GLASS RAILING

Speaker: Tony Leto, The Wagner Companies

Agenda

• Types of glass used in glass railings
• Post systems vs. glass balustrades
• Wet Glaze vs. Dry Glaze
• Code Requirements
Types of Glass

- Annealed glass
- Heat strengthened glass
- Tempered glass

Float Glass

- Made by floating molten glass on a bed of molten metal, typically tin.
- This method gives the sheet uniform thickness and very flat surfaces.

Also known as the Pilkington process, named after the British glass manufacturer Pilkington which pioneered the technique in the 1950s.
Annealed Glass

• Annealing
  – Process of slowly cooling glass to relieve internal stresses after it was formed.
  – If not cooled slowly, internal tension (stress) will be there making it instable and subject to breakage.
  – The process may be carried out in a temperature controlled kiln known as a Lehr

Annealed Glass

• Annealed glass
  – Glass which has not been annealed is liable to crack or shatter subjected to relatively small temperature change or mechanical shock.
  – Break Pattern ➔
    • Results in dangerous shards
Heat Strengthened and Tempered Glass

- Both are produced using the same processing equipment
- Heating the glass to approximately 1,200 degrees Fahrenheit, then force-cooling it to create surface and edge compression

Heat Strengthened Glass

- The cooling process is slower, which means the compression strength is lower. In the end, heat-strengthened glass is approximately twice as strong as annealed, or untreated, glass.
- Break Pattern ➔
Tempered Glass

- The cooling process is accelerated to create higher surface compression and/or edge compression in the glass.
- It is the air-quench temperature, volume and other variables that create a surface compression of at least 10,000 pounds per square inch (psi).
- This is the process that makes the glass four to five times stronger and safer than annealed or untreated glass. As a result, tempered glass is less likely to experience a thermal break.
- Break Pattern
  - breaks into small pieces
  - suitable for safety glazing

Nickel Sulfide Inclusions

- Contaminants that sometimes make it through the float glass manufacturing process
- Will cause spontaneous glass breakage over time
- *Butterfly* wings indicate fracture origin
- Total elimination difficult but good suppliers make a difference
- Gas fired vs. oil fired ovens
- Heat soaking
Heat Soaking

- Heat soak testing is a destructive test.
- Tempered Glass is put into a heat Soak Oven and brought to and held at a temperature of 555 degrees Fahrenheit for two hours.
- Most glass containing Nickel Sulphide will shatter during this process and thus be eliminated from the glass project.

Edge Finishes

<table>
<thead>
<tr>
<th>Edge Diagram</th>
<th>Description</th>
<th>Typical Application</th>
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<tr>
<td>Ground</td>
<td>Flat Ground</td>
<td>Silicone structural glazing with exposed edges</td>
</tr>
<tr>
<td>Ground</td>
<td>Flat Polish</td>
<td>Silicone structural glazing where edge condition is critical for aesthetic purposes</td>
</tr>
<tr>
<td>Ground</td>
<td>Ground Pencil Edge</td>
<td>Mirrors, decorative furniture glass</td>
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<tr>
<td>Ground</td>
<td>Polished Pencil Edge</td>
<td>Mirrors, decorative furniture glass</td>
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<tr>
<td>Ground</td>
<td>Ground Miter</td>
<td>Silicone structural glazing</td>
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<tr>
<td>90° Angle</td>
<td>Bevel</td>
<td>Mirrors, decorative furniture glass</td>
</tr>
<tr>
<td>Natural Cut</td>
<td>Seamed Edges</td>
<td>Normal edge treatment for heat-treated glass</td>
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Laminated Glass

- Two or more lites of flat or bent glass and one or more interlayers
  - Bonded together with heat and pressure
  - Flexible interlayers
    - Standard PVB, EVA, polyurethane, cast-in-place
  - Stiff interlayers
    - Stiff PVB or Ionoplast
- Railing applications
  - In-Fill Panels
  - Glass Balustrades
- As of 2015, IBC now requires laminated glass in all glass railings

Safety/Glass Retention

- Laminated glass fragments adhere to the interlayer after breakage
  - Minimizing cutting/piercing injuries
  - Minimizing falling glass
  - No boarding up until replacement can be made

- Broken tempered glass vacates the frame requiring a board up until new glass is installed
Decorative Options

- PVB interlayers serve as the substrate for 4-color digital printing process
- Custom images and colors protected by outer glass plies
- Laminates can incorporate white PVB for translucency

Colored Interlayers

- **PVB**
  - Clear
  - Translucent White and Opaque White
  - Colors (e.g. red, violet, blue, green)
- **Ionoplast**
  - Clear
  - Translucent White
Exposed Edge Durability

- Ionoplast laminate’s ability over time to resist the formation of defects along the edge as a result of temperature and humidity
- PVB laminates are durable, but moisture sensitive

Concerns

- Edge Alignment
- Wet Glaze Setting
Concerns

- Edge Alignment
  - Laminate Quality
    - Excerpt from ASTM C1172: 8.5.3
      For some laminated applications, such as, point supported glass and balustrades, where the edges of the laminate are exposed, tighter length and width tolerances may be requested by the customer. Consult the supplier to determine their capabilities.

