



Glass Balustrade Design - Safety Considerations
Safety Design in Buildings Conference
– Kuwait 2017

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WSP Facades

Safety Design in Buildings
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Learning Objectives

The objective of this presentation is to provide an understanding of particular aspects of glass balustrade design in the context of safety.

*Structure of this presentation:

- Presented by an expert speaker.
- Bullet points are provided as a speaker aid only.

The Presenter: Lindsay Mellum

Lindsay has been a Façade Consultant in the Middle East for 10 years, and leads the façade design team at WSP.

With a background in design and construction, and 12 years' experience in the facades industry, Lindsay has developed the Façade team at WSP into one of the largest specialist façade consultant teams in the region. She has also been involved in advisory committees and industry organizations in the region, including input into the GCC codes.

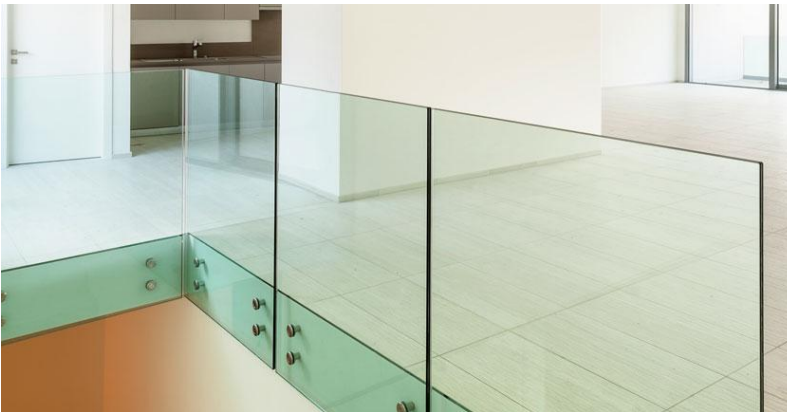
Currently Lindsay and the team are working on nearly 100 buildings for the Dubai Expo 2020, a number of high-end hotels throughout the Middle East, and several elective ACP cladding replacement projects on high-rise buildings.

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Overview



Source: Glassplan, London

- Glass selection
- Balustrade purpose
- Main aspects for safety
- Component factors for safety

Balustrade Selection

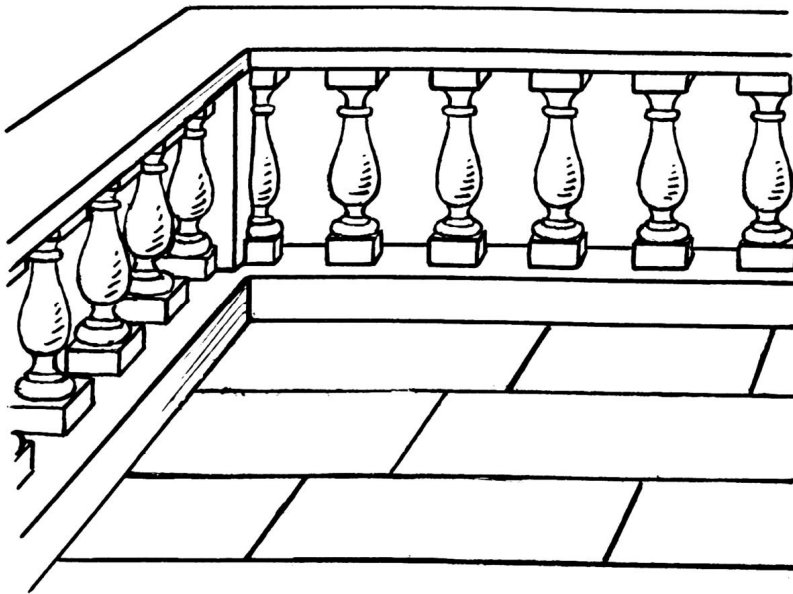


Source: United Glass, Auckland

Glass Selection Factors:

- Colour
- Protection
- Privacy
- Fire safety
- Weather protection
- Weight
- Ventilation
- Many more...

Glass Selection - Balustrades



Source: Wikipedia

Functions:

- **Contributes to the aesthetics of a building**
- **Elegant**
- **Balustre (balaustro, from balaustra, "pomegranate flower")**

Glass Selection - Balustrades



Source: S-Vision Glass

Functions:

- Protection
- Separation
- Wind break

Glass Selection - Balustrades



Source: Adelaide Balustrade & Fencing

Functions - **SAFETY**

- Protection
- Separation

Glass Selection - Balustrades



Source: Adelaide Balustrade & Fencing

Functions - **SAFETY**

- Protection
 - Hazard
 - Fall
 - Wildlife
 - Traffic
 - Wind
- Separation

Glass Selection - Balustrades



Source: Adelaide Balustrade & Fencing

Functions - **SAFETY**

- Protection
 - Hazard
 - Fall
 - Wildlife
 - Traffic
 - Wind
- Separation
 - Control
 - Queue
 - Stair
 - Crowd

