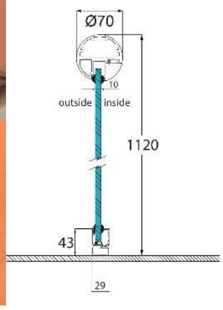
<u>Orbit system handrail with and without internal reinforcing bar:</u> (0.74 kN) *PAGE 1* (B1WLBC09022023)

Structural Calculations for Orbit system handrail with and without 58 x 4mm internal steel reinforcing bar using 48.3mm x 5mm CHS posts & 170 x 100 x 20 baseplates

Our ref: B1WLBC09022023 **Issue date: Feb 2023**

Orbit Balustrade fixed between two walls

Orbit Balustrade on a 3 sided balcony with a central post



Orbit section

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 8579:2020	BSI Standards Publication	Guide to the design of balconies and terraces

<u>Design loads:</u>

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 = Qk1	=	A uniformly distributed load of 1.0 kN/m^2
Point load on glass infill = point load	=	0.50 kN applied to any part of the glass infill panels

Orbit system: handrail with or without internal reinforcing bar: ***PAGE 2*** **(B1WLBC09022023)**

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

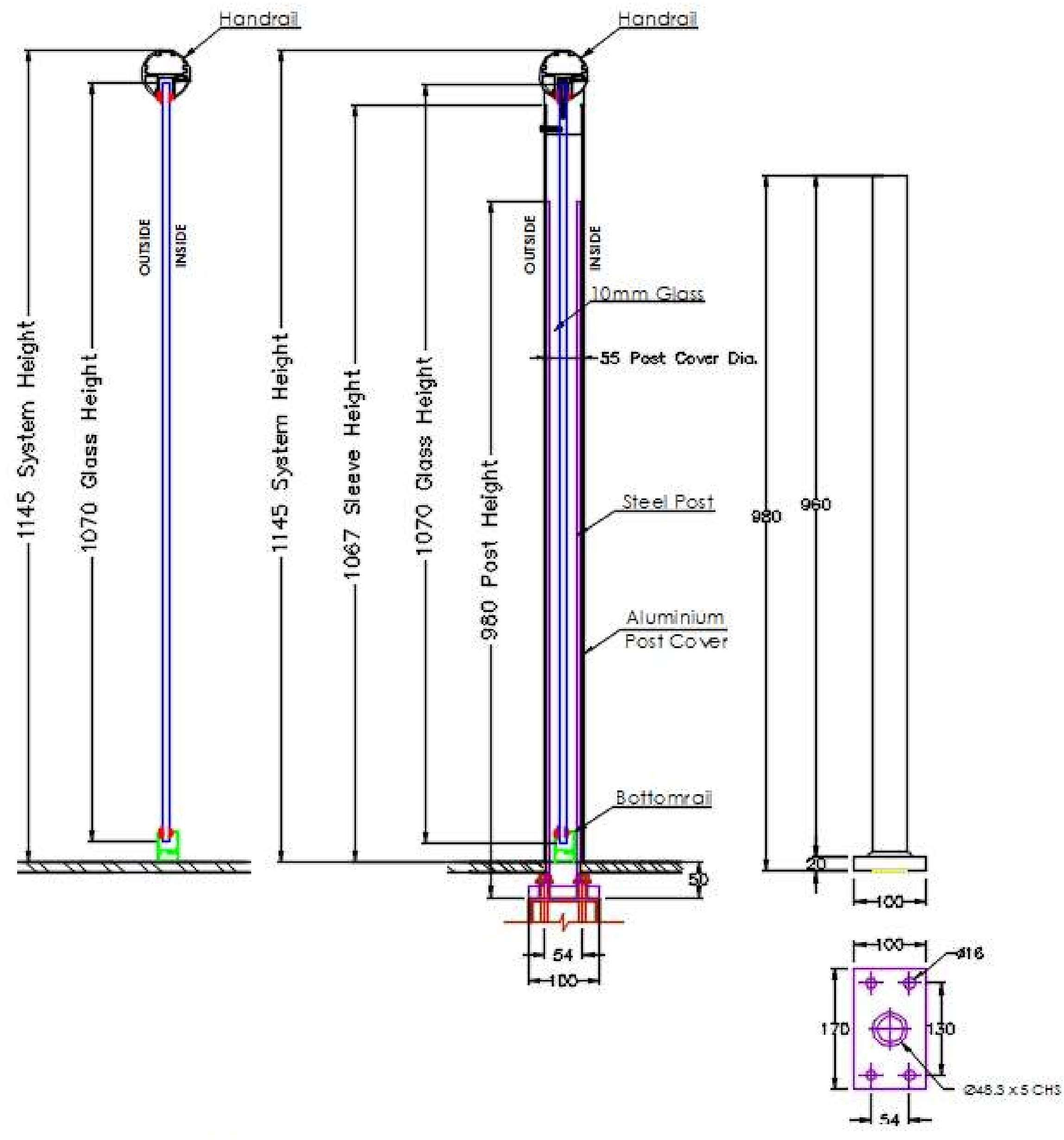
Table 2: BS6180:2011

- These loads are considered as three separate load cases. They are not combined. Wind loading is also considered as a separate load case.
- Factored loads are used for checking the limit state of static strength of a member.
- The 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 system handrail (with or without bar): ***PAGE 3*** **(B1WLBC09022023)**



Section of Orbit system, post and base plate details.

Orbit system handrail (with or without bar): ***PAGE 4*** **(B1WLBC09022023)**

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'* and UK National Annex to EN 1991-1-4:2002 + A1:2010. We have chosen to prepare a calculation based upon certain conditions, resulting in specific coefficients.

