JOURNAL OF green building
VOLUME 1 NUMBER 3 SUMMER 2006

IN THIS ISSUE

INDUSTRY CORNER

RESEARCH ARTICLES

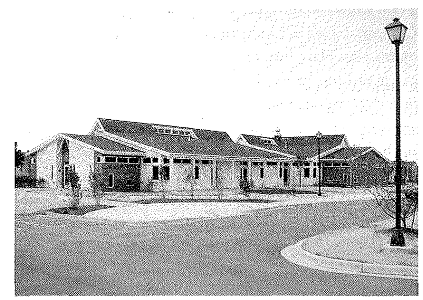
PRAIRIE CROSSING CHARTER SCHOOL: COMFORT AS A PRINCIPAL COMPONENT OF HIGH PERFORMANCE SCHOOL DESIGN

Pat Dolan, AIA,[1] Bill Sturm, AIA,[2] and Chris Wollmuth, M. Arch.[3]

INTRODUCTION

The design and construction of sustainable buildings has had an evolving motivation. Initially, sustainable design was guided almost wholly by a desire of a few to minimize the environmental footprint of our buildings. Yet as sustainable design became better understood, the economic benefits of sustainable strategies have become an increasing motivation for many owners. For some, the focus is on the returns provided by decreased maintenance and operation costs, while for others the increase in worker productivity—through decreased absenteeism, a reduction in errors, and overall gains in worker output—is beginning to drive the decision-making process. But when we are talking about an educational environment, we are not talking about workers producing, but instead are concerned about children learning. Yet the fundamental goal of each remains similar: by providing comfortable, healthy environments designers can remove the impediments to productivity or learning directly attributable to our built environment.

If we think specifically about schools, careful consideration to comfort is even more important than in a commercial setting precisely because of the primary occupants. School-aged children have lower body masses and are, therefore, more susceptible to many of the factors addressed by the design: allergens being distributed or accumulated in a building, toxins being released by building materials, and unwanted changes in indoor air temperature. In addition, children are more susceptible to breaks in concentration caused by environmental factors like those named above as well as changes in noise levels or illumination. Such disruption directly affects students' ability to focus on and retain their lessons.



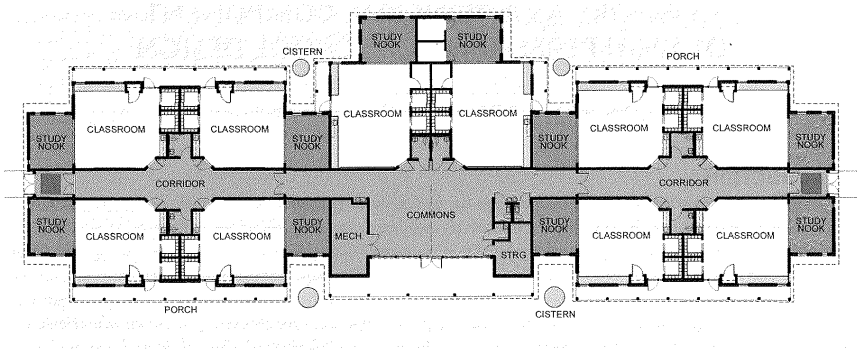
So while there is a greater body of evidence focused on worker productivity in sustainable buildings, the most cost-effective green building strategies for schools should focus on maintaining the highest level of comfort for their primary occupants—children. By considering comfort, sustainable strategies can be employed that directly affect the learning of students. As registered architects and engineers, we are required to maintain basic human health and welfare in school design, but few of us use student comfort as an overriding design principle that crosses all facets of the project design.

Prairie Crossing Charter School (PCCS), a new school in Grayslake, Illinois, was designed with just such a thought process. The school building is an addition to an existing campus and was programmed to include only classrooms (no offices, cafeteria, or gymnasium).

The surrounding buildings include a historical one-room schoolhouse and a barn with grain silo set in a new housing development with styling modeled on traditional Midwest farmhouses. It is a community that values environmental protection and enhancement, a sense of place, and a sense of neighborhood. As such, they wanted their school to reflect those goals and aesthetics, while providing a premier learning environment for their children. The following outlines the specific goals identified as key to student comfort and the specific strategies used in pursuit of those goals.

