Sustainable Foundations

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When Portland State University decided to renovate Shattuck Hall—one of the campus’ oldest buildings, originally built in 1915 as an elementary school—the design team used the opportunity to also create a teaching laboratory for architecture students by leaving the building systems visible. A radiant ceiling panel shows the copper tubing that carries hot or cold water. Exposed original ductwork distributes fresh air. Concrete columns reveal the building’s skeleton.

W hile staying within the original $11.7 million budget, the project boosted the building’s energy performance with the use of radiant ceiling panels and daylighting. The team designed with the theme of “systems on display.”

Shattuck Hall houses part of the School of Fine and Performing Arts including the Department of Architecture. The building’s green transformation has produced dynamic facilities, including a multilevel open plan, naturally lit open spaces, columnar enclosures containing model-making, wood-working, metal-working, foundry and digital fabrication.

Goals
In addition to deferred maintenance and seismic, accessibility, and mechanical and electrical system upgrades, Shattuck Hall’s renovation addressed five pedagogic goals:

• Respect and reveal the structure of the original building;  
• Insert new elements and/or systems in a complementary, yet distinct manner; 
• Tell the story of the design and construction;  
• Create a building that provides comfort and demonstrates energy-efficient performance; and  
• Reveal sustainability as one dimension of a compelling design aesthetic.

Capitalizing on Strengths
The design team incorporated existing elements into a passive strategy that expanded Shattuck Hall’s program without increasing its size or budget. Shattuck Hall’s thermal mass is key to moderating temperatures, and the concrete-framed structure allowed for the strategic insertion of concrete shear walls in four discreet locations to stabilize the entire structure.

The existing fan rooms and duct layouts were inadequate for heating and cooling use but ideally sized for providing required building ventilation. The design team added a new dedicated outdoor air system (DOAS) with highly efficient fans to move air from outside through the existing ductwork running vertically to every classroom in the three-story structure. The DOAS is a variable air volume system that is controlled through variable frequency drives. In open spaces, columnar enclosures house the ducts that carry fresh air—a sustainable green transformation of every major building system. The 2008 project did not touch windows when unoccupied.

Energy Performance

In addition to its green characteristics, Shattuck Hall is a major renovation designed to provide an energy-efficient building.

The DOAS designed to reduce airflow to a space based on its use. Occupancy sensors turn off the building HVAC control system to reduce airflow to a space when unoccupied.

During a renovation in the 1980s, the existing operable windows were retained and refurbished to ensure their continued operation. With an impressive head height of 11 ft 6 in., they supply abundant daylight with excellent penetration, even on cloudy days.

Daylight sensors were installed in each classroom to adjust the rooms’ electric lighting in response to the amount of daylight available via continuously dimming ballasts. Occupancy sensors turn off lights when spaces are vacated and prompt the building HVAC control system to reduce airflow to a space when unoccupied.

Building at a Glance

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Occupancy, daylighting and CO2 sensors are incorporated into this layout. In the student lounge on the third floor, the design team purposely turned the radiant panels upside down as an educational tool to reveal the copper tubing and fittings that make the system work. The ceiling panels function equally well inverted or upright since the heating (or cooling) surface is still exposed to the space.

The tubing in the radiant panels holds heating hot water or chilled water supplied from the campus’ central utility plant via a closed loop. A heat exchanger provides the existing glazing, but the team used double glazing in the openings created by the renovation. Single-pane glass remains in the stairwells.

The renovation juxtaposed original and new materials. The visible building systems create a learning lab for students. As an added bonus, the existing maple hardwood floors only required refinishing for the most part.

Adding New Life

The renovation team met regularly with local design review committees to preserve the 1915 neoclassical brick façade. The building was an elementary school until 1969 when Portland State University bought it to provide additional classroom space for its growing student body.

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(the 2005 Oregon Energy Code was determined by the USGBC to be equivalent to ASHRAE Standard 90.1-2004 for LEED purposes), but it beats the projected energy use intensity of 48 kBtu/ft²·yr with an actual EUI of 45.87 kBtu/ft²·yr.