BS 8579:2020 'Guide to the design of balconies and terraces' further defines upper bound pressure coefficients for rectangular buildings which are up to 50m in height. These upper bound coefficients are different and dependent on the location of the balcony/terrace; top-level, mid-level, or on the corner of the building.

Each location, in combination with the position of the balcony/terrace on the building will result in a specific characteristic wind pressure. The calculation in this document uses a characteristic wind pressure of **1.29 kN/m²**. We have also prepared **a table in the summary** that shows the parameter changes if the wind pressure exceeds **1.29 kN/m²**.

Characteristic wind pressure	=	**1.29 kN/m²**
Wind load reaction on the handrail	=	**1.29 kN/m²** x 0.5725
	=	0.74 kN/m
	=	same value as the specified imposed line load

For sites that have a **characteristic wind pressure** of **1.29 kN/m²**, the specified imposed uniformly distributed line load on the handrail and the characteristic design wind loading on the handrail are the same.

Wind pressure on the glass is greater than the specified overall design imposed UDL. Wind loading is therefore the controlling condition in terms of glass design.

Partial safety factor considering wind load as a separate leading variable action	γ_{Q1}	=	1.50
Ultimate design wind pressure		=	1.29 kN/m² x 1.50
		=	**1.935 kN/m²**

Summary of design loads:

Element	**Service load**	**Ultimate load**
Horizontal imposed wind and line load applied to the handrail 1100mm above finished floor level (ie 1130mm above the top of the base).	0.74 kN/m	1.11 kN/m
Wind load on the glass	1.29 kN/m²	1.935 kN/m²
Point load applied to the glass in any position	0.50 kN	0.75 kN

Orbit system handrail (with or without bar)

Section properties of handrail (with bar):

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}	=	67 cm^4
Least elastic modulus about the y-y axis	W_{el}	=	17.43 cm^3
Partial factor for material properties	γ_{M1}	=	1.10
Shape factor (assessment)	α	=	W_{pl}/W_{el}
		=	1.2 say

