Steel is Sustainable Construction

Back to School

By Beth S. Pollak

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The University of Oregon's Lillis Business Complex in Eugene, OR, used steel to provide an open classroom environment and a model for sustainable design.

A steel-framed "green" building was the solution to expansion plans for the University of Oregon's Lundquist College of Business in Eugene, OR. The new building reflects the business school's innovative approach to learning, while blending with the historic character of the campus. The result is a four-story, 140,000-sq.-ft steel-framed building that replaces the existing Commonwealth Bridge Building.

The new building features a four-story glass atrium and provides a 300-seat auditorium, a 220-seat lecture hall, classrooms, faculty offices, a distance learning center and a career services center. The building was substantially complete in August 2003, two months ahead of schedule, and is now in use.

Structural-steel framing was chosen over other systems for the building because of the complexity of the structural grid and the desire for an exposed-structure aesthetic. Structural steel also allowed the team to create an open, light environment for learning within tight budget and schedule requirements.

The University wanted the Lillis Business Complex to serve as a model for sustainable design and energy efficiency. "Our curriculum reflects the values of the Pacific Northwest business community," says Philip Romero, dean of the Lundquist College of Business. "One of the strongest of those values is the recognition of the preciousness of our natural environment, and the need to protect resources."

The building meets the provisions for a LEED™ silver rating. The use of structural steel contributed to the building's sustainable design. Incorporating structural steel into a building design can earn LEED points for the use of recycled and locally manufactured materials. Learn more in the article "Structural Steel Contributions Towards Obtaining a LEED Rating" in the May 2003 issue of *Modern Steel Construction* at **www.modernsteel.com**.

Other sustainable elements include high energy efficiency; photovoltaic cells (solar panels) that are integrated into the glazing system; a perimeter day-lighting scheme using modulating controlled shades and dimmable ballasts; recycled building materials; a small test-case green roof; and water-conserving fixtures.

Close Quarters

The building's location presented a challenge to the design and construction team. "This project was built on the busiest quad on campus," said Construction Manager Bart Ricketts, of Lease Crutcher Lewis. "We tied into three buildings that were occupied at all times."

Two of the buildings, Gilbert East and Gilbert West, are historic buildings built in 1916 and 1920. Since the new building's story heights were different from the adjacent buildings', it was necessary to accommodate the elevation changes at the connecting points. The detailing at these locations was especially complex due to the presence of seismic joints and elevators at the connections that serve all the levels of the building. "We had to have two-sided elevators to provide access to the different buildings," said Chris Thompson, P.E., project principal for Degenkolb Engineers. "Their floor levels didn't align with the new building. We used steel to create intermediate landings for those levels."

The new Lillis Complex also tied into a third building, the Chiles Business Center, and both were designed with the same floor-to-floor height.

"We also had to construct a material-access bridge on site, in order to span over the root structures of 100-year-old trees lining the north end of the quad," Ricketts said. "This access bridge was used for all major deliveries, especially steel deliveries to the lay-down and picking area adjacent to our tower crane."

In addition, the Lillis Complex was built over a utility tunnel that had to be carefully protected. The tunnel serviced the quad for chilled water and electrical systems, and provided fiber optics systems for the entire campus.

Fresh Ideas

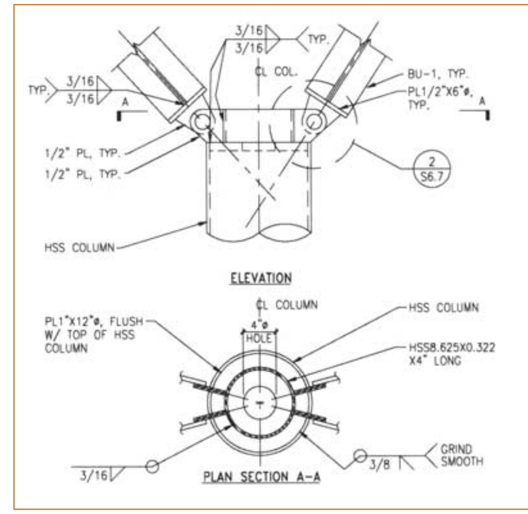
The building is designed to meet Oregon's seismic requirements. The lateral-force resisting system is special concentric brace frames in the north-south direction, and eccentric brace frames in the east-west direction. "The reason that we chose the eccentric brace frames in the one direction was that we needed to accommodate door openings for classrooms and offices that needed to pass through the brace frames," Thompson said. "The two systems are tuned so that they complement each other and aren't detrimental to each other. We used computer analysis to fine-tune the design."