1, 2, 3. Serena Sturm Architects, www.serenasturm.com. Mr. Dolan, Mr. Strum, and Mr. Wollmuth may be reached at (847) 564-0370 or info@serenasturm.com.

Building floor plan.



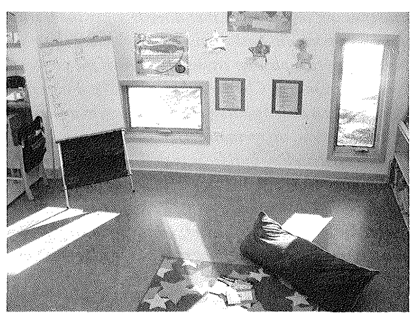
MAINTAIN STUDENT CONNECTION WITH THE ENVIRONMENT

Comfort Goal: While much of the teaching environment takes place indoors, it is important to our sense of place and our grounding as participants in the ecosystem that we be aware of and connected to the natural environment that surrounds us. Books like *Last Child in the Woods* and *Building for Life* are at the forefront of the discussion and research showing the core benefits of exposing children to nature. As such, it is not only important to have easy access to a site designed to be explored, but also facilitate that exploration by making more subtle aspects of our environment evident.

Strategies: As is the case in any building, this is most directly addressed by windows and doors. By including exterior doors in all classrooms, and windows that allow views to the landscape from all areas of the classroom, PCCS provides a direct and real connection with the exterior environment. To enhance this feeling, the doors connect to a carefully designed path system that weaves through the native landscaping rather than rushing students to their next destination. Students are invited to interact with the fauna and flora that are native to their environments, becoming aware of their natural cycles. In addition, windows in a small "Study Nook" adjacent to each classroom are specifically located at a height for students seated on the floor or in low chairs to view the landscape. Thus plants, and potentially animals and insects, will be viewed in a way not otherwise possible. Taking this connection one step further, gutters at the roofs of the Study Nooks were left off in favor of rain dispersal systems that let rainwater fall to the ground without causing excess erosion, not only highlighting weather conditions but also showing water percolating naturally into the ground.

Exterior path system with view of window configuration.

Student windows at the "Study Nook."

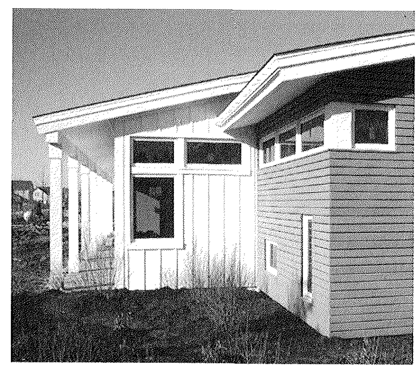


COMPREHENSIVE LIGHTING STRATEGY

Comfort Goal: With so many lessons in education initiated or focused on visual tasks, quality lighting is an essential component of a good learning environment. In basic terms, this means avoiding glare and harsh contrast, while more technically it means providing good quality light of a full color spectrum. It also means focusing on daylight as a primary provider of light, the benefits of which were made apparent in a study by Heschong Mahone Group where it was shown that students in daylit classrooms perform 20–26% better on test scores.

