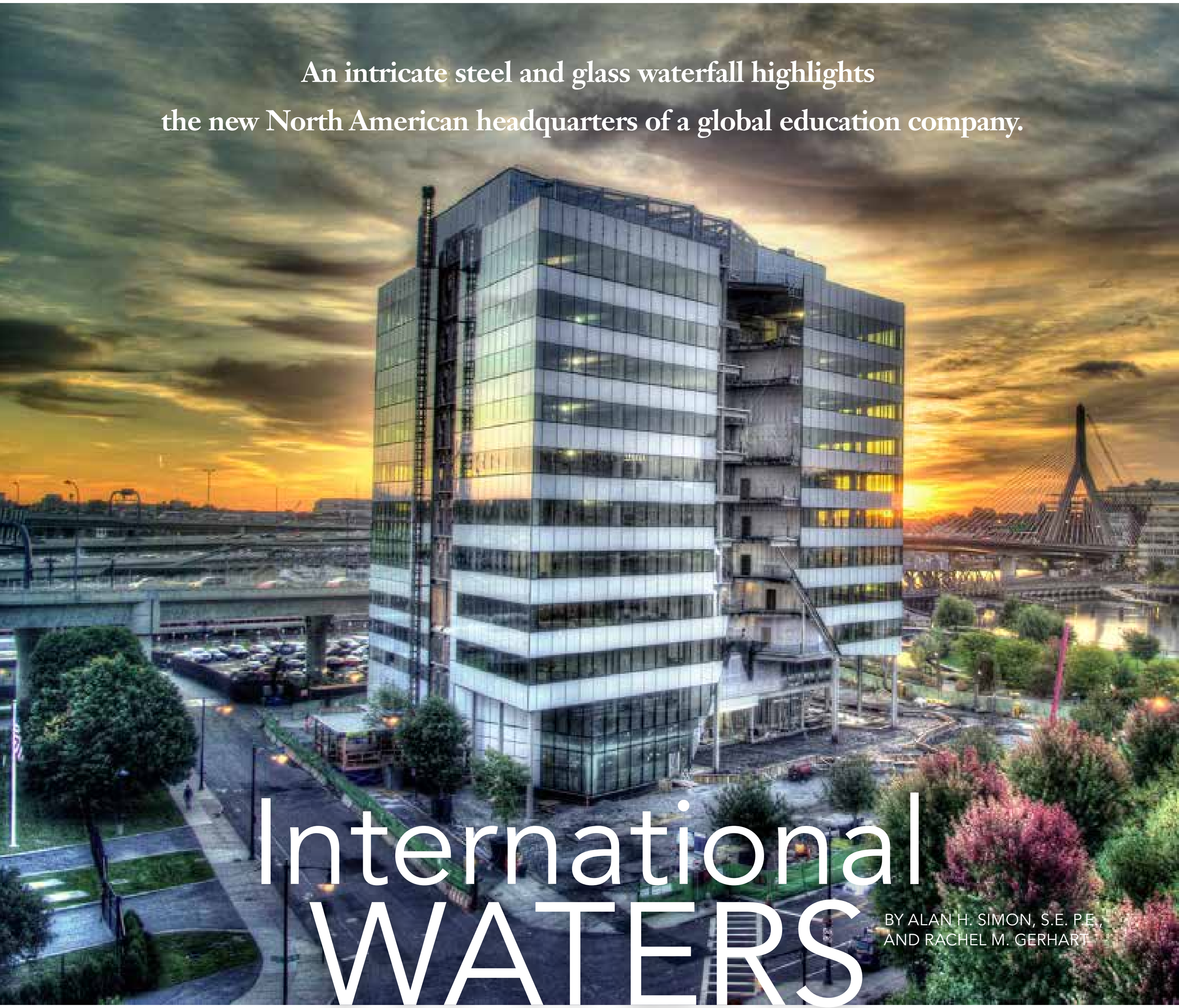
An intricate steel and glass waterfall highlights the new North American headquarters of a global education company.



# International WATERS

BY ALAN H. SIMON, S.E. P.E., AND RACHEL M. GERHART

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**TO DESCRIBE EF EDUCATION FIRST** as worldly would be an understatement.

The company, which turns 50 this year, specializes in language training, educational travel, academic degree programs and cultural exchange, and has 40,500 staff and 500 offices and schools located in more than 50 countries.

