Structural Calculations for Orbit 'Mirror' Juliet balconies using BALCONY 1 type handrail (70mm Diameter)

Our ref: MJULB1NB080719 **Date of issue: July 2019**

Orbit "Mirror" Juliet Balconies using Balcony 1 handrail system

DESIGN TO EUROCODES & CURRENT BRITISH STANDARDS

Design standards:

EN 1990	Eurocode 0:	Basis of structural design.
EN 1991	Eurocode 1:	Actions on structures.
EN 1993	Eurocode 3:	Design of steel structures.
EN 1999	Eurocode 9:	Design of aluminium structures.
BS EN 1990:2002 + A1:2005	Eurocode:	UK National annex for Eurocode
BS 6180:2011	British Standard:	Barriers in and about buildings.
BS EN 1991-1-1-4:2005 + A1 2010	Eurocode 1	Wind actions on structures

Design loads: Occupancy class/es for which this design applies (Table 2: BS6180:2011)	=	Domestic and residential activities (i) & (ii) Office and work areas not included elsewhere (iii), (iv) & (v) Areas without obstacles for moving people and not susceptible to overcrowding (viii) & (ix)
Service load on handrail	Q_k	0.74 kN/m uniformly distributed line load acting 1100mm above finished floor level. (Table 2: BS6180:2011)
Service load applied to the glass infill	Q_{k1}	A uniformly distributed load of 1.0 kN/m^2
Point load on glass infill		0.50 kN applied to any part of the glass fill panels.

Orbit 'Mirror' Juliet Balcony System ***PAGE 2*** **(ref: MJULB1NB080719)**

Table 2 **Minimum horizontal imposed loads for parapets, barriers and balustrades**

Type of occupancy for part of the building or structure	Examples of specific use	Horizontal uniformly distributed line load (kN/m)	Uniformly distributed load applied to the infill (kN/m²)	A point load applied to part of the infill (kN)
Domestic and residential activities	(i) All areas within or serving exclusively one single family dwelling including stairs, landings, etc. but excluding external balconies and edges of roofs	0.36	0.5	0.25
	(ii) Other residential, i.e. houses of multiple occupancy and balconies, including Juliette balconies and edges of roofs in single family dwellings	0.74	1.0	0.5
Offices and work areas not included elsewhere, including storage areas	(iii) Light access stairs and gangways not more than 600 mm wide	0.22	—	—
	(iv) Light pedestrian traffic routes in industrial and storage buildings except designated escape routes	0.36	0.5	0.25
	(v) Areas not susceptile to overcrowding in office and institutional buildings, also industrial and storage buildings except as given above	0.74	1.0	0.5
Areas where people might congregate	(vi) Areas having fixed seating within 530 mm of the barrier, balustrade or parapet	1.5	1.5	1.5
Areas with tables or fixed seatings	(vii) Restaurants and bars	1.5	1.5	1.5
Areas without obstacles for moving people and not susceptible to overcrowding	(viii) Stairs, landings, corridors, ramps	0.74	1.0	0.5
	(ix) External balconies including Juliette balconies and edges of roofs. Footways and pavements within building curtilage adjacent to basement/sunken areas	0.74	1.0	0.5

© BSI 2011 • 9

Table 2: BS6180:2011

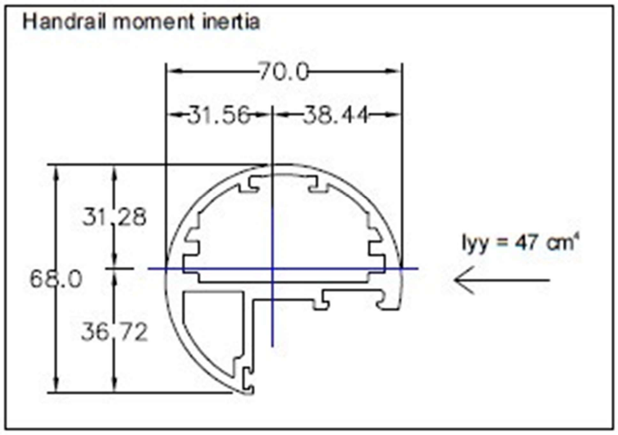
- These imposed loads are considered as three separate load cases. They are not combined.
- Factored loads are used for checking the limit state of static strength of a member.
- The imposed service loads are multiplied by a partial factor for variable action $\gamma_{Q,1}$ of 1.5 to give the ultimate design load for leading variable action.