Design ultimate resistance
to bending about the y-y axis M_{Rd} = $M_{o,Rd}$

$$= \alpha W_{el} f_o / \gamma_{M1}$$

$$= \frac{1.2 \times 17.43\ cm^3 \times 130\ N/mm^2 \times (10)^{-3}}{1.1}$$

$$= \mathbf{2.472\ kNm}$$

Section properties of handrail (without bar):

Properties as above except as follows:

Inertia about the y-y axis	I_{yy}	=	47.0 cm^4
Least elastic modulus about the yy axis	W_{el}	=	12.227 cm^3
Design ultimate resistance to bending	M_{Rd}	=	$\alpha W_{el} f_o / \gamma_{M1}$

about the y-y axis

$$= \frac{1.2 \times 12.227\ cm^3 \times 130\ N/mm^2 \times (10)^{-3}}{1.1}$$

$$= \mathbf{1.734\ kNm}$$

Handrail with bar: single span and corner system:

Design ultimate horizontal load on handrail load on handrail. F = 1.11 kN/m

Max. span between points of support. L = 3.3 m

Design horizontal moment on handrail between points of support, based upon simply supported spans (worst case) M

$$= \frac{1.11 \times (3.3)^2}{8}$$

$$= 1.51\ kNm$$

$$= \; < \; 1.732\ kNm \quad = \quad OK$$

Service load deflection of 3.3m ss span d

$$= \frac{5 \times (740 \times 3.3)\ (3300)^3}{384 \times 70\,000 \times 67 \times (10)^4}$$

$$= 24.36\ mm$$

$$= \; < \; 25mm \quad = \quad OK$$

SUMMARY:

The handrail (with bar) is adequate to support the design loading on single spans & corners on spans up to 3.3m between points of support ie. a wall fixing or a handrail corner joint.

Handrail (without bar): Single span and corner system: **Page 6** **(B1WLBC09022023)**

Design ultimate horizontal load on handrail	=	1.11 kN/m				
Max. span between points of support	=	3.0 m				
Ultimate moment on handrail	=	$\frac{1.11 \times (3.0)^2}{8}$	=		**1.245 kNm**	
			=	<	**1.734 kNm**	**OK**
Service load deflection on ss spans of 3.0m	=	$\frac{5\,(740 \times 3.0)\,(3000)^3}{384 \times 70\,000 \times 47 \times (10)^4}$				
	=	**23.72 mm**	=	<	**25mm**	**OK**

SUMMARY:

The handrail (without bar) is adequate to support the design loading on single spans and corners up to 3.0m span between points of support (ie. a post, a wall fixing, or a handrail corner joint) in terms of both moment capacity and service load deflection limitations.

Longer balconies with posts:

On longer balconies the handrail (without bar) is used in conjunction with 48.3mm x 5mm vertical posts installed at **1.90m** maximum spacing to support the handrail.

48.3 x 5mm CHS posts: properties of section:

Steel grade	=	S 275 to EN 10025		
Nominal value of yield strength	=	f_y	=	275 N/mm^2
Nominal value of ultimate tensile strength	=	f_u	=	430 N/mm^2
Inertia of section	=	I_{xx}	=	16.20 cm^4
Elastic modulus of section	=	W_{el}	=	6.69 cm^3
Plastic modulus of section	=	W_{pl}	=	9.42 cm^3
Partial factor for material properties	=	γ_{M1}	=	1.10
Partial factor for class 1 sections	=	γ_{MO}	=	1.00
Modulus of elasticity	=	E	=	210 000 N/mm^2