And it just unveiled its new $125 million, 12-story North American headquarters facility in Cambridge, Mass., this past fall. The 300,000 sq.-ft building, one of the largest entirely open-plan workspaces in Massachusetts, is designed to capitalize on the facility's 360° views of Greater Boston and uses nearly 4,000 tons of steel. The panoramic views and open, flexible work spaces—as well as the glass and steel "waterfall" entrance—are intended to inspire collaboration and creativity among the EF team members.

EF wanted the new facility—whose address is, appropriately, 8 Education Street—to be more than just a company headquar-

Photos courtesy of EF Education First, Skanska and NIF

Visitors enter EF Education First's new 300,000-sq.-ft North American headquarters via a glass and steel "waterfall."

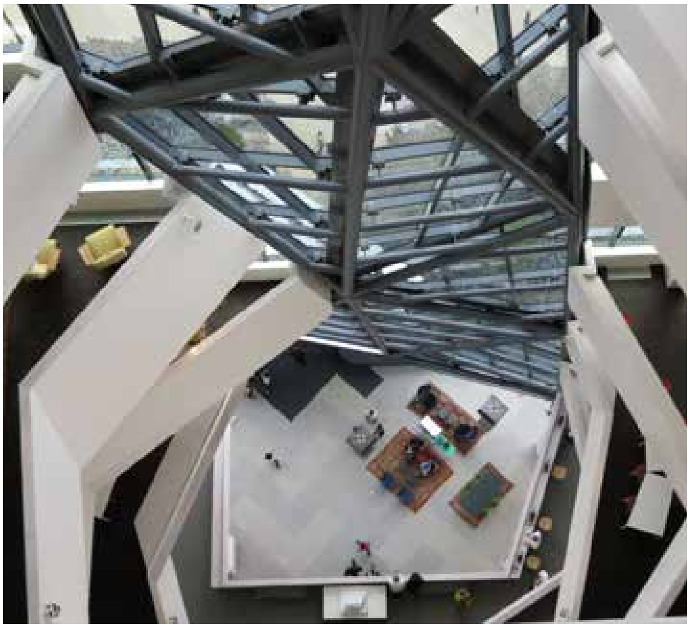
ters. The structure needed to fulfill multiple purposes, including public access to more than 31,000 sq. ft of space on the both the ground and mezzanine floors; a 14,000-sq.-ft restaurant with outdoor seating; staff amenities including a Hubway Station (Boston's shared-bike program), private showers and a salon.

The geometric extruded parallelogram-shaped structure includes up to 16 different flexible workspaces on each of the seven office levels. Each level above the main floor uses a raised-floor system throughout, allowing for more rea-

An inside look at one of the waterfall node castings (left) and connecting a node to five round HSS (right). A combination of fillet and partial-penetration welds were used to complete the connections at each steel node.

One of the complex nodes of the waterfall.

Twelve connection points were used to attach the waterfall frame to the building structure.



sonable floor tolerances and larger open spans—ranging up to 45 ft—with exposed ceilings. In addition, the three lower levels incorporate an enclosed parking garage in the back of the building with office and atrium space in the front. Originally, the garage was designed as a cast-in-place, post-tensioned slab system but was changed to steel to accelerate the schedule and to align the garage framing with that of the building's steel superstructure. As a result, this eliminated the once-needed, heavy transfer girders at the lower parking levels and allowed for moment frames to be converted to braced frames. By changing the garage to steel framing, a total of six months was saved on the overall schedule, allowing EF's owner, Bertil Hult, to fulfill its commitment to the State to occupy the building by the fall of 2014.

The change to braced frames also eliminated a more than 4-psf dead load over the entire building's framing system as well as several time-consuming moment connections. EF also challenged the team to eliminate a pesky column in front of the main entrance, and in the pathway to the elevators, to keep the desired unobstructed, open feel. By using the shape of the building, two columns were merged at the base level into a single 30-ft-tall W14x455 column, which was then offset to a more desirable position and "hidden" in the waterfall. This column branches into a tree column and acts as an inverted truss between levels two and four to support the columns above level four, which remained in their original locations.

## Flowing Façade

The building's most striking feature, and most significant design accomplishment, is the waterfall window structure cascading down the façade of the full 150-ft building height—a centerpiece that reflects the facility's proximity to the Charles River. The glass forming the waterfall protrudes in and out of the building and changes geometry at every level. The waterfall's architectural consultant, Wingardh Arkitektkontor AB of Sweden, collaborated with architect of record Wilson Architects on developing this feature into a curtain wall skin supported by an exposed structural steel frame, which was designed by Simon Design Engineering (SDE).

