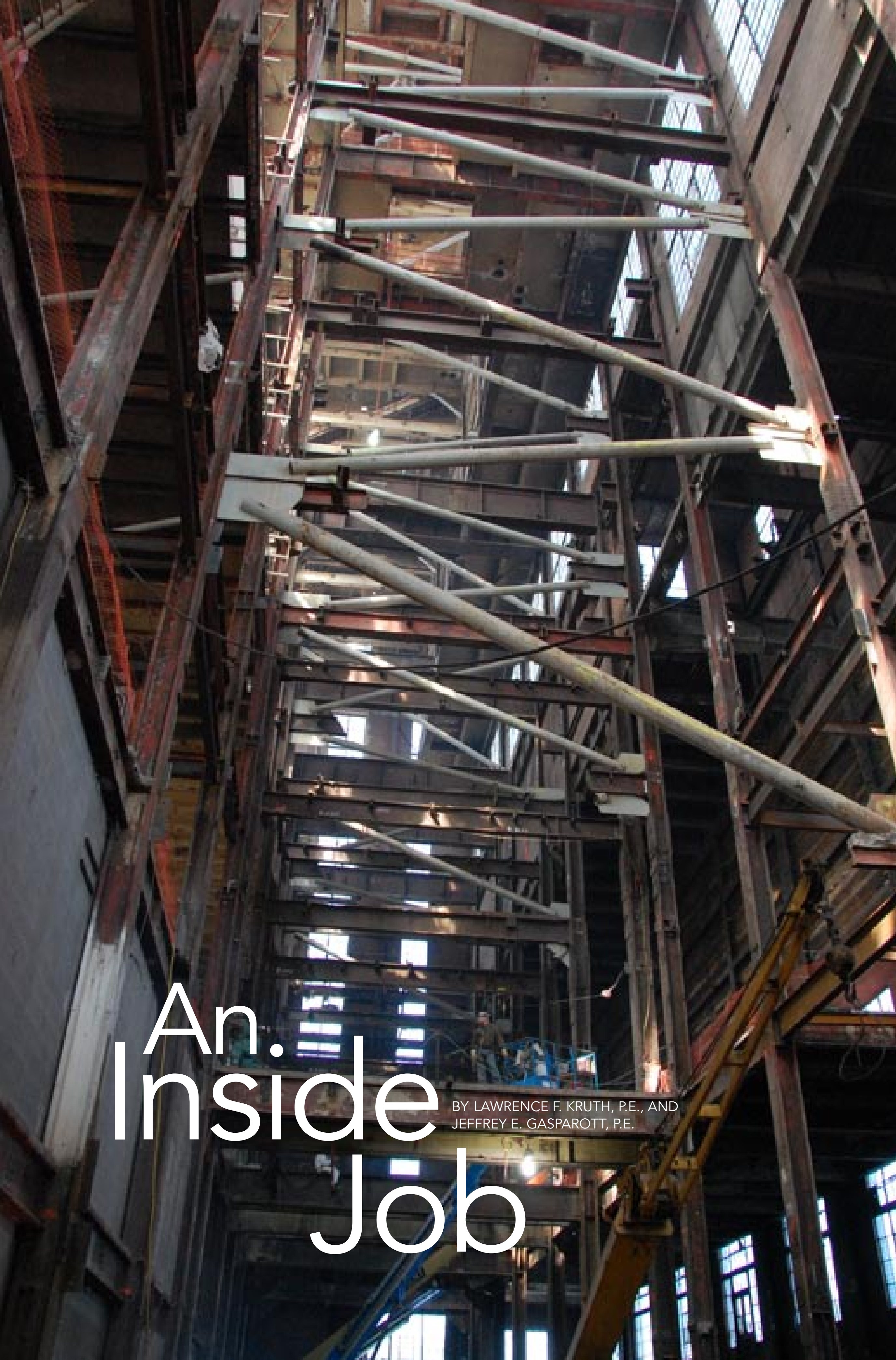


Douglas Steel Fabricating Corporation

An Inside Job

BY LAWRENCE F. KRUTH, P.E., AND JEFFREY E. GASPAROTT, P.E.

Converting a nearly abandoned vintage power station into prime office space relied on a detailed erection plan and flawless execution.

IMAGINE BUILDING a ten-story steel-framed office building inside an existing masonry structure, all the while having to both preserve and support the heavy shell. Then add the complication that much of the existing steel had to be removed before the new framing and floors could be installed. This was the challenge facing the project team charged with renovating the historic and beloved Ottawa Street Power Station in downtown Lansing, Mich.