Design ultimate resistance for bending about the x-x axis

$$M_{pl,Rd} = \frac{\alpha \times f_y \times W_{pl}}{\gamma_{Mo}}$$

$$= \frac{1.2 \times 275\ \text{N/mm}^2 \times 9.42\ \text{cm}^3 \times (10)^{-3}}{1.0}$$

$$= \mathbf{3.11\ kNm}$$

Ultimate moment on post to top of base with posts at 1.90 m centres

$$M_d = (0.74 \times 1.90) \times 1.13 \times 1.5$$

$$= 2.38\ \text{kNm} < 3.11\ \text{kNm} \quad = \quad \textbf{OK}$$

Service load deflection of post supporting 1.90m of handrail

$$\Delta = \frac{P\,L^3}{3\,E\,I}$$

$$= \frac{(740 \times 1.90)\,(1130)^3}{3 \times 210\,000 \times 16.20 \times (10)^4}$$

$$= 19.88\text{mm}$$

Combined total displacement handrail + post = 19.88 + 3.82

$$= 23.70\ \text{mm} < 25\text{mm} \quad = \quad \textbf{OK}$$

Longer balconies with 48.3 x 5mm CHS posts:

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 loads on fixings io recommended.

SUMMARY:
The Orbit handrail without internal steel reinforcing bar, in conjunction with 48.3mm x 5mm thick CHS posts, is adequate to support the design loading on the handrail in terms of both bending strength and deflection limitations for posts spaced at up to 1.90m centres.

Baseplates and HD bolts:
Baseplates are 170 x 100 x 20mm with 4No. 16mm diameter holes for HD bolts spaced 654mm apart centre to centre front to back. (refer to drawing on page 3).

Max. spacing of posts	=	1.90m		
Height from underside of baseplate to line of action of horizontal imposed UDL	=	1.15m		
Design horizontal service imposed and wind load on handrail	=	0.74 kN/m		
Design service moment on post to underside of baseplate	=	0.74 x 1.90 x 1.15		
	=	**1.617 kNm**		
Lever arm between centres of bolts in tension and compression	=	54mm		
Working load bolt tension on 2 No. bolts	=	1.617 kN / 2 No. x 0.054	=	14.971 kN/bolt

Applying the BS 6180: 2011 recommendation, this design ultimate load bolt tension of **22.46 kN/bolt** becomes the **design working load bolt tension.**

The nominal ultimate tension capacity of M12 (8.8 grade) bolts is **37.80 kN/bolt**. This equates to a working load capacity of **25.20 kN/bolt**, which is adequate.

Where connecting to hollow steel sections or blind fixings while maintaining 1.9m max. post spacing, **Blind Bolts** or similar may be used. Technical data sheet reference Blind-Bolts-Terch-Data-Metric gives the following values for their High Tensile Hot Dip. Galvanised Bolts designed to BS EN 1993-1-8:

Tensile resistance	=	34.80 kN/bolt.
Shear resistance over thread	=	46.70 kN/bolt.
Shear resistance over slot	=	29.00 kN/bolt

By inspection, shear forces are well below these values.

SUMMARY:
M12 (8.8 grade) bolts with standard nuts & washers can be used where access is available to install them while maintaining 1.9m max. post spacing.

M14 Blind Bolts or similar can be used where installing into hollow sections, or in the case of blind fixings while maintaining 1.9m max. post spacing.

Orbit system handrail (without bar): longer balconies with posts:

Baseplates: 170mm long x 100mm wide x 20mm thick:

For posts at 1.9m max. spacing, ultimate moment to top of baseplate	=		1.11 x 1.9 x 1.13		
	=		2.383 kNm		
Plastic modulus of baseplate 100mm wide x 20mm thick	=		$\frac{100 \times (20)^2}{4}$		
	=		10000 mm^3		
Ultimate moment capacity of base	=		$\frac{275\ N/mm^2 \times 10000mm^3 \times (10)^{-6}}{1.0}$		
	=		2.75 kNm		
	=	>	2.383 kNm	=	OK

SUMMARY:
170 x 100 x 20mm thick baseplates in steel grade S275 are adequate to support the design loading.

Welded connection between post & baseplate:

The CHS post is welded to the top of the baseplate by means of a full-strength butt weld or a continuous fillet weld.

