Steel is Sustainable Construction

Creative Quarters

By Beth S. Pollak, with Fred Teitgen, P.E.

The steel-framed expansion of Harley-Davidson's Willie G. Davidson Product Development Center in Wauwatosa, WI is a sustainable structure designed for innovative thinking.

Seeking an addition that would include mock-up space for their product development teams, the Harley-Davidson Motor Company decided to expand its Wauwatosa, Wisconsin-based Willie G. Davidson Product Development Center (PDC). Working as a design-build team, architect Flad & Associates, Inc., Flad Structural Engineers, and general contractor Affiliated Construction Services (ACS) created a new steel-framed addition, which integrated sustainable design principles and earned a LEED™ (Leadership in Energy and Environmental Design) certification. On this and other projects, incorporating structural steel into the building design helps earn LEED points for the use of recycled and locally manufactured materials.

Open Expansion

The existing product development center is a two-story, steel-framed building, with exposed structural elements. The new addition links to the existing center and matches its aesthetic. "We wanted to keep the main product development center as the focal point. The new building resembles and ties back to the original one. Its main corridor links the two buildings," said Marc Schellpfeffer, project architect with Flad & Associates.

The new 70,000-sq.-ft, two-story structure features exposed structural steel throughout, with suspended ceilings only in the conference rooms and rest room areas. This creates a "high-tech garage" feel, said Tim Peckham, construction manager for ACS. The architect and structural engineer had successfully designed with exposed structural steel for the Flad office building, featured in the August 1996 issue of *Modern Steel Construction*, and they were receptive to using it again.

Another reason steel was chosen was for its ability to create large-span, column-free spaces. The first floor has open office cubicles, and the second floor consists of open-studio "mock-up" spaces where Harley motorcycles are developed and perfected. The 100'-long pedestrian corridor linking the second stories of the existing and new buildings features exposed structural steel. "We used as many bolted connections as we could to express the building structure and to provide a more aesthetically pleasing detail within the facility, especially in the main corridor," Schellpfeffer said. "You can see the cross bracing and rods with turnbuckles at every structural bay as you walk through the main corridor."

The bridge was designed in two major sections. The portion to the east is integrated into the existing framing of the older building. "This was a complicated detailing challenge," said Fred Teitgen, P.E., structural project manager with Flad. "A number of new footings were constructed within the older-building's footprint and new gravity/moment frames were introduced. The west portion is rigidly attached to the new building and extends east towards the older building. A longitudinal sliding joint was introduced where the two segments join. Moment-resisting bents resist wind loads perpendicular to the bridge. This allows the greatest sense of openness below the bridge at ground level. The bridge steel was conventionally erected along with the other building framing."

Structural Strategy

Double-angle shop-welded, field-bolted connections were used throughout most of the new structure. Where moment-resisting connections were required for lateral-load resistance, bolted-web, welded-flange connections were used. At the primary lateral-load resisting bays, which used K-braces, the beam-gusset plate assemblies were field-bolted to the columns and the HSS braces were field-welded to the gussets.

Floor beams at 40′ spans are composite W21×44 members spaced at 7′-1″ o.c. Beams with 44′ spans are composite W21×57 members spaced at 7′-1″ o.c. Exterior girders are typically W24×55 members spanning 28′-4″ and interior girders are typically W30×90 members spanning 28′-4″.

Roof joists are typically 28LH08s for 40′ spans and 32LH09s for 44′ spans. W21×44 girders are typically used at exterior bays and 27″-deep joist girders are typically used at interior bays. Columns ranged from W12×53s to W12×96s. In some instances, W16 columns are used where they cantilever above the roof level and receive architectural feature wall panels.

The structure's central light well admits daylight deep into the interior.

A light-well feature essentially slices the roof diaphragm into two sections. "This required a special analysis of the roof diaphragm interaction between the two segments and extension of transfer struts through the sky-well space to interconnect the two segments," Teitgen said. "A longitudinal lateral-load resisting braced-bay was provided at each segment at the sky-well interface."

The office floor used an in-floor electrified cellular steel deck. A distributing trench-header ran the length of the building and required special attention to beam layout to maintain floor-carrying capacity and additional steel angle bracing in the plane of the floor to achieve required diaphragm strength.

Some unique steel rod cross-bracing occurs at every bay crossing the light-well framing. "It is designed to reduce the length of the columns that cantilever above the light-well," Teitgen said. "The bracing is detailed to serve as both a structural and architectural element."

RAM Structural System was used for both gravity- and lateral-load design. RISA-3D also was used to analyze the lateral-load-resisting system as a double-check and to model the sky-well slot in the diaphragm. A Flad spreadsheet program developed from Mathcad and Excel was used to design the connections of the concentric brace system. Floor vibrations were assessed using the FloorVibe2 program.

For the foundation, spread footings were used. The lighter weight of the steel framing helped reduce foundation costs and the amount of excavated material.

Intumescent coating was required in certain areas of the building for fire protection. "The corridor between the existing and the new building required a two-hour fire separation between the two buildings," Schellpfeffer said. "So steel located there that penetrated the two-hour wall required an intumescent coating where exposed."