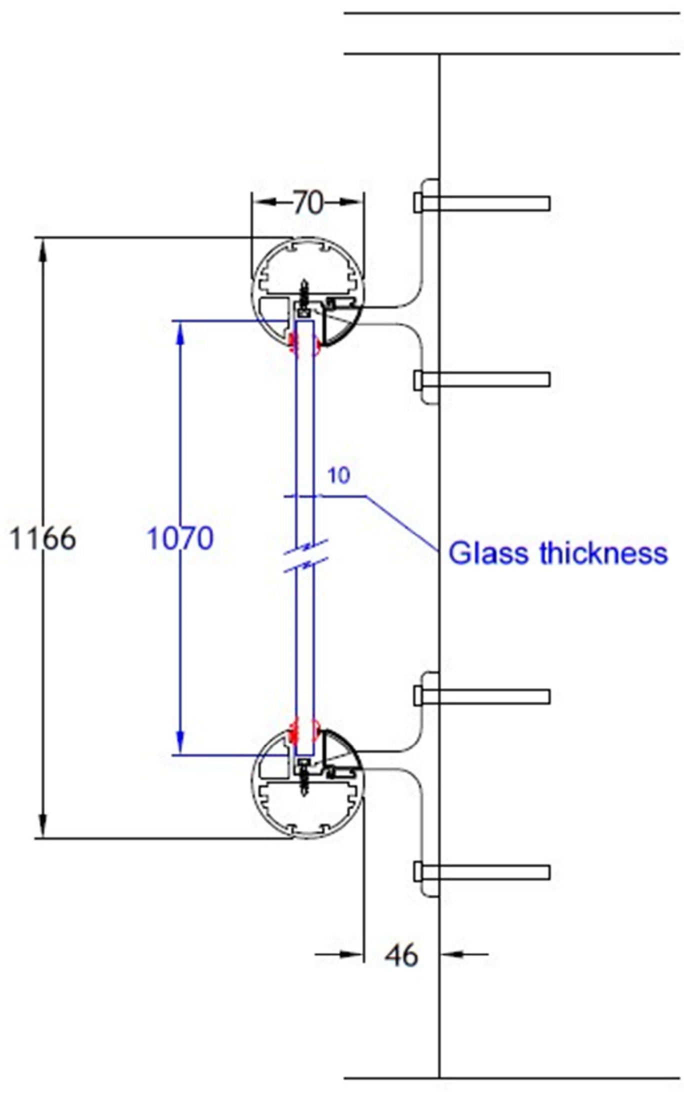
Deflection:

All structural members deflect to some extent under load. Service loads are used to calculate deflections.

The total displacement of any point of a barrier from its original unloaded position under the action of service loads is limited to 25mm.

Orbit 'Mirror' Juliet Balcony System





Typical section & handrail profile moment of inertia

Wind load parameters:
Design wind loads are influenced by a number of variable factors. These include site location, site altitude above sea level, type of terrain, and height of balustrade above ground level.

These parameters and conditions are defined in BS EN 1991-1-4:2002 + A1: 2010 '*Actions on structures – wind actions' &* UK National Annex to EN 1991-1-4:2002 + A1:2010. We have chosen to prepare a calculation based on certain conditions, resulting in specific coefficients.

The formula applied results in an overall ***characteristic wind pressure***. The design and calculation will be relevant not only to the conditions specified herein but to any combination of factors that result in a characteristic wind pressure that is equal to or less than the one specified in the calculation. The selected wind load coefficient will cover the majority of sites in England and Wales and apply to 'mirror' Juliet balconies of any length.

a) Sites located geographically within the 23m/sec isopleth in Figure NA 1 off the UK National Annex.

b) Site altitude 100m maximum above sea level.

c) Top of balustrade located 35m maximum above ground level.

d) Site located in a coastal area exposed to the open sea, terrain category 0 of BS EN 1919 Table 4.1. This is the most severe exposure category. Smaller wind load coefficients apply to less exposed inland sites, terrain categories 1 to 1V.

e) Site located in country terrain or less than 1.0 km inside town terrain.

f) Sites with no significant orography in relation to wind effects. (ie. orography coefficient 1.0). Increased wind load coefficients apply to sites near the top of hills, ridges, cliffs or escarpments.

g) Directional, seasonal, and probability factors are all taken as normal, for which the relevant coefficient is 1.0. This is a slightly conservative approach.