The EUI does not include the process load of a gas-fired teaching foundry in the building that adds 13.7 kBtu/ft²·yr. The gas used by the foundry does not offset the heating load because dedicated exhaust fans that serve the foundry space evacuate process loads from the area.

Shattuck Hall’s energy consumption is exceptionally low compared to standard academic buildings, and is saving the university $13,000 per year in operational costs.

The design team renovated all of Shattuck Hall’s restrooms, installing low-flow fixtures, waterless urinals and dual-flush toilets. Surrounding landscaping requiring permanent irrigation was replaced with plant species that do not require irrigation. These factors contributed to an overall water use reduction of 44%.

Controlling Humidity
To avoid condensation on the radiant panels, humidity levels are monitored in the building. Moisture sensors on the radiant piping can increase the chilled water temperature (normally delivered at 56°F). If the humidity level is excessive or if condensation is sensed, the sensors trigger an alarm.

Space humidity levels are controlled through the ventilation system. The fresh air passes through a cooling coil that reduces the moisture in the incoming air and controls the humidity in the building. Occupants also can open the windows for fresh air, so the humidity monitoring is critical.

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A new electrical distribution system and efficient lighting installed throughout the building provide students and faculty the flexibility to work in various ways in various spaces. Exposed cable trays suspended in the corridors highlight Shattuck Hall’s technology upgrade for tech-savvy students. Provisions for future video projectors are included in the trays so that images of student work or presentations by visiting lecturers can be shown on the corridor walls.

Seismic Reinforcement
As part of the project’s teaching strategy and to support the need for a variety of student spaces, the design team solved the seismic instability of the corridor walls by using different strategies on two separate floors. On the second floor, just inside the classrooms, the team built stud walls next to the old gypsum block walls to seismically support them in a fashion similar to adding a veneer wall to a building’s exterior. This new stud cavity also serves as a power and data wiring pathway.

Exposed technologies showcase the theme of “systems on display” and present learning opportunities for architecture students. Shown here is the ceiling of the student lounge, where radiant heating and cooling panels are turned upside down as an educational tool to reveal the copper tubing and fittings.

The building has used less electricity than predicted due to either lower plug loads or lighting loads. The lower electricity use led to increased heating, resulting in higher than expected steam use. Electricity use reflects decreased building occupancy during the university’s term breaks. The water use model was based on LEED calculations, which account for the low-flow plumbing fixtures, number of building occupants and types of occupants. The LEED calculations consider students as transient building occupants and estimate students’ water use to be one-sixth of a full-time building occupant. It is likely that architecture students are spending more time in the building than the LEED assumption for a typical student.

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<th>Actual</th>
<th>Modeled</th>
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<tr>
<td>Domestic Water (gallons)</td>
<td>241,620</td>
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On the third floor, the seismically unstable walls were removed to create open space for a studio setting that invites collaboration while enhancing natural ventilation and daylighting. Rolling partitions, suspended from tracks, increase flexibility by creating options for privacy or additional pin-up space as needed. The finishes of this space were removed to reveal all building systems to the architecture students.

The walls near the four stairways in the building were seismically reinforced with concrete shear walls. This arrangement enables the flexible use of typical spaces throughout the building.

The elevator was moved to reestablish one of two original light wells and convey daylight into the upper two levels and the partially below-grade first floor metal foundry and welding shop. The second light well was open on the top two floors, and windows were added to provide additional daylight from the light well to the building corridors.

The first-floor shop serves as a gathering place where students from different disciplines exchange ideas and collaborate.
The panels’ dramatic sculptural qualities express the beauty of using a small amount of material ideas. It also gives students hands-on experience with forming and working with materials to learn how buildings are made, furthering the theme of “systems on display.” Relocating the elevator and opening the light wells also allowed the design team to revise the existing entrance-level hall. While preparing for a new entrance enclosure and stair, the design team opened the second-floor corridor by replacing the walls with new windows, allowing daylight from the light well to fill the departmental offices to create naturally lit space for student reading. It also functions as a gathering and exhibition space.

