HIGH ON HEALTH CARE

Project team ingenuity and the use of structural steel meet demanding program requirements for world's tallest children's hospital

By Larry Flynn

"Constructability" is the defining word used by Robert Gallo to describe the driving force behind the design and construction of the new Ann & Robert H. Lurie Children's Hospital of Chicago. From the start of structural steel erection in March 2009, it took only eight months for erectors to reach the roof of the towering 23-story, 1.25-million-sq-ft building, says Gallo, construction executive for Mortenson Power, the joint venture construction manager on the project. The fast-paced erection of the project's 9,400 tons of structural steel was only possible, Gallo says, because the project structural engineer Magnusson Klemencic Associates (MKA), Seattle, and the contractor's erection engineer Ruby + Associates, Farmington Hills, Mich., were focused on "what made the steel frame constructable."

Even though the project is unique in its challenges and design solutions, the structural design enabled the erection process to begin in a conventional manner. "Success for the project came in not trying to find the best theoretical solution, but in seeking the best practical and economical solution that worked," says Gallo.

"It was inspiring to see how quickly everything was going up," says Mortenson Power's Peter Rumpf, building information modeling (BIM) manager on the project, adding that it was no accident. "That happens when the entire team is working well together."

Located on a tight, L-shaped 1.8-acre lot in downtown Chicago's dense Streeterville neighborhood, the site also is impacted by a 30-ft easement on its eastern side. The location and considerable program requirements for the complex health-care facility dictated the architectural expression of the building. The project's architecture team was led by Zimmer Gunsul Frasca Architects (ZGF), Los Angeles, architect of record, with Solomon Cordwell Buenz (SCB), Chicago, as architect of the building exterior and public space, and Anderson Mikos Architects, Ltd., Oakbrook Terrace, Ill., to assist with the medical planning. "The interior program and layout really defined the shape of the exterior of the façade," says Lanny Flynn, principal with MKA's Seattle office. "The team did an excellent job creating a handsome-looking building."

Reaching new heights

According to project officials, when completed in 2012, the $632-million facility will be the tallest children's hospital in the world at 23 stories and more than 440 ft tall. Four basic floor plates comprise the building, but in an unusual configuration for a hospital. Level 1 is straightforward with ambulance bays, the loading dock, storage areas and the drop-off drive and lobby. But Level 2 is unique in that it contains the emergency department and lobby along with two pedestrian bridges connecting to an adjacent hospital and a

Photo: Richard Lanenga, courtesy Zalk Josephs Fabricators

Rising more than 440 ft in the air, the Ann & Robert H. Lurie Children's Hospital of Chicago is the tallest children's hospital in the world.

parking garage. Seven diagnostic and treatment floor plates contain the procedure rooms, imaging, pre- and post-operation facilities and other support programs for the hospital. The 12-story upper level patient bed wing is comprised of two 24-bed pods with each pod divided into three units of eight beds.

Because hospital buildings continually undergo changes, Flynn avoids putting shear walls or braces in areas that require flexibility for planning and future modifications. Elevator cores, however, seldom change throughout the life of a hospital, notes Flynn. At Lurie Children's, concrete shear walls were integrated into the centrally placed elevator core enabling the core to serve as the building's wind-resisting system.

Photo: Magnusson Klemencic Associates

Ten transfer trusses housed in the hospital's 10th mechanical space reduce the number of columns on the first level freeing up space.

floors to other trades. Senior Structural Engineer Ron Goetze, P.E., says the firm used the inherent flexibility of structural steel to address the concerns of the structural engineer of record regarding potential deviations from the intended design load path and to satisfy the constructability-first approach of Mortenson Power. The light weight of the steel frame allowed for reasonably sized temporary support members and connections. Temporary connections were shop-installed and bolted connections were used for easier removal.

Shoring towers were not able to be used in the erection process because of the height to the underside of the cantilever—228 ft to the underside of the 14th floor—and if used the only access road through the site would be blocked. Instead, a cable system with custom pulleys was selected because it could assist in the erection and hold certain members in place while more were brought up for placement. The cable system's turnbuckles also provided a method of fine tuning the steel elevations prior to connecting the permanent vertical truss diagonals.

Transfer trusses eliminate columns

The architectural and structural teams worked together to see that many of the columns stacked throughout the height of the building. There were, however, a number of columns identified early in the design which interfered with the functionality of areas on Level 1, including the ambulance bays, loading dock and the drive-in lanes of the drop-off area. These columns needed to be eliminated from the first level but kept intact in the upper levels of the hospital.

The solution was to use the 42-ft-high interstitial mechanical room space on the 10th level to house 10 transfer trusses. The lower levels were posted onto two transfer girders that worked in tandem. According to Flynn, this eliminated the need to have a temporary erection column, facilitated the erection and construction sequencing and overcame any issues with deformation compatibility. A column at Level 7 was separated, with three levels posting down to transfer girders and three levels suspended by trusses located in the mechanical room.

Photo: Mortenson Power

A six-story super truss, erected using a cable system, cantilevers the last bay of the patient wing from Level 14 through 22.

Cantilevered patient wing

To maintain a symmetrical layout and similar orientation to the units in the 288-bed patient wing for hospital staff, the last bay of the wing cantilevers to the east. A six-story super truss was integrated into the wing at three locations starting on Level 16 and extending up to Level 22. While the vertical load for the truss is transferred to a single column line the chord forces created by the cantilever were addressed at levels 22 and 16.