Wind load design:

Basic site wind speed	$V_{b, map}$	=	23m/sec	
Site altitude above sea level	A	=	100m	
Top of balustrade height above ground	z	=	35m	
Altitude factor	C_{alt}	=	$1.0 + (0.001 \times A)\ (10/z)^{0.2}$	
		=	$1.0 + (0.1)\ (10/35)^{0.2}$	
		=	1.0 + (0.1) (0.7783)	
		=	1.08 say	
Directional, seasonal & probability factors	C_{dir}, C_{season}, C_{prob}	=	1.0	
Site wind speed	V_b	=	$V_{b,map}\ (C_{dir} \times C_{season} \times C_{prob})\ (C_{alt})$	
		=	23m/sec x 1.08	
		=	24.84m/sec	
Site wind pressure	qb	=	$0.613\ (V_b)^2$	
		=	$0.613 \times (24.84)^2$	
		=	378 N/m^2	
Exposure factor	Ce(z)	=	3.50	(Figure NA 7)
Peak velocity pressure	qp	=	qb x Ce(z)	
(Characteristic wind pressure)		=	0.378 x 3.50	
		=	1.323 kN/m^2	
	say	=	**1.35 kN/m^2**	

<u>Section properties of handrail & lower rail:</u>

Material type	Extruded aluminium type 6063 T5		
Characteristic 0.2% proof stress	f_o	=	130 N/mm^2
Characteristic ultimate tensile strength	f_u	=	175 N/mm^2
Modulus of elasticity	E	=	70 000 N/mm^2
Shear modulus	G	=	27 000 N/mm^2
Moment of inertia about the y-y axis	I_{yy}	=	47 cm^4
Moment of inertia about the x-x axis	I_{xx}	=	27.89 cm^4
Least elastic modulus about the y-y axis	W_{ely}	=	12.227 cm^3
Least elastic modulus about the x-x axis	W_{elx}	=	7.595 cm^4
Partial factor for material properties	γ_{M1}	=	1.10
Value of shape factor (conservative value)	α	=	W_{pl}/W_{el}
		=	1.2 say

Ultimate bending resistance about the y-y axis M_{Rdy}

$$= M_{o,Rd} = \frac{\alpha W_{el} f_o}{\gamma_{M1}} = \frac{1.2 \times 12.227\ cm^3 \times 130\ N/mm^2 \times (10)^{-3}}{1.1}$$

= **1.734 kNm**

Ultimate bending resistance about the x-x axis M_{Rdx}

$$= \frac{1.2 \times 7.595\ cm^3 \times 130\ N/mm^2 \times (10)^{-3}}{1.1}$$

= **1.079 kNm**

Design ultimate horizontal imposed load on the handrail	F_i	=	0.74 kN/m x 1.5
		=	1.11 kN/m
Design ultimate wind load on the handrail & lower rail	F_w	=	1.35 kN/m^2 x 0.583 x 1.5
		=	1.18 kN/m

For sites that come within the parameters listed on page 4, wind load on the handrail is slightly greater than the imposed load and is therefore the dominant design condition.

Maximum length of handrail		=	2840mm
Width of support brackets		=	50mm
Maximum span of handrail between points of support	L	=	2790mm

Design horizontal moment on handrail between points of support.

$$= \frac{1.18\ kN/m \times (2.79)^2}{8}$$

= 1.148 kNm

= < 1.734 kNm OK

Service load deflection of handrail for a simply supported span of 2.79m

$$= \frac{5\ F\ L^4}{384\ E\ I}$$

$$= \frac{5\ (787 \times 2.79)\ (2790)^3}{384 \times 70000 \times 47 \times (10)^4}$$

$$= 18.87\text{mm}$$

$$= < 25\text{mm} \qquad \text{OK}$$

Summary: For sites that come within the parameters listed on page 4 of these calculations, the Balcony 1 system handrail is adequate in terms of ultimate moment capacity and service load deflection limitations for spans up to 2.79m between points of support.