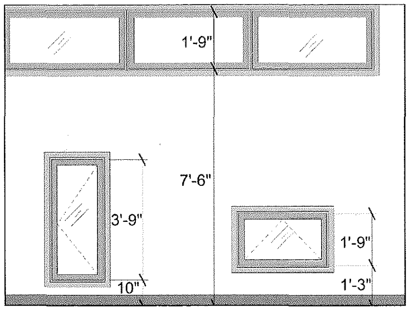
Strategies: While natural light has tremendous benefits, it can be problematic by creating glare, harsh shadows, and uncomfortably high contrast. To avoid these pitfalls, careful design strategies were employed that directly affect the layout and look of the building. To begin, the school is oriented on an east-west axis maximizing northern and southern exposure that can be controlled with shading devices, in this case long porch overhangs. In addition, glazing on the southern exposure is carefully configured to combine select view glass with an almost continuous clerestory. The result is diffuse natural light filling the classrooms and study nooks and views to the surrounding landscape while minimizing unwanted glare or heat gain. Interior spaces like the corridors also have natural light through roof monitors and glazing in interior partitions that borrow daylight from the classrooms. Thus, all regularly habitated spaces have natural light. These natural lighting strategies were then complemented by and integrated with carefully designed electric lighting. As with the natural lighting, diffuse and even light levels are sought and in this case achieved using color-adjusted, high-efficiency, long-lasting fluorescent direct/indirect lighting. The lighting is also configured parallel to the exterior wall with switching organized so that rows of electric lights can be turned off progressively further from the windows as daylight is available (teacher control was essential to avoid the distractions of an automated system turning lights on or off mid-lesson, or even mid-sentence.)

Window overhangs.



Continuous clerestory & view glass with direct/indirect fluorescent lighting.

Window configuration.

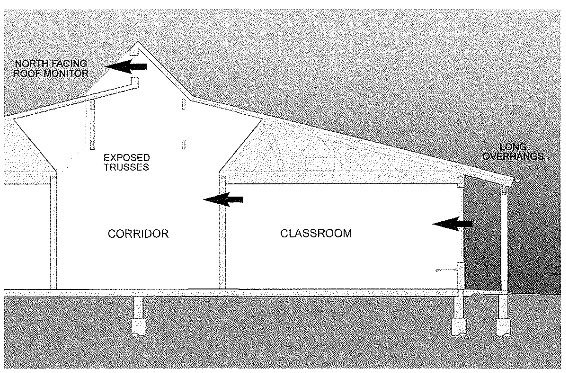


MECHANICAL SYSTEMS

Comfort Goal: Fundamentally, any mechanical system is designed for the comfort of occupants. But given the small stature of the students at PCCS (grades K–6) there was a particular emphasis on providing clean, conditioned air to the lowest portion of all spaces. An essential component of this delivery was to avoid potential pitfalls encountered in some systems: primarily drafts, hot and cold spots, and mechanical system noise (both air distribution fans and condensers). Some occupants, however, felt that simply relying on the mechanical systems is a one-size-fits-all solution. In this case, PCCS sought the flexibility of individual classroom control over alternative conditioning options to reduce dependence on conditioned air in favor of fresh air. While each of these goals seems self-evident, the careful implementation of each led to unexpected solutions.

