual Comfort

The enclosure can have a great impact on determining the visual quality of interior spaces. Visual comfort is provided by an environment with good views and appropriate light levels, free of glare and excessive contrast. The decisions made on the size, configuration and location of windows in the enclosure can decrease or increase the need for electric lighting and can provide better work environments for the occupants.

> *"When a series of linked efficiency technologies are implemented in concert with each other, in the right sequence and manner and proportions, there is a new economic benefit to be reaped from the whole that did not exist with the separate technological parts."*
>
> *Factor Four,* Weizsacker, Lovins and Lovins

Consider the following when designing the enclosure:

Design buildings with a narrow footprint. Buildings with a shallow depth provide access to daylighting as well as opportunities for passive conditioning and views.

Provide views to the outside. Views to the exterior environment provide occupants with a sense of connection to the outside. Windows can improve morale by helping to create an awareness of the seasonal cycles, daylight, weather and outside activity. Studies performed by the Electric Power and Research Institute (EPRI) reveal that people are more comfortable and productive in environments that combine daylight with well-designed electric lighting systems.

Size and orient glazing area to allow for daylighting. Large amounts of glazing, especially on the east and west facades, are not an appropriate approach to daylighting, as they are difficult to shade. Occupants near to the window often complain of excessive contrast and glare, while others deeper inside the building do not derive much benefit. A split window configuration combined with a light shelf allows for light to penetrate deep into a space without creating problems for those next to the window. Windows that are located higher in a space or above a light shelf provide a better quality of light, while windows below can be controlled with blinds as conditions require.

Choose an appropriate performance for glazing for the different building conditions. The two factors that affect visual performance of glass are the shading coefficient and the visible light transmittance. The shading coefficient is determined by the amount of solar energy that comes through the window as infrared energy. Visible light transmittance describes the amount of daylight that penetrates the glass. The dark grey and reflective windows of the 1980s were an attempt to balance increasing internal loading of computers and lights against the sun's loads. These windows didn't allow as much heat gain, but they also didn't allow much light. In some installations, it is difficult to tell the weather or the time of day because of the strong grey cast.

Fortunately, advances in glazing and coatings have created more options. Now clear, green tinted and blue-green tinted glass provide similar shading coefficients with better visible light transmittance. Always look at shading coefficient and visible light transmission when choosing a glass. Consider "tuning" your glass to different orientations to compensate for various lighting conditions.

Allow occupants to adapt to changing conditions with window treatments. Even the most careful window and glazing design cannot account for the dynamics of changing lighting conditions. Excessive contrast and reflective glare can be dealt with by designing operable blinds and moveable shades with user controls.

Perforated shading devices also allow high levels of visibility to the exterior while providing thermal and UV solar protection.

checklist

Enclosure Systems

Thermal Comfort

- *Optimize the thermal envelope before relying on building space conditioning systems for environment control.*
- *Use available computer modeling whenever possible to investigate the performance of various thermal envelope materials and configurations.*
- *Understand the relationship between radiant surface temperatures and comfort. High performance glazing and enclosure systems that provide acceptable interior surface temperatures can reduce the need for expensive perimeter conditioning systems.*
- *Recognize the influence of site and building orientation when designing building enclosure systems. Select wall and glazing materials that respond to variations of wind and solar loads associated with orientation.*
- *Understand the role of building mass in controlling thermal comfort, especially in interiors. High mass buildings have an inherent ability to stabilize temperature swings and can contribute to cooling strategies using nighttime air.*
- *Bring the outdoor into the building. Designs that incorporate atriums, light wells or connections to patios and terraces can also integrate natural light and ventilation.*
- *Choose enclosure systems that perform well in varying seasonal conditions. Exterior rain screens with vented voids behind, such as brick cavity walls or pressurized curtain walls perform better that solid masonry or low quality window mullion and glazing combinations.*
- *Select enclosure materials and detail building assemblies to limit uncontrolled infiltration.*
- *Depend on thermal envelope performance and natural space conditioning and ventilation strategies before engaging mechanical systems*
- *If outside conditions are acceptable, design the structure to take advantage of prevailing breezes to maximize natural ventilation.*

Visual Comfort

- *Provide environments that are visually stimulating. Humans respond well to variations in lighting levels, comfortable contrasts and pleasant changes in light and shadow.*
- *Provide as much natural light as possible. Coordinate supplemental light sources with available daylight.*
- *Consider creative integration of daylight, energy efficient lighting options and effective control strategies. Include daylight as a factor when trying to meet industry standards for lighting.*
- *Optimize the spaces being illuminated with the appropriate colors, surface treatments, room proportions and ceiling heights for the tasks involved.*