Concerns

- Wet Glaze Medium
  - Moisture plus a highly alkaline cement-based grout can attack the laminate interlayer resulting in delamination.
  - Do not use Portland based grouts with laminated glass in wet-glazed railing systems.
  - Alternate: Gypsum based grouts
Holes and Notches in Glass
Per ASTM C1048

<table>
<thead>
<tr>
<th>Glass Thickness</th>
<th>1/4&quot;</th>
<th>3/8&quot;</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Diameter</td>
<td>5/16&quot;</td>
<td>7/16&quot;</td>
<td>9/16&quot;</td>
<td>1-3/16&quot;</td>
</tr>
<tr>
<td>(B) Distance</td>
<td>1/2&quot;</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>(C) Distance</td>
<td>1/2&quot;</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>(E) Distance</td>
<td>1-5/16&quot;</td>
<td>2-7/16&quot;</td>
<td>3-1/4&quot;</td>
<td>4-7/8&quot;</td>
</tr>
<tr>
<td>(F) Radius</td>
<td>1/4&quot;</td>
<td>3/8&quot;</td>
<td>1/2&quot;</td>
<td>3/4&quot;</td>
</tr>
</tbody>
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Railing System Design

- Glazing as infill
  - Posts are the primary structural members.
- Glazing Balustrade Systems
  - Glass is the primary structural member
Glass Panel Railing

- Uses Vertical Posts
- Glass Panels inserted between posts using glass mounting hardware
- Very good sightlines
- Typical Glass size: 3/8" to ½"
  - Tempered/laminated is required.
- Provide holes in glass
Glass Balustrade Systems

Glass Shoe Mount Detail

- Gasket
- Section Through Attachment Hole
- Counterbored Hole
- Weld Block
- Anchors:
  - 1/4" x 3/8" Bolts
  - 1/2" Dia. x 4" Deep

- 1/4" x 4" Steel Plate with minimum of 20" of Concrete Under Hole
- Minimum Distance from Edge of Glass to Center of Anchor = 4"
Typical Assembly

• No Vertical Posts
• Tempered Glass is the structural balustrade
  • Note: Now must be laminated
• Will meet load requirements when properly installed and specified
• May be Wet or Dry Glazed
• Excellent sightlines

Wet Glaze Solution

• Uses “Standard” Base Shoe
• Wet Glaze Options
  • Quick Setting Expansion Cement (gypsum based)
    • Do not use Portland based cements with laminated glass.
  • Silicone
  • Do not use epoxy fillers
• Best suited for exterior applications and curved railings
Wet Glaze Process

• Plumbing
  – Plumb base
  – Use shims to plumb glass
  – For stairs, dam top of shoe to capture grout
  – Align top glass edges
  – Pour cement
  – Dixie Foam across the top with silicone bead or
  – Gasket at top

Dry Glaze

• Permits the mounting of glass without cement
• Glass panels may be removed and replaced as needed
• Labor savings in installation costs
• No mess
• No damming of shoe or waiting for grout to set.
Dry Glaze Solutions

• 80% labor savings
• Lighter weight

• No special tools
• No mess

Handrail Attachment to Glass

• You must drill holes in glass BEFORE tempering.
• Handrail graspsability requirements apply
Top Rail

- No size limitations
- Must meet structural requirements

Glass Railing Code Requirements

Prior to 2015 IBC

IBC 2407.1.2: Support. Each handrail or guard section shall be supported by a minimum of three glass balusters or shall be supported to remain in place should one baluster panel fail. Glass balusters shall not be installed without an attached handrail or guard.
I would say “no”

- Guard is improperly used in this requirement
  - “Guard” by definition is the full structure not the part that is supported by the glass.
- This “handrail” is not required
  - This is not a stair or ramp
- Handrail is in place due to the ambiguity of the code language.
- Interpretation should have been that a handrail should have an attached handrail and a guard should have an attached top rail
- Attempts to change this were not welcome as fabricators prefer the ambiguity.

Does this ½” monolithic glass guard meet this requirement?