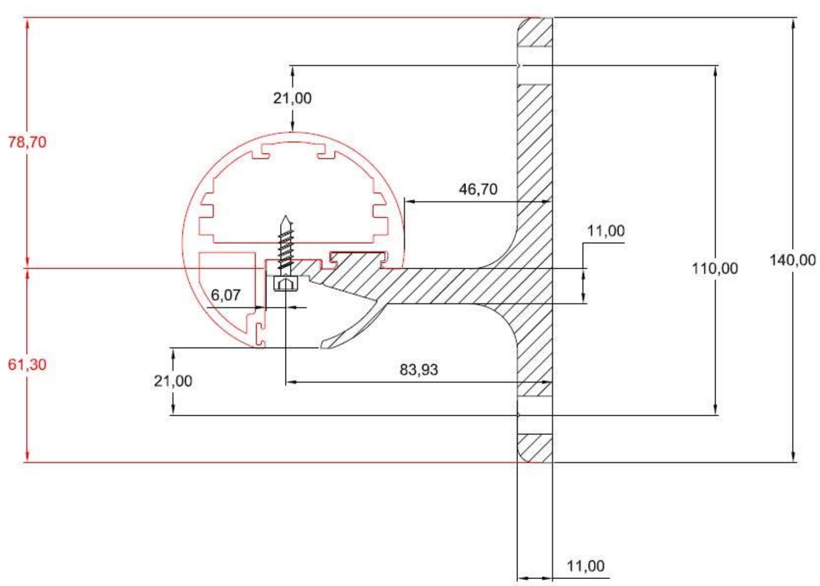
Lower rail

The lower rail supports horizontal wind load equal to that on the handrail, and also vertical load due to the self-weight of the glass and rails.

Self-weight of glass	=	0.25 kN/m^2 x 1.07	=	0.268 kN/m
Self- weight of handrail + lower rail	=	2.581 kg/m x 2 No.	=	0.005 kN/m
				0.273 kN/m
Partial safety factor for permanent loads	=	1.35		
Factored vertical load	=	0.273 x 1.35	=	0.369 kN/m
		say	=	0.37 kN/m
Factored vertical moment on lower rail on 2790mm span	=	$\frac{0.37 \times (2.79)^2}{8}$	=	0.36 kNm
	= <	1.079 kNm	=	OK

By inspection, stresses and deflection of the lower rail due to combined horizontal and vertical loading are within the capacity of the section. For sites that come within the parameters listed on page 4 of these calculations, the Balcony 1 system lower rail is adequate in terms of ultimate moment capacity and service load deflection limitations for spans up to 2.79m between points of support.

Handrail brackets:



Handrail brackets

The horizontal imposed load on the handrail acts outwards over the clear width of the opening, ie. 2580mm max. opening width for a 2840mm long handrail. Handrail support brackets are 50mm wide, so the maximum length of the handrail is 2790mm between points of support. The overall length of the glass is 170mm less than the length of the handrail. ie. 2670mm max. Wind loading is taken to act inwards or outwards on the 2670mm length of the glass.

Ultimate horizontal load on the handrail bracket H = $\left(1.35\ kN/m^2 \times 1.5 \times \frac{1.166}{2}\right) \times \frac{2.67}{2}$ = 1.58 kN

The handrail is attached to the bracket by means of a slotted connection and two 4.8mm diameter stainless steel self-tapping screws.

Properties of stainless steel self-tapping screws:

Material type	=	stainless steel grade 304
Characteristic ultimate tensile strength	=	621 N/mm^2
Characteristic 0.2% proof stress	=	290 N/mm^2

Phillips self-tapping screws: ultimate shear capacity taken from the table on page 7 of Lindab's technical literature (see below).

Nominal thickness of aluminium in the handrail and bracket at screw positions (Nom t mm)	=	5mm	
Ultimate shear capacity of 4.8mm diameter screws safety class 1 for Nom t = 2.5mm	=	3.64 kN/screw	(from Lindab's table)

For safety classes 2 and 3 this shear value is divided by 1.1 and 1.2 respectively. Safety class 3 is the highest safety class and has been assumed to apply to balustrades. The shear capacities given in Lindab's table are based upon a material having a tensile yield limit of 350 N/mm^2.

