Taking Things in a New DIRECTION

BY FAZ EHSAN, P.E., PH.D.

Creative collaboration and framing flexibility allow a university hospital project to successfully take on a major programmatic change well into the construction phase.

All images courtesy of Thornton Tomasetti

ONE OF THE COUNTRY'S largest universities is adding what will be one of the country's largest hospitals to its campus.

Construction of the $464 million James Cancer Hospital and Solove Research Institute at The Ohio State University's Wexner Medical Center (WMC) in Columbus is on track to reach substantial completion later this year. When it opens, the 20-story, 1.1 million-sq.-ft facility will be one of the 15 tallest hospitals in the U.S. The hospital includes seven acute cancer care floors, three critical care floors and one bone marrow transplant floor and will accommodate 420 new beds. In addition, it houses operating rooms, chemotherapy stations, an interventional radiology suite and an emergency department. The design integrates patient care, research and education space on several of the hospital's floors.

Superstructure Selection

The building's structural system consists of a steel superstructure supported on auger cast pile foundations. Resistance to lateral loads is provided by concrete shear walls at elevator cores. As the project is located in a flood plain, a 27-in. concrete mat slab was used in the basement to resist hydrostatic uplift.

The selection of a steel framing system was driven by a number of factors, the most important of which was the need to create a flexible space. Large bay sizes were required to accommodate the variety of programmatic elements to be included in the facility and to minimize column transfers. Typical bay sizes were 30 ft, 8 in. in the east-west direction and varied from 23

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Tower crane tie-ins were used in lieu of traditional tie-in members.

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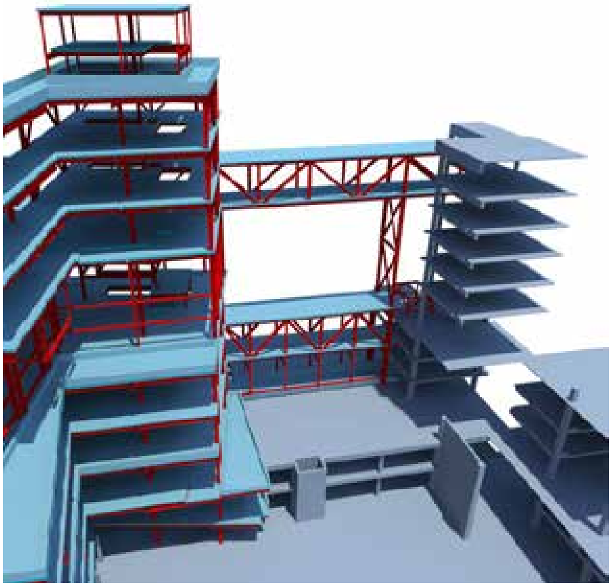
Steel framing for the linear accelerator vaults.

The project uses 12,550 tons of structural steel.

A model of the bridge between the WMC and Rhodes Hospital.



A Revit model of the WMC.

ft, 8 in. to 46 ft, 4 in. in the north-south direction. In all, the completed building will use 12,550 tons of structural steel.

Steel structures are also advantageous for congested construction sites, where portions of a new structure may be constructed over, under and sometimes through existing facilities. For this project, a multi-level bridge spanning approximately 90 ft (employing a steel truss with W14 diagonals, verticals and chord members) connects the new facility to the existing Rhodes Hospital to the east. The bridge was required to span over a portion of the hospital that needed to remain operational during construction. In addition, it required an independent gravity and lateral support system since the existing hospital did not have the capacity to support the new loads. The solution was to support one end of the bridge on two cruciform-shaped steel columns (made from W24×176 members) threaded through the existing building and supported on a grade beam and micropile foundation system, which minimized the disruption to operations.

Sudden Shift

The ability of the steel superstructure to be retrofitted during construction and beyond was another major factor in the system selection. In large complex healthcare facilities, the construction schedule may last for a number of years, with the structural construction proceeding well ahead of the build-out. Advances in medical technology as well as changes in the programmatic requirements of the facility during construction can be addressed with relative ease in a steel superstructure. Such programmatic changes can certainly be significant, but generally not as much as adding an entire floor after construction begins. But that's just what happened with the WMC.

In December 2010, almost three months after construction had commenced, OSU received a $100 million federal grant that was to be used to construct a new radiation oncology center. The center would include seven linear accelerators, a brachytherapy unit, MRI and CT rooms and other support functions. Two options were studied for locating the proposed center: building a standalone facility adjacent to the new hospital or integrating it with the already-under-construction WMC.

In the standalone option, the new radiation oncology center would be built on the site of an existing parking structure adjacent to the hospital. In this scenario, however, travel distances for the patients between the new center and the hospital would be significant. In addition, the parking structure would need to be replaced, adding to the infrastructure costs.