Elastic modulus of 48.3 x 5mm CHS	=	6.69 cm^3
Maximum ultimate elastic bending stress on post	=	$\frac{2.383 \times (10)^6}{6.69 \times (10)^3}$
	=	356.2 N/mm^2
	=	1.781 N/mm^2 on a 5mm thick section
Transverse capacity of a 10mm fillet weld	=	1.925 kN/mm

SUMMARY:
A continuous 10mm fillet weld around the perimeter of the post is adequate.

Also adequate are a full-strength butt weld, or any combination of welds that achieves a full-strength connection.

Orbit system (with and without bar):

Glass design:

Design standard = Institution of Structural Engineers publication *'Structural use of glass in buildings (second edition) February 2014'.*

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

Characteristic = 120 N/mm^2

design strength

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

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 bending strength of prestressed 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

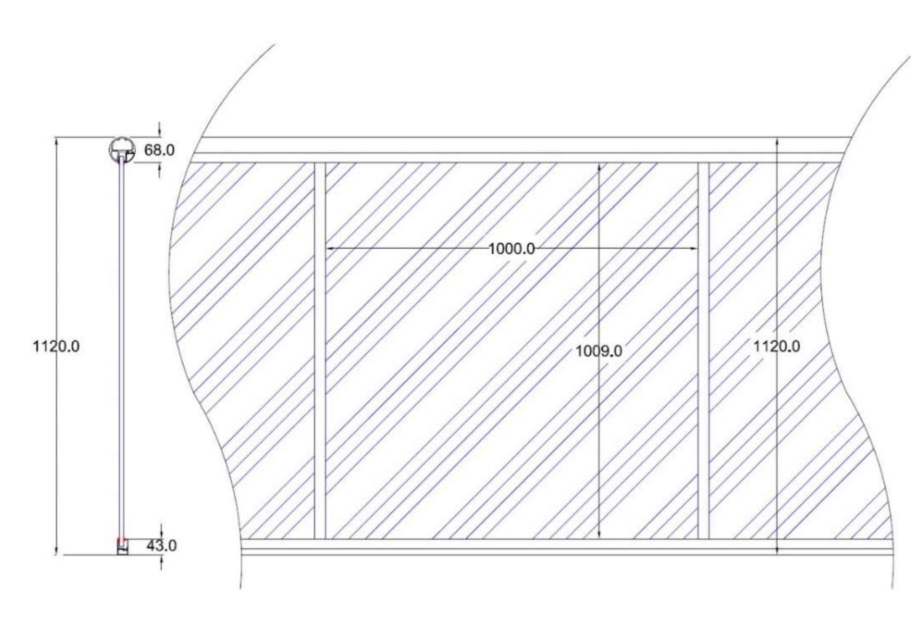
$$f_{g;d} = \frac{0.89 \times 1.0 \times 45}{1.6} + \frac{1.0 (120 - 45)}{1.2}$$

= **87.53 N/mm^2**

Orbit system handrail (with and without bar):

Glass infill (cont):

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	Mu	=	$f_{g;d} \times Z$		
		=	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 over a span of 1000mm between the bottom rail and the handrail has been used.

Separate design loading conditions are considered:

1. Uniformly distributed service wind load on the infill of 1.29 kN/m^2

Ultimate UDL on glass	w	=	1.29 kN/m^2 x 1.5	=	1.935 kN/m^2
Ultimate moment on glass due to UDL on span of 1.0m	Mu	=	$\frac{1.935\ kN/m^2 \times (1.0)^2}{8}$	=	0.242 kNm/m
		=	< 1.459 kNm	=	OK

2. Point service load on the infill of 0.5 kN

Point load on the glass	=	0.5 kN point load applied in any position		
Worst case for bending stress on the glass due to point load	=	point load applied at mid-height of glass		
Ultimate moment on glass due to point load	=	$\frac{0.5\ kN \times 1.5 \times 1.0m}{4}$	=	0.1875kNm

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

Moment capacity of 300mm	=	1.459 kNm x 0.3	=	0.4377 kNm
strip	=	> 0.1875 kNm	=	OK

The glass is adequate to support the ultimate design loading in terms of bending capacity.