In the east-west direction, eccentric brace frames have typical column sizes of W14×120 from the ground floor to the third floor. From the third floor to the roof, columns decrease to W14×68. Braces typically are HSS 8×8×$^{5}/_{8}$, and beams are W12×96.

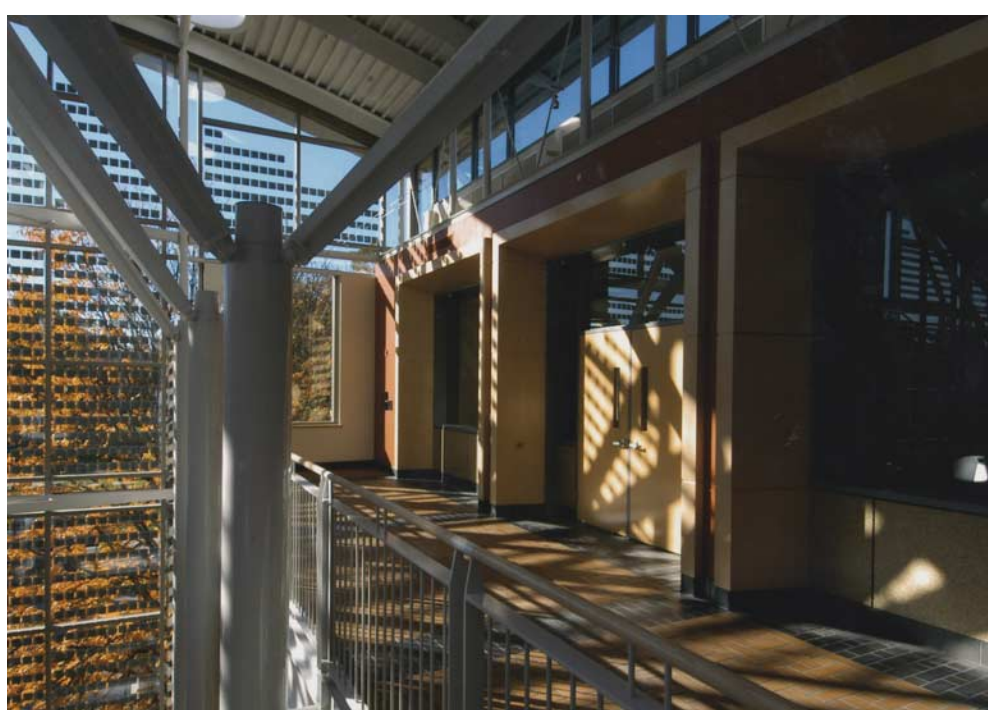
In the north-south direction, special concentric braced frames have typical column sizes of W12×87 to W12×50, and braces are HSS 6×6×$^{5}/_{16}$.

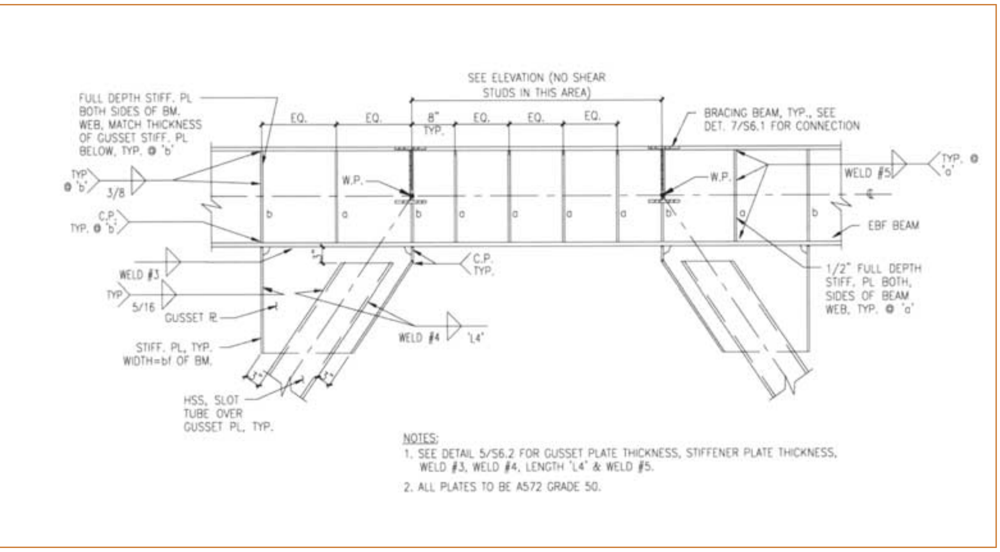
The heart of the Lillis Business Complex is its four-story glass-enclosed atrium. It is constructed with exposed curved roof members and "tree" columns that support them. The columns of the trees are round HSS 12.75×0.500. "The tree branches are built-up members, created with tapered $^{3}/_{8}$" plate welded together with fillet welds in a cross section," Thompson said. "They vary from 6" at the end of the members to 12" at the middle, and they are tapered on a smooth, circular curve."

