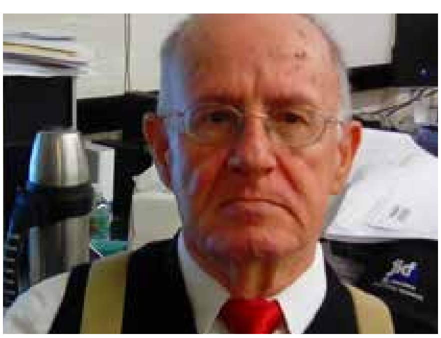
Learning Experience

Photos: Cynthia DeMatteo Falconer

BY JAMES FALCONER, PE, PENG, CYNTHIA DEMATTEO FALCONER, TOM TORRENTI, PE, AND ROBERT GENNETT



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TWO DECADES AGO, in an effort to modernize and improve its public school facilities, the city of New Haven launched its ongoing School Construction Program.

Since its initiation in 1998, the program has seen the renovation or construction of 46 schools totaling 4.2 million sq. ft and $1.6 billion. The latest project under the program is the Reginald Mayo School Early Childhood Learning School, which replaces the Helene Grant School (Grant was a school teacher who worked in the New Haven school system for half a century). The new facility is the largest public preschool in the state and the city's only early childhood learning school.

Framed with nearly 600 tons of structural steel, the main building for the new school consists of two wings with a maximum length of 190 ft—one featuring classrooms, a cafeteria and offices and another dedicated to administrative spaces—that stretch out at a 90° angle from one another from a hexagonal anchor section with a maximum side length of 133 ft. A new, smaller steel-framed administrative building, using approximately 50 tons of steel, was also part of the project.

The L-shaped plan of the main building is a series of block forms that represent the classrooms, with each block requiring long, column-free spans that facilitate open and flexible classroom spaces. The maximum span of the beams in the longitudinal direction is 38 ft, 10.5 in., which is longer than the typical beam span length for this type of building, and beams that support the stud brick façade were restricted to a maximum deflection of 0.3 in. in order to follow the provisions of local building code requirements for masonry walls. As a consequence, heavier-than-normal beams were used.

With a total area of 84,000 sq. ft and a height of 44.5 ft, the main structure consists of ordinary moment-resisting frames built up with 10-in. and 14-in. hollow structural section (HSS) columns (A500 Grade B) and wide-flange beams (ASTM A992) with sizes ranging from W21×201 to W12×40, all topped by a composite steel deck with concrete topping for the second floor and open-web steel joists with non-composite steel deck for the roof. The deck edges incorporate a $3/8$ in. plate to serve as a concrete pour stop as well as to provide horizontal support for the perimeter wall studs. In addition, kicker bracing was deployed along the edge beams to minimize cantilever slab deflection.

A collaborative approach and a team experienced in school construction made quick work of a steel-framed early childhood learning center.

The new Reginald Mayo School Early Childhood Learning School is the largest public preschool in Connecticut.

After selecting the ordinary moment system for the typical framing, the design team determined a minimum column size of HSS 10×10×⅝ everywhere except at the hexagonal center portion, where larger HSS14×14×⅝ columns were required. Moment connections were employed to achieve an unobstructed area of work, and using HSS columns helped facilitate multiple-direction connections at the same elevation in some areas. A number of HSS columns were strengthened, with help from RAM, to prevent local buckling where they connected to the beams. RAM indicates when to reinforce the wide-flange column webs for shear and additionally places top and bottom stiffeners at the beam-column connection points for wide-flange columns—though not in this case since the columns were hollow. Each frame, moment and shear element was analyzed, and the transfer forces to the column were determined to need reinforcement to avoid local buckling. The procedure involved cutting off columns, installing horizontal plates and welding the new assemblies to the original columns.

The center hexagonal building is used as a cafeteria and theater, and its complicated nexus was addressed via a couple of center main frames consisting of HSS trusses connected to the HSS columns and circled by ordinary moment-resisting frames. The center of the hexagon is crowned by a skylight that provides natural light to the cafeteria and is supported by two perimeter strengthened joists that were beefed up to take on the increased load. Because of the required sound isolation between the cafeteria and the classrooms, 8-in. reinforced concrete masonry units (CMUs) were implemented, and the heavy load imposed on the second floor is reflected in the size of the steel support beams, which are W21×166.

The building's exterior consists of steel studs finished with a brick façade, with relief joints distributed along the face of the building. The egress stairs needed to be isolated from the rest of the building in order to achieve a two-hour fire rating refuge as prescribed in the 2012 *International Building Code*. The typical approach is to use reinforced CMUs built as independent towers in the footprint of the building, but the towers interrupted the continuity of the steel frame, thus demanding additional members to circumvent them. As such, the conceptual design of the school did not consider the stair towers as part of the overall lateral-resisting system.

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above: The administrative building uses roughly 50 tons of steel.

above and below: The main school building uses roughly 600 tons of structural steel framing.

In one of the building's large openings, which involved a 25-ft span, steel hangers and kicker bracing were implemented in accordance with AISC Design Guide 22: *Façade Attachments to Steel-Framed Buildings* (**www.aisc.org/dg**). The bottoms of the hangers were back-connected to the roof beams via kickers to control rotation. The load in this particular case exceeded 500 lb per ft, with an eccentricity of 1 ft. Kickers around the perimeter of the building addressed deflections and were used in conjunction with the cantilever steel plate, which was modeled in Revit and placed on top of all the beams around the building, with the second-floor exterior wall resting on it. A decision between using a) thicker plate to take the load of the wall and concrete slab or b) thinner plate combined with kickers, had to be made, taking into consideration that a small deflection of the end of the cantilever slab might cause cracks in the façade bricks. The kicker option was eventually selected as it ended up being the most economical choice.

