14: LAMINATED GLASS INTERLAYERS

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DEVIL'S DETAIL

LAMINATED GLASS

Laminated glass consists of two or more pieces of glass bonded together by interlayers. The glass can be flat or curved and the interlayer can be flexible or stiff. Glass thickness and interlayer type will depend on the results of load calculations, glazing system design, and environmental conditions.

The 2015 IBC states, "Glass used in a handrail, guardrail, or a guard section shall be laminated glass constructed of fully tempered glass or heat strengthened glass and shall comply with Category II of CPSC 16 CFR Part 1201 or Class A of ANSI Z97.1."

LAMINATED GLASS RAILINGS

For many years, monolithic tempered glass was the glass type most often found in glass railings. While heat strengthened and tempered laminated glass was always an option, it was not the typical choice. However, requirements in the 2015 International Building Code (IBC) have shifted to laminated glass for safety reasons, and this change has prompted some important installation questions.

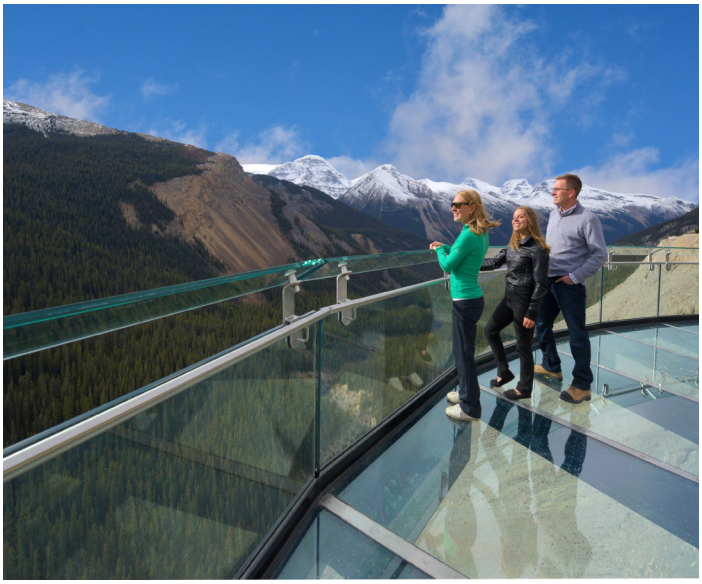
Glazing in railing infill panels should be of an approved safety glazing material with a minimum thickness of one quarter-inch. Although monolithic tempered glass has been replaced by laminated glass in handrails and guards, either tempered or laminated glass can be used for infill panels.

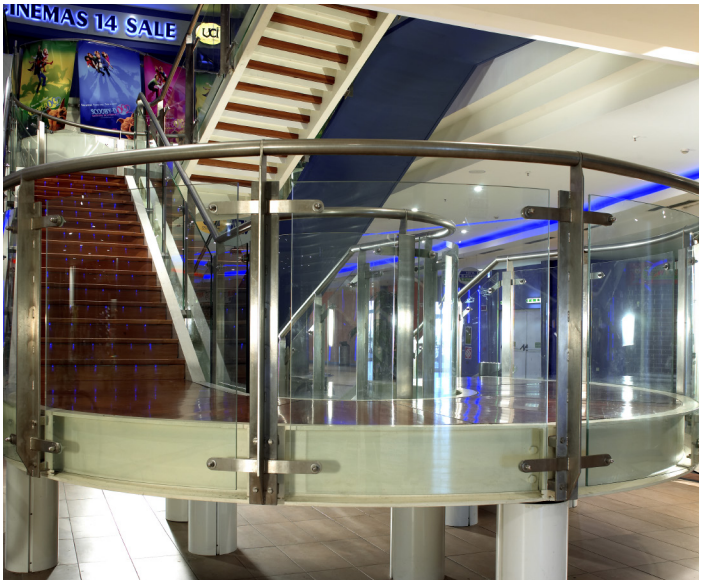
LAMINATED GLASS BENEFITS

Laminated glass offers post-breakage retention of glass particles. Depending on the glazing system design, laminated glass can continue to serve as a barrier until a replacement panel is installed. Even in minimally supported glass railing designs, laminates made with a stiff interlayer can provide some load-carrying capacity after breakage.

