ARMED with Collaboration

BY ANDREA K. REYNOLDS, S.E., P.E.

A collaborative process leads to a bold new facility for a prominent defense contractor.

BAE SYSTEMS WANTED TO MAKE a strong, yet elegant, statement with its new facility.

And the world's second-largest global defense contractor has done just that on an existing brownfield site in Sterling Heights, Mich., formerly owned by TRW Automotive. The new development is vastly different from the surrounding industrial buildings that were traditionally geared towards the automotive industry.

The facility sits on 80.6 acres and is comprised of a 164,000-sq.-ft, four-story engineering building connected to a 55,000-sq.-ft high-bay prototype facility. Both buildings sit adjacent to a reconditioned automotive test track and were designed to house 600 employees.

The long and slender engineering building was sited along an east-west axis to provide the best possible orientation for daylighting. The curved glass end of the building leans forward with a simple elegant move: transforming a rectangle into a parallelogram and creating a prominent point at the northeast corner. The southeast corner is softened with a curve and then this form is extruded vertically while tilted out towards the adjacent main thoroughfare, Van Dyke Avenue. The curve was introduced to soften the ruggedness of the building shape and present a pleasant face toward the street traffic.

Workplace of the Future

The interior of the approximately 400-ft-long by 100-ft-wide engineering building was designed as a "workplace of the future." Structural steel was configured in a regular column grid system that reduced the 99-ft, 3-in.-wide building into bay lengths of 46 ft, 6 in.; 29 ft, 9 in.; and 23 ft and widths of 24 ft. The offset core and enclosed offices were situated in the shorter bays, with the longer 46-ft, 6-in. bays creating a large, open office layout for the engineers—a configuration that maximizes daylight and provides future flexibility.

Structural steel provided a very economical and simple solution for the building structure. W-shape columns support composite steel girders oriented along the width of the building as well as the intermediate composite steel beams, spaced approximately 10 ft on center, that are oriented along the length of the building. The supported floors consist of composite floor slab constructed of 3½-in. lightweight concrete over 3-in. metal deck. The supported roof levels consisted of structural steel framing supporting 1½-in. metal roof deck with insulation and single-ply roofing.

The lateral stability of the building was provided by ordinary steel moment frames. The location of the building in a relatively low-seismic region enabled moment frames as a cost-effective solution that further accommodated the desired flexible and collaborative open work spaces that BAE Systems desired.

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Transparency

Transparency was a key factor in the design, as it was highly instrumental in BAE Systems' own identity and expressive of the environment they desire for their employees. The design of the exterior façade was a challenge for the architect, structural engineer and contractor as large portions were created with curved and slanted glass. The glass was designed in trapezoidal sections starting at the sharp northeast corner of the building and progressing along the curve on the southeast corner, and exposed structural steel provided a light and open cladding support element for the glass panels.

For the canted and curved east end of the building, the exposed structural steel was carefully located to minimize the visual impact on the transparent façade and to coordinate with the architectural details. Rectangular HSS columns were incrementally tilted forward and progressively rotated so that each column would be perpendicular to the façade and have the same minimal appearance when viewed from the building exterior. Adding further complication to the geometry, the transparent, canted and curved portion of the building rises from an expanded footprint at the first floor that follows a compound curve. All of the framing was modeled in Revit. 3D views of the model and a series of plans includ-

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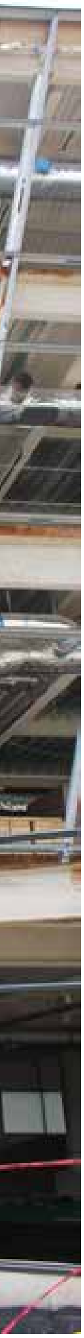
ing coordinate points and rotation angles were used to convey the complicated geometry in a straightforward manner.

Prototype Facility

The design and construction of the prototype facility was fast-tracked to meet the demanding project schedule and development requirements. In contrast to the transparency of the engineering building, the cladding for the prototype facility is very opaque as it is clad with stained black precast concrete and dark grey insulated metal panel. The structural system for the prototype facility consists of 48-ft-long and 32-in.-deep long-span structural steel bar joists that span the north-south direction. The roof joists are supported by W16 steel girders that bear over columns that are spaced 24 ft apart in the east-west direction. The W16s are spliced 5 ft from the columns to create a continuous line of girders. A steel channel girt system was provided to support the insulated metal panel exterior walls. Additional steel columns were introduced around the perimeter along the east and west façades to reduce the column spacing and girt spans to 24 ft. The prototype facility was designed to support several 20T and 40T bridge cranes, as well as column-mounted jib cranes. Steel provided economical solutions to support the cranes from secondary steel crane columns, runway girders and steel rails.

Ordinary steel concentrically braced frames provide the lateral for resisting system. All of the bracing was designed for tension-only loads and consists of single angles in effort to minimize the bracing sizes, detailing requirements and impact on space. The bracing in the east-west direction of the building consist of L4×4 X-braces located along the two interior columns lines. The bracing in the north-south direction are located along the exterior of the building, and the braces use the additional perimeter columns and consist of single-diagonal L8x6 braces to provide space for exterior doors.

The structural system provided a very simple and cost-effective solution to achieve long spans and high-bay space that offered ample space to maneuver and perform research and development on large military vehicles. It also enabled quick construction; the



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The Prototype facility opened within 11 months of breaking ground. The quick construction of this building allowed BAE Systems to get their research operations underway prior to the completion of the office building approximately 19 months later.

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Prototype facility opened in August 2010, within 11 months of breaking ground. The quick construction of this building allowed BAE Systems to get their research operations underway prior to the completion of the office building in March 2012.

Collaborative Process

RAM Structural System was used to assist in the structural analysis and Revit was used to document all of the architectural and engineering systems. The design team used Navisworks for clash coordination between the various systems to reduce issues in the field and potential impacts to the tight schedule; it proved particularly useful for the skewed and sloped framing.

The use of these 3D modeling tools was critical from analysis through fabrication and installation of the steel. The structural engineer creatively considered how the information for the canted curved and rotated framing was conveyed on 2D drawings to ensure proper construction and installation. The plans indicated the coordinates and rotation for each column at both at their tops and bottoms, and snapshots of the 3D model were also included to further clarify the design intent. Additionally, the design team facilitated construction by collaborating in face-to-face meetings armed with analysis, BIM and detailing models to coordinate during the shop drawing submittal process. Together they worked through potential issues as the detailing model was being built, prior to fabrication. As a result, the team was able to essentially eliminate potential issues during the steel erection, and the bulk of the structural steel for both the prototype facility and the engineering building was erected in matter of a couple of weeks, with no erection-related RFIs despite the complicated framing. ■

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