No effective option existed for adding insulation to the exterior walls, so the design team reduced heat gain where it could with added roof insulation and a high albedo reflective roof membrane. The existing operable window shades inside the 8 ft windows provide shading and glare control as do the surrounding mature trees.

A Building that Teaches
The idea of recreating Shattuck Hall as an educational tool permeated every decision of the project. The design team believed that students should have an in-depth understanding of the underlying principles of high performing buildings, systems and materials. The fundamental premise was to demonstrate the results of the team’s decision-making process for students and faculty to observe, consider and discuss.

Rather than slide in state-of-the-art sustainability behind the scenes, the design team displayed building systems to inform architecture and fine art students about these aspects of design and help them plan and create with sustainability in mind. Freestanding steel panels, which screen the administrative area from the general space of the central office, are designed to transform incrementally from flat panels into three-dimensional origami. They have laser-etched lines showing the steps and operations required to convert them into a variety of forms, demonstrating the “act of making.”

Top Glass partitions enclose the architecture faculty offices, allowing daylight to pass through. The previous office suite was about one-third the size of the new space, which connects to a central gathering area/reading room. The visibility and daylighting throughout the space strengthens the connection between faculty and students.

Above Throughout the building, open, well-lit spaces provide gallery space to showcase student and professional work. Most of the existing maple hardwood floors only required refinishing.

The panels’ dramatic sculptural qualities express the beauty of using a small amount of material
Building renovations were designed to allow for future evolution and growth of the building's program. The radiant ceiling can be taken part of a new architectural element or were inserted adjacent to historic elements. This approach placed elements such as the cable tray next to the historic interior arches in the corridor and power/telecom wiring inside the shear walls. The existing building's floor structure presented a challenge. The design team found that the floor consisted of a concrete pan system with a 2 in. depth at the top of the pan, and the wood floor sleepers were cast into a concrete topping.

The nature of the exposed systems creates a powerful teaching tool for future architects and designers occupying the spaces. For instance, every seismic upgrade element became a final finish in the completed spaces. And where new systems occurred, they either became a part of a new architectural element or would be inserted adjacent to historic elements. This approach placed elements such as the cable tray next to the historic interior arches in the corridor and power/telecom wiring inside the shear walls.

The existing building's floor structure presented a challenge. The design team found that the floor consisted of a concrete pan system with a 2 in. depth at the top of the pan, and the wood floor sleepers were cast into a concrete topping. The team determined that it was not economically feasible to alter the floor system, so a radiant ceiling system was designed. The ceiling system is also more responsive to space temperatures than a floor system, offers acoustical benefits, and is reconfigurable for future renovations.

Building renovations were designed to allow for future evolution and growth of the building’s program. The radiant ceiling can be taken down and reinstalled. The concrete shear walls were placed at the building corners, and no other load-bearing walls were added. The mechanical spaces were maintained removed to enhance the building program. The building has already been renovated for the new office and studio spaces. Likewise, instead of allocating existing classroom module was maintained existing classrooms for the new office and studio spaces. New systems for the existing classrooms were inserted without demolition of those spaces. Likewise, instead of allocating resources to seismically brace all ceilings and walls, many of those elements were removed to enhance the building program. This design approach yielded great harmony between the new and existing elements.

Building strategies for designing efficient and comfortable buildings. The immediate cooling or warming effect from the radiant ceiling and fans expands the temperature range that occupants perceive as comfortable. Experiencing this environment helps students realize that comfort is determined by factors beyond the temperature displayed on a thermostat, and equips them to think openly about strategies for designing efficient and comfortable buildings.

Conclusion

The Architecture Department has already benefited from the project, which has contributed to the department’s recent accreditation and the addition of a graduate program, highlighted its sustainable design focus and helped recruit talented faculty and students. The building demonstrates that sustainability does not have to mean increased costs. Renovation projects that preserve existing buildings eliminate the environmental costs of materials required for new construction, and efficiency upgrades can lead to long-term savings for building owners. Shattuck Hall provides a prototype for projects that seek to incorporate creative, sustainable design on a modest budget.

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