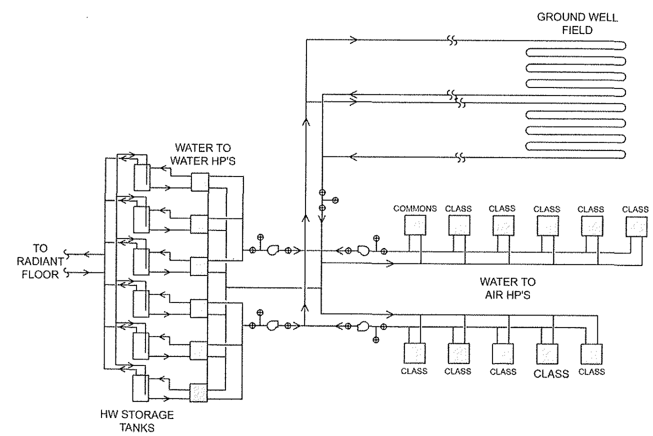
Strategies: To meet the system comfort goals, a geothermal system was selected that delivers heat through a radiant floor and forced air cooling. The ventilation system, utilizing energy recovery which transfers energy from conditioned air being exhausted to fresh air being brought into the building, was designed as a completely independent system ensuring that fresh air could be provided regardless of the need for conditioned air. The geothermal system is not only exceptionally efficient, it alleviates the need for exterior condensers and their associate fan noise during cooling (particularly important for a school that emphasizes students being outside in the area immediately surrounding the school). The cool air is distributed through ceiling diffusers that drop air into the room at low speeds (which is possible because the cool air naturally falls to the floor and to the level of students). The heating, on the other hand, is delivered through a radiant floor slab that not only delivers warmth at the level of small children, it avoids the potential drafts and fan noise of heat being driven down to students from ceiling diffusers. By avoiding the high-speed fans required to push the air down, there are also significant energy savings over the long term. The radiant floor enhances natural convection, which helps clean the air. As used, hot air contaminated with particulates and carbon dioxide rises, it accumulates undisturbed at the ceiling (rather than being recirculated by high-speed air from ceiling diffusers) where it is exhausted. To further maximize comfort, each classroom has a programmable thermostat that addresses the needs of each particular room (which can vary widely depending upon orientation) and provides energy savings in night and weekend setbacks. To avoid mechanical ventilation altogether, alternative systems were incorporated. Most simply and visibly, ceiling fans were installed in each classroom to take the edge off the days of only mild discomfort. In addition, the building was designed to take advantage of fresh air through natural ventilation. Operable windows provide a path for natural air currents to flow into the building, through the classroom, and into the hallway, to be exhausted through operable roof monitors. The north facing monitors high in the roof peak take advantage of the stack effect and natural air flow over the ridge to draw air in and through the building. Overall, the mechanical system is extremely energy efficient and carefully designed to address student needs. Even so, PCCS makes every effort to take advantage of natural systems to condition the interior spaces.

Natural ventilation path with daylight indicated.



Interior classroom windows.

The schematic of the ground source heat pump at PCCS.



MATERIAL SELECTION

Goals: Given the sensitivity of small children to pollutants and allergens in their environments (as is evident in an increase in the prevalence of asthma by almost 75% from 1980 to 1994 and the associated loss of almost 10 million school days to asthma, as noted in the May 2005 issue of Environmental Building News), material selection and maintenance is a key component of any healthy building. An important first step is the selection of materials with absolutely minimal volatile organic compounds (VOCs). By avoiding unstable materials that off-gas (everything from flooring adhesives to paints), indoor air is kept free of pollutants that can affect the students. Selecting materials that are easy to clean and avoid trapping particulates is also important. Only when the dirt and debris that is inevitably introduced by occupants can be properly cleaned is the long-term health of the building ensured.

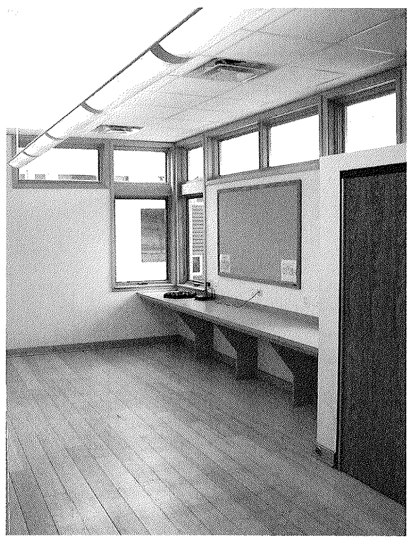
Strategies: At PCCS, the low VOC paint on all walls is the most visible example. More subtly, low VOC adhesives and mastics were used so that no materials introduced to the building contained unstable compounds that would eventually fill the space with pollutants. Similarly, materials that were easy to clean of dirt, allergens, and pollutants were used. Stained concrete, bamboo, and cork were selected because of the ability to clean them easily and effectively. Bamboo and cork (which are now readily available from national manufacturers) are naturally renewable materials, yet are durable enough to outlast many flooring alternatives (making them additionally sustainable). As a final step, PCCS implemented a green cleaning program in which cleaning agents are carefully selected to avoid problematic chemical compounds and also the chemical build-up associated with some cleaning agents. The program uses cleaners that meet the Green Seal's Industrial and Institutional Cleaners (GS-37) standard which have less of an impact on the environment than their traditional counterparts because they are generally less toxic and contain lower concentrations of VOCs, ozone depleting chemicals (ODCs), and carcinogens.