IBC 2407.1.2: Support. Each handrail or guard section shall be supported by a minimum of three glass balusters or shall be supported to remain in place should one baluster panel fail. Glass balusters shall not be installed without an attached handrail or guard.

I would say “no”

- IBC clarified this with an exception referring to “top rail” in place of incorrect use of “guard”:
  - 2009
    - Exception: A top rail shall not be required where the glass balusters are laminated glass with two or more glass plies of equal thickness and the same glass type. The panels shall be designed to withstand the loads specified in Section 1607.7.
  - Exception updated in 2015:
    - Exception: A top rail shall not be required when the glass balusters are laminated glass with two or more glass plies of equal thickness and the same glass type when approved by the building official.
- IBC position is that no top rail is required if the glass is laminated or the guard meets the structural load requirements.

Does this ¾” monolithic glass guard meet this requirement?

IBC 2407.1.2: Support. Each handrail or guard section shall be supported by a minimum of three glass balusters or shall be supported to remain in place should one baluster panel fail. Glass balusters shall not be installed without an attached handrail or guard.
Glass Railing Load Requirements

- Glass Railing specific Load Requirement:
  - IBC 2407.1.1 Loads. The panels and their support system shall be designed to withstand the loads specified in section 1607.8. A design factor of four shall be used for safety.

- All Guard and Handrail Requirements:
  - IBC1607.8.1 Handrails and guards. Handrail assemblies and guards shall be designed to resist a linear load of 50 pounds per linear foot (plf) (0.73 kN/m) in accordance with Section 4.5.1 of ASCE 7.
  - IBC1607.8.1.1 Concentrated Load. Handrails and guards shall be designed to resist a concentrated load of 200 pounds (0.89kN), in accordance with Section 4.5.1 of ASCE 7.

  ASCE7 notes the load needs to be placed at the “top” of the guard.

Glass Requirements

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

- Glazing in railing in-fill panels shall be of an approved safety glazing material that conforms to the provisions of Section 2406.1.1. For all glazing types, the minimum nominal thickness shall be ¼ inch (6.4 mm).
  - Exception – Single fully tempered glass complying with Category II of CPSC 16 CFR Part 1201 or Class A of ANSI Z97.1 shall be permitted to be used in handrails and guardrails where there is no walking surface beneath them or the walking surface is permanently protected from the risk of falling glass.
2015 Glass Railing Code Requirement and Exception

2015 IBC: Section 2407.1.2
Support – Each handrail or guard section shall be supported by a minimum of three glass balusters or shall be otherwise supported to remain in place should one baluster fail. Glass balusters shall not be installed without an attached handrail or guard.

Exception – A top rail shall not be required where the glass balusters are laminated glass with two or more glass plies of equal thickness and the same glass type when approved by the building official. The panels shall be designed to withstand the loads specified in Section 1607.8.

2018 Glass Railing Code Requirement and Exception

- No longer requires local code approval.
- R308.4.4.1 Structural glass baluster panels. Guards with structural glass baluster panels shall be installed with an attached top rail or handrail. The top rail or handrail shall be supported by a minimum of three glass baluster panels, or shall be otherwise supported to remain in place should one glass baluster panel fail.
  - Exception: An attached top rail or handrail is not required where the glass baluster panels are laminated glass with two or more glass plies of equal thickness and of the same glass type.
What is Nelophobia?

- **Nelophobia** is the **fear of glass (breakage)**.
- **Nelophobia** is also called **Hyalophobia** and **Hyelophobia** and related to **Crystallophobia** (fear of crystal or glass).
Glass Failures in Guards

- Monolithic Tempered Glass was breaking across North America
  - Toronto
  - Austin
  - Houston
  - Seattle
  - New York City
  - Chicago
  - Dallas
  - Cleveland

Falling Glass – United States Investigations

- Inclusions
- Removal of top rail
- Product design
- Installation issues
- Building movement
- Construction process
- Laminated glass option – value engineered
- Heat soaking not 100% effective
Glazing in Wind-borne Debris Regions

- Wind-borne debris regions include the Gulf of Mexico, Atlantic coastline, Hawaii
- Balusters and in-fill panels shall be laminated glass
- Glass supporting top rail
  - The assembly shall be tested according to the impact requirements
  - Top rail shall remain in place after impact

Conclusions

- Railing systems designed with laminated glass provide safety and glass retention after breakage
- Ionoplast interlayers are stronger, deflect less, and provide better post-glass breakage performance in minimally supported railings
- Building code requirements for railings allow laminated glass and, in some cases, require laminated glass for missile impact and structural glass systems
- Sealant compatibility and glazing support details require special attention
THANK YOU FOR ATTENDING

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