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Glass Railing Systems

Presented by:
Vicente Montes
Curtain Wall Design and Consulting, Inc.

Learning Objectives

• Updates to ASTM Glass Railing Standard
• Overview of IBC requirements for glass railing systems
• Requirements per other standards
Examples (Unobstructed Views)

Additional Examples

- With top rail (guard rail)
- With vertical posts
- With infill panels
Something to consider

ASTM E2358
-Standard Specification for the Performance of Glass in Permanent Glass Railing Systems, Guards, and Balustrades-

- Scope
  - Based on the health and safety of all potential users.
  - For normal and anticipated building uses, but not for abuses.

- Design Requirements
  - Guardrail Systems (4.1.1)
    - 42" from walking surface
  - At least 48" when adjacent surface is more than 20 ft
    - Public assembly
    - Elementary schools
    - Multi-family buildings
ASTM E2358

• Handrails (4.1.2)
  – Corridors, ramp, walkways, enclosed stairways
  – Slope of at least 1 in 20.
  – Height not less than 34”
  – Height no more than 38”

• Transfer Rails Systems
• Railing System Penetrations
• Hand-grip

• Performance Requirements
  Deflection (6.2)
  – Load at vertical support
    • \( \frac{h}{12} = \frac{42}{12} \)
    • 3.5”
  – Horizontal load at rail mid-span
    • \( \frac{h}{24} + \frac{l}{96} = \frac{42}{24} + \frac{60}{96} \)
    • 2.375”
  – Vertical load at rail mid-span
    • \( \frac{l}{96} = \frac{60}{96} \)
    • 0.625”
ASTM E2358

- Classification (5.1)
  - Type I – VI
  - Level of Performance
    - Level 1 – Basic
    - Level 2 – Safety
    - Level 3 – Enhanced
    - Level 4 – Enhanced

<table>
<thead>
<tr>
<th>Type</th>
<th>Concentrated Load on Rail: 690 N (150 lb)</th>
<th>Uniform Linear Load on Rail: 200 N/m (30 lb/ft)</th>
<th>Pendulum Impact Performancea</th>
<th>Performance Level Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>I–II</td>
<td>Pass</td>
<td>Pass</td>
<td>Not Required</td>
<td>Level 1 (Type I)</td>
</tr>
<tr>
<td>I–IV</td>
<td>Concentrated Load: 850 N (190 lb)</td>
<td>Uniform Load: 230 N/m (30 lb/ft)</td>
<td>Pass</td>
<td>Level 2 (Type II)</td>
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<tr>
<td>I–V</td>
<td>Concentrated Load: 1300 N (290 lb)</td>
<td>Uniform Load: 230 N/m (30 lb/ft)</td>
<td>Pass</td>
<td>Level 3 (Type III)</td>
</tr>
<tr>
<td>I–VI</td>
<td>Concentrated Load: 1600 N (660 lb)</td>
<td>Uniform Load: 880 N/m (130 lb/ft)</td>
<td>Pass</td>
<td>Level 4 (Type IV)</td>
</tr>
</tbody>
</table>

ASTM E2353

- Standard Test Method for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades-

- Tests
  - Static Loads
  - Shot Bag Impact Test
  - Pendulum Impactor Test

- Performance after impact

<table>
<thead>
<tr>
<th>Classification Number</th>
<th>Description</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Glazing unbroken</td>
<td>Glazing completely retained in system and unbroken</td>
</tr>
<tr>
<td>2</td>
<td>Glazing broken and retained</td>
<td>No passage of a 7.6 mm (0.3 in.) diameter solid sphere with a horizontal load of 16 N (4 lb)</td>
</tr>
<tr>
<td>3</td>
<td>Glazing broken and shards contained</td>
<td>Glazing shards separated from system not greater than 6452 mm² (10 in²) of equivalent weight of original glazing specimen</td>
</tr>
<tr>
<td>4</td>
<td>Glazing broken and shards not contained</td>
<td>Glazing shards separated from system are greater than 6452 mm² (10 in²) of equivalent weight of original glazing specimen</td>
</tr>
</tbody>
</table>
ASTM

- ASTM WK59324
  - Standard Practice/Guide for Design of Glass Railings and Guards and Balustrades