Safety in Design

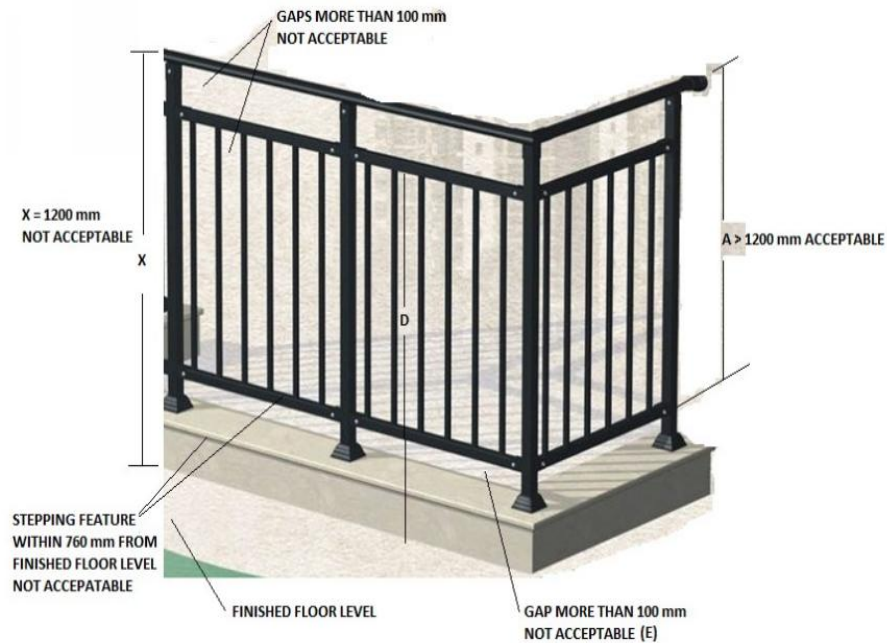


Figure 1.16.b.: Balcony Railing Specifications

Source: UAE F&LS Code of Practice

→ Height

- Typically 1.1m internationally
1.2m in some locations in ME

→ Openings

- Max opening 100mm

→ Climbability

- Climbable features up to 760mm only permitted if overall height is adjusted
- Max height may start from a rail
- Consider the presence of furniture

Let's Not Forget Windows - Some Similarities



Source: UAE F&LS Code of Practice

- **A window can provide access to a hazard if opened – effectively becoming a balustrade**
- **Distance to Window from FFL**
 - Usually lower than windows
- **Openings**
 - Max opening 100mm – sometimes more is allowed
- **Climbability**
 - Climbable features should be limited
 - The distance limit may start from a climbable feature (e.g. a transom)

Strength



Source: Oxworks

→ Strength

- Various loads
- Various conditions
- Various limits

Strength - Load Sources



Source: Oxworks

→ Strength

- Various loads
 - People
 - Wind
 - Impact
- Various conditions
- Various limits

Strength - Load Conditions



Source: Oxworks

→ Strength

- Various loads
 - People
 - Wind
 - Impact
- Various conditions
 - Point load
 - UDL
 - Post, panel, rail, etc
- Various limits

Strength - Load Limits / Magnitudes



Source: Oxworks

→ Strength

- Various loads
 - People
 - Wind
 - Impact
- Various conditions
 - Point load
 - UDL
 - Post, panel, rail, etc.
- Various limits
 - 0.89kN at any point generally?
 - 1.5kN people?
 - 3.0kN crowd?
 - 4.0kPa wind?
 - Reduction of DWP by 0.4kPa on an external balustrade?

Strength - Aspects to Consider



Source: Yes Glazing Solutions

→ Strength Aspects

- Safety factors for imposed loads (typically x4)
- Post-breakage safety
- Post-breakage capacity
- Methods of capturing the glass
- Stresses
- Deflections
- The handrail

Components - Glass



Source: Stairs Direct

- **Components - Glass**
 - May be an infill panel

Components - Glass



Source: SHS Products

→ Components - Glass

- May be an infill panel
- May provide the whole structure (cantilever)
 - Should not be monolithic
 - Potentially limited post-breakage safety
 - Therefore laminated
 - Two layers bonded by a polymer

Components - Glass - Glass Used in a Laminate



→ Components - Glass

- May be an infill panel
- May provide the whole structure (cantilever)
 - Should not be monolithic
 - Potentially limited post-breakage safety
 - Therefore laminated
 - Two layers bonded by a polymer
- Unlikely to be annealed glass
- Could be heat-strengthened (HS)
- Could be fully-tempered (FT) (take care with FT glass)