A curved stair cantilevers from the atrium columns, which are round HSS 5.565×0.258, with WT 12×31s as secondary framing. A large pre-cast concrete "portal" at the main entry is surrounded by glass curtain wall, so vertical and horizontal steel trusses span between the edges of the floor on either side of the atrium, and between the ground floor and the atrium, to provide out-of-plane

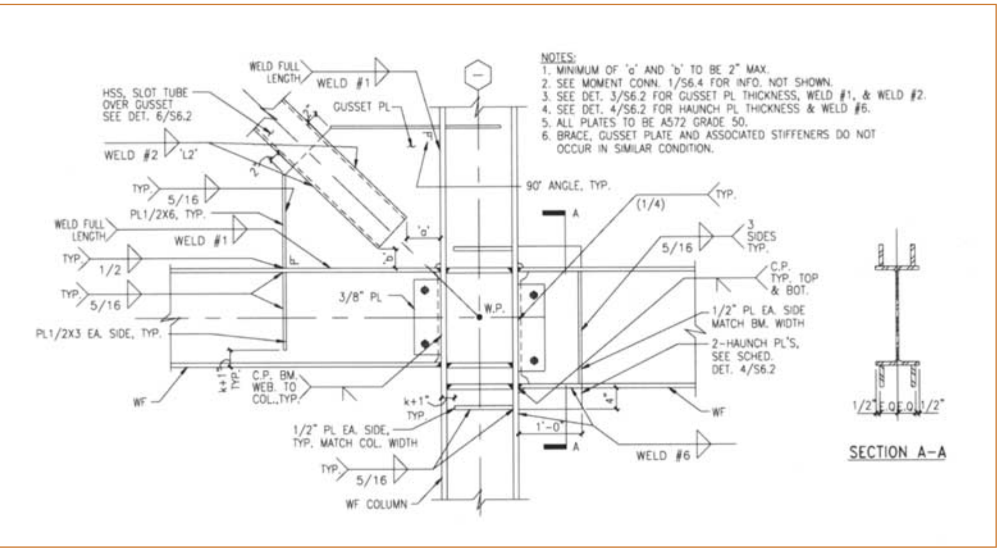


Above, center, and below: The exposed curved roof structure of the central atrium is supported by "tree" columns composed of round HSS "trunks" with "branches" of tapered $^{3}/_{8}$" plates welded into a cruciform cross-section.





A detail of the shear-link portion of the eccentric braced frame system. ECBFs accommodate door openings in the plane of the brace.



A detail of the brace connection at the column for an ECBF.

support. Horizontal truss members brace the precast walls, and are HSS 5.563×0.375 round pipe. Diagonal members are double angles, 2×2×¼, with all-welded connections. Vertical trusses are HSS 5.563×0.375, with double-angle 2×2×¼ for diagonals.

A single pipe column located under a circular skylight provides gravity support for the intermediate landings of the west stair. Rod bracing is provided at the clerestory. Tie rods support the fourth-floor terrace on the north side of the building.

Member sizes vary from W8 up to W33, typically W18 for floor beams and W14 for columns. "Most gravity connections are single-plate shear connections," said Jake Stept, P.E., project engineer for Degenkolb Engineers. "We used RAM Structural System for gravity design, SAP2000 for the lateral analysis, and RISA-3D for some specific framing areas."