The team's collaborative solution was much like building a ship in a bottle. Two hatches in the roof would be used for access through which all the steel would be lowered into the structure and set in place. Meeting the challenge was not easy, but not impossible either; and it was heavily reliant on careful and precise craftsmanship coupled with detailed planning and coordination.

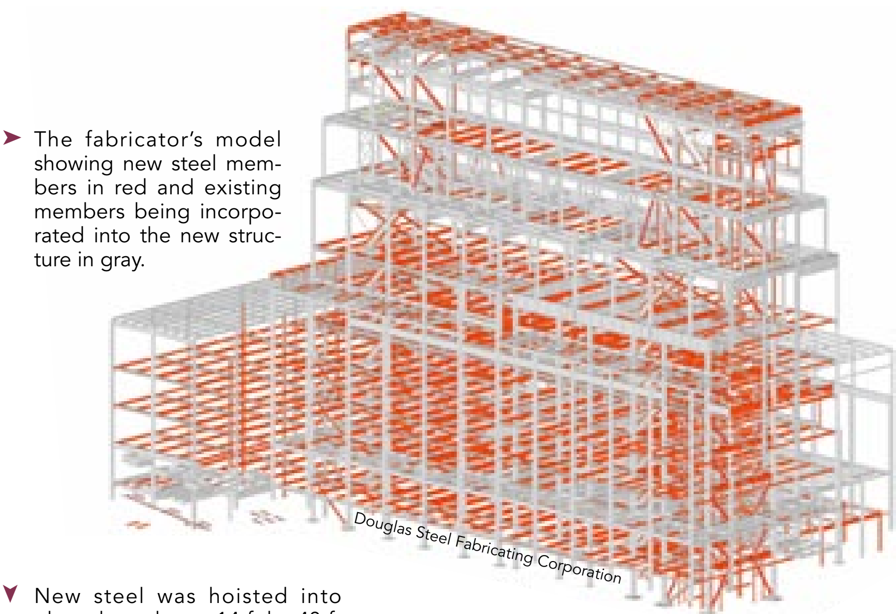
Fabricator involvement began early on this project when representatives of The Christman Company, the Lansing-based developer spearheading the power station's redevelopment, approached Douglas Steel Fabricating Corporation in the spring of 2008.

Christman was seeking the firm's expertise in evaluating design alternatives to convert the power plant into a modern, energy-efficient ten-story office building without disturbing the historical exterior. The decision to reframe the interior steel had provided a vision for the project, but someone still had to figure out how to do it.

Initially Arup, the structural engineer of record, used documents from the original 1939 construction of the power plant to create a Revit model of the structure. Engineers then deleted and added members to the model as required to meet the end requirements of the structure, all the while keeping in mind the owner's and architect's requirements as well as the structural strength requirements.

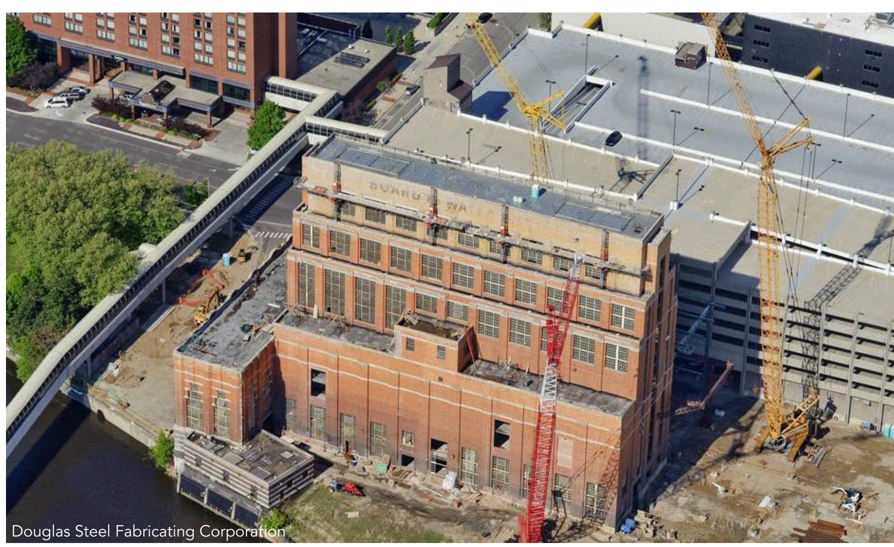
The EOR's new design used the existing columns as part of the new structure as well as most of the existing perimeter beams and some existing interior beams. However, many of the new floors were not at the same elevation as the existing levels in the power plant, so new beams were needed as framing from column to column, infill beams, and additional bracing.

