Shattering Myths About Glass

As architects and builders put more faith in the structural properties of glass, its use has expanded to all areas of design.

By Josephine Minutillo

GLASS MAY BE STRONGER than concrete, but you're not likely to see too many glass columns holding up floor slabs. Nevertheless, more and more projects are beginning to embrace glass as a structural element to create innovative facades and interiors as well as bold urban spaces.

Though vast expanses of glass are not holding up huge sections of the soon-to-open Museum aan de Stroom (MAS) in Belgium, it certainly looks as if they are. The surprising building, designed by Dutch architects Neutelings Riedijk and located along Antwerp's waterfront, contains a series of stacked boxes housing galleries, each twisted 90 degrees and connected by a spiraling staircase. Visitors traveling up the staircase have broad, unobstructed views of the harbor and city center thanks to the groundbreaking use of corrugated glass in the facade.

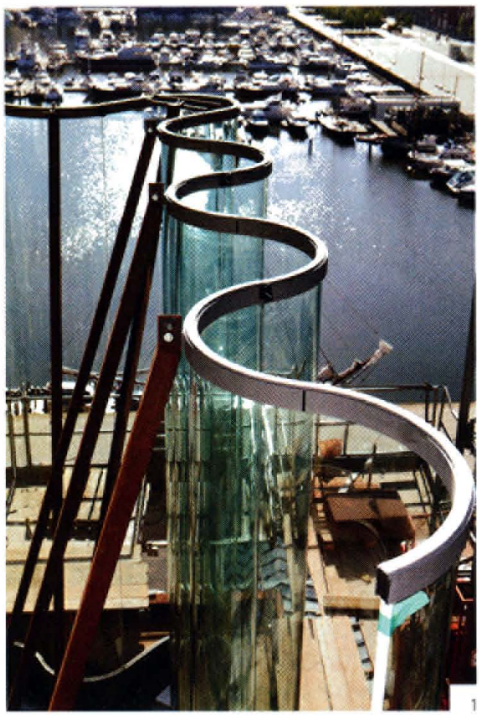
"If you used straight panels, the glass would have been enormously thick because the free span is 18 feet," explains Rob Nijsse of ABT consulting engineers. "Since the corrugated glass is so much stronger in bending, we were able to use ½-inch-thick panels to take up the wind load for the large span." Nijsse first used corrugated glass in the Casa da Música in Porto, Portugal, designed by Office for Metropolitan Architecture (OMA) and completed in 2005. There, three layers of 13-foot-high corrugated panels rest on top of each other to form nearly 40-foot-high window openings within the heavy concrete facade.

With MAS, the heavy elements of the facade seem to float above the glass, which wraps around the building. In reality, the concrete boxes cantilever out from a central core and are separated from the glass panels by a 2-inch-wide airspace. "We had to keep the glass clear of the cantilever because there's a tendency for the concrete to deform slightly when it is loaded with people," says Nijsse.

At the building corners, two layers of 18-foot-high panels are stacked on top of each other. The stacked glass panels in the Casa da Música incorporate steel I-beams to help support the wind load, but only a hollow steel tube, which is set back 1.5 feet behind the corrugated panels, is used for that purpose at MAS's 36-foot-high spans. To connect the stacked panels, a steel U-profile is glued to the top of the lower panel and the underside of the upper panel, then bolted together with a corrugated steel plate in front and back. Structural silicone joins the individual vertical panels, each forming one S-shape 5.25 feet long.

The corrugated glass is fabricated in a similar fashion to curved glass, but goes one step further. A flat glass panel, cut to the appropriate dimensions, is placed in a furnace, where it melts over a mold. Since the glass gets its stiffness from its shape, the designers could use ordinary float glass rather than laminated or tempered glass, allowing significant cost savings.

According to Nijsse, the curved glass only produces slight deformation in views when standing at a distance from the panels. Its effect on the overall building, he says, is a "spectacular openness."



