Built to Last

BY WILLIAM ANDREWS, S.E., RAFAEL SABELLI, S.E., AND GON NG, P.E.

The Kirsch Center at DeAnza Community College stands as an eco-friendly example of how sustainability and structural steel go hand-in-hand.

YOU CAN LEARN A LOT FROM A BUILDING. As the lead demonstration building for energy innovation and sustainability of the 108-campus California Community College system, the Kirsch Center for Environmental Studies at DeAnza Community College in Cupertino, Calif., is a building that "teaches about energy and resources." Integrating state-of-the-art energy and communications technologies in a unique demonstration of "whole building" and "environmentally responsive" design advantages, the facility was designed as a showcase for energy efficiency and renewable energy technology, in hopes to encourage other community colleges to design and construct sustainable buildings.

The award-winning project is the culmination of nine years of groundwork laid by DeAnza faculty, staff and students through open workshops in which participants debated, sketched, and brainstormed concepts. The two-story, 22,000 sq. ft building is framed in structural steel—an integral component in sustainable concepts, due to its inherently high recycled content and its ability to integrate well with sustainable design features without incurring a significant cost premium to the structure.

The structural system was designed in accordance with the 2001 California Building Code, which consists of the 2002 AISC *Seismic Provisions for Structural Steel Buildings* and the 1997 Uniform Building Code, including amendments by the California Division of the State Architect (DSA is the enforcement agency for public school and community college construction in California). Where conflict existed in the seismic requirements between the two documents, the most stringent requirement was followed. Supported on a conventional spread footing foundation with slab-on-grade, the typical column bay spacing is 21 ft by 18 ft and 21 ft by 38 ft. The second-floor framing is a composite system with lightweight concrete fill over composite steel floor deck and wide flange steel beams. The roof framing consists of metal deck on a 3:12 slope over wide flange beams, with long cantilevered overhangs at the south face of the building. The seismic/wind lateral force resisting system is a special concentric steel braced frame (SCBF). The exterior cladding system consists of cement plaster and sheathing over light gage steel stud framing.

Challenges Come to Light

While the basic framing system is conventional, a number of structural challenges emerged through implementation of the sustainable design concepts:

High-volume fly ash. The use of high-volume fly ash (HVFA) concrete fill over metal deck required specification of 56-day design compressive strength versus 28-day strength. This meant that the composite steel beams would take longer to reach their full design strength, something the contractor needed to recognize in the construction schedule.

Diaphragm discontinuities. The use of extensive day lighting led to the creation of several large roof clerestories and a two-story atrium at the main entry. This created irregularities and discontinuities in the roof and floor diaphragm systems. The desire to further maximize day light-

For tension, the exposed braces are reinforced by four angles mounted over the corners of the square HSS brace. These angles provide additional area to prevent a weak section where the brace is slotted to fit over the gusset plate.

ing on the north face of the building drove the decision to orient the framing in the east-west direction—parallel to the exterior face of the building—in order to minimize the depth of the spandrel beams and maximize the glazing height.

Cantilevered framing. Special cantilevered framing details were developed to create a long, thin, profiled roof overhang to shade south-facing windows at the second floor. Support of exterior sunshade elements was provided by supplemental HSS steel framing, which was carefully coordinated with the architect and embedded in the exterior stud wall system.

Photovoltaic system. Additional steel roof framing was added to provide secure anchorage locations for the photovoltaic system mounted over the roof deck.

Unusual floor conditions. The second-floor framing in the west wing was designed for the additional weight of a 3 in. topping slab with a radiant heating system. In the east wing, however, the preference for a raised access floor led to a vertical step of 15 in. in the second floor, creating challenges in maintaining continuity in the lateral load path of the diaphragm, while also accommodating mechanical and plumbing penetrations throughout the floor deck.

Exposed steel framing. Minimizing the use of unnecessary finish materials, especially dropped ceilings, led to exposure of much of the structural steel framing. To minimize the added cost associated with specifying Architecturally Exposed Structural Steel (AESS), only steel columns, braces, and stairs were designated as AESS, following the basic requirements of the AISC *Code of Standard Practice*, Chapter 10. The added cost of specifying all exposed steel as AESS was judged unnecessary; instead, the AESS designation was only given to framing members that were most visible to the building occupants.