The ultimate shear capacity of 3.64 kN/screw has therefore been reduced by 290/350 and divided by 1.2 to represent safety class 3 and 290 N/mm^2 yield stress rather than 350 n/mm^2. The adjusted shear capacity is then 2.51 kN/screw.

As a worst possible case for shear force on the self-tapping screws, it will be assumed that they resist the whole of the ultimate horizontal force on the brackets. ie. that the slotted connection does not contribute to the design resistance.

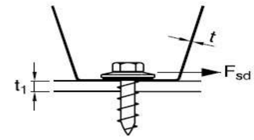
Ultimate shear force/screw	=	0.79 kN/screw	
	= <	2.51 kN/screw	OK

Orbit 'Mirror' Juliet Balcony System ***PAGE 8*** **(ref: MJULB1NB080719)**

<u>Handrail brackets:</u>

Shearing force, construction screws

Dimensioning value F_{sd} kN/screw. Attention is paid both to failure of the edge of the hole and shearing failure in the screw. Safety class 1.



Nom t mm	When calculating t mm	Tensile yield limit N/mm²	Screw diameter 4.2 mm		Screw diameter 4.8 mm		Screw diameter 5.5 mm		Screw diameter 6.3 mm	
			t_1 =t	t_1 = 2.5 t	t1 =t	t_1 = 2.5 t	t_1 =t	t_1 = 2.5 t	t_1 =t	t_1 = 2.5 t
0.4	0.32	250	0.26	0.54	0.28	0.61	0.30	0.70	0.32	0.81
0.5	0.41	250	0.38	0.69	0.40	0.79	0.43	0.90	0.46	1.03
0.6	0.52	250	0.52	0.86	0.56	0.98	0.60	1.12	0.64	1.29
0.7	0.60	350	0.93	1.41	1.00	1.61	1.07	1.85	1.14	2.12
0.8	0.73	350	1.25	1.72	1.34	1.96	1.43	2.25	1.53	2.58
1.0	0.93	250	1.29	1.56	1.38	1.79	1.47	2.05	1.58	2.34
1.0	0.93	350	1.80	2.19	1.93	2.50	2.06	2.86	2.21	3.28
1.2	1.13	350	2.41	2.66	2.58	3.04	2.76	3.48	2.95	3.99
1.5	1.42	250	2.39	2.39	2.60	2.73	2.78	3.12	2.97	3.58
1.5	1.42	350	3.03*	3.03*	3.63	3.82 | 3.64	3.89	4.37	4.16	5.01
2.0	1.91	350	3.03*	3.03*	4.16 | 3.64	4.16 | 3.64	5.72 | 5.20	5.72 | 5.20	6.49	6.74
2.5	2.40	350	3.03*	3.03*	4.16 | 3.64	4.16 | 3.64	5.72 | 5.20	5.72 | 5.20	7.80 | 6.76	7.80 | 6.76

In the area of number pairs in the table and marked *, shearing failure in the screw is decisive.
The value to the left in each number pair relates to carbon steel screws, while the number to the right relates to stainless steel screws.

Except of the table at the foot of page 7 of Lindab's technical literature

<u>Bracket fixing bolts:</u>

There are two M10 or M12 fixing bolts per bracket located 110mm apart vertically. The centre of the top bolt is approximately 70mm above the middle of the 11mm thick projecting part of the bracket. The centre of the lower bolt is approximately 40mm below this position.

<u>Handrail brackets:</u>

Maximum handrail length	=	2840mm		
Maximum horizontal wind load on bracket	=	1.58 kN		(ultimate)
Maximum ultimate pull-out load on lower bolt	=	$1.58 \times \frac{70}{110}$	=	1.00 kN
Maximum ultimate pull-out load on upper bolt	=	1.58 - 1.00	=	0.58 kN

BS 6180:2011, section 6.5, recommends that barrier fixings, attachments and anchorages should be designed to withstand a greater load than the design loading for the barrier generally. This is intended to ensure that under an extreme load condition, barriers show indications of distress by distortion, before there is any possibility of sudden collapse due to failure of the fixings. A 50% increase in the design load on fixings is recommended.