Orbit system handrail (with and without bar):

Glass deflection:

1. Overall UDL:

Service load deflection due to the design overall UDL:

Inertia of glass 10mm thick x 1000mm long	=	$\frac{1000 \times (10)^3}{12}$			=	83333 mm^4
Service load deflection due to a UDL of 1.29 kN/m^2 on a simply supported span of 1.0m	=	$\frac{5\,w\,L^4}{384\,E\,I}$				
	=	$\frac{5 \times (1290 \times 1.0)\,(1000)^3}{384 \times 70\,000 \times 83333}$				
	=	2.88 mm	<	$\frac{span}{65}$	=	OK

2. Point load:

Conservatively, for deflection calculation purposes consider that the design point load is carried by a 300mm wide vertical strip of glass:

Inertia of glass 10mm thick x 300mm long	=	0.3 x 83333 mm^4			=	25 000 mm^4
Service load deflection due to a point load of 0.5 kN applied at mid-span	=	$\frac{P\,L^3}{48\,E\,I}$				
	=	$\frac{500 \times (1000)^3}{48 \times 70\,000 \times 25\,000}$				
	=	5.95mm	<	$\frac{span}{65}$	=	OK

SUMMARY:

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

Handrail wall fixings:

The standard wall fixing: This consists of 3mm thick stainless-steel angles bolted to the wall with 2 No. M8 stainless steel resin anchors or similar and secured to the handrail with 2 No. 4.8mm diameter stainless steel Phillips self-tapping screws. (refer to drawing on page 12).

The allowable simply supported span of the handrail (with bar) between points of support is **3.3m**.

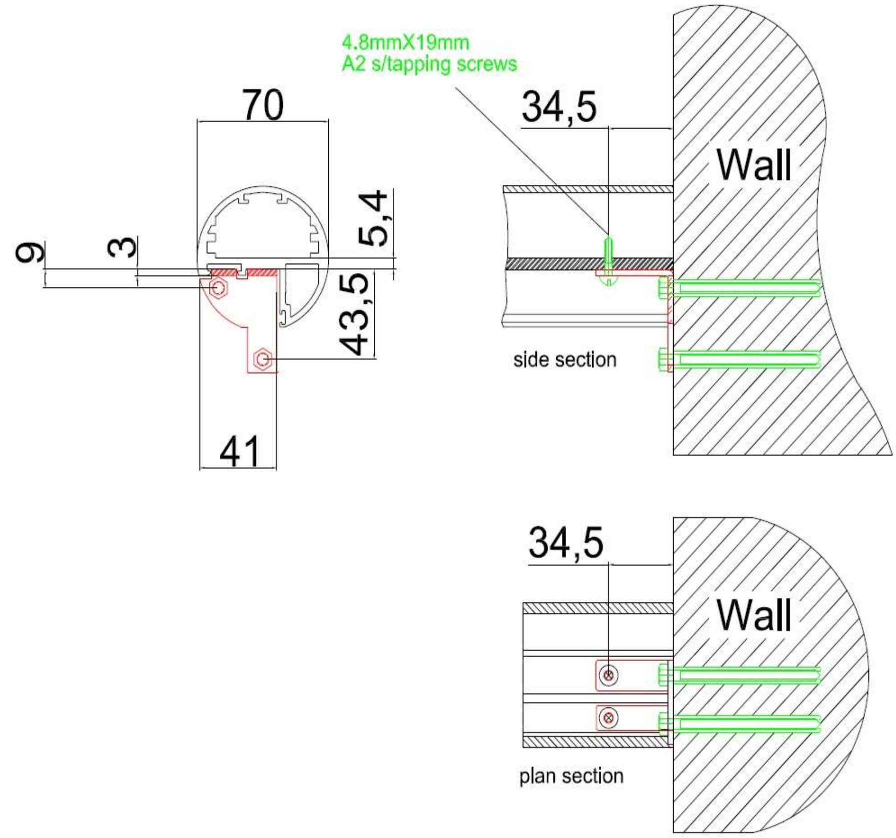
Horizontal service (working) load on the wall fixing for a span of 3.3m	=	0.74 kN/m x 1.65m
	=	**1.221 kN/fixing**

The maximum simply supported span of the handrail (without bar) between points of support is **3.0 m**.

