

Pulling Together

BY MATTHEW H. JOHNSON, P.E. AND PETER M. BABAIAN, P.E.

Collaboration between architect and engineer produces a functional and aesthetically pleasing steel-framed structure.

IN THE SPORT OF CREW, ALL TEAM MEMBERS MUST PULL TOGETHER TO WIN; RACES ARE NOT WON BY A SINGLE ROWER. Similarly, building projects require collaboration and coordination—teamwork—to succeed.

This proved true in 2005, when the engineering firm Simpson Gumpertz and Heger (SGH) worked closely with Jeff Peterson, of Peterson Architects, to design, detail, and deliver a new, state-of-the-art boathouse along the Malden River in the greater Boston area for the Tufts University men's and women's crew teams. As with many projects, a tight budget and construction schedule required a well-coordinated team with early involvement from the structural engineer.

Buoyed by Teamwork

A boathouse, by its basic nature, has a tight plan with a very specific program and layout. Peterson had extensive experience with boathouse design and construction, in addition to personal experiences as a rower. The boathouse is an approximately 10,000

sq. ft, steel-framed structure supported on reinforced concrete grade beams and pressure-injected footings at the river's edge. The first level, at grade, houses all the crew team equipment, including the shells and oars, with some ancillary space for storage and mechanical equipment. The second floor includes locker rooms, offices, meeting rooms, and a grand multi-purpose room with a wall of glass overlooking the river.

The central element to Peterson's contemporary design proposal was a sloping butterfly-winged roof culminating in a 14-ft-tall glass wall overlooking the river. In addition, the design exposed and emphasized the structural framing of the roof and overhanging eaves.

Being involved early and understanding the architectural goals allowed SGH to work closely with Peterson to develop preliminary details that would be the basis of the structural design. Given the budget, schedule, and architectural ambition, SGH recommended a system of composite structural steel floor framing, structural steel roof framing, and a lateral load resisting

system of ordinary concentrically braced frames. For many old and new boathouses in this region, timber and/or engineered lumber are the predominant framing systems. However, the ability to construct a butterfly roof with continuous eave overhangs—on budget and on time—necessitated the use of structural steel. Steel permitted a structure that was lighter in both material and appearance.

Anchoring the Program

The boathouse is positioned with the long axis parallel to the river, which runs north to south. The valley of the butterfly-winged roof slopes north-south at ½:12 and is off center to the west. Each wing of the roof slopes up from this valley. The slope of the short wing (east) of the roof is ¾:12. The slope of the long wing (west) of the roof is 1¼:12.

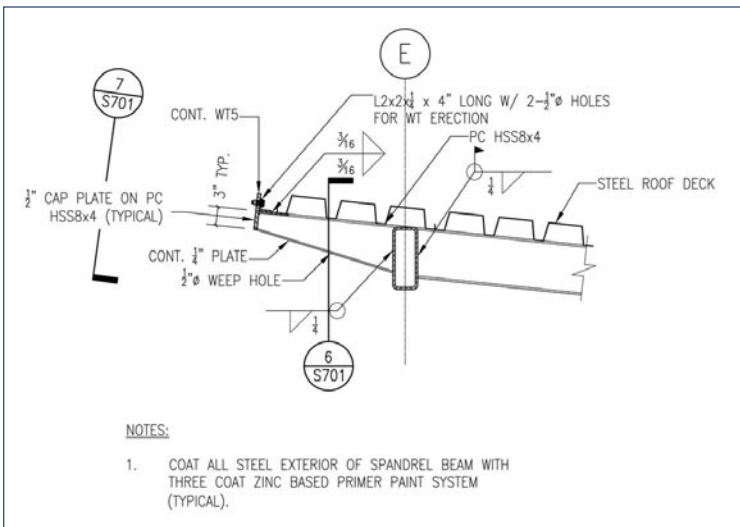
The bay doors for the crew shells are at the south of the long axis. The main entrance is at the southwest corner of the building, where pedestrians enter into a vestibule that contains a stair and eleva-



Top, left: The distinctive cantilevered roof is framed with HSS columns and beams.

Top, right: The wood-framed deck is supported by steel cantilevers. All exterior steel received a three-coat paint system finish.