Code Requirements
IBC 2015

- Glass supports (IBC 2403.2)
  - If not firmly supported on all four sides
    - Construction documents
    - Shop drawings
    - Analysis
    - Test data
Code Requirements
IBC 2015

- Glass General Requirements (IBC 2406)
  - Safety Glazing required
  - Hazardous location (IBC 2406.4, 2406.4.4)
    - Structural baluster
    - In-fill panels
    - Regardless of area or height above walking surface.
  - Hazardous locations – Requirements
    - Permanently marked (IBC 2406.3)
      - Manufacturer
      - Standard with which it complies

- Glass in Handrails and Guards (IBC 2407.1)
  - Laminated glass – Category II or CPSC 16 CRF Part 1201 or Glass A of ANSI Z97.1.
    - Minimum ¼" tempered glass is allowed at:
      - No walking surface beneath
      - Walking surface beneath is permanently protected from the risk of falling glass

Code Requirements
IBC 2015

- Loads (IBC 2407.1.1)
  - Design factor of 4 must be used
  - IBC Section 1607.8
    - 50 plf applied at the top
    - 200 lb applied at the top
  - WL on all vertical exterior glass (IBC 2404.1)
  - On all vertical exterior glass
  - From Section 1609 for components and cladding

- Support (IBC 2407.1.2)
  - Each guard section to be supported by a minimum of 3 glass balusters
  - Guard to remain in place if one baluster panel fails.
    - Top rail is not required if glass is laminated.
    - Some local codes require a top rail. Therefore this exception would not apply.
  **2018 IBC. Panels shall be tested to remain in place as a barrier following impact or glass breakage in accordance with ASTM E2355**
Case Study

• Glass Failure

• CDC’s preliminary investigation
  – Post-tension cable failure

• Additional glass failures
  – Poor design
    • (red indicates beyond yield limits)
Case Study

• Solution
  – Glass replacement
  – Stanchion re-design
    • Using FEA
    • Stainless Steel (45 ksi yield strength)

Glass in Railing Systems

• Tempered glass considerations
  – Nickel Sulfdide (NiS)
    • Thermal cycles
    • Sudden explosion
    • Breakage probability (5ft x 3ft panel)

• Heat soaking

<table>
<thead>
<tr>
<th>Glass Thickness</th>
<th>m² per Pane</th>
<th>Pans per Pane</th>
</tr>
</thead>
<tbody>
<tr>
<td>4mm</td>
<td>430</td>
<td>220</td>
</tr>
<tr>
<td>6mm</td>
<td>255</td>
<td>145</td>
</tr>
<tr>
<td>10mm</td>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>15mm</td>
<td>105</td>
<td>50</td>
</tr>
<tr>
<td>19mm</td>
<td>85</td>
<td>45</td>
</tr>
</tbody>
</table>
Discussion

- Handrail height is from 34" to 38" (code definition)

- Handrails are not guards (based on height definition)
  - Handrails are only required by code at stairs

- In the event of one glass baluster failing, the guard needs to remain in place and needs to resist the specified loads.
  - Simple edge protectors will not meet this requirement.
Is a Top Rail required or not?

- This section protects the public in the event of an individual panel failure. The adjacent panels will hold the railing and prevent people from falling.

- Does this mean that as long as a handrail is installed a guard (top rail) is not required?

IBC 2407.1.2. Each handrail or guard section shall be supported by a minimum of 3 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.
Laminated Glass Examples

Discussion

- Questions asked to ICC via their “Code Opinion Submission Form”

- Can a glass rail system be installed without a guard on top of the glass if there is a handrail attached to the glass? In other words… no cap, exposed top edge of glass at 42 inch height with a handrail mounted on the side of the glass and handrail height
  - ICC response: “No”

- Weather the system has an attached handrail or not, does the guard (piece on top of the glass) have to meet the loading requirement if one baluster fails.
  - ICC response: “Yes”
Conclusion

• Considerations when designing with glass
• ASTM
• Code requirements
• Is a top rail required?
• Additional documents
  – ICC AC 273 – Acceptance Criteria for Handrails and Guards

Thank You For Attending!

• Presenter’s Name: Vicente Montes
• Company: Curtain Wall Design and Consulting, Inc.
• Email: vmontes@cdc-usa.com