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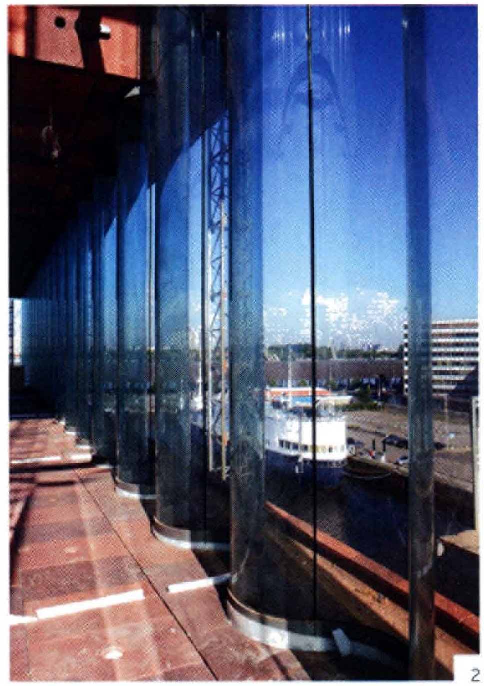

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OPPOSITE: **Soon to open along Antwerp's waterfront, the Museum aan de Stroom was designed by Neutelings Riedijk. The spiraling exhibition "boxes" appear to float above vast expanses of glass.**

1.,2. **The building is one of the first to use structural corrugated glass. Panels 18 feet high are stacked on top of each other at the building's corners.**

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Continuing Education

Use the following learning objectives to focus your study while reading this month's ARCHITECTURAL RECORD/ AIA Continuing Education article. To earn one AIA learning unit, including one hour of health, safety, and welfare (HSW) credit, turn to page 119 and follow the instructions.