Integrating the new center with the hospital, while minimizing travel distance and eliminating the need to replace the parking structure, had its own challenges. The linear accelerators, with their heavy shielding and vibration requirements, would ideally be located on grade (OSU has a commitment that no patient functions are to be located below grade, where some clients typically might locate linear accelerators vaults). But since the hospital is located in a flood plain, all sensitive medical equipment had to be located on an elevated floor. That being the case, it was determined that the program for the radiation oncology center, in order to fulfill a "patient first" strategy, would be located on a new second floor that would be inserted into the existing design. Other hospital functions would need to be relocated to maximize the benefit of the radiation oncology floor. There would also be a very significant impact on the mechanical, electrical and plumbing systems. But the advantages of improving inpatient movement and the ability to leverage the hospital services in the integrated scheme outweighed potential design and construction challenges, and the decision was made to proceed with the integrated scheme.

A Race Against Time

The building was well under construction when this decision was made, creating a new project schedule that encompassed all trades. Practically all the piles under the building footprint, as well as approximately half of the pile caps and mat foundations, had already been installed. In addition, nearly 30% of the steel superstructure had already been fabricated, up through and including the sixth floor. The start of steel erection was delayed five months, but the new project schedule accounted for this shift and the steel package finished on time within the new schedule. (The overall project schedule was extended by eight months; building an entire new facility would have taken an estimated additional three to four years.)

At this point, the key issues to be addressed included minimizing the impact on the construction schedule and reusing structural components that had already been constructed or fabricated. To keep the pile rigs on site and avoid remobilization, structural engineer Thornton Tomasetti began to develop additional pile and pile cap requirements, based on generalized load assumptions, as soon as a general layout of the radiation oncology floor became available. The structure was also reanalyzed for wind and seismic loads that accounted for the additional height and mass of the building. Additional piles were installed and newly installed pile caps and mat foundations were reinforced to support the new loads. The status of design and construction were reviewed by the design and construction teams via conference calls and web meetings almost every other day.

The steel fabricator, Cives, had already procured all wide-flange steel from the mill and had completed fabrication through Level 6 when the new direction was approved. Detailing was completed through Level 11, with the initial detailing model complete through the roof.

In order to assess the impact of the change to the building columns, it was agreed that the most efficient approach would be for Thornton Tomasetti to develop an entirely new column schedule for the building, which would allow Cives to review against columns that had already been detailed and fabricated. It was determined that more than 825 column members were impacted, and Cives and Thornton Tomasetti were determined to reuse as many as possible. Modified splice locations resulting from the use of existing and/or previously fabricated material were proposed by Cives and were reviewed by the design team. As a result of this collaboration, a coordinated column schedule was developed that maximized the use of original material, and only 17 out of the 825 impacted members were deemed unusable.

For the steel floor framing, the approach was also to reuse and repurpose as many of the members as possible, and more than 3,000 pieces of fabricated steel were reworked to the new design. Beams that had already been fabricated but were larger than required to support the design loads were not replaced wherever possible. At other locations, where the new strength and serviceability requirements were exceeded, previously fabricated beams were reinforced with plates and T-sections. A surplus list of fabricated steel members was maintained and continuously updated by Cives and shared with the design team. As the design and construction continued to progress, "scrap" steel from the surplus list was used wherever possible.

Linear Accelerator Vaults

The location of the linear accelerator vaults on the elevated structure posed unique challenges to the design team. Linear accelerators require significant shielding to prevent radiation from escaping to surrounding areas. The concrete walls, floors and ceilings of the vaults range between 4 ft and 5 ft thick, with areas of both normal-weight and high-density concrete. To minimize disruption to the construction sequence, a steel frame was designed to support the vault floor and ceiling concrete. The concrete slab was designed to be cast in two pours; the initial pour was designed as a reinforced concrete slab on steel deck to support the shielding concrete, which was cast in a second pour. Floor framing members were embedded into the shielding concrete to maximize the headroom at the floor below. Had an all-concrete system been used, the vault concrete would have required shoring down to the foundations two stories below. The steel approach allowed the steel construction to proceed well ahead of the vault concrete placement and hence eliminated the need for this shoring.

Another erection innovation involved the tower crane tie-ins. Due to setbacks in the building profile, which created a large distance from the north tower crane to the superstructure at the tie-in levels, traditional tie-in members were insufficient. Leveraging their knowledge of the base building, Thornton Tomasetti designed and detailed a secondary structure on the roof of the lower-rise portion of the building, allowing the tower crane tie-in forces to be transferred to the base building using conventional tie-in members. (Without the temporary tower, a leave-out bay, through complex spaces on the imaging floors, would have been required.)

The versatility of the steel superstructure to accommodate change, the collaborative approach of the design and construction teams and timely decisions by the owner allowed a very significant change to be incorporated into a project that was well under construction—in a sense adding a "bonus" floor to the building that will no doubt add to its value when it opens. ■

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➤ The multi-level bridge spans approximately 90 ft between the two structures.