Introduction

Judson University, a private Christian liberal arts university in the northwest Chicago suburb of Elgin, IL has completed a sustainable building project that has drawn national attention. The Harm A. Weber Academic Center, designed by British architect and Cambridge University Professor C. Alan Short, features a fully integrated hybrid natural ventilation design, significant natural day lighting, a photovoltaic system integrated into the southern building envelope, and an extensive landscape improvement scheme. It has been designed to achieve a LEED Gold rating by the US Green Building Council, featuring a number of innovation credits.

The facility is projected to use 47% of the energy of a conventional academic building by using natural ventilation during approximately half of the year. The $25M, 88,000 s.f. facility is funded primarily by private donors and has garnered significant grants from the 2004 Federal Energy and Water Appropriations Bill for $7.5M, Illinois Clean Energy Community Foundation, two grants totaling nearly $200K as well as a Kresge matching grant for $600K (with a bonus of $150K for achieving LEED Silver or above). The Weber Center was opened in August 2007.

Program and Orientation

This individual project has had an influence on both the campus culture and the leadership of the University. From ethical considerations to energy stewardship to health
and wellness attributes, the project has raised a dialogue about man's relationship to the environment not previously present at the institution. This impact will surely affect the future of planning and renovation at this 1200 student University, and it is our belief that it will impact the region as model for future sustainable development.

The new Weber Center joins the central library with academic spaces for the Division of Art, Design and Architecture. The central library occupies approximately 30,000 g.s.f. on two levels. The Division of Art, Design and Architecture occupies approximately 40,000 g.s.f. The new building serves approximately 300 students and 16 faculty.

Source: K.Kaiser adaptation of Burnidge Cassell and Associates construction documentation

The building is organized into three distinct elements in plan: a deep plan library/studios “block” element, a “bowtie” classroom element, and a studio/office “bar” element. The block part of the building contains plenum and mechanical spaces and some limited academic space on the first floor, the library exists on floors two and three, and a
contiguous architecture studio space and seminar rooms are located on the fourth floor. An atrium is located in the center of this part of the building. The “bowtie” element is made up of the primary concourse with a gallery on the main level with studios on each of the other levels, all on the west side; and a series of stacked classrooms on the east side of the concourse. The studio/office “bar” is similar floor by floor with art and design studios at the ends of the bar and faculty offices in between along the south elevation. The building is four stories total and occupies a site that completes a “soft rectangular quad” shared with two dormitories, a science center, and the University chapel. The University President, Dr. Jerry Cain, describes the new campus plan as a celebration of the heart and mind of the College, with the Chapel at one end of the quad and the new Library at the other, with a new sustainable landscape between.

**Construction Materials**

![Diagram](image.png)

Source: Burnidge Cassell and Associates construction documentation

The dominant building material is concrete, both in the wall and floor/ceiling elements, which is necessary for the purposes of thermal mass. Thermal mass is a key component of the natural ventilation system. In most cases, the ceilings and walls are exposed as radiating surfaces for warmth or coolness. Primarily for acoustic purposes, there are many areas that have suspended ceiling treatments, and many others with tack-able wall surfaces.

The exterior walls are stick framed extensions approximately four feet from the pre-cast concrete walls. These volumes contain the chase spaces for the vertical air flow in the
natural ventilation scheme. It also provides a relief for solar shading, described later in this paper.

The exterior finish materials are brick veneer at the lower level, and a combination EIFS and metal panels at the top. Window sill, jamb and head are finished in a white metal panel system, primarily to indirectly bounce day light into the facility.

Another significant feature is a glazed atrium in the middle of the library/studio element that serves as both a day lighting element as well as the primary conduit of fresh air supply.

**Hybrid Natural Ventilation Design**

The first and foremost innovation of the new facility is the use of Natural Ventilation. Built primarily of pre-cast concrete, the building will draw cool air at the lower level, circulate this air throughout the facility through various routes, and ultimately exhaust the air through roof termini.

The combination of these elements creates a stack effect which both draws and exhausts naturally buoyant warm air. In the library/studio element, the stacks are imbedded in the perimeter walls.
In the bar element, the stacks are located along the south façade. They are very similar to the library/studio element, with one difference; the stacks have glazing areas that allow for Building Integrated Photo-voltaics. This is described in greater detail later in the paper.