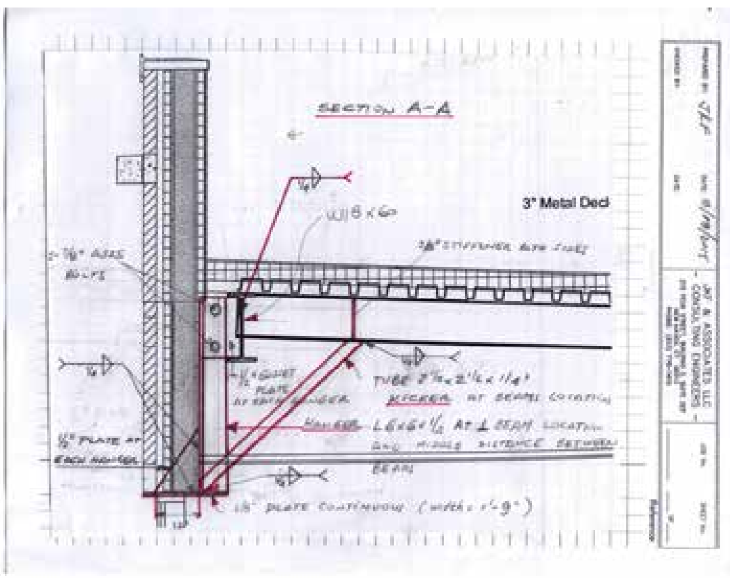
Charles Chamulak, vice president and shop superintendent with fabricator Schenectady Steel, expressed that the sheer number of plate connections was a challenge for the shop. "It was our first experience with such a large number of continuity plate moment connections," he said. "We had done them previously on various projects, but they were typically fillet welds from HSS to plate, whereas this project had a substantial number of full-penetration welds. It was definitely a challenging project as far as fabrication went."

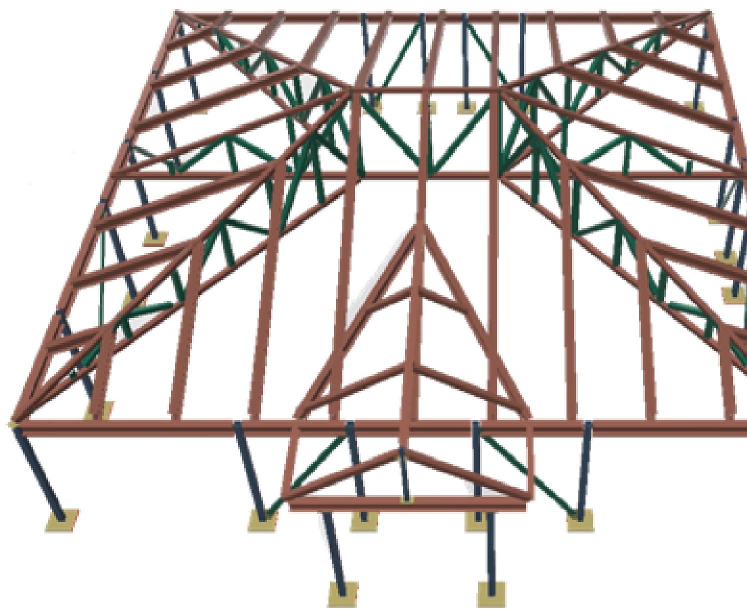
But trial and error proved to be the solution, with Chamulak explaining that the straightness of the HSS column assemblies was maintained by repositioning them numerous times during welding to keep from introducing too much heat on any one side or elevation.

The framing for the smaller, administrative building consists of a combination of HSS sections and wide-flange beams, with the main lateral force-resisting system being made of bracing built up in the perimeter walls. The main vertical force-resisting elements consist of a Warren truss connected to four hip trusses resting on the perimeter wall, which is made up of 6-in. HSS columns topped off by a 12-in.-deep wide-flange section, thus leaving an interior area uninterrupted by columns. The connections of the trusses and purlins to the vertical force-resisting

above and below right: Framing models of the administrative and main buildings.

below: A sample connection drawing.





below: The framing for the smaller, administrative building consists of a combination of HSS sections and wide-flange beams, with the main lateral force-resisting system made of bracing built up in the perimeter walls.

above: With a total area of 84,000 sq. ft and a height of 44.5 ft, the main structure employs an ordinary moment-resisting frame system.

below: Joist framing at the skylight.

For the framing of the main building, the design team determined a minimum column size of HSS 10×10×5⁄8 everywhere except at the hexagonal center, where larger HSS14×14×5⁄8 columns were required.

elements were achieved with high-strength F3125 Grade A325 bolts that provided an adequate safety factor for stability during construction as well as for lateral distribution in the final service condition.

Construction for the entire project was accomplished in 20 months and with minimum change orders, which was facilitated in great part via the collaborative, model-based approach. In addition, several of the companies working on the project had already worked on multiple other area schools in the recent past, so strong communication between team members was realized from the very beginning. ■

Owner
City of New Haven, Conn., School Board of Education

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Gilbane, Inc., R.I.

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Structural Engineers
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Steel Fabricator, Erector and Detailer
Schenectady Steel Company, Inc., Schenectady, N.Y. AISC CERTIFIED FABRICATOR