The service load on the wall fixing for this condition	=	0.74 kN/m x 1.5m
	=	**1.11 kN/fixing**

Orbit system handrail (with and without bar) **PAGE 12** (B1WLBC09022023)

Standard Orbit wall fixings:



The horizontal load on the handrail is applied to the fixing angles at the position of the Phillips screws located 34.5mm from the back of the angles. The wall fixing bolts are 34mm apart centre to centre horizontally.

Forces on wall fixings: handrail (with bar):

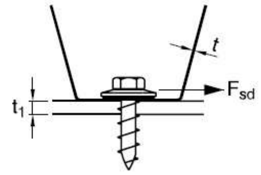
Allowable simply supported span	=	**3.3m.**		
Direct tension on anchor bolts from service load on the front handrail	=	0.74 kN/m x 1.65m / 2 No. bolts	=	0.61 kN/bolt
Shear force on the anchor bolts and ss screws from service load on the side handrail	=	0.74 kN/m x 1.65m / 2 No. bolts or screws	=	0.61 kN/bolt or screw
Service load pull-out load on the anchor bolts from service load on the side handrail	=	(0.74 x 1.65) x 34.5 / 34	=	1.24 kN/bolt
Combined total service load pull-out force on the anchor bolts	=	0.61 + 1.24	=	1.85 kN/bolt
Applying a 50% increase on fixing loads as recommended in BS 6180:2011			=	**2.775 kN/bolt**

<u>Orbit system handrail (with and without bar):</u> **PAGE 13** (B1WLBC09022023)

<u>Phillips stainless steel self-tapping screws</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.

Excerpt of the table at the foot of page 7 of Lindab's literature headed 'Shearing force, construction 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 loads taken from the table in Lindab's technical literature.
Thickness of aluminium in the handrail at screw positions = 5.4mm

Thickness of stainless steel angle brackets (Nom t mm) = 3.0mm

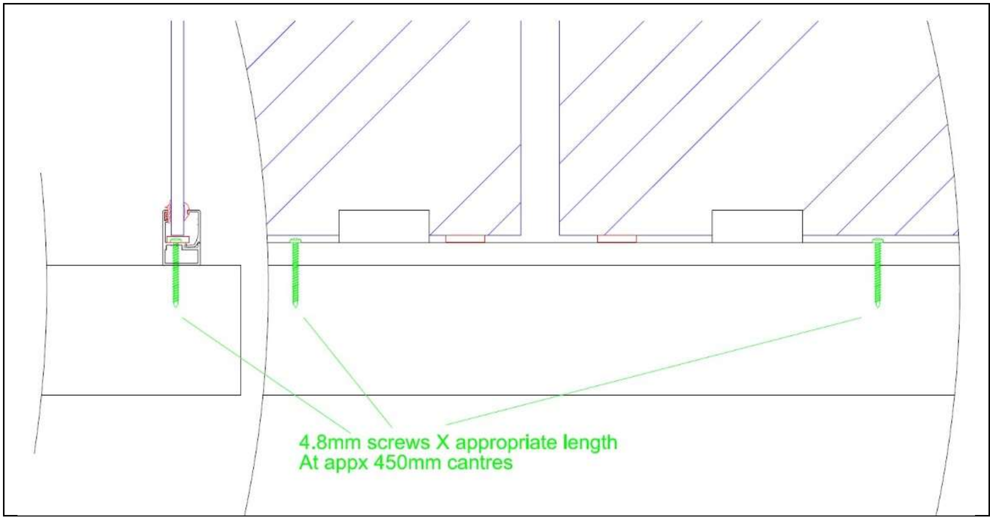
Ultimate shear capacity of 4.8mm diameter screws, safety class 1 for Nom t = 2.5mm = **3.64 kN/screw** (from Lindab's table)

For safety classes 2 and 3 this 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 material having a tensile yield limit of 350 N/mm^2. The values given in the table have been adjusted to allow for the yield stress of stainless-steel type 304 (290 N/mm^2).