Steel erection went smoothly. "The steel went up very quickly, in about three weeks," he said. "That's the ease of building with steel: knowing that you're getting a quality structure, that's a simple structure to put together."

Green Choices

The idea to "go green" and pursue a LEED certification originated with ACS, who guaranteed that a sustainable design would stay within the project budget and time frame.

"I promised I'd get the LEED certification at no extra cost," Peckham said. "For me, it's just common sense, and it's the right thing to do. It makes sense economically and it's good for the environment. There's no reason not to do it, because the intent is to create a high-performance, well-designed building anyway."

He says that investing in particular "green"-building design elements created improvements elsewhere that more than offset any initial costs of sustainable construction. "We couldn't spend extra money, so we were forced to do things the right way. When we spent additional money in one area, we made sure we saved an equal amount of money somewhere else. For example, we increased the quality of the building envelope enough to reduce the size of the heating and cooling system. This also reduces the operating cost for the client for heating and cooling the building. We gained LEED points in both areas, and benefited twice by the initial investment."

Another way that costs were managed was through the choice of design-build project management. "We had a single-source contract to design and build, which helped with the cost and schedule," Peckham said. "We like design-build, because it creates a single-source responsibility approach to the work. We can control the money and the schedule, and do it quickly. We can work out a contract with an owner up front, so we can do the site work and excavation before the building design is complete. This allows us to start work well ahead of time. With individual subcontracts for individual parts of the work, we can manage the cost very well."

Sustainable Features

For sustainable site design, one challenge was that the new building was to be located in a wooded area with a wetland that runs through it. "We had to determine how to move materials and erect them on site without moving into any more of the wooded area than necessary," Schellpfeffer said.

The team designed the building to minimize impact and retain the character of the existing wooded site as much as possible, said Garrick Maine, of Flad & Associates. "We did a survey of all the trees and sited the service roads. We minimized the removal of major trees. We removed some of the undergrowth, and replanted it elsewhere on the site."

The building received 11 LEED points for its indoor environmental quality. "Indoor environmental quality was carefully monitored," he said. "We used low-VOC-emitting paints, carpets, sealants and adhesives. For buildings that are renovations or direct additions, you need to make sure that you seal the new building off from existing construction. You have to keep the ductwork clean and use high-efficiency filtration, and provide photographic documentation that you have developed and implemented this plan."

Another aspect of this indoor environmental quality is providing natural light to building occupants. "It's partly so that occupants can have exterior views, and connect with nature; and it's partly energy saving, because with enough daylight, you can reduce the use of artificial light and reduce heating and cooling levels," he said.

In this case, the choice of a structural steel frame helped facilitate the entrance of natural light. "Steel is an open, lightweight structural system that allows for curtain walls and skylights," Peckham said.

Openings through the first floor permit light from the second-floor skylight to enter the first floor. Specialized controls for the dimmers on the artificial lights in the building allow them to adjust depending on the amount of natural light coming into the building.

The project also received LEED credits for the extensive use of recycled materials. "We used materials with high recycled content, and that were manufactured locally, within a 500 mile radius of the site," Maine said. "Flad also has a master specification that addresses LEED credits, and demands the highest recycled content possible. ACS uses it for their subcontractors. Before bidding projects, we ask subs to identify post-consumer and post-recycled products, as well as fabrication and plant locations."

Steel's recycled content is near 100%, and it's a material that can be recycled repeatedly without losing its quality. (For more information on the use of structural steel in sustainable design, please visit **www.aisc.org/sustainability** or view the article "Structural Steel Contributions Toward Obtaining a LEED™ rating" in the May 2003 issue of *Modern Steel Construction,* available online at **www.modernsteel.com**.)

"Everything from the steel to the carpets was recyclable," Schellpfeffer said. "ACS also organized the site to recycle materials that otherwise would have gone to landfill. When subs were working, they had specific dumpsters to dispose of their materials for recycling."

The project team worked with WasteCap Wisconsin to implement a comprehensive construction-waste management plan, which Maine says can save money as well as help the environment. "We produce 136 million tons of construction waste every year in this country, but the Environmental Protection Agency (EPA) estimates that 50%-80% of material on construction projects can be diverted. Flad always tries to implement a good construction-waste management plan, and on this project, 76% of construction waste was diverted."

He says some companies, like recyclers, will purchase waste products, and even companies that don't purchase them sometimes will haul the material for less than what it would cost to send it to a landfill. "Savings here help pay for the administrative efforts, tracking and diversion associated with waste management. The result has been no cost increase, and sometimes money is saved as a result. Harley-Davidson saved $10,000."

The total building cost was about $9 million, of which only $57,600, less than one percent, went towards the LEED certification. Building construction began in May 2002 and was completed in February 2003.

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RAM Structural System, RISA-3D, FloorVibe2

Detailing Software
SteelCad

Steel Joist Supplier
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Intumescent Paint
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Photos courtesy Harley-Davidson Motor Company and Affiliated Construction Services.