Applying the above recommendation, the **working load** pull-out force on the lower bolt becomes **1.00 kN.**

For practical purposes a **working load** pull-out force of **1.00 kN**/bolt is specified for both the top and lower bolts.

For handrails shorter than 2840mm overall (2580mm clear opening width) the design working load pull-out forces on the anchor bolts are reduced pro-rata.

Handrail brackets:

Design working load pull-out forces on handrail bracket fixing bolts for standard length handrails.

Handrail o/a length	opening size	working load tension on each bolt (including 50% increase recommended in BS 6180)
1280mm	1020mm	0.45 kN
1500mm	1240mm	0.53 kN
1680mm	1510mm	0.59 kN
1860mm	1690mm	0.66 kN
2180mm	1920mm	0.77 kN
2450mm	2190mm	0.86 kN
2840mm	2580mm	1.00 kN

Physical properties of handrail and lower rail brackets:

The brackets are 50mm wide and have 1 No. 12mm diameter hole top and bottom for M10 bolts, making the effective width of the vertical leg 38mm. The bolts are located 110mm centre to centre.

Material type: Extruded aluminium type 6063 T5

Limiting stress in bending: $f_o = 130\ N/mm^2$

Plastic modulus of 11mm thick section x 38mm effective width: $W_{pl} = \frac{38 \times (11)^2}{4} = 1150mm^3$

Moment capacity of 11mm thick section x 50mm wide: $M_{Rd} = \frac{130\ N/mm^2 \times 1150mm^3 \times (10)^{-6}}{1.1} = 0.136\ kNm$

Dimension from centre of lower bolt to root radius at middle section = 20mm approximately

Factored applied moment on lower part of bracket: $M = 1.00\ kN \times 0.02 = 0.02\ kNm$
$= < 0.136\ kNm$ = OK

Dimension from centre of upper bolt to root radius at middle section = 50mm approximately

Factored applied moment on upper part of bracket: $M = 1.00\ kN \times 0.05 = 0.05\ kNm$
$= < 0.136\ kNm$ = OK

Direct tensile stress on central 11mm thick x 50mm wide section $= \frac{1.58\ kN \times (10)^3}{11 \times 50} = 2.87\ N/mm^2$ = OK

Summary: The handrail brackets are adequate to resist the ultimate load design forces.

Lower rail brackets:

The brackets support the dead load from the glass and rails plus wind loading.

Factored dead load from glass + rails $= 0.37\ kN/m \times 1.166 = 0.43\ kN/m$

Factored vertical load per bracket (max) $= \frac{0.43\ kN/m \times 2.67}{2} = 0.57\ kN$

Factored wind load per bracket (max) $= 2.025\ kN/m^2 \times 0.583 \times \frac{2.67}{2} = 1.58\ kN$

Factored vertical load moment per bracket (max) $= 0.57\ kN \times 0.086 = 0.049\ kNm$

Lower rail brackets:

Bolt loads are similar to the handrail bracket loads but with an additional tension force arising from the moment applied from the self-weight of the glass and rails.

Factored vertical load from glass + rails	=	0.57 kN/bracket		
Distance from centre of glass to face of supporting wall	=	86mm		
Factored moment from glass + rails	=	0.57 kN x 0.086	=	0.049 kNm
Additional bolt tension due to this moment	=	$\frac{0.049\ \text{kNm}}{0.110}$	=	0.45 kN/bolt
Total maximum ultimate bolt tension	=	1.00 + 0.45	=	1.45 kN/bolt

Applying the BS 6180:2011 recommendation that barrier fixings, attachments and anchorages should be designed to withstand a 50% increase on calculated loads, the maximum design **working load** pull-out force on the fixings becomes **1.45 kN/bolt.** For practical reasons this working load will be specified for both bolts on the lower rail brackets. Bolt loads on shorter balconies are reduced pro-rata.

The nominal tension capacity of M10 (4.6 or 8.8 grade) bolts is significantly greater than 1.45 kN. The allowable load is therefore determined by the pull-out resistance of the drilled resin anchor bolts or similar selected by the installers, and also by the strength of the structure into which they are installed to support these loads, and not by the tension capacity of the bolts themselves.