Constructing the atrium and the rooftop was complex. "The detailing of the interface between the structural steel, the steel decking, and the exterior skin materials at the roof level was tricky, because we had a curved roof component on top of the atrium," Ricketts said.

Another challenge was the northeast 220′ second-floor lecture hall, which contains a sloped floor. The roof above includes several skylights in a radial configuration. The floor and roof are supported by cantilevered steel members at the front and back of the classroom, which allowed the team to minimize the structure depth and maximize the ceiling height in the auditorium below. The floor of the lecture hall is the ceiling of the 300-seat auditorium below. On one side of the double cantilever, members are W30×99, and on the other, they are W30×108. Framing between the ends of the cantilever is W16×31.

The team designed the floor-beam webs with penetrations for ducts and pipes to pass through, which allowed architects to maximize the ceiling heights and expose the bottoms of many of the floor and roof beams without exposing the duct work.

"Working with exposed structural steel in general can be challenging," Ricketts said. "It needs to be erected and handled properly, and protected with a good paint system. In this case, we were successful in protecting the high-end look of the exposed steel in the middle of the building."

Careful architectural design decisions meant the structural steel did not require fire-protective coatings. "The design team divided the complex with area separation walls," he said. "This gave two-hour separations between each wing, so from a fire- and life-safety standpoint, we didn't require fire-protective coatings."

Green Goals

The decision to aim for a LEED rating was made after the project was already bid to subcontractors, so the general contractors, architects and design consultants had to retroactively assemble the documentation for LEED certification and submittals. "We pulled it off and it was great," Ricketts said. "The design team had used a lot of the sustainability guidelines and the thought process behind LEED when designing the building in the first place, so it was already part of the base bid. LEED principles and guidelines were part and parcel with the original design, so there was minimal construction-cost premium to the university."

The architectural and structural design of the building contributed to energy-efficiency goals. SRG Partnership established the orientation and configuration of the building to help achieve maximum energy efficiency, exceeding state energy code requirements by more than 50%.

The floor slabs were designed with a 7″ composite slab on the upper floors, thicker than typically seen in similar construction.

This was done to increase the thermal mass, or heat capacity, of the building, and to take advantage of the "thermal flywheel" effect: an extra-thick floor slab helps the building heat up more slowly in the summer and cool more slowly in the winter. On summer nights the building is flushed with cool air, pre-cooling the mass so the building heats up slowly during the day. On summer days, little mechanical cooling is needed before 5:00 p.m. This reduces reliance on the central heating/air system, which was downsized accordingly. Most of the classrooms have a tiered-floor configuration consisting of raised platforms with the space below used as a ventilation plenum, to enhance this thermal effect.

Other "sustainable" goals features include the following:

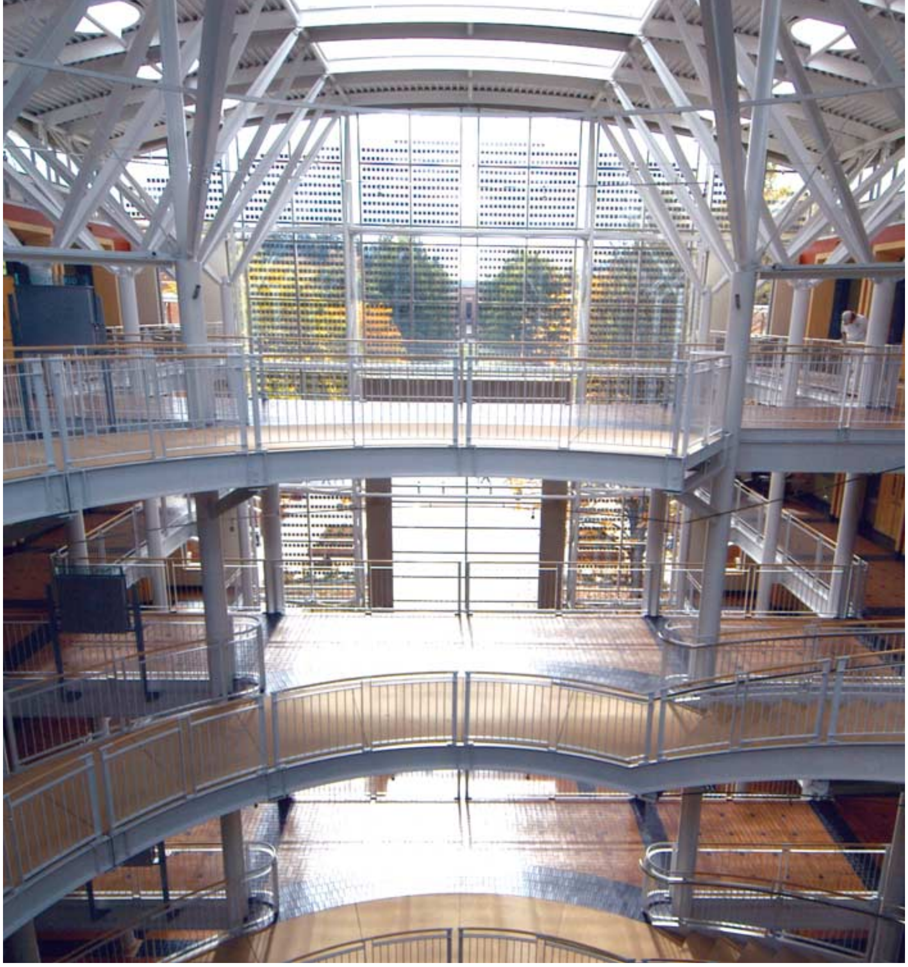
Daylighting: Sunshades and light shelves are incorporated to control heat gain and glare, while allowing lighting for video projection and classroom work. The east-west orientation optimizes light exposure, reducing the need for electric lights most of the year.