The ultimate shear capacity of 3.64 kN/screw is 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 ultimate shear capacity is then **2.51 kN/screw**, which exceeds the design shear value and is therefore adequate.

Orbit system: handrail (with or without) internal reinforcing bar:

Bottom rail fixing:



The standard bottom rail fixing consists of 4.8mm diameter screws at 450mm centres.

The worst case for design loading on the fixings is when the design service point load of 0.50 kN on the glass acts at the position of a fixing.
The fixing screw is then subjected to a working load shear force of 0.50 kN/screw.

The allowable load on the fixing screws varies depending upon the type and thickness of the material into which the screws are inserted.

As an example, fixing to a balcony deck comprising 15mm thick plywood strength class C16, group 1, the basic allowable working load single shear value given in BS 5268: Part 2 : 1996 for a No. 10 (4.88mm) screw 45mm long is 0.519 kN.

Where a pre-drilled steel component of adequate strength is screwed to a timber member, the basic lateral load of 0.519 kN is multiplied by a modification factor of 1.25, making an allowable shear value of 0.648 kN, which is adequate in relation to the design working shear load force of 0.50 kN.

Other values of allowable shear load on fixings will apply where the deck material is of different strength and/or thickness.

The installers should satisfy themselves that the fixings chosen are adequate to resist the design loads in relation to the fixing material in each individual installation.

SUMMARY

Orbit system: handrail (with or without 58 x 4mm steel internal reinforcing bar) using 48.3mm diameter x 5mm thick CHS posts fitted to 170 x 100 x 20 baseplates:

1) These calculations demonstrate that for sites that come within the parameters listed on pages 1 to 5, on single span and corner balconies, the **Orbit system handrail (with bar)** can support the design ultimate loads over spans up to **3.3 metres** between points of support. (i.e.. a handrail wall fixing, or a handrail corner joint).

2) **The Orbit system handrail (without bar)** can support the design ultimate loads over spans up to **3.0 metres**.

3) On longer balconies where the length of the balustrade exceeds **3.3m**, the **handrail (without bar)** is used in conjunction with vertical posts installed to support the handrail at a maximum spacing of **1.9m** between post centres. The posts comprise **48.3mm diameter x 5mm thick** circular hollow steel sections (CHS) sheathed in aluminium.

4) Posts are not required at 900 handrail corner joints. Stability at corners is provided by the glass panels acting as vertical buttresses, in conjunction with direct tension in the side handrails connected to the main building structure.

5) The CHS posts are welded (full-strength butt welds, continuous 10mm fillet welds, or any combination of welds that achieves a full- strength connection) to **170 x 150 x 20mm** steel base plates. 14mm diameter holes are provided for 4 No. M12 holding down bolts.

6) For the maximum span of **3.3m** on single span and corner balconies, the horizontal **working load pull-out force** on the wall bracket fixing bolts is **2.63 kN/bolt**. The horizontal **working load shear force** on the wall fixing bolts is **0.915 kN/bolt**. 9mm diameter holes are provided for M8 drilled resin anchor bolts or similar.

7) For longer balconies, where the handrail (without bar) is used in conjunction with posts installed at a maximum spacing of **1.90m**, the design working load pull-out force on the baseplate holding down bolts is **14.971 kN/bolt**, which equates to an ultimate pull-out force of **22.46 kN/bolt**. These values include a 50% increase in calculated loