

How design-assist and the  
“boneyard” concept cut design  
and construction time in half.

# A World-Class Community Hospital for the American Military

BY MATT MUHLENKAMP, P.E., LEED AP BD+C

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**A KEY ELEMENT** of the U.S. Department of Defense's 2005 Base Realignment and Closure (BRAC) program was modernizing and upgrading the delivery of medical services, especially in the region surrounding the nation's capital. The plan included closing the historic yet aging Walter Reed Army Medical Center and gave rise to a new world-class, sustainable medical facility: Community Hospital at Fort Belvoir, which opened in August 2011.

The challenge was to deliver one of the military's largest hospital projects, which included numerous complex elements, within a relatively short period of time. Using an unusual approach for this type of project, the design and construction team was able to place an early mill order for steel and adopt a plan to design based on pre-ordered and available material. The result was excellent collaboration and timely project completion.

The new hospital is made up of seven interconnected buildings: four clinic buildings fanning out from the central hospital building, flanked by two above-ground parking structures at each end. The three-story and four-story clinic buildings are separated by open courtyards known as healing gardens. Atop each clinic is the hospital's signature architectural feature: a winged roof, which also serves as a collector element to facilitate rainwater reuse. The eight-story main hospital building is positioned in the center of the expanding arch, with a 120-bed "double petal" curved bed tower sitting atop a tiered podium. Sections of the podium that are directly visible from the patient tower are designed as green roofs, enhancing the healing environment and helping the building achieve LEED certification.

### Starting Out and System Selection

At the Fort Belvoir Community Hospital, the mission to bring a full menu of clinical and hospital services to the military community in the region began with a plan to bring the U.S. Army Corps of Engineers, the U.S. Army Health Facility Planning Agency, the contractor and designer together in what was a relatively new delivery method for large hospital projects: Integrated Design-Bid-Build (IDBB). The mission had a clear end date, requiring the hospital be opened and operational by September 2011. With only five years from concept to completion, all the participants recognized early that an integrated approach to project delivery would be the key to success.

Very early in the project the architect and engineers from the HDR-Dewberry Joint Venture identified several framing options as meeting the project's goals. Most notably, these included providing a structure system meeting current code requirements for seismic and wind resistance, as well as the military's requirements for force protection and progressive collapse mitigation. One of the overarching themes of the project was to provide a hospital built to private industry standards while meeting the very specialized security and force-protection needs of a military hospital.

One engineering challenge was to meet both the Unified Facilities Criteria (UFC) and the *International Building Code (IBC)*. Successful integration of these two standards was made easier by a general transformation of the UFC requirements toward those in the current *IBC*. Conflicts between these two standards were resolved by applying the stricter provision of the two codes. Provisions found in the *IBC* were usually, but not always, less restrictive than the standard *United Facilities*



- ▲ **Above:** Steel framing along the perimeter employed adjustable bolted edge angles that were welded into final position. Pre-installed rebar couplers provided for ease in installation of edge reinforcing bars.
- ▲ **Below:** SidePlate moment connections were used throughout the project. The connection from the infill beam to the column stub employed a bolted web connection and field-welded flange connections.

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◀ The curved outlines of the patient tower were created from straight segments.



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- ▲ Braced frames at mechanical penthouses provide the additional stiffness required in these areas.
- ▼ Buildings are connected by truss bridges, which are designed to allow both people and essential utilities to reach the outermost clinic buildings.



*Guide Specifications* language. By finding measured and considered ways to adapt typical industry construction methods while meeting or exceeding the design criteria (UFC and *IBC*), the engineers were able to trim the overall delivery schedule without compromising on the safety and security of the building.

For the superstructure, an ordinary steel moment frame system utilizing SidePlate connections was determined to meet the needs of the architectural layout, the schedule and the budget. Composite steel and concrete framing was employed for the floor framing system. The type of structural system was a factor in preparing the building layout, along with critical architectural considerations, including in-depth studies of patient and provider flow through the building, required equipment clearances and medical adjacencies, as well as the application and updating of the Military Health System guideplates showing room by room equipment layouts. These helped determine the required bay spacing for the clinic and the hospital: 30-ft by 30-ft for the hospital, and 27-ft, 4-in. by 32-ft for the clinic buildings. The SidePlate moment connections were used extensively to increase stiffness. At the mechanical penthouses, braced frames were used to provide the required structural stiffness. The sweeping curves of the clinic roofs and the curved outline of the patient tower were created from a number of straight elements oriented to create the buildings' organic outlines.

During the early stages of design, the general contractor identified potential savings to cost and schedule in the foundation system. Controlled modulus columns were employed to achieve allowable bearing capacities of up to 8,000 lb per sq. ft under the large spread footings, reducing the footing sizes and the quantity of cast-in-place concrete.

### Schedule

BRAC requirements mandated the transfer of medical services to the new Community Hospital at Fort Belvoir begin by September 2011. For the creation of a hospital of this size and complexity, the schedule required a delivery method accelerating design and construction, and overlapping the two. Integrating these elements early, while keeping the essential design and construction functions separate, the goal was to reduce the expected delivery time from 10 years to less than five. No other solution would be able to meet the mandates of the BRAC program.

During the early phases of design and construction, in 2006 and 2007, planing and design of the infrastructure improvements were well under way in order to be ready for the transformation of the open site on the Fort Belvoir South Post into a busy medical complex. Roadway, power and water distribution, and sewer improvements and upgrades were required in order to prepare the site, formerly a nine-hole golf course, for its new mission. The location ultimately housed a number of other construction projects, including the new Medical Command Center, Dental Clinic and Warrior-In-Transition Unit, among others. The construction contract was awarded in September 2007.



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- ◀ Staged construction of the Main Hospital building beginning at the northwest corner. Beyond, the framing of the clinic buildings, including the curved roofs, are nearing completion.
- ▶ The sweeping curves for the winged roofs were created from a number of straight elements.



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- ▲ Framing of the curved roofs at the southern-most clinic is being completed as concrete for the tunnel providing major services from the Central Utility Plant is being cast. The buildings were constructed from the extreme ends inward, from the outer clinic building to the central main hospital structure.

### "Design-assist" and the Boneyard

The essence of the IDBB process on the Fort Belvoir Hospital was a cooperative design process that the design and construction teams referred to as "design-assist." As soon as the general contractor was selected, their personnel immediately began the process of informing and improving the design, which was maturing for core and shell deliverables. This concept of design-assist was not new to the general contractor nor to the architect and engineer, who had successfully engaged in design-assist projects for decades. However, the scale of this project and the schedule and budget pressures required that the design-assist process begin early and that the lines of communication be open and short. In late 2007, the contractor located its project offices within the architect's offices, and work continued in earnest.

Having selected a steel moment frame system, the work of the structural engineering and the steel subcontractor and detailing teams of HDR, Banker Steel, and Mountain Enterprises became the focus of some of the very first design-assist meetings. The Corps of Engineers oversaw, facilitated and directed the work of these teams, although direct communication between engineer and detailer was encouraged throughout the process.

As the design-assist process for the overall hospital continued to modify and change the building, as it would for another four years, the steel team began to focus on the schedule. While design was still evolving, the schedule required that the mill orders be placed. In 2007 and early 2008, the process of shop drawing approval for the clinic buildings began while design was still progressing on the hospital. The design-assist team adopted, with the Corps, the idea of a structural steel stockpile, or "boneyard"—a concept successfully used by the steel contractor on other large schedule-driven projects.

The boneyard concept was simple: As design changed, steel framing members that needed to be revised or replaced because of evolving conditions would be stockpiled and repurposed elsewhere on the project in later phases. The adoption of the boneyard concept allowed early mill orders to be placed and shop drawings to be approved while design on other portions of the building was proceeding. The timing of the early mill orders was integral to completing the project on schedule and to controlling costs. Careful consideration of what was in the changing stockpile was required during the later phases of the project, as various problems were encountered and solved. This interdependence of design, fabrication, and erection of steel



### Community Hospital's Medical Mission

As part of the National Capital Region's integrated military healthcare organization, the medical mission for the new Community Hospital at Fort Belvoir is two-fold. Its primary function is to replace the Walter Reed National Military Medical Center. Provision of clinical outpatient care and long-term care, as well as transitional medicine and cutting edge cancer treatment, are a major focus of 55 primary and specialty care clinics that are located at the new hospital. Nearly half of the 1.275 million sq. ft of building area is dedicated to clinical and specialty care, as well as the administrative offices and operations centers service the new facility.

The new hospital also replaces the aging DeWitt Hospital located at Fort Belvoir. Hospital functions such as surgery, intensive care, emergency, imaging, labor and delivery, diagnostic, and inpatient services are delivered primarily from the main hospital building, which occupies the center of the new facility.



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▲ Serving as an architectural signature, the winged roofs atop each of the four clinics also collect rainwater for reuse in landscape irrigation.



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▲ The new Fort Belvoir Community Hospital replaces the aging Walter Reed Army Medical Center and DeWitt Hospital with a 1.275 million sq.-ft world-class facility.

members was an early hallmark of the project, and set the stage for future cooperation for the entire project. The practice of collaborative design and construction was often repeated in the later phases and with other disciplines, often preceded with the mantra "just like we did with the steel framing."