◄ The demolition and removal of old steel and setting the new steel proceeded from the ground up, although the primary portals for moving steel in and out of the structure were two hatches in the roof.



➤ The fabricator's model showing new steel members in red and existing members being incorporated into the new structure in gray.

▼ New steel was hoisted into place through two 14-ft by 40-ft hatches installed in the roof.



Lawrence F. Kruth, P.E., is vice president of engineering, technology and safety with AISC-member Douglas Steel Fabricating Corporation. Jeffrey E. Gasparott, P.E., is a project manager with Ruby + Associates, Inc., and an AISC Professional Member.

Due to the introduction of new loading, many of the original built-up columns and plate girders required special evaluation during the connection design to account for varying material grades and composite sections.

To maneuver the steel in the turbine hall, the fabricator/erector installed a new crane for the duration of the project which allowed the use of the existing crane way.

In the turbine hall, new steel for the fourth floor was attached to the crane rail. The third floor steel was then hung from the bottom of the fourth floor steel.

Throughout the development of the new framing plan, Douglas Steel provided ongoing value engineering suggestions to help minimize construction costs. One such suggestion was to change the 4-in.-diameter rod bracing to HSS sections. It was accepted because this bracing would not be visible in the final construction of the structure and would significantly reduce fabrication and erection costs.

Verifying Field Conditions

Douglas Steel had hired Ruby + Associates to develop a safe method to stabilize the building during both demolition of the interior structural steel and reconstruction of the new building components. From April to September 2008, Douglas Steel and Ruby performed site surveys and evaluated and suggested framing alternatives for this project. These suggestions included revising bracing configurations and developing innovative connections of new steel to existing riveted built-up structural steel shapes.

When the framing design was completed, the EOR provided a CIS/2 version of the model so the fabricator could import it into its SDS/2 modeling software. Due to concerns that the original documents might not reflect actual field conditions, the fabricator then used traditional surveying methods to verify the dimensions and elevations of the second, fifth and eighth floors.

In most cases the building had been accurately built to the dimensions on the historical documents. In fact, the elevations of the top of steel matched exactly. However, there were variations in column-to-column dimensions ranging from -0 in. to +½ in. Based on that finding, the fabricator decided to accommodate up to 1 in. variation in column-to-column dimensions in the connection design for the new beams. That also meant the infill beams would have to accommodate the same variation.

Connection Design

In preparing for fabrication, Douglas Steel used both the historical documents and the building model to locate where each new member attached to either an existing column or member. Each location was laid out on the existing steel, photographed and measured. Quite a few areas were encased in masonry or concrete and were the first areas that the demolition contractor opened up for final measurements and photographs.

In some cases, even though the elevation of the new steel was not at the same elevation as the existing members, the top of steel at the new floor levels was only inches above the existing top of steel. To accommodate that, the fabricator developed a method to use the existing riveted steel end connection as part of the new design while still accounting for the member's potential growth by 1 in., which required evaluating the connection for the maximum eccentricity.

The existing member was removed by carefully removing the rivets in the web of the beam, then inserting a shear plate into the gap between the existing angles. The erection drawings indicated the dimension to be held from hole to hole in the new shear plate. The shear plate was then welded to the existing connection angle and the beam could be erected.

This process of evaluating each connection condition was used for all of the approximately 2,000 beams on the project, based on loading transmitted in the EOR's CIS/2 model. Throughout this evaluation Douglas Steel had to evaluate not only the existing connections but also many of the existing column shapes and plate girders.

Many columns consisted of standard structural wide flange shapes with plates and other structural shapes, such as channels and angles, riveted to the base shape. Similarly, plate girders—some in excess of 7 ft deep—to which new members would be attached also had to be evaluated.

Even though Douglas Steel's in-house engineering staff designed the majority of the connections for this project, the bracing connections were attached to existing columns which also consisted of built-up shapes riveted together. To help with this task, Douglas Steel contracted with Ruby + Associates to design these unconventional connections along with complex gravity connections that mated new framing to the original.

In this connection carefully removed rivets were replaced by bolts as part of the new connection. Also note the slotted hole in the beam seat.

About the Erection

Having developed a good plan for fabrication, the other challenge was how to manage the significant demolition and reconstruction while maintaining the building's structural stability. Acting as the erector as well as fabricator, Douglas Steel developed an innovative erection technique that enabled erection of the internal structure without disturbing the building exterior.