Laminated glass can incorporate ultra-clear interlayers that complement ultra-clear glass, or can incorporate translucent and tinted interlayers for greater privacy. Decorative options include printing colors or images on the interlayer from high-resolution graphics files, and the ability to encapsulate materials, such as LED lights.

The most well known flexible interlayer is polyvinyl butyral (PVB). Developed in the 1930s for automotive windshields, PVB offers durability, safety, and improved acoustics. The interlayer effectively blocks up to 99 percent of ultraviolet radiation, a major cause of fading to interior fabrics and furnishings. A minimum .030-inch thick PVB is used for safety glazing; often .060-inch thickness is used with tempered and heat strengthened glass laminates.





STIFF INTERLAYERS

In the stiff interlayer category, Ionoplast interlayers are 100 times stiffer than standard PVB and five times more tear resistant. Stiff PVB is also available to provide greater structural performance, but is limited in temperature to 30 degrees Celsius. Ionoplast interlayers were developed for wind-borne debris protection after Hurricane Andrew in the 1990s, but soon became a popular structural interlayer for glass facades, railings, and walkways. Ionoplast interlayers are available in ultra-clear and translucent white. The .035-inch interlayer can be used for safety glazing compliance, and either .035-inch or .060-inch is used in heat-treated laminated glass.

LAMINATED GLASS QUALITY

ASTM C1172 is the standard used to assess laminated glass quality. While the standard addresses common blemishes that can result during processing, it does not present tolerances for specific architectural applications, such as point-supported glass or glass balustrades, when the laminate edges are exposed. Instead, Section 8.5.3 instructs the user to contact the manufacturer to determine the capabilities. Since many glass railing designs are frameless, the alignment of the two pieces of glass in the laminate presents a critical quality concern.

Post-fabrication of heat-treated laminates is a subject of debate in the glass industry. ASTM C1048, the quality standard for tempered and heat strengthened glass, does not currently allow post-fabrication polishing of glass edges. However, some fabricators offer this option.