BUILDING ENVELOPE

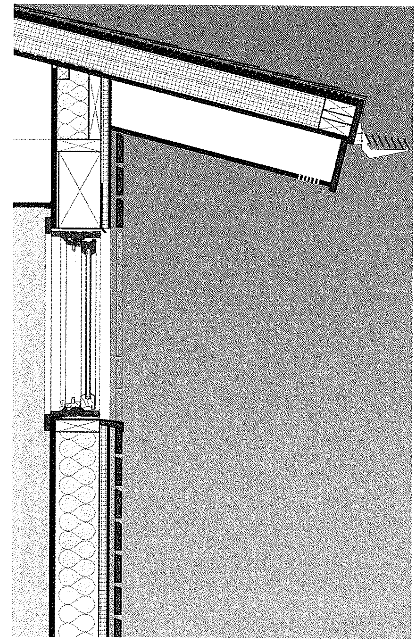
Goals: While seemingly self-evident today in our well-sealed environments, in order for any building

Cork at Study Nooks with water based window stain.

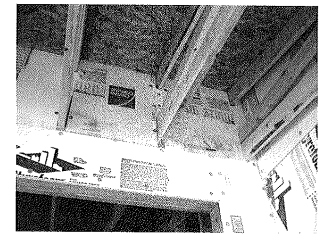
Bamboo at classrooms & Ecospec paint.



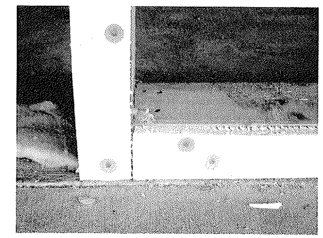
Rainscreen design with air space.



Insulation carefully inserted at trusses.



Insulation at window mullions.



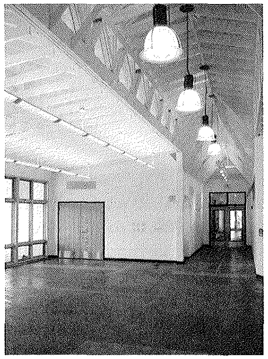
to be comfortable there can be no drafts, hot or cold spots, or other thermal transfer issues. In addition, the growing issue of mold needs to be carefully addressed with a properly designed building envelope.

Strategies: Addressing each of these ideas boils down to an attention to detail, during both the design and construction of the building. In design, the building must have a complete thermal envelope and air barrier. This means avoiding thermal bridging in which highly conductive items like structural steel extend from interior to exterior environments (which can cause both a cold spot and, potentially, water problems due to condensation). It also calls for careful detailing and construction observation around complex details and intersections of different systems (roof to wall intersections or around window openings, for instance.) Finally, at Prairie Crossing, the design of the exterior wall avoided trapping moisture by utilizing a rainscreen design. In such a system, the exterior skin is held off the building, in this case by 3/4" vertical furring strips, allowing for air movement on both sides of the material. This allows for proper drying of the skin and avoids trapping moisture with its inherent problems of material degradation and, possibly, mold development.

As the design progressed, sustainable ideas pervaded the building because of the desire to carefully and purposefully design for the comfort of students. Once introduced, the idea that other areas should be affected by the same ethic was apparent. In this way, several other sustainable strategies were investigated that, while perhaps not directly affecting student comfort, affected the performance and sustainability of the building as a whole.

RIGHT SIZING

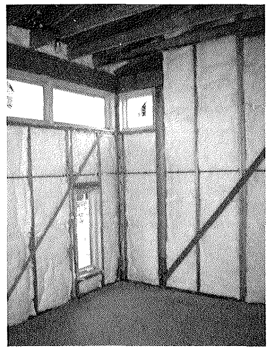
Goals: The embodied energy of the building—that is, the energy associated with acquisition, processing, Commons Area with stained concrete floors and exposed trusswork.



and installation of all the materials in a project—is a tremendous measure of a building's environmental footprint. A fundamental goal of any sustainable project, therefore, should be to reduce the embodied energy in the building, while also considering how materials will be disposed of to complete their life cycle. An easy way to accomplish this is to carefully study material use.