The process involved installing two temporary 14-ft by 40-ft roof hatches in the existing building, hoisting all of the steel from the east or west side of the building through these roof hatches, and setting the new steel from the ground up. That meant that all steel would be set "in the blind"—the crane operator would not see the piece being lowered into position nor would he see the ironworker setting the piece. This required a detailed erection plan with a reliable communication system between the ironworkers and the crane operator. In addition, it would be necessary to demolish as much of the existing steel to be removed and recycled as early as possible in order to open a free path of travel for the hoisted piece from the top of the building to the bottom.

Ruby + Associates performed a structural analysis for the renovation using a finite element model, and provided floor-by-floor sequencing to facilitate and maximize internal demolition while still achieving stability. Ruby's largest challenge was to balance the systematic removal of the ten-story structure's interior with ever-changing load paths, levels of acceptable stress, and overall lateral deflections on the fragile brick façade. Through that analysis, Ruby identified what existing steel members had to be retained as reconstruction occurred, and when those members could be "surgically removed" as reconstruction progressed from the ground up. With careful analysis and planning, structural stability was maintained during demolition and reconstruction without the need for additional bracing being added to the structure.

The procedure developed by Ruby and Douglas was to install all of the new connections on the existing steel beginning by using scaffolding at the basement level to access the steel at the first floor. The connections were installed on the south half of the first floor. Then, as the connections on the north half were being installed, the steel beams and bracing at the south half were erected and bolted up. After the south half of the floor was completely erected, decking and shear studs were installed. The north half steel was erected while the concrete was poured on the south half of the floor.

After the concrete on the south half had set, and while the steel beams, braces, decking and shear studs were being installed on the north half, scaffolding was placed on the new floor on the south half of the first floor allowing the connections for the south half of the second floor steel to be welded into place. By the time these connections were in place, the north half of the first floor had been poured and connections were welded in this

Commitment From All Sides Makes It Happen

The Ottawa Street Power Station, located along Lansing, Michigan's Grand River, is one of the downtown skyline's most distinguishing features. It has been a commanding presence since its construction in 1939 by the Lansing Board of Water and Light. The power station was designed in the distinctive Art Deco style, and is significant for both its grandeur and its role in providing electricity and steam heat to downtown Lansing from 1939 until the late 1980s. Besides the Michigan Capitol dome itself, the power station—with its broad base, stepped arch windows and metal doors, blocky tower form and graded-hue masonry—is one of the capital city's most visually dominating structures.

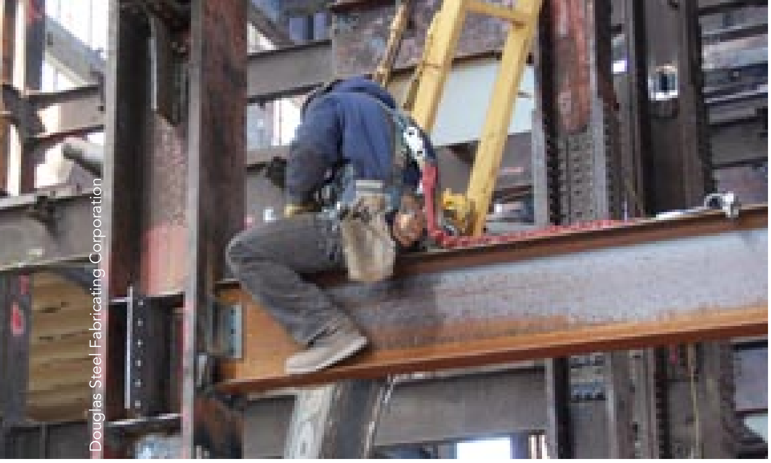
The plant was decommissioned in 1992 and sat idle for nearly a decade as a new use for the structure was sought. In 2001 a portion of the facility was retrofitted with a chilled water plant and high-pressure steam distribution facility to provide cooling for downtown businesses. But that still left the site very underutilized.

In 2007 the Christman Company, a Lansing-based developer and construction management firm, announced with a number of its partners a plan to redevelop the facility into a Class A office environment. There were three key elements to the plan. First, Accident Fund Insurance Company of America agreed to a long-term lease of the facility as its new national corporate headquarters. This kept several hundred jobs in the area, as well as setting the stage for several hundred new jobs in the near future.