Components - Glass - Kinds / Types - Annealed

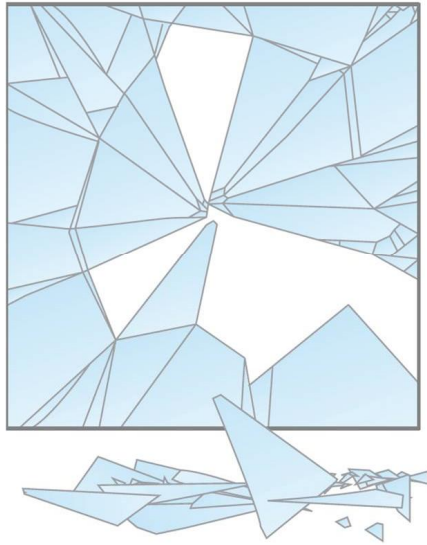


→ Components – Glass - Kinds

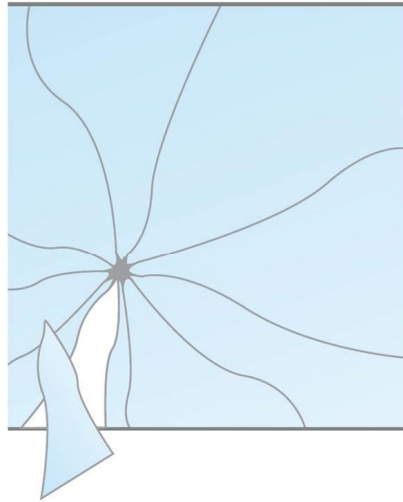
- Annealed glass
 - Float glass
 - Relatively weak
 - Susceptible to thermal cracking
- Heat-strengthened (HS)
- Fully-tempered (FT)
(also called toughened)

Components - Glass - Kinds / Types - Heat Strengthened

FLOAT GLASS



HEAT-STRENGTHENED GLASS



Source: Crystal India

→ Components – Glass - Kinds

- Annealed glass
- Heat-strengthened (HS)
 - 2 x strength of annealed
 - Susceptible to thermal cracking
 - Not susceptible to NiS cracking
- Fully-tempered (FT)
(also called toughened)

Components - Laminated FT Glass - Fully Tempered



Source: GGF

- **Components – Glass - Kinds**
- Annealed glass
 - Heat-strengthened (HS)
 - Fully tempered (FT)
 - 5 x strength of annealed
 - Not susceptible to thermal cracking
 - Susceptible to NiS cracking
 - FT in a laminated form:
 - Loses all of its strength on cracking
 - Retains all of its mass

Components - Laminated FT Glass - Various Interlayers

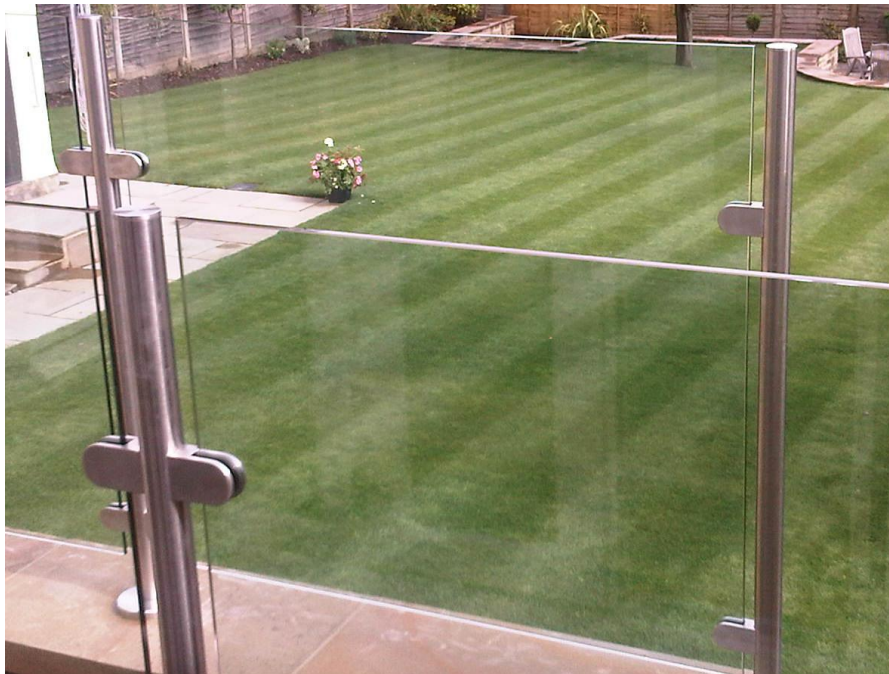


Source: GGF

→ Components – Laminated FT Glass

- These videos show:
 - PVB interlayer
 - Structural interlayer (SentryGlasPlus)
- The difference is the post-breakage safety / capacity
- Consider the temperature when calculating capacity. PVB is flexible, and calculations typically done at 22°C may fail at 50°C.