Although the original scheme speculated as to the possibility of a fully-natural ventilation system, as is common in many European climates, and other climates Prof. Short has built in, it became very clear early on that this would not be possible in the local climate due to the extreme temperatures of winter and summer, the tendency of wild temperature
fluctuations periodically throughout the year, and the challenges posed by humidity. In
consultation with the local mechanical engineers KJWW, a hybrid approach was
developed that would attempt to minimize the use of conventional heating and cooling.
This ambitious natural mode/mechanical mode system was developed to take advantage
of the conditions of the local climate. Generally speaking, the building will operate
during the mild seasons of spring and fall primarily in natural mode. It will also be able to
take advantage of unusually mild times during the summer and winter months. Similarly,
the mechanical mode will engage during the extreme seasons and whenever the need
arises during the temperate seasons. The mechanical system has been designed as if there
were no natural system at all since there will be times of the year that it will likely be in
full operation.

Two items are important to note from a design standpoint. First, the modern application
of the principle of the stack effect is something that Prof. Short and his colleagues have
mastered in their local climates; so the technology is proven through a number of existing
buildings that serve as case studies. It is actually a centuries-old technology. The basic
principle at work is that hot air rises. But of course, there is a significant amount of
engineering involved with the design of such a system; and the building does behave like
one integrated system. Secondly, air buoyancy and pressure differentials are properties of
the discipline of physics. One of the key aspects of the stack effect that is not
immediately apparent is that as the heated air moves toward the release point, it tends to
produce a vacuum effect; it literally draws or pulls air through the spaces from which it
has just passed. It is in this second way that the air flow begins to make sense. Artificially
warmed air rising from my laptop does not naturally go sideways, it goes up. In this
building, the air warms and is drawn laterally by the pressure created by the stack effect.
Warm air moving sideways is not intuitively sensible. So one of the things done early in
the process, both to justify, but also clarify, the system to the client and user groups, was
to secure two different types of pre-construction testing. Alan also insisted on it as part of
his professional services.

One type of testing involved Computational Fluid Dynamics (CFD) modeling and
analysis of the library element natural ventilation strategy. The second involved a testing
of the Building Integrated Photo-voltaic (PV) system along the southern façade.

The CFD model demonstrates the directional air flows following the designed paths of
the intake and exhaust in each of the spaces throughout the building. It models the
incoming air temperature, tracks the routes of airflow through the entire building,
modeling the changes in temperature, and models the exiting of the air.

The University also funded an analogue format test. This test examined the Building
Integrated PV system. The south façade is described graphically below:
On the one hand, the stack elements on the south elevation are similarly detailed as they are on the library element. It is a vertical chase, drawing exhaust air in from each floor, and exhausting the warmed air to the attic and then out a terminus. The warmed air is either exhausted or the heat reclaimed and reused. On the other hand, this wall has a PV system which generates a limited amount of electricity (22kW). A significant problem
with PV is the heat generated because it is a dark surface and creates heat as a result of absorbing solar radiation. Eliminating the heat is often a necessity because it affects the cooling load. Alan has placed the PV in the south wall of each of the vertical stack elements. What this does, is artificially heats the air within the chase, air which is already getting warmed by collecting the warmed air from each floors. The net effect of this artificial and increased heating of the air within the stack is that the buoyancy is increased, making the draw of air, or the changes of air, faster and more substantial.

The testing was performed by the Cambridge University British Petroleum Institute for Multiphase Flow. The model is submerged in a water bath, with different colored dyes used to represent different floors (not temperature), and heat coils applied to the floor of each of the two levels to simulate heat generated by users, computers, lighting, etc. and one is also applied laterally to the stack to simulate the heat generated by the integrated PV. The dyes provide the evidence that as the temperature increases, the warmer fluids move to the perimeter stack and are exhausted.

Source: Cambridge University British Petroleum Institute for Multiphase Flow
Day Lighting

The design uses a sensible, engineered approach to harvesting daylight. Two primary strategies are a significant amount of glazing and a deep exterior envelope poche. The four foot thick wall cavity serves to reduce the majority of direct solar gain; engineers conducted a series of plan, section and elevation studies on each of the facades. Simultaneously, the cavity produces a light shelf surface that bounces light from the tapered sill to the ceiling spaces within, allowing both ambient and indirect lighting, harvesting light through multiple means.

This approach is in its own way a building integrated system which screens out the potential solar gain but allows for ambient day light. Instead of add-on sun screening elements applied to the elevations, the poche of the building envelope creates the overhang that shields direct gain.

