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Sustainable brilliance at Harvard

A groundbreaking stainless steel sunscreen is revolutionizing climate control at one of Harvard University's largest buildings, keeping it cool in summer and warm in winter. This tensile façade system combines solar control with cutting-edge design and fabrication techniques, utilizing a lace-like Type 316L stainless steel that offers the delicacy and lightness of sheer fabric.

© Brad Feinknopf

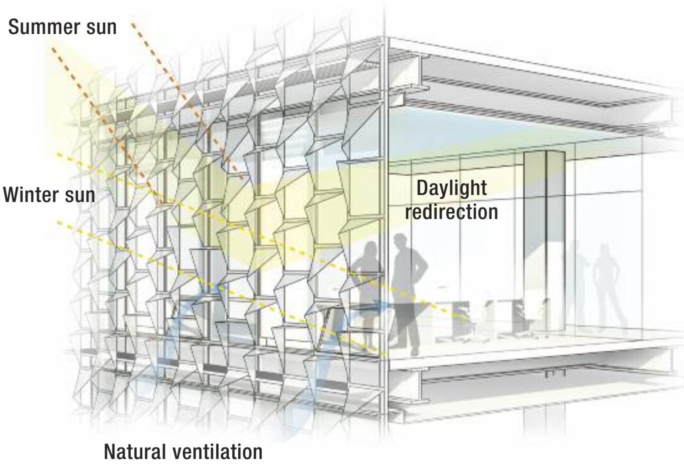
The Science and Engineering Complex (SEC) at Harvard University, opened in 2021, is one of the world's most energy-efficient buildings. The SEC is the landmark of the university's new Allston Campus, located directly across the Charles River from the main campus in Cambridge, MA. Designed by Behnisch Architekten, the complex provides a central location for multiple technical departments, symbolizing the expanding role of interdisciplinary science in the 21st century.

At 50,000 m^2, the SEC is one of Harvard's biggest structures to date. A highly public, communicative zone focused on teaching and collaborative spaces occupies the lower floors. They extend as terraced green roofs into the landcaped courtyard at the southern side of the building. Above, three elevated four-story blocks house laboratory space for biological, chemical, physical, optical, electrical, and computer science research. These lab blocks are connected by two glazed, multi-story atria that provide light-filled social hubs and facilitate natural ventilation. While the terraces and the atria each have their own energy-efficient façade design, the lab blocks have the most spectacular one, featuring the world's first hydroformed stainless steel shading screen.

The SEC complex stands as a beacon for the new Allston Campus, symbolizing innovation and progress.

Energy efficiency and comfort

The hydroformed screen is an important component of a comprehensive integrated climate and energy concept. It sheaths the upper-floor laboratory and research spaces and adapts to the orientation of the building with different panel shapes. All panels of the screen are precisely positioned to shield against solar heat gain during warmer months, while admitting beneficial sun during the winter, significantly reducing cooling and heating loads all year-round. The panels are shaped to bounce natural light inside while still allowing for panoramic views to the outside.



Façade performance diagram. © Behnisch Architekten

Panel development

A team of engineers and lighting and climate specialists worked closely together with the fabricators to optimize the screen panels for strength, fabrication and visual qualities. In the initial design phase, advanced software was used to study the various material and geometric options for the panels and their comparative levels of embodied energy. It was found that CO_2 emissions could be significantly reduced from 1,790 metric tons for a 3 mm aluminum panel to 234 metric tons for a 2 mm stainless steel panel, and even further to 117 metric tons for a 1 mm panel.

The theoretical calculations were followed by practical tests. Full-scale mockup panels, made of stainless steel with thicknesses of 1 mm, 1.5 mm and 2 mm, were tested adhering to specified geometric parameters based on structural, fabrication-related and environmental principles. While the 2 mm panels were the most structurally robust, forming crisp bends and interior corners proved challenging. With 1 mm thickness, the overall stability of the panels was insufficient. Additionally, the long edges were warping, due to the release of the hydroforming stresses when the panels were laser cut, as well as some effects from the heat of the laser. The best result was achieved by using 1.5 mm stainless steel, with integrated stiffening folds. Combined with heat treatment to allow the internal grain structure of the stainless-steel sheet to align with its formed geometry, it proved structurally stabile enough, without compromising the sleek aesthetic of the design. After hydroforming and annealing (heat treating), the panels were laser cut around the edges and silicone bead blasted.