The team's approach was to create a self-supporting ladder frame for the waterfall, which would lean against the building. The frame itself was made and erected to AESS standards and cleaned to the requirements of the SSPC-SP 6/NACE No. 3, *Commercial Blast Cleaning* standard, with two coats of Tnemec paint applied. Wilson Architects and SDE collaborated on the expression of the structural form, from the aesthetic impacts of connective nodes and exposed curtain wall anchors to the placement hierarchy of the ladder frame members. All framing members are HSS round sections of varying wall thicknesses; in some instances up to 1⅛-in.-thick material was sourced to maintain the desired aesthetic. A total of 100 tons of steel were used to create the waterfall.

The analysis of the waterfall frame needed to account for the relative differential movements, both laterally and verti-

Erection of the waterfall, which uses 100 tons of structural steel and spans the full height of the building.

The waterfall itself was made and erected to AESS standards and cleaned to the requirements of the SSPC-SP 6/NACE No. 3, *Commercial Blast Cleaning* standard; two coats of Tnemec Paint were applied.

cally, of the building frame. Because of its truss-like geometry, care had to be taken in developing releases to assure the waterfall did not end up bracing the building and causing damage to the façade or the waterfall glazing. Twelve connection points were used to attach the waterfall frame to the building structure, eight of which use a custom piston-type slide connection that attaches to the building steel and reaches out to accept the waterfall while allowing for vertical and lateral movement in one direction. Four other slide bearing plate connections provide vertical support but allow lateral movement in both directions.

The waterfall frame's fabricator, Newport Industrial Fabrication (NIF), introduced the idea of steel castings for the nodes, as all the connections for the waterfall are exposed. A preliminary design ensued and after a few trials, a node connection was successfully developed, resulting in the use of eight spherical steel castings of 12¾-in. nominal outside diameter with 1½-in. wall thickness made from grade-50 steel and machined to ±0.03-in. tolerances. The castings were carefully located to retain the desired aesthetic while remaining structurally sound and cost-effective. In addition, the entire system was modeled to accommodate wind and ice development, and a snow-melt system, including gutters, was incorporated into the waterfall design. The gutters are directly supported by the waterfall framing and are integrated into the glazing along designated facet edges to maintain the clean look of the waterfall.

The biggest challenge with the waterfall connections was interpreting the forces at each node and determining the best way to normalize the forces for an analysis. In the end, a finite element model of the waterfall frame was constructed and the forces were resolved by hand for connection design. Each node required its own unique analysis to determine member prioritization and detailing for joining of the HSS members. Full-penetration welds at the connections were avoided due to the increased cost and also to minimize distortions; combinations of fillet and partial-penetration welds were used to complete the connections at each steel node casting.

## Testing a Waterfall

NIF fabricated and welded each node in an arbitrary, accessible orientation, then arranged adjacent fabricated nodes in a second mocked-up position. Once this second position was established, NIF installed 330 one-off curtain-wall attachment anchors. The unique 3D geometry of the space frame and each attachment anchor was developed from the fabrication model, transferred to an adapted survey instrument (a total positioning system or TPS), then used to lay out and build each step of the fabrication. This as-built information was later transmitted to the field, providing direction and troubleshooting, to ensure that the nodes and members were installed perfectly. The perimeter of the waterfall was sealed to the building with an expansion joint to create water-tightness as well as provide a thermal break.

A cantilever stair connects all levels of the atrium and provides a central causeway for truly interconnected spaces that facilitate communication throughout the company. This spirit of collaboration was echoed in the building's design and construction, resulting in a truly unique structure that is helping to revitalize Cambridge's North Point neighborhood and provides a global organization like EF with a world-class base for its North American operations. ■

**Owner**
EF Education First

**Design-Builder**
Skanska USA

**Design Architect**
Wingardh Arkitektkontor AB

**Architect**
Wilson Architects, Inc.

**Structural Engineer**
Simon Design Engineering, LLC

**Steel Fabricators**
United Steel, East Hartford, Conn. – Building (AISC Member/Certified)
Newport Industrial Fabrication, Newport, Maine – Waterfall (AISC Member/Certified)