Left: The tapered eaves are framed with tapered HSS sections fabricated by cutting an HSS at an angle and welding a plate for a bottom flange.



tor for access to the second floor. The first and second floor vestibule in this location projects from the face of the building with a curtain wall that leans out from the building. The butterfly roof extends beyond this projection. The second floor south façade—the high point of the sloping butterfly-winged roof—is a glass wall facing the river. Doors through the glass wall allow access to a cantilever steel-framed deck that wraps around the east side to provide panoramic views of the river.

The dual slope butterfly-winged roof is an aggressive architectural design for a smaller structure. Coupled with the overhanging eaves that project up to 6 ft from the face of building and wrap the corners, it was clear that the bulk of design and detailing efforts would be concentrated around the roof structure. Early on, the architect and engineer collaborated closely to establish preliminary metal deck roof systems, framing layouts, spacing, and a hierarchy of roof beams and girders with respect to their exposure inside and outside the building. SGH also worked with Peterson to review

typical connections as would eventually be developed by a steel fabricator (typical in the Northeast), to understand which connections should be explicitly detailed by SGH (to control their geometry) and which connections would be performance-specified (for design and economy) by the steel fabricator. With this information in hand, SGH-prepared preliminary structural designs, plans, and details.

The second-floor framing is a standard composite concrete and steel floor system with 3¼ in. of light weight concrete placed over 3 in., galvanized, composite metal deck. Typical beams are W16s and are spaced at 10 ft on center to support the dead load of all permanent construction, including hanging shells and oars, and live loads of 100 psf at the second floor.

A central column line at this level helps reduce the depth of the structural framing. The “spine,” or valley, of the butterfly roof is eccentric to the central longitudinal building axis. By providing the central column line between the first and second floor, the transfer girders for columns supporting

the roof are able to be the same depth as the typical floor framing spans (23 ft long with a 10 ft spacing) while maintaining overall material economy.

The roof framing is a 3 in. painted metal roof deck spanning 10 ft on center between beams. For the area over the multi-purpose room, Peterson designed exposed, painted HSS beams, girders, and columns. Tapered HSS outriggers, or through-girder beams, support the extended eave. SGH developed detailed sections of this location, including the connection to the structure and the curtain wall, to assist the steel fabricator.

The detailing of the butterfly roof was key to a cost-efficient, durable system. The details were made as consistent as possible so that there was repetition. Further, the details were coordinated with the architectural roof edge conditions so that the required wood blocking is continuously supported. SGH detailed each overhanging eave condition including the through-girder connection, exterior corner connection, and interior corner connections. Additionally, SGH detailed the

elevation in lieu of providing a slope ratio (e.g. 1¼:12) to eliminate issues or requests for information (RFIs) associated with the anomaly conditions so often connected with seemingly complex geometries. In the end, there were no RFIs associated with the roof design and detailing.

All exposed structural steel was designated as Architecturally Exposed Structural Steel in accordance with AISC *Code of Standard Practice* Section 10. For the exterior girders, SGH worked directly with painting system manufacturer Tnemec to design and specify a three-coat, cold galvanizing and finish paint system to provide architectural quality to the finish, durability to the structure, and accommodate the required field welding details.

The lateral system consisted of ordinary concentrically braced frames in the

exterior walls of the structure. Concentrically braced frames provided the required strength and stiffness as well as material economy. Additionally, concentrically braced frames allowed for smaller HSS columns that could be hidden within the exterior wall construction without pilasters. In the glass wall, the HSS tubes fit within the curtain wall window system as well.

The structural steel framing system was analyzed using the RAM Structural System for gravity and lateral load analysis and design. Hand calculations were used to verify computer analyses and for many of the detailing conditions. **MSC**

Matthew H. Johnson is a senior staff engineer at Simpson Gumpertz and Heger and served as project manager. Peter M. Babaian is a senior engineer and served as project engineer.

Owner

Tufts University, Boston, Mass.

Architect

Peterson Architects

Structural Engineer

Simpson Gumpertz and Heger, Waltham, Mass.

Engineering Software

RAM Structural System

Fabricator/Detailer/Erector

Santini Brothers Iron Works, Medford, Mass. (AISC member)

General Contractor

L/R Construction, Framingham, Mass.