Hydroforming

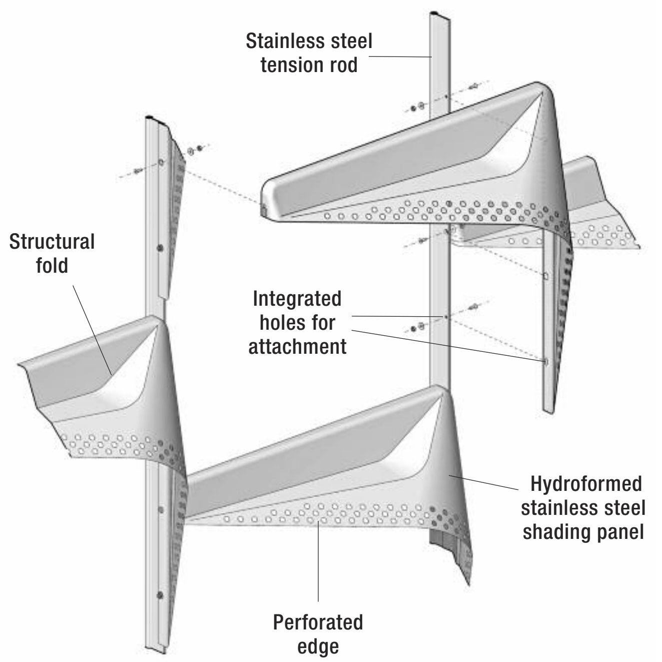
Hydroforming is a cold-working fabrication method where a highly pressurized fluid is used to form metal sheets or tubes into a mold. Since its beginnings in the middle of the last century, mainly in the automotive industry, the process has constantly improved. Nowadays, with the help of modern computer technologies, hydroforming has become an essential technique in various industries, including automotive, aerospace, medical equipment or consumer goods. Modern hydroforming allows for the creation of intricate shapes that would be difficult or impossible to achieve with traditional forming methods. The process is valued for its ability to produce strong, lightweight parts with high dimensional accuracy and smooth surfaces. The inherent ductility of austenitic stainless steel makes them particularly suitable for hydroforming. For example, partially corrugated tubes used for Type 316L stainless steel water service lines, known as SPCT, also make use of the technology to form the corrugations.

A light and airy "veil"

In total, 12,800 screen panels were fabricated in 14 different shapes. Each panel is 0.75 m by 0.75 m and weighs just under 4.5 kg. These panels form interlocking squares that look like the holes of a wide mesh screen at a distance. This mesh visually compresses the enormity of the building. From the inside, the screen's large apertures create a loosely knit square pattern over the unobstructed views out of the windows, providing an unifying aesthetic among the varying interior spaces. All panels are perforated with laser-cut holes around the metal edges to soften the contrast between shadow and light.

The sunscreen is meticulously optimized to withstand New England's vast seasonal changes. The 2% molybdenum in Type 316L stainless steel provides corrosion resistance sufficient to prevent staining from deicing salts used during winter in Boston. This stainless steel also has good ductility, allowing it to undergo significant deformation without fracturing. Good ductility is essential for hydroforming, where the material needs to stretch and conform to the shape of the mold cavity without tearing or wrinkling. The strength of Type 316L stainless steel makes it suitable for applications where structural integrity is crucial.

The thermal enclosure behind the screen is triple-glazed, and punctuated with operable windows to facilitate natural ventilation of the building's interior.



Schematic drawing of the screen components, which are all Type 316L stainless steel. © Behnisch Architekten

The stiffness and the low weight of the panels enabled a minimal tensile support structure. Each panel is bolted directly to vertical Type 316L stainless steel tension rods. The light, minimalist quality of the supports also plays a role in the SEC's comprehensive energy strategy. Heavy support structures used to project external sun shading off a façade can unintentionally darken the building. However, the SEC's airy tensile system blocks little natural light. Those in the building still have sweeping views of the outside while lighting costs are reduced.

Vegetated roof terraces on the lower levels contribute to thermal comfort and offer additional outdoor recreation areas.

LEEDing the way

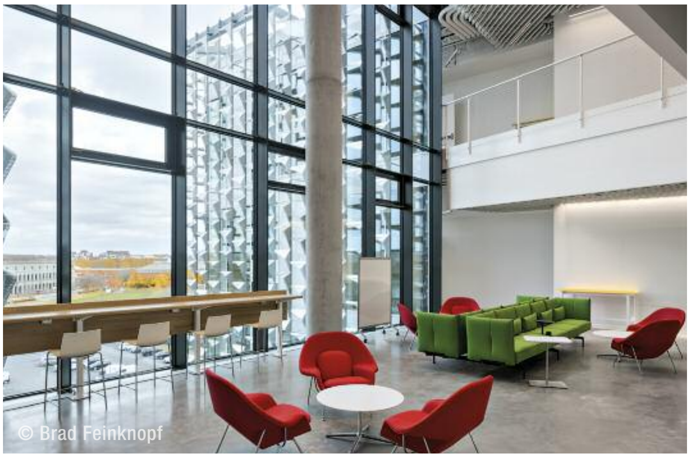
The structure's cutting-edge design reflects the world class research of those who use the building. The SEC is also a groundbreaking example of sustainable building practices. In addition to using a sunscreen to minimize heating, cooling, and artificial lighting, energy is also saved through systems that precisely control ventilation and maximize heat and rainwater recovery.

The façade system also plays an important role because it allows the opening of windows. This enables the extensive use of natural ventilation to circulate fresh air, without the need for energy-intensive fans. For laboratories and clean rooms, which traditionally use enormous amounts of energy for ventilation, appropriate air flows have been carefully determined to reduce ventilation rates without compromising the safety of researchers. Highly efficient heat exchangers transfer the heat or cold from the spent air that is exhausted to the fresh air that enters the building.

The project, which has received LEED Platinum and Living Building Challenge (LBC) Petal certification in Materials, Beauty, and Equity, is expected to have 43% lower greenhouse gas emissions than a comparable standard building.* (Martina Helzel)

* ASHRAE 2010 baseline building

Modular, flexible laboratory environments ensure the adaptability of the space for decades to come.



Generously glazed lounges between the laboratory blocks provide daylight and facilitate natural ventilation.