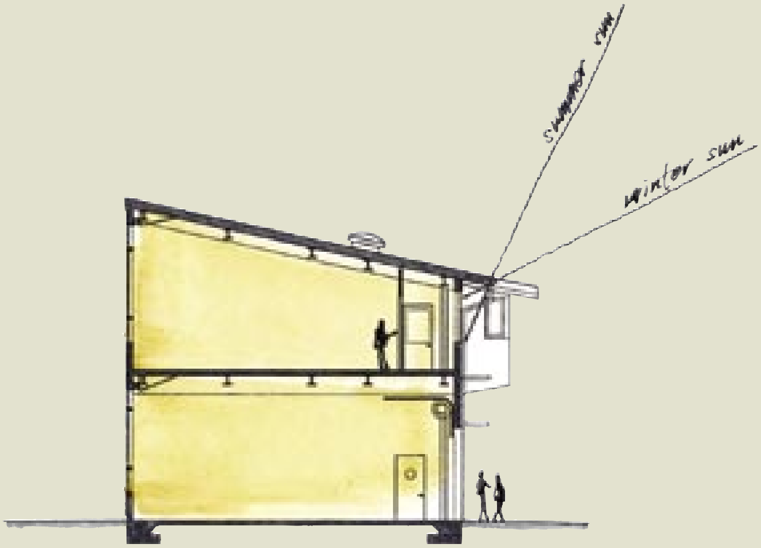
Designing for Quakes

The Kirsch Center is located approximately five miles from the San Andreas Fault and thirteen miles from the Hayward Fault, which have the capability of generating an earthquake of Richter magnitude 7.9 and 7.1, respectively. Consistent with the California Building Code (CBC), the Kirsch center was designed for an expected ground acceleration of 57 percent *g*. Using a response spectrum, and a Response Modification Coefficient (*R*) of 6.4 (as specified for SCBF in the CBC), the design base shear was calculated to be 32 percent of the weight of the building.

Getting Green

AS A FACILITY FOR ENVIRONMENTAL STUDIES, THE KIRSCH CENTER HAS A CERTAIN GREEN REPUTATION TO MAINTAIN. From its conception, through design and construction, and now into its educational use, the Kirsch center stands as an outstanding example of a sustainable higher education building. Below are some of the sustainable features the project planners incorporated into the building:

- LEED Gold Certified as established by the U.S. Green Building Council.
- 60 to 70 percent below California Title 24 Energy Standards.
- Building sited adjacent to an outdoor environmental study area.
- Structural steel, manufactured with 95 percent recycled content.
- Light-gage steel partition and cladding framing with 95 percent recycled content.
- East-west orientation for passive solar benefits, plus natural day lighting through clerestories and a central atrium.
- Advanced natural ventilation in the west wing/raised floor for air distribution and flexibility in the east wing.
- Rooftop photovoltaic panels to generate electricity.
- Radiant heating/thermal mass in the concrete floors.
- Rainwater collection for irrigation.
- Model for use of recycled/renewable/nontoxic materials and finishes.



The braces are prominently featured as interior architectural elements.

Typical gusset-plate detailing for the braces ensure that the SCBF perform as intended, accommodating both the expected tension and compression behavior of braces. In tension, the exposed braces are reinforced by four angles mounted over the corners of the square HSS brace. These angles provide additional area to prevent a weak section where the brace is slotted to fit over the gusset plate. The gusset plate is shaped like a paddle to provide the area that is required to resist the brace tension (including a factor R_y of 1.4). This area is symmetric about the brace centerline, providing for a more compact gusset plate than more typical methods.

The welds of the gusset plate to the beam and column flanges are sized to be slightly stronger than the expected gusset material strength, so any yielding required to redistribute stresses in the connection will take place in the ductile gusset, rather than in the less ductile weld material. In compression, the gusset provides a hinge zone to permit brace buckling without loss of connection integrity. This hinge zone is at least twice the gusset thickness, as is typical to provide for adequate plate rotation capacity (and as is required by the CBC).

Additionally, the gusset at the beam-column connection (which is a rigid connection) provides haunch plates that aid in the transfer of moment between the beam and column. The presence of these plates relieves the gusset plate from resisting these haunch forces, which tend to cause high stresses at the re-entrant corner of the gusset-flange intersection. These haunch plates also provide stiffening of the gusset to resist compression.

Because of the steep brace angle, braces exert a large vertical force on the beams at the beam/column/brace connection. The relatively shallow beams require reinforcement to transmit this shear to the columns, and the shear plate is extended to serve this function. On the second-floor V-braced frames in the east wing (where the slab is lower to allow for a raised access floor), a different approach was used for the design of gussets at the beam midspan. In order to prevent the gusset from extending above the raised floor, a fixed bracing connection was designed. In this approach, rather than providing a hinge in the gusset to accommodate the rotation associated with brace buckling, the connection is designed to restrain the brace rotation; thus when the brace buckles, it forms a plastic hinge adjacent to the connection (in addition to the plastic hinge that forms at the brace midpoint and the hinge at the other end of the brace). This allows the brace to be brought very close to the beam flange, as no hinge zone is required.

Fixity is achieved by sandwich plates, which provide two additional benefits. First, providing two plates permits the brace-to-gusset connection to transfer forces in a shorter distance, thus ensuring a very compact connection. Second, this connection does not require a reduction of the brace area, so no reinforcement is required; the eccentricity between the brace and the connection, required for the calculation of shear-lag effects, is much smaller. As the braces are expected to buckle out-of-plane, the bracing connection must resist moments that tend to twist the beam. These are transmitted to an orthogonal beam via a section stiffened with split HSS sections. MSC

William Andrews and Rafael Sabelli are principals, and Gon Ng a project engineer, with DASSE Design Inc. in San Francisco.

Owner
DeAnza Community College, Cupertino, Calif.

Executive Architect
VBN Architecture, Oakland, Calif.

Design Architect
Van Der Ryn Architects, Sausalito, Calif.

Structural Engineer
DASSE Design Inc., San Francisco

Engineering Software
ETABS
RAM Structural System

General Contractor
S.J. Amoroso, Inc., Redwood Shores, Calif.