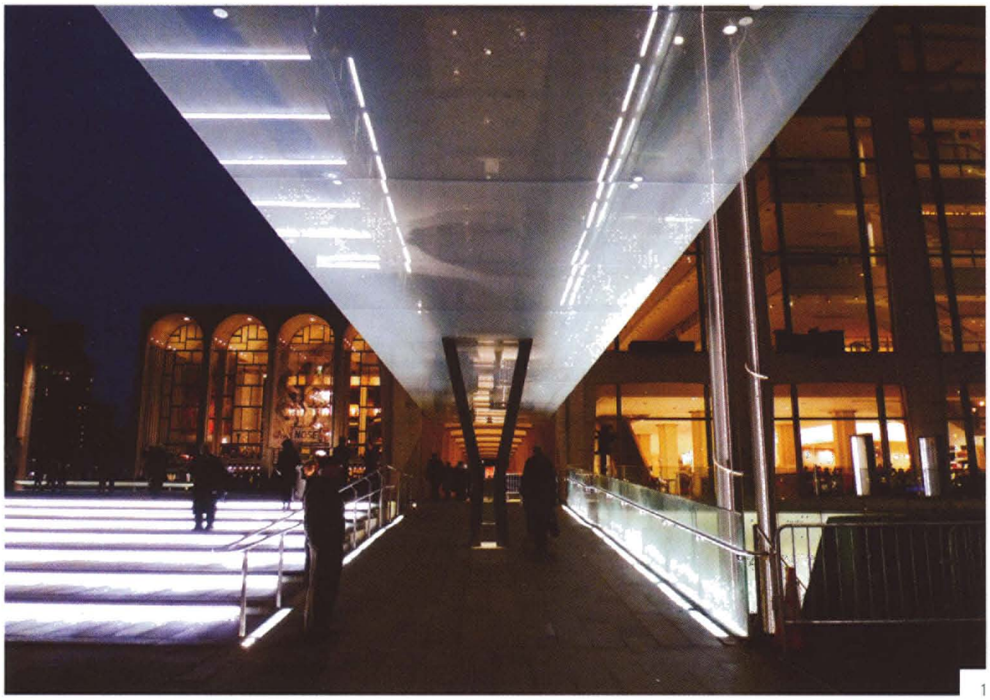
Learning Objectives

1 Recognize the differences between annealed, tempered, and laminated glass.

2 Understand the advantages and disadvantages of various types of glass.

3 Understand how various glass structures are assembled.

4 Identify innovations in the use of structural glass.



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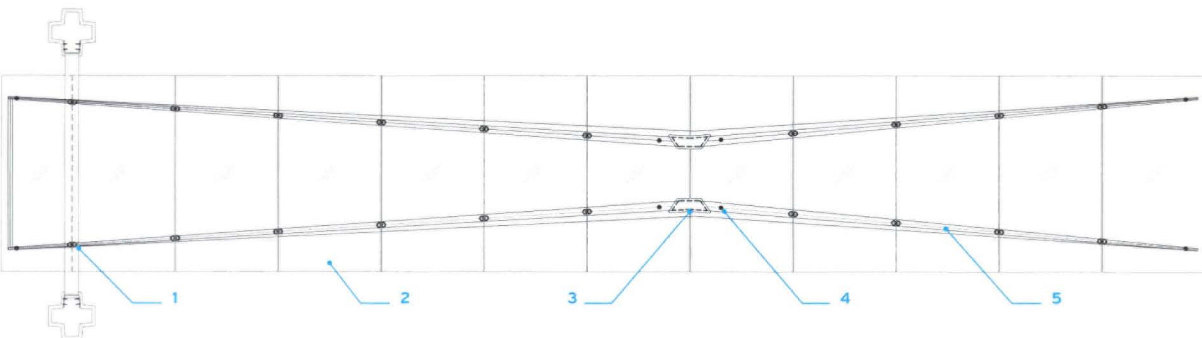
1. Two 89-foot-long glass canopies were recently unveiled as part of the ongoing redesign of New York's Lincoln Center by Diller Scofidio + Renfro.

2. In a design by KieranTimberlake in collaboration with Olin, two all-glass pavilions act as gateways to the transit concourse below Philadelphia's Dilworth Plaza. Connected by a single arcing gesture, each rises 20 feet.



1 Building-interface support member
2 Overhead glazing
3 Pier
4 Rotule fitting
5 Overhead beam

LINCOLN CENTER CANOPY PLAN

Of course, the desire to create a spectacular openness makes glass the material of choice. Diller Scofidio + Renfro enlisted Dewhurst Macfarlane, engineers of the iconic, glass-themed Apple flagship stores, for the design of a pair of canopies at New York's Lincoln Center. "They really just wanted a slab of nothing to keep the rain off people walking from the buildings to the street," recalls Tim Macfarlane. The nearly 90-foot-long canopies connect to existing building columns at one end and are supported by a pier toward the middle, leaving close to 40 feet of overhead glass to cantilever above.

"The real innovation here is that the glass structure stabilizes the steel," Macfarlane says. "We've gone from steel supporting glass, to glass supporting glass, to glass supporting steel." The canopies consist of a series of 14-foot-6-inch-by-7-foot-7-inch glass panels, joined by weathering silicone, underneath a pair of bent steel beams, which, according to the engineers, would buckle were it not for the glass below. A small glass panel located between the legs of the pier provides lateral support to the canopy.

The 2-inch-thick laminated glass, fabricated by the German manufacturer Seele, incorporates another recent innovation. An ionoplast seal binds the layers of glass together for full composite action, making the material itself part of the structure and allowing for a very stiff and relatively thin panel. Panels using earlier bonding materials like polyvinyl butyral (PVB) were not as strong, because the laminated sheets would behave independently rather than as a single unit. "If we didn't use ionoplast, the glass would probably be 3 to 4 inches thick," Macfarlane explains. "It's a big savings in terms of weight." Another project by Dewhurst Macfarlane, for a balustrade at the Victoria & Albert Museum in London, uses ionoplast to bond glass to metal.

Since the canopies' unveiling earlier this year, Macfarlane and his team have noticed that some visitors – who don't seem to have as much faith in the glass as the engineers do – prefer to walk around the glass structures rather than beneath them. For an underground entrance at Dilworth Plaza in Philadelphia, "There's no 'walking around it' option," Macfarlane jokes.

Designed by KieranTimberlake in collaboration with Olin, two 17-foot-wide, all-glass pavilions connected by a single arcing gesture are planned as gateways to a below-grade transit concourse. "A continuous circle is set against a Classical facade," says Macfarlane. "It's a simple gesture that deserved a simple solution."

That solution eliminated any steel structural members or metal connections whatsoever. Instead, the 2-inch-thick laminated-glass panels of the curving roof are joined by structural silicone and supported entirely by vertical glass panels – without fins – of equal thickness. "It's basically a giant glued structure," says Dewhurst Macfarlane associate Nicholas Roach. The walls support all vertical and lateral loads, including wind and snow. Wind loads present the greatest challenge, especially at the top of the staircases, where the wall reaches nearly 20 feet in height. "We needed to transfer those loads down the cantilever where it is stiffer," Macfarlane explains. "The closer you get to the bottom, the more capable the structure is of supporting the load."

PHOTOGRAPHY: © MARK BUSSELL (1); COURTESY KIERANTIMBERLAKE (2)