A Cool School

BY THOMAS A. DIBLASI, P.E., S.E.C.B.

Curving glass walls and enclosed outdoor "rooms" promote this steel-framed elementary school in Connecticut to the head of the class.

GROWTH IS A TRICKY BUSINESS. With it comes new opportunity as well as the stress of modification. In the 1990s, the town of Fairfield, Conn., found itself in the situation where it was outgrowing many of its educational facilities due to an increase in population over the years. In response to this situation, the town embarked on an ambitious school construction program which included extensive renovations and additions to a number of existing schools as well as the construction of three new schools.

One of these new schools was Burr Elementary, the town's eleventh elementary school. Located on a heavily wooded site in the heart of a residential neighborhood, and less than a half-mile from the Connecticut Audubon Society, the project siting created both environmental and political challenges. To navigate these challenges while adhering to a modest budget, the Town engaged the services of Roger Duffy, leader of the Education Lab of Skidmore, Owings & Merrill (SOM).

Blending In

From the onset, it was clear that the design of the project would need to be sympathetic to the surroundings, minimizing any environmental impact. SOM's Education Lab recognizes that the presence of natural light enhances the educational experience, and so a feeling of openness was emphasized. The building was configured to allow existing trees to perforate the plan, creating a series of courtyards that became outdoor classrooms within the building volume. This approach minimized the site disturbances and provided SOM with the opportunity to integrate nature with the day-to-day experiences of the students.

The building design was founded on the *Connecticut State Building Code* which was based on the *BOCA National Building Code* (1996). Under this code, the structure was designed and detailed to resist seismic performance category "C" earthquake loads and 80 mph hurricane wind loads (fastest mile wind speed).

The supported floor framing system of the building consisted of a concrete slab on composite metal deck, supported on composite steel beams and girders. The roof framing system was made of metal deck supported on a combination of steel joists and structural steel framing. Round HSS shapes were used for exposed columns; wide-flange columns were used elsewhere. Lateral loads were resisted by a series of concentrically braced frames.

Thomas DiBlasi is a principal structural engineer at DiBlasi Associates.

Winding Walls

Burr Elementary's most unique feature is the curved glazed curtain wall, which is capped with curved, exposed W27 girders. This façade system was incorporated at the building's entrances as well as the interior courtyards. These curved portions of the building, many of them amorphous in their plan appearance, created the most significant structural design challenge for this project. As the exposed girders served both architectural and structural functions, there was an extraordinary amount of interdisciplinary coordination required during the development of the design concept. While the HSS column locations along the curved façades may at first appear to be quite random, they were, in fact, carefully established to coincide with the curtain wall mullion locations. During the initial design, many of these façade sections incorporated spiral curves. During a 2001 constructability review with the construction manager and a structural steel fabricator while in the design development phase, it was determined that at that time (in 2001), there were very few firms which were capable of bending beams in spiral curves. In order to increase the field of bending firms who could potentially pursue the project, the decision was made to revise the design to only utilize curves with constant radii. To create the amorphous plan shapes, different sections of beams were rolled to the established radii and were subsequently welded together to create the appearance of a single beam with a varying curvature.

In addition to the beam splices required to attain the desired curvature, splices would also be required for shipping purposes. When completed, all splices in the architecturally exposed structural steel (AESS) elements would need to create the visual appearance of a single, monolithic beam section.

Left: The transparent, curved façade of the entrance court was one of the project's biggest design challenges.

Below: A 3-D architectural rendering of Burr Elementary's layout without the roof.

SOM

In the exterior courtyards, the curved steel spandrel beams cap the glazed curtainwall system.

Natural light—known to enhance the educational experience—was a large factor in design considerations.

The means by which the weld access holes would be addressed at the flange groove welds proved to be a bit challenging. The initial thought was to fill the access holes with weld metal. However, after further evaluation, there were concerns that such an operation could lead to triaxial stresses which could potentially crack the flange groove welds. These concerns were ultimately determined to be well-founded when the access holes in the mock-up were filled with weld metal, and ultrasonic testing revealed the presence of cracks in the flange welds. The potential problem was reconciled by filling the access holes with a metallic filler, which was subsequently ground to the contour of the fillet.

To facilitate fabrication of the curved beam sections, the construction documents included detailed layout information for each curved beam segment. As these curved segments did not lend themselves to the use of a conventional column grid system, a separate column layout plan was included in the structural construction documents.

Under the Public Eye

Another challenging aspect of this project was brought about by the low floor-to-floor height in the two-story classroom wings. Unlike more conventional steel-framed schools which feature a floor-to-floor height of 12 ft to 13 ft, this school featured an 11 ft floor-to-floor height. Due to the low height, it was necessary to route much of the ductwork and piping through the beams rather than below the beams. There were more than 150 beam penetrations throughout the structure.

On the surface, this might seem to be an inefficient means by which to design a building, but one must keep in mind that the structural cost of the building is only a portion of the total building cost. As this was a public project, construction cost was under scrutiny throughout the design phase. While there was without question a cost associated with the use of beam penetrations, there was a more significant monetary savings associated with the reduction in the height of the costly curtainwall system. Furthermore, from an HVAC standpoint, the reduced building volume resulted in lower heating and air conditioning costs. The key to the success of this system was close coordination between the structural, mechanical, plumbing, and fire-protection disciplines. All of the penetration sizes and locations were identified on the structural construction documents. Prior to fabricating the structural steel, a final coordination meeting was conducted with the mechanical and plumbing subcontractors, and some adjustments to the openings were made.

To further improve the cost-effectiveness of the structural framing design, each beam containing one or more penetrations was analyzed to determine if web reinforcing was required at the openings; such reinforcing was provided only where it was found to be necessary based on this analysis. Ultimately it was found that reinforcing was required at less than 50 percent of the beam penetrations. In those cases where reinforcing was required, it was identified on the framing plans. Since a reinforced opening is considerably more expensive than an unreinforced opening, significant cost savings were realized by avoiding the temptation to arbitrarily reinforce each beam penetration.

As a result of the collaborative efforts between the various design disciplines and the associated construction trades, construction for this project was completed in 2004 at a cost which was five percent below the owner's budget. In 2005, Skidmore, Owings and Merrill received AIA New England's Citation for Design Excellence. In addition, the project's teamwork was recognized with the receipt of Building Team Project Awards from *Building Design & Construction* magazine and the Connecticut Building Congress. **MSC**

Owner
Town of Fairfield, Conn.

Owner's Representative
PinnacleOne, Middletown, Conn.

Architect
Skidmore Owings & Merrill, LLP, New York, N.Y.

Structural Engineer
DiBlasi Associates, P.C., Monroe, Conn.

Engineering Software
RAM Structural System; RAM Advanse
AISC's WebOpen and WinTorq

Detailer, Fabricator, and Erector
United Steel, Inc., East Hartford, Conn. (AISC member and SEAA member)

Curved Steel
Max Weiss Co., Milwaukee, Wisc. (AISC member bender/roller)

Construction Manager
Turner Construction Company, Milford, Conn.

Photography
Robert Polidori