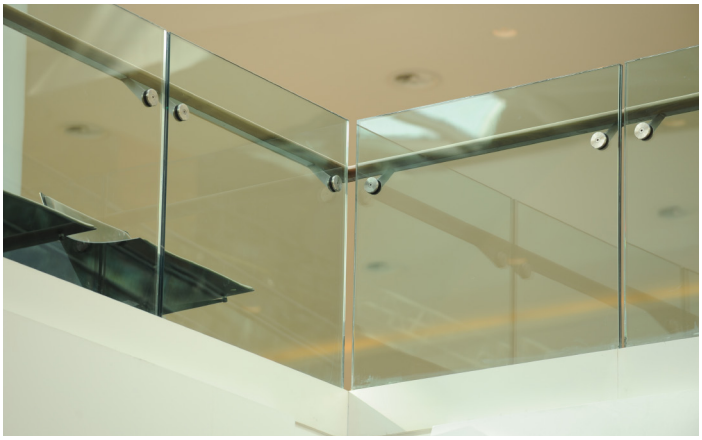
OPEN EDGE DURABILITY

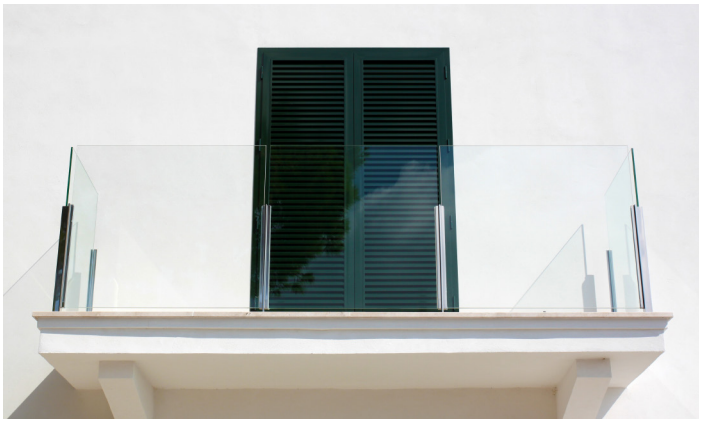
Laminated glass offers years of defect-free performance. Prolonged moisture or water exposure can compromise the durability of the interlayer at its edge. A standard practice incorporates some form of drainage, such as weep holes, to evacuate standing water. PVB interlayers are more sensitive to continuous moisture exposure than ionoplast interlayers. For interior applications, this may not be an issue; however, it does become an important consideration in exterior edge-exposed glass railings. For these applications, the ionoplast interlayer is recommended.

SEALANTS AND SYSTEMS

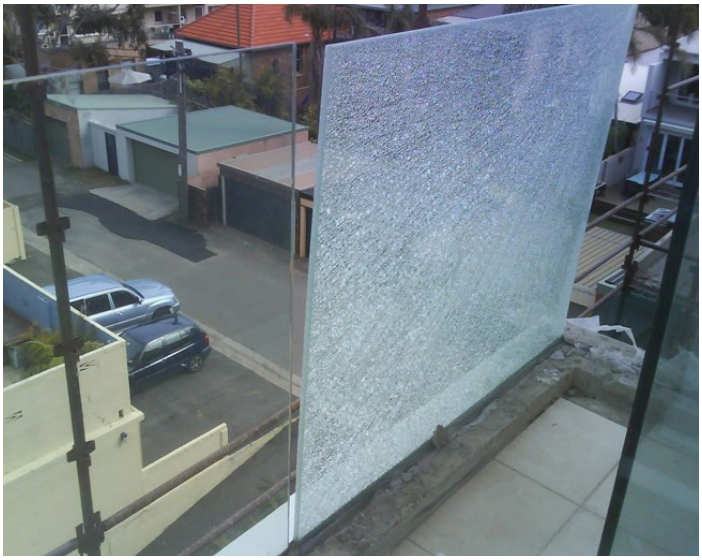
Compatibility of sealants and grouts with laminated glass must be verified prior to installation. Research has shown that moisture plus a highly alkaline cement-based grout can attack the laminate interlayer and result in delamination. Best practices recommend against the use of cement-based grout with laminated glass in wet-glazed railing systems. There are sealants/grouts that have been tested with laminated glass and shown to be compatible. Sika offers a two-part polyurethane grout (Sikaglaze GG 735) that has been tested with both PVB and ionoplast interlayers.

One way to avoid sealant incompatibility is to install a dry-glazed system. These systems do not use sealants or grouts during the installation process, which avoids concern for a chemical reaction between the interlayer and the sealant. Dry-glazed systems typically incorporate a base shoe. The glass panel is held in place through a sealant-free locking system. Suppliers C.R. Laurence (Taper-Loc) and Wagner (Panel-Grip) offer dry-glazed hardware.