Second, to make the project financially feasible, Christman developed a public-private partnership consisting of the Accident Fund and its parent company (Blue Cross Blue Shield of Michigan), Christman, the City of Lansing, the State of Michigan, the Lansing Board of Water and Light (the current building owner), and others. This partnership ultimately will result in the largest package of public financing mechanisms ever assembled for a commercial development in Michigan, including a state job creation grant, brownfield tax increment financing (TIF), state and federal historic tax credits, a renaissance zone, and many others.

Finally, the Ottawa Street Power Station also became registered on the National Park Service's National Register of Historic Places, which further facilitated development of the overall economic package. The overall commitment built among the various participants ultimately is leading to a successful project completion in 2011.

The adaptive reuse of Lansing's 1939-vintage Ottawa Street Power Station through a $182 million rehabilitation is reclaiming one of the city's most beloved landmarks.



▲ Connection design often was complicated by the close proximity of existing steel and connections. Note the slotted holes in the shear plate attached to the column web. To see more photos of this project, visit **www.modernsteel.com/photos**.

▲ The power station's steel framing and grate floors were designed to fit around generators, turbines and boilers, providing access for operations and maintenance. Much of the facility sat unused for a quarter century before the renovation began in 2008.

area while the steel was set on the south half. This same procedure was used from floor to floor throughout the erection process. As the steel was set, the stairs were installed to allow access for all trades as floors were ready.

Using a Temporary Crane

Erection of the steel in the turbine hall area presented an additional challenge. The turbine hall was basically constructed as a lean-to type structure. It had a much lower roof than the balance of the building and only needed to have a third and fourth floor installed in this area. To complicate the matter, the existing turbine crane, crane rail and crane girder needed to remain in the structure for historical reasons. The final design required that the fourth floor steel be attached to the lower portion of the crane girder and the third floor steel be hung from the bottom of the fourth floor steel.

However, the cooling towers for the chillers in the basement were mounted on a freestanding structure over the top of the turbine hall roof. That made it impossible to construct temporary roof hatches for steel delivery and placement as had been done with the main structure.

In order to erect the steel in this area, Douglas Steel decided to take advantage of the existing crane way. The existing crane could not be used because it was a 70-year-old historical artifact and had not been operated for more than 25 years. Instead, Douglas Steel had a custom overhead crane constructed to run on the existing crane rails.

The new crane was sized to span the entire turbine hall and of sufficient capacity to hoist the new steel in this area. Because the crane would have to travel to the outdoor crane way to unload the steel from the trucks, it was equipped with a radio-controlled pendant.

The method used to erect the steel was to unload the trucks at the north end of the building, hoist the fourth floor beam through the large door in that area, then travel to the south end of the building and set the member in place. The third floor beam that hung below the fourth floor beam was then set. That procedure was followed for each of the beams, working from south to north. After the last beam was placed, the custom crane was removed from the outdoor crane way and hauled back to Douglas Steel's storage facility.

Avoiding Economic Surprises

Douglas Steel performed the entire construction process under its Cost Management Program. This required committing to a Guaranteed Maximum Price (GMP) early in the design phase and track costs through the construction process. All back-up cost data was submitted throughout the project with every invoice to justify costs.

While the project remains under construction, Douglas Steel completed the main structural steel erection ahead of schedule, even with a late start due to site delays. Douglas Steel continues to support the construction effort by offering structural design support from in house engineering staff to design supplemental support steel for various items not anticipated in the initial design phase of the project. In essence, Douglas Steel is designing, detailing, fabricating and erecting support steel to prevent construction delays.

Other Project Highlights

The project is expecting to be LEED certified, an effort that started with the inherent sustainability of tapping the embodied energy of a significant existing structure.

Construction waste management has also been significant, with achievement to date of nearly 100% waste diversion, by weight, with 7,000 tons of material, including 800 tons of steel and 600 tons of concrete, diverted from landfill. With respect to salvage, about 75% of the building's existing brick will be cleaned and reused, as well as 95% of existing masonry on the building.

Reconfiguring a power plant into a ten-story office setting involves significant demolition and reconstruction. Managing reconstruction activities to maintain the building's structural stability can be quite a challenge. However, cooperation and communication combined with expertise and everyone's dedication to the success of the renovation has this project well on its way to successful completion. MSC

Owner/Developer
The Christman Company, Lansing, Mich.

Architect
HOK, St. Louis

Structural Engineer of Record
ARUP, Chicago

Construction Engineer
Ruby + Associates, Inc., Farmington Hills, Mich.

Steel Detailer, Fabricator, and Erector
Douglas Steel Fabricating Corporation, Lansing, Mich. (AISC Member)

Structural Software
Revit Structure, SDS/2, SAP 2000, RISA 3D