Strategies: The first priority is to do careful building programming so that rooms and their sizes directly reflect needs and intended uses. In doing so, not only are materials for build-out and finishing carefully tailored to the needs of occupants, but long-term operating costs are reduced, as mechanical systems don't work in unused or underutilized spaces. During programming the effect can be to reduce room size and count, and also to design flexible spaces that can accommodate a variety of uses. At PCCS, for instance, each classroom has a small "Study Nook" adjacent to it. This space complements the classroom environment with an area that can be adapted to each individual classroom, and even changed from day-to-day, without affecting the core teaching area of the class. Finally, analyzing the building to see where materials could be eliminated or reduced had a great effect on the embodied energy of the building. In this case, leaving standard roof trusses exposed in common areas, as well as staining a structural concrete floor slab, avoided additive materials (ceiling grid on the ceiling or tiles on the floor), while also eliminating the need for repair and replacement over time. Less visibly, the plywood sheathing that would typically envelope the building was replaced with steel straps (that have recycled content and are recyclable) greatly reducing wood consumption.

Exterior wall with building straps in lieu of sheathing.

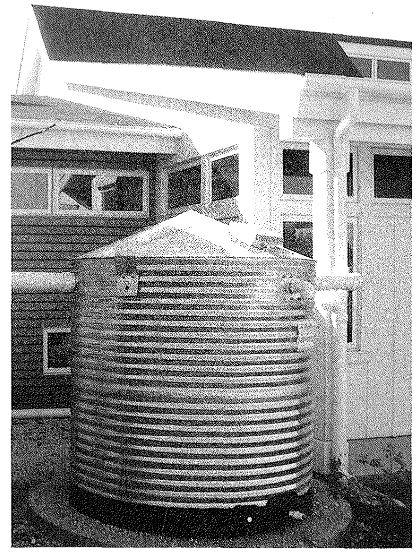


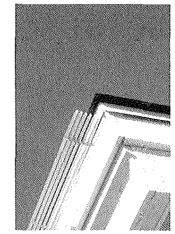
WATER MANAGEMENT

Goals: The management of water on-site might seem strange. The first and most obvious goal is to reduce potable water use, both inside and outside the building. The second more subtle goal is to manage rainwater that falls on site. Our stormwater system is a tremendous infrastructure burden that can be alleviated if rainwater that falls on site stays on site.

Strategies: Inside the building, dual flush toilets and sensored lavatory faucets limit water use to its most fundamental need while also serving to demonstrate to the students the value of water as a natural resource. Outside, cisterns collect rainwater that falls on the roof, storing it to be used by students to irrigate their gardens, rather than using hose water from the building. In the larger picture, the goal is not to use irrigation in any fashion, assisted at PCCS by the use of native plantings which are adapted to the natural cycles of regional weather. These plants minimize irrigation needs with deep root systems that help the heavy rainfalls of the region percolate into the soil rather than running into storm drains. The design emphasizes this with the use of rain dispersal gutters that allow rainfall that does not enter cisterns to fall and be absorbed on site.

Rainwater cistern.





Rain dispersal gutter.

CONCLUSION

The resulting design, focused on the comfort of students, creates a supportive learning environment: it keeps students connected with their natural environment, it provides abundant natural light while ensuring that all lighting is even and diffuse, it maintains internal temperatures evenly and conditions spaces in a way particularly well suited to small children, and it gives staff the means to maintain good indoor air quality for the life of the building. When comfort is the fundamental criteria to evaluate design strategies, the vast majority of decisions support a truly sustainable design. Designing for comfort, while keeping the well-being of occupants at the forefront, reduces the environmental footprint of a building and results in accomplishing one of that building's original and most fundamental goals.

Author's Note: For those interested, the design process of PCCS also referenced the USGBC's LEED checklist and is a registered project. It is applying for a LEED Silver rating recognizing the design's careful siting and landscaping, energy and water efficiency, thoughtful material choices, and clean indoor air.