The braces for the super truss were oriented to allow the corridor to pass through beneath its diagonal braces without interference. The diagonals were placed at three locations in the floor plate. Chord members were transferred through strut action and diaphragm bracing at these locations and extend back, reacting to the concrete core walls of the building.

Ruby + Associates' erection design focused on enabling the cantilevered portion of the tower to be constructed from the bottom up to expedite the turnover date of the lower cantilevered

The cable system shared the construction load with the partially installed permanent system to reduce the impact on the original design forces. A large number of cables were used in the system to keep the load from overloading the first permanent members of the super truss that were put in place. Adjacent framing also was readily available to help support loads from the cantilever. The main building also was used as the back span of the temporary cantilever to support the resistant uplift load. At the completion of the cantilever erection, the turnbuckles provided the means to gradually transfer the shared forces back into the permanent structure using a pre-defined turnbuckle loosening sequence.

The 12-stage erection sequence was modeled to arrive at the theoretical deflections that occurred at each stage. Surveying targets were set up on the edge of the main building and the outer part of the cantilever at each floor level in the cantilevered area to monitor actual relative deflections. The area was monitored daily and the data shared with the architect.

Total BIM a game changer

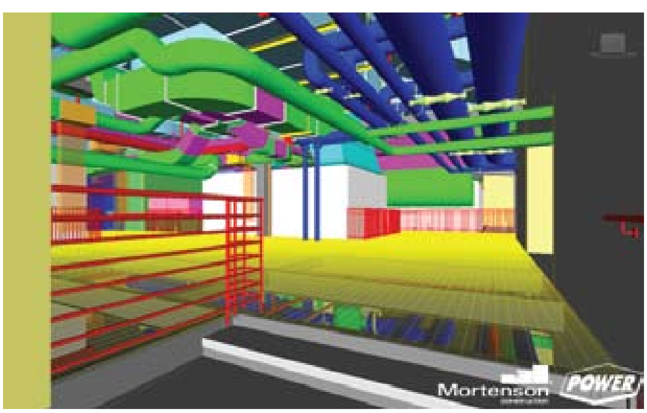
At 1.25 million sq ft, Lurie Children's is one of the largest hospital projects to be designed using 3-D building information modeling (BIM) software throughout, including the complete mechanical design. "No other children's hospital has a 1.25 million sq-ft mechanical design in 3-D," says BIM Manager Peter Rumpf. "It was an enormous effort."

The BIM model also is being used by Mortenson Power as a coordination tool on the project.

An advantage for the project team was that each of the primary members of the team had experience with BIM. Structural engineer Magnusson Klemencic Associates was well versed in Revit structures and other 3-D software as well as various BIM processes. Lead architect ZGF had used Revit Architecture and Mortenson and Power had both used virtual design technologies on notable projects prior to this joint venture "But none of us had done it on 1.25 million sq ft of a research children's hospital," says Rumpf. And few members of the team had worked on projects modeled in 3-D all the way through the mechanical engineering. Affiliated Engineers Inc., Chicago, created a complete MEP design model allowing the MEP subcontractors to better understand the design intent of a very challenging mechanical system. Their efforts directly impacted the success of the coordination process.

The project team was a complex one with the team's consultants located in various cities across the U.S. But the team was able to leverage the technology of software packages such as Navisworks and others to keep the design progressing and coordinated across the project, Rumpf says.

Image: Mortenson Power



Though the hospital's mechanical room space is 42 ft high, this BIM model shows how densely compact the space is.

As contracts were being signed, the entire project team met for four days to decide how to use technology on the project. Roles and responsibilities were defined and the scope of work and level of detail were decided on, as was how data would be exchanged. "What you leave out of the model is arguably just as important as what you put into it," Rumpf says.

With a BIM project of this size and scope, one might expect that complex contracts were created for the project, but not so, according to Rumpf. A traditional CMGC approach was employed for the construction contract. "You can have successful BIM projects that don't have tri-party agreements or shared risk," says Rumpf. "The key is to be incredibly collaborative within the team. You don't need a contract to tell you to do that."

Photo: Mortenson Power

Modeling the entire hospital through mechanical design demanded close collaboration by the BIM coordination team.

A trial design was conducted before the team began work on the children's hospital. Lead architect ZGF designed a mock three-story, 20,000-sq-ft office building and the design and construction team used the same modeling software that each member intended to use on the hospital project. The models were shared by the team and the BIM protocol manual was adjusted based on lessons learned from the trial design.

The dense 10th floor mechanical level has been the most challenging part of the project for the team, says Rumpf. As of October 2009, 10 full-time modelers had been working for eight months coordinating this level alone.

Improvements in the interoperability of the different software packages made the critical difference in the success of the project from a BIM perspective, says Rumpf. "If the project was built five years ago, I don't think we would have had the interoperability to pull it off." He says the BIM management team was able to rely on the integrity of the structural information after it was translated from the SDS/2 analysis model of AISC certified member steel fabricator Zalk Josephs Fabricators, LLC, Stoughton, Wis., and converted from a CIS/2 file into a DWG file for coordination.

"Total BIM is a game changer for the AEC industry," says Rumpf. Just as the auto, aerospace and process industries have been doing for years, building construction is "now able to have a digital prototype of buildings as complex as the children's hospital." ■

Larry Flynn is industry marketing manager with the American Institute of Steel Construction (AISC) in Chicago. In October 2009, Robert Gallo, Peter Rumpf, Lanny Flynn, Ron Goetze and other members of the Ann & Robert H. Lurie Children's Hospital of Chicago project team took part in a breakfast presentation and site tour of the project. Sponsored by the Associated Steel Erectors and AISC, more than 150 architects and engineers attended the event.