Ventilation: Air is drawn through louvers in the exterior walls, through a raised floor plenum, through the rooms, then collected in the corridor ceiling, and out through the four-story atrium to the outside. In the atrium, air circulation is enhanced by the required smoke-evacuation fan system, normally used only in the event of a fire. Some rooms have ceiling fans for added circulation.

Efficient Lighting and Controls: Dimmable fluorescent lighting with electronic ballasts automatically adjusts to the amount of daylight present indoors. Lighting levels also can be controlled by system presets. Occupancy sensors will shut off lights and fans when rooms are unoccupied, saving electricity. "Smart" plugs are wired to an occupancy-sensing system, and turns off devices like desk lamps and computer monitors when rooms are unoccupied.

Green Roof: A roof bed holding drought-tolerant plants in 3" of soil was installed. In the summer, it absorbs sunlight, reducing heat-gain and extending the life of the roof system. In winter, the plants reduce the rate of rain runoff into the city storm-water system, and act as a natural filter for water that does runoff.

Solar Panels: This structure houses the second-largest photovoltaic (PV) array in Oregon. The south-facing, glass-integrated PV panels in the curtain wall of the four-story atrium generate 44 kW



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The four-story central atrium features solar cells integrated into the glazing system.

of electricity. Glass-integrated PVs also are located on some of the roof skylights, and flat PV panels are located on the roof itself. Power generated at the Lillis Business Complex is sold to a local utility.

Advanced Monitoring System: A central computer measures inside and outside light levels and temperature, building occupancy, heating load, and power generation, and adjusts controls automatically for maximum efficiency.

Site and Landscaping: Sustainable landscaping techniques were used to accommodate existing natural conditions, and careful choices of landscaping plants minimize the use of water and chemical pesticides.

Recycling and Reuse: 90% of the old building's mass was recycled. Structural steel framing contains almost 100% recycled content, and concrete also contains recycled content.

Flooring: Linoleum flooring, a natural, biodegradable product made from linseed oil and waste products of the wood industry was used on a jute backing. Most carpeting is Interface carpet tile made from recycled carpeting, with a prolonged life span as tiles can be moved to equalize wear.

Indoor Environmental Quality: The building design allows fresh air circulation. Materials that generate ozone-depleting chemicals were avoided, and low-VOC paint and finishes were used.

Owner
University of Oregon, Eugene, OR

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SRG Partnership, Inc., Portland, OR

Structural Engineer
Degenkolb Engineers, Portland, OR

Civil, Mechanical and Electrical Engineers
Balzhiser & Hubbard Engineering, Eugene, OR

Construction Manager and General Contractor
Lease Crutcher Lewis, Portland, OR

Landscape Architecture
Cameron McCarthy Gilbert, Eugene, OR

Engineering Software
RAM Structural System, SAP2000, and RISA-3D

For more information on the use of structural steel in sustainable design, please visit **www.aisc.org/sustainability**.