Site Development and Ecological Landscape Improvement

A final significant aspect of the project is the extensive landscape improvement scheme. Designed by British Landscape Architect, Slaine Campbell, the design solution includes moving a 70 stall parking lot that was in the middle of a collection of campus buildings (Ohio, Wilson, Apartments/Health Center, Science and Chapel) to a perimeter location.
which is nearly completely screened from view, but still in close proximity. It was replaced with a sustainable landscape “quadrangle” scheme that incorporates a series of complementary ecological elements including: down lighting, storm water flow, control and storage, bioswale elements filtering phosphorous and other ground water pollutants, infiltration through retention and permeable surfaces, with resultant evapo-transpiration. Evapo-transpiration is a natural process that oxygenates the air and yields fresh air at the places of air intake near the new facility, but also to the surrounding facilities and climate. The indigenous landscape will be significantly enhanced and protect biodiversity and ecosystems, not to mention serving as an outdoor classroom in ecology and sustainable landscape. New landscaping includes:

**Trees and Shrubs:** Kentucky Coffee Tree, Black Walnut, White Oak, Pin Oak, American Linden, River Birch, Northern Redbud, New Jersey Tea, Buttonbush, Gray Dogwood, American Witchhazel, Fragrant Sumac, Staghorn Sumac, Austrian Pine, Browns Yew, Purple Leaf Wintercreeper.

**Stormwater Plantings:** Brown Fox Sedge, Spike Rush, Virginia Wild Rye, Torrey’s Rush, Rice Cut Grass, Softstem, Swamp Milkweed, Water Plantain, Monkey Flower, and Broad-Leaf Arrowhead.

**Low Prairie Plantings:** Little Blue Stem, Prairie Wild Rye, Prairie Switch Grass, Prairie Drop Seed, Thimbleweed, Wild Columbine, Butterfly Milkweed, Smooth Blue Aster, While Wild Indigo, and Partridge Peas.

Source: K.Kaiser adaptation of Burnidge Cassell and Associates construction documentation
Conclusion

The Harm A. Weber Academic Center is a fascinating learning laboratory. It will serve as a regional model for energy efficiency and alternative methods of building design. It will serve as a living laboratory for engineers, architects, students, and the public for years in the future. It may play a role in adjusting requirements in energy codes and alternative technologies. It may indicate a future LEED category or set of categories. But if none of these are the case, the building itself, at an estimated premium of 10-15% above conventional construction costs, will require less energy to operate, and will very likely be a pleasant place to study and teach. Quoting Alan Short’s 2005 research article entitled *A Hybrid Environmental Design Strategy for a College Building in a Continental Climate*, “The costs for delivery of energy are greater in the standard US building than in the Judson Building during every month of the year. This is because, in the standard US buildings, significant amounts of energy are consumed by the fans, whereas in the Judson Building, fresh air is often delivered passively…

![Graph](image_url)

**Standard US Academic Building, Monthly Heating, Cooling and Fan Energy Loads**

![Graph](image_url)

**Harm A. Weber Academic Center, Monthly Heating, Cooling and Fan Energy Loads**

Source: Short and Associates, Chartered Architects
…Passive ventilation with neither heating nor cooling is possible for 29% of occupied hours and for 23% of such hours ventilation pre-heating is required…The consequence of these performance differences is that the predicted annual energy cost is 43-47% less than the standard US building…The mechanical plant is only needed 48% of the occupied hours of the year.”

In fact, the potential savings in energy consumption resulted in a surprising finding early in the design process. It had been our intention to use a ground based geothermal system for the mechanical system. As we know, the payback on these systems is typically between 5-10 years. But because of the built-in energy savings because of the architecture itself, the engineers calculated a 17 year payback for our system. This made the use of geothermal unrealistic on the one hand, but revelatory on the other. Geothermal is a great system to alternatively heat and cool a conventional building; every conventional project should employ geothermal as a key strategy whenever possible. The Harm A. Weber Academic Center, however, is an unconventional building, heated and cooled unconventionally. The architecture itself responds to the local climate in an active way. Contrary to the way most of us think about this climate when we design buildings, that is, defensively protecting against the environment, Prof. Short has delivered a design strategy that is extremely optimistic as to the potential of the climate to shape and contribute to the key principles of health, safety, and welfare.

The Harm A. Weber Academic Center is a strong approach to the future design of campus buildings because it is not merely celebration of technology and innovation; it is a solid approach to work with abundant and naturally existing sets of systems. It will result in energy efficiency, but also indoor air quality. It features abundant day lighting which has been proven to improve workplace performance and reduce absenteeism. There is little to no chance of “sick building syndrome” because ventilation is always fresh and natural, low-emitting materials are utilized, and carbon dioxide is monitored. It goes without saying that the building will greatly benefit the professional education of the future architects under our charge at Judson University, and will serve as a living laboratory for years to come.

[This is an excerpt from professional papers written collaboratively by Keelan P. Kaiser, AIA and Dr. David M. Ogoli for the US Green Building Council, Chicago Chapter, 2005 LEED Extra Credit seminar series at the Chicago Center for Green Technology and 2005 Illinois Annual AIA Convention. It is a summary of the extensive research and professional work of Short and Associates and Burnidge Cassell and Associates and their consulting architects and engineers on behalf of Judson University.]