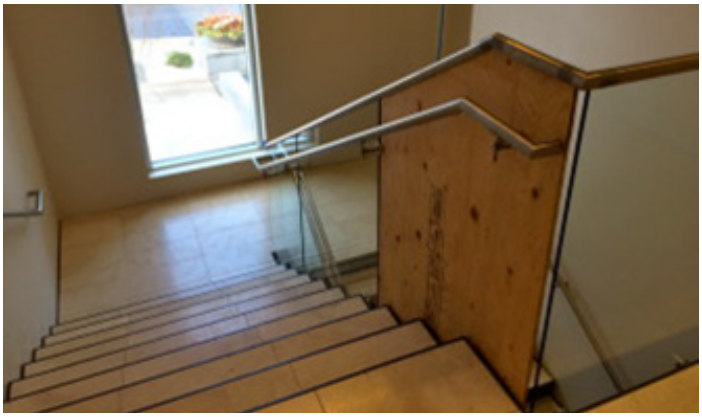


Left to right: Laminated glass railing at the Glacier Skywalk in Canada; curved, laminated glass railing at a movie theater in Genoa, Italy; two views of glass balcony guard rail with top rail eliminated; side-by-side intact and broken laminated panel made with ionoplast interlayer showing how particles remain in place when broken; wood infill panel in glass railing after monolithic tempered glass breakage; impact testing of laminated glass



TOP RAIL ELIMINATION

Glass handrails or guard sections require a minimum of three glass balusters for support or must be otherwise supported to remain in place if one baluster panel should fail. Glass balusters must be installed with an attached handrail or guard. Code permits the elimination of the top rail only if the glass is laminated, with two-ply glass of the same type and thickness, and with approval from the building code official.



WINDBORNE DEBRIS REGIONS

In windborne debris regions, glazing for both balusters and infill panels are required to be laminated glass. When the top rail is supported by glass, the assembly requires large- or small-impact testing. The top rail must remain in place after impact.

INDUSTRY STANDARDS

ASTM has published two standards on glass railings. The test method is ASTM E2353; the specification is ASTM E2358. These standards are available for purchase on the ASTM website (https://www.astm.org). The latest standard to be published in Canada is the Canadian Standards Association (CSA) A500 Guard standard. Published in 2016, the Canadian standard covers design, testing, materials, and installation of guards in buildings.

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Kuraray America, Inc., provided information for this Devil's Detail. Trosifol® – part of the Kuraray Group – is a leading global producer of PVB and ionoplast interlayers for laminated safety glass applications in the architectural, automotive and photovoltaic industries. The evolution of the Trosifol & DuPont Glass Laminating Solutions (GLS) merger over the last three years resulted in consolidation of the Trosifol, SentryGlas® and Butacite® product brands into a single brand: the new Trosifol. Trosifol now offers the world's broadest portfolio of innovative glass-laminating solutions, including structural and functional interlayers for safety and security applications, sound insulation, and UV protection. For decorative applications, Trosifol supplies colored interlayers, digitally printable films, and other innovative products for interior design projects. UltraClear films exhibit the lowest Yellowness Index (YID) in the industry. Trosifol serves the ever-changing demands of the global glass industry with seven worldwide production sites and five R&D centers. For more information, visit http://www.trosifol.com.

Valerie Block is an Architectural Marketing Consultant covering the Northeast for Kuraray. She lives in Philadelphia and is a frequent presenter at industry events.

To schedule an AIA LU Continuing Education Session (1 credit HSW) on Safer Glass Railings Made with Laminated Glass, contact Valerie Block: valerie.block@kuraray.com.

RESOURCES

"Tracking down Glass Baluster Failure," by William J. Nugent and Mark K. Schmidt, Architects' Guide to Glass, October 2007. (http://industry.glass.com/USGlass/2007/October/balustrades.htm)

"Use of Laminated Glass in Glass Railing Systems," Glass Information Bulletin, Glass Association of North America, March 2011. (http://imaging-sciences.com/images/stories/LD%2009-0311%20-%20Use%20of%20Laminated%20Glass%20in%20Glass%20Railing%20Systems.pdf)

About the Devil's Details

The AGI educational series illustrates and describes common glazing challenges as a means to communicate best practices for the design and construction industry, not as a sole source for design guidance. AGI recommends design professionals consult with an AGI contractor regarding specific project challenges. AGI contractor profiles may be accessed at www.theagi.org. To share a devilish detail of your own, contact info@theagi.org.