

# ARCHITECTURAL RECORD



## Straight Story On Curves

Fabrication advances allow architects to make glass buildings that are not only transparent or translucent but sculptural.

*By James S. Russell, FAIA*



Reflections of passing ships move constantly across the rippling, patterned surface of the Elbphilharmonie, a concert hall, hotel, and luxury apartment complex nearing completion on a riverfront site in Hamburg. Ascan Mergenthaler, Herzog & de Meuron's senior partner, describes the sensuous mixture of curved and flat panels atop a brooding 1966 brick cocoa warehouse as “hard and liquid, and at the same time reflective as well as translucent.”

Technical innovation has made curved—also called bent—glass newly versatile. Aesthetic motives vary. While Basel-based Herzog & de Meuron wanted a surface that would react to changing light, Chicago's JAHN is using curved glass to soften the silhouette of 50 West, a 64-story residential tower with rounded corners rising in Lower Manhattan.

More varied and durable coatings for controlling heat gain and glare have improved the performance of curved glass. New vacuum-deposition techniques have made coatings tough enough to be applied prior to a variety of manufacturing steps, says Bruce Milley, the architectural design manager of Guardian, a major supplier to glass-bending fabricators. This improves visual consistency, permitting calibration of thermal properties, reflectivity, and solar heat-gain coefficient, he explains.

Curved insulated glazing units (IGUs)—typically made of two sheets of glass separated by a sealed air- or gas-filled gap—are now possible, even at large sizes, though they remain challenging to manufacture. Giles Robinson, a partner at Foster + Partners in London, points to improved tolerances, which means less waste, he says. Still, every piece must be bent individually, explains Daniele Petroni, a project manager at Permasteelisa North America, which engineers and installs complex facade systems. The process of heating the glass, draping it over a mold, then cooling it down, demands enormous attention

to maintaining exact dimensions and avoiding surface distortion.

Diverse installation tactics help realize the elusive qualities of transparency, translucency, and reflection. The curved-glass IGU panels in JAHN's 50 West are conventionally detailed, with the glass attached on all sides to aluminum extrusions. Foster + Partners, by contrast, uses bravura engineering to minimize the visible profile of framing and structure at Fortaleza Hall, a visitor center that opened in 2010 at the SC Johnson headquarters in Racine, Wisconsin, known for its Frank Lloyd Wright buildings. Fortaleza, a 132-foot-wide oval in plan, has only slender external columns holding up the projecting roof, which shades the glass wall to minimize reflections and solar heat gain. The architects were able to use single-glazed units because only the base of the cylindrical exhibition space, below grade, requires tight temperature control. Narrow T-shaped horizontal rails support glass panels more than 17 feet long and 7 feet high while cables tensioned between the roof and foundation stiffen the entire wall system. The pavilion anticipates the quarter-mile-diameter doughnut-shaped headquarters that the firm has designed for Apple in Cupertino, California. It will be clad in giant bent-glass panels more than 30 feet long and 10 feet high.

On a former horse pasture in New Canaan, Connecticut, a 1,400-foot-long pergola snakes down a slope. Once the \$60 million project is complete next fall, this "river," as it is referred to by its Tokyo-based architect, SANAA, will frame views into a 75-acre nature preserve and retreat. Spaces along the river, including a library, a dining room, and an indoor amphitheater—where the nonprofit Grace Farms Foundation will host events focusing on faith, the arts, and justice—will be almost invisible because they are being enclosed in curved walls of transparent glass.

The broad roof at Grace Farms shades the walls and minimizes reflections, while curved IGUs were chosen for their thermal performance. Painstaking fabrication has minimized the visual interruption caused by the vertical joint at the meeting of panels as large as 12 feet tall and 7 feet wide. The joint itself is about ½-inch wide, but spacers and sealants—covered by a fritted strip for neatness—help it read like a hairline. "SANAA didn't build the architecture around the limitations of insulated units," says Andy Klemmer, project director of the Paratus Group, the project manager. "We set new boundaries for IGUs, to accommodate the architecture."

Two types of curved glass are used at the Elbphilharmonie which, after numerous delays and ballooning costs, is now slated to open in January 2017. In some places, one edge of a IGU panel bulges out or is sucked in, and the resulting gap is filled with a swiveling ventilation panel. Elsewhere, laminated glass flares out from the wall like a wine flute, shaping a balcony rail as a drooping curve.

Glass this complex can require as many as six fabrication steps, with coating, bending, heat-strengthening, laminating, silk-screening, and assembly into insulated units, says Guardian's Milley. At the Elbphilharmonie, a cloudlike dot pattern was silk-screened around the edges of panels, inscribing transparent ovals that express the rhythm of spaces inside and help shield the interior from the sun while maintaining translucency.

With fabricating and installation choices so varied, “there's no rule of thumb,” says Milley, to estimate the additional cost of bent glass. Conventionally sized units mounted in framing off-site reduce the premium. Yet the reason to use bent glass is often to achieve an extraordinary clarity or alluring tactility, which can entail labor-intensive fabrication and installation. Some clients will go the extra distance: “At Grace Farms, we have an incredibly patient client willing to take some risks,” Paratus's Klemmer explained. “They wanted to make the building exceptional.”

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