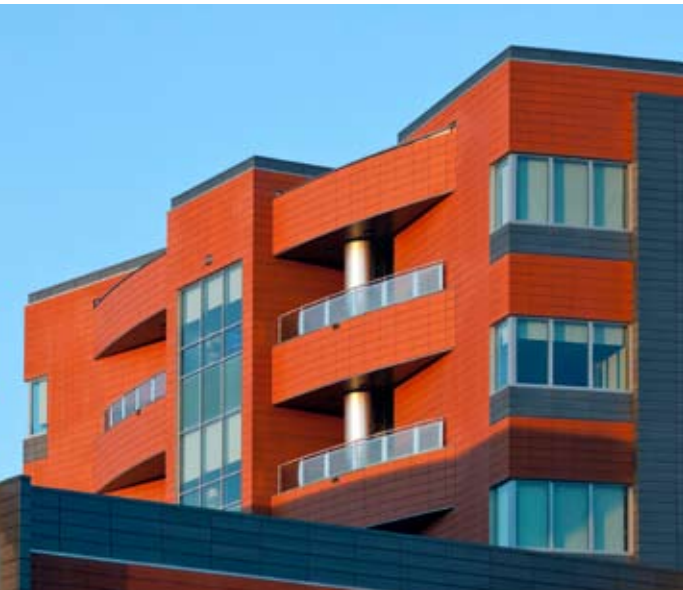
Adapting to changes in the locations, weights, and requirements of specific medical and mechanical equipment proved challenging during fit-out, but was eased by the ability to draw members from this stockpile. As members were efficiently repurposed, the contents of the stockpile rose and fell during the four-year construction of the hospital, resulting in the repurposing of most of members that were part of the boneyard.

### BIM and Coordination "On the Fly"

The schedule-driven just-in-time detailing, approval, and erection process of the structural steel members and supplemental steel framing was a constant challenge on the project. The sharing of BIM models created by both the design teams and the steel detailers was essential to the quick processing of the final shop drawings. The structural engineering team modeled the building using Revit Structure software, while the architectural, mechanical and electrical teams modeled using

both AutoCad Architectural desktop and Autodesk Building Systems. Taking these designs into production, the steel modeling performed by the detailers was primarily completed using Tekla Structures software. The general contractor was able to bring all this information together using Navisworks BIM software packages.

Later in the project, the positive working relationship between the general contractor, the steel fabricators, detailers and the structural engineers helped the design and construction teams overcome many challenges. Fit-out for this complex hospital resulted in competition for usable space among the many systems that were required, including structural, mechanical, electrical, plumbing and medical equipment. Numerous on-site BIM visualization meetings allowed the engineers and contractors to virtually "fly through" the space, finding conflicts and proposing solutions to framing and systems configurations. Meeting and working with the detailed 3D models on site and literally in the shadow of the project, BIM meeting conclusions were immediately followed up by confirmation of the actual conditions as they progressed day by day.



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▲ The distinctive wing shaped layout of the interconnected buildings focuses visitors to the main entrance of the hospital. Native plantings and rain-screen cladding systems were some of the many approaches used to achieve an expected LEED Silver certification, with a possible Gold certification.

### Sustainable Patient Care

Energy efficiency, sustainability and providing a healing environment were important considerations during the design and construction to the Fort Belvoir community as well as to the Military Health System community. Choices of materials and regional sources, optimizing building orientations, and using energy-saving and water-saving features are just some of the strategies used by the design team. Those choices are expected to result in an estimated \$450,000 dollars per year in energy savings due to the 27.6% reduction in baseline energy usage per the ASHRAE 90.1-2004 standards.

Additionally, more than 1.6 million gallons of potable water will be saved each year through the collection and reuse of rainwater for irrigation. Design choices also have reduced CO<sub>2</sub> emissions from the building by more than 4,000 tons per year. The building is currently tracking to achieve a LEED Gold Certification, which exceeds the original goal of LEED Silver. Having met the BRAC mandated guidelines, the Fort Belvoir Community Hospital is now operating as a “Flagship of Military Medicine.”

MSC

#### Owner

United States Government

#### Architect and Structural Engineer

HDR-Dewberry Joint Venture, Alexandria, Va.

#### Steel Team

##### Fabricator

Banker Steel Co., LLC, Lynchburg, Va. (AISC Member)

##### Detailer

WSP Mountain Enterprises, Sharpsburg, Md. (AISC Member)

##### Erector

L.R. Wilson & Sons, Inc., Gambrills, Md. (AISC Member)

#### General Contractor

Turner-Gilbane Joint Venture, Arlington, Va.

#### Construction Manager

U.S. Army Corps of Engineers, Norfolk District