The installers should satisfy themselves that the anchor bolts chosen are adequate to resist the specified working load pull-out forces, and also that the structure into which the bolts are to be installed is adequate to resist this force.

Glass infill:

Design standard: Institution of Structural Engineers publication *Structural use of glass in building (second edition) February 2014.*

Glass type: 10mm thermally toughened soda silicate safety glass with smooth 'as produced' finish with polished edges.

Characteristic design strength = $120\ N/mm^2$

Ultimate design stress $f_{g;d} = \frac{K_{mod} \times K_{sp} \times K_{g;k}}{\gamma_{M;A}} + \frac{K_v (f_{b;k} - f_{g;k})}{\gamma_{M;V}}$

where:

K_{mod} = 30 second load duration factor
= 0.89 for a domestic balustrade load

K_{sp} = glass surface profile factor
= 1.0 for float glass 'as produced'

$f_{g;k}$ = characteristic strength of basic annealed glass
= $45\ N/mm^2$

K_v = manufacturing process strengthening factor
= 1.0 for horizontal toughening

$f_{b;k}$ = characteristic strength of processed glass
= $120\ N/mm^2$

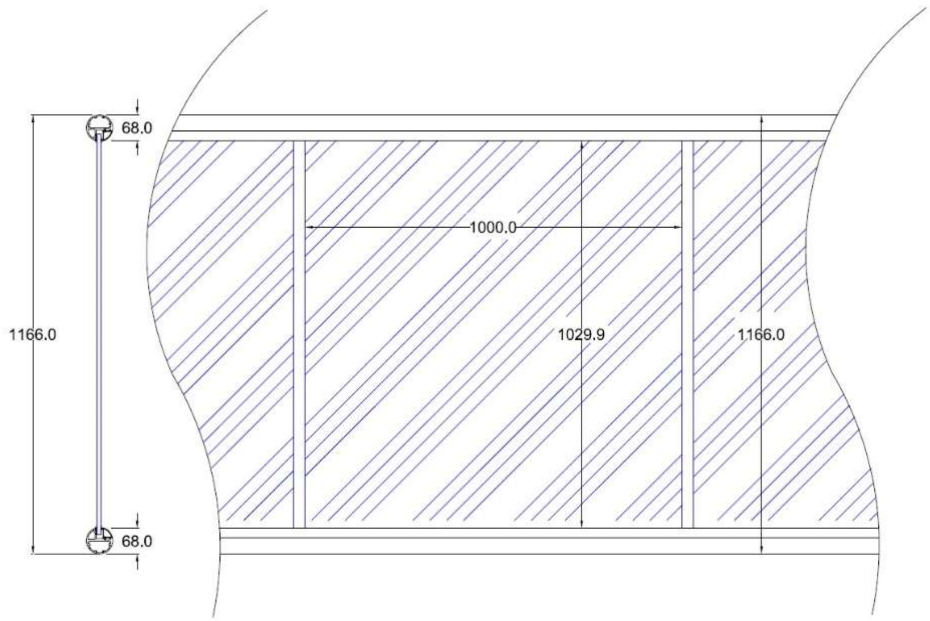
$\gamma_{M;A}$ = material partial factor
= 1.6 for basic annealed glass

$\gamma_{M;V}$ = material partial factor
= 1.2 for surface prestressed (toughened) glass

Ultimate design stress $f_{g;d} = \frac{0.89 \times 1.0 \times 45}{1.6} + \frac{1.0\ (120 - 45)}{1.2}$
= **$87.53\ N/mm^2$**

Section modulus of glass 10mm thick $Z = \frac{1000 \times (10)^2}{6} = 16667\ mm^3/m$

Ultimate moment capacity of glass 1000mm wide x 10mm thick $M_u = f_{g;d} \times Z$
= $87.53\ N/mm^2 \times 16667 mm^3 \times (10)^{-6}$
= **1.459 kNm/m**



Glass panels can be any length.

For the purposes of design and checking a nominal glass panel width of 1000mm simply supported between the bottom rail and the handrail has been used.