Components – Posts and Fixings



Source: Stairs Direct

- **Components – Posts and Fixings**
- Posts may provide the support
 - There may be a combination of post, panel and handrail
 - Fixings capture the glass from the posts
 - Consider deflection versus stress
 - deflection may not be a concern in high wind load applications

Components – Posts and Fixings



Source: Mirrors and Glass UK

- **Components – Posts and Fixings**
- Posts may provide the support
 - Fixings capture the glass from the posts
 - Consider deflection versus stress
 - deflection may not be a concern in high wind load applications
 - The highest stresses are likely to be at the fixings

Components - Base Channel



Source: Pinterest

→ Components – Base Channel

- Many calculations show a cantilever glass balustrade like this

Components - Base Channel



Source: SZG Glass

→ Components – Base Channel

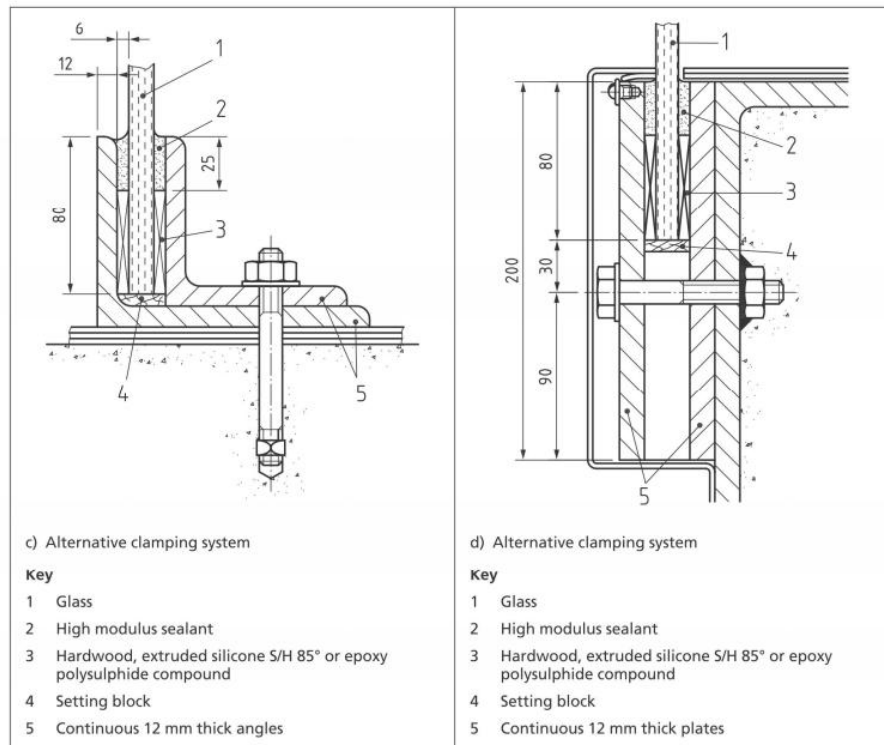
- But the reality is more like this
- Calculations must reflect the reality

Components - Base Channel

BRITISH STANDARD

BS 6180:2011

Figure B.2 Typical clamping systems for free-standing toughened glass balustrades (continued)



→ Components – Base Channel

- Guidance from the Standards
- Provide either:

- Packing and a high modulus sealant (as per the image)

- Grout and weather seal (so, in the context of the image, 3 would be grout, and 2 would be a low modulus weather seal)

- This is often incorrectly shown as packing and weather seal – therefore offering limited support

Source: BS 6180

Components - Base Channel



→ Components – Base Channel

- Alternatively use proprietary systems
- Ask for test reports
- Consider testing all types (sustained load – not just impact)

Components - Handrail



Source: DuPont

→ Components - Handrail

- Contributes to load capacity?
- Connects multiple panels
- Protects the glass edge from you
- Protects you from the glass edge

Components - Handrail



→ Components - Handrail

- Contributes to load capacity?
- Connects multiple panels
- Protects the glass edge from you
- Protects you from the glass edge
- **Necessary on a stair**

Components - Handrail



Source: Frameless Impressions

→ Components - Handrail

- Contributes to load capacity?
- Connects multiple panels
- Protects the glass edge from you
- Protects you from the glass edge
- Necessary on a stair
- Consider the material
 - bare metal in the ME can get hot (coated metal is usually cooler)
- Recommended by some authorities if the hazard is a fall

Summary



→ Summary

- Consider all of the conditions of the application and legal requirements
- Select the glass carefully
- Consider post-breakage safety
- Make sure that the support condition is represented in the calculations
- Review the interaction of the components and where they are required.

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Thank you!

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