Two separate design conditions are considered:

<u>Uniformly distributed service wind load on the infill of 1.35 kN/m²</u>

Ultimate UDL on glass = $1.35\ kN/m^2 \times 1.5 = 2.025\ kN/m^2$

Ultimate moment on glass due to UDL on 1.0m span = $\frac{2.025\ kN/m^2 \times (1.0)^2}{8} = 0.253\ kNm/m$

$= \; < 1.459\ kNm/m$ = OK

<u>Service point load of 0.5 kN applied in any position on the glass</u>

Worst case for bending stress occurs when the point load is applied at mid-height of the glass.

Ultimate moment on glass due to point load = $\frac{(0.50\ kN \times 1.5) \times 1.0m}{4} = 0.1875\ kNm$

Conservatively, it is assumed that this bending moment is carried by a 300mm wide vertical strip of glass.

Moment capacity of 300mm strip = $1.459\ kNm \times 0.30 = 0.4377\ kNm$

$= \; > 0.1875\ kNm$ = OK

Glass deflection:

Inertia of glass 1000 x 10mm = $1000 \times (10)^3 / 12 = 83333mm^4$

Service load deflection due to a UDL of $1.35\ kN/m^2$ = $\frac{5 \times (1350 \times 1.0)(1000)^3}{384 \times 70\,000 \times 83333} = 3.013mm$

= OK

Inertia of glass 300 x 10mm = $0.03 \times 83333mm^4 = 25\,000\ mm^4$

Service load deflection due a point load of 0.5 kN at mid-span = $\frac{500 \times (1000)^3}{48 \times 70\,000 \times 25\,000} = 5.95mm$

= OK

The glass is adequate in terms of both bending strength and deflection.

SUMMARY

Orbit 'Mirror' Juliet balconies using BALCONY 1 type handrail (70mm Diameter)

1. For the occupancy classes listed on pages 1 & 2 of these calculations, on sites that come within the wind load parameters listed on page 4 (and/or have a design characteristic wind pressure no greater than 1.35 kN/m^2) the Balcony 1 (70mm diameter) handrail in extruded aluminium grade 6063 T5, in conjunction with 10mm thick toughened glass panels, is adequate to support the imposed and wind loads specified in relevant British and European standards for spans up to 2.79 metres between the centres of support brackets.

2. The handrail and lower rail support brackets in extruded aluminium grade 6063 T5 are adequate to support the specified loads for spans up to 2.79 metres between bracket centres.

3. For the design loading and 2.79 m maximum span between bracket centres, the design **working load** direct pull-out force on each handrail bracket fixing bolt is **1.0 kN/bolt**. The design working load pull-out forces on the bracket fixing bolts for other standard length handrails are listed below:

Handrail length o/a	Opening size	Working load tension on each bolt (including 50% increase recommended in BS 6180)
1800mm	1020mm	0.45 kN
1500mm	1240mm	0.53 kN
1680mm	1510mm	0.59 kN
1860mm	1690mm	0.66 kN
2180mm	1920mm	0.77 kN
2490mm	2190mm	0.86 kN
2840mm	2580mm	1.00 kN

4. For the design loading and 2.84 m maximum length of the lower rail, the design **working load** direct pull-out force on each lower rail fixing bolt is **1.45 kN/bolt**. The design working load pull-out forces on the bracket fixing bolts for other standard length lower rails are listed below:

Lower rail length o/a	Opening size	Working load tension on each bolt (including 50% increase recommended in BS 6180)
1280mm	1020mm	0.65 kN
1500mm	1240mm	0.77 kN
1680mm	1510mm	0.86 kN
1860mm	1690mm	0.96 kN
2180mm	1920mm	1.12 kN
2450mm	2190mm	1.25 kN
2840mm	2580mm	1.45 kN

5. The installers should satisfy themselves that the fixing bolts chosen are suitable to resist the loads specified above, and also that the structure into which they are to be installed can support these loads.

6. The 10mm thick thermally toughened safety glass panels are adequate to support the design loads specified in the relevant British and European Standards.

7. The 4.8mm diameter self-tapping stainless steel screws connecting the handrail and lower rail to the aluminium support brackets are adequate to support the design loads specified in relevant British and European Standards.

Prepared for and on behalf of Balconette by
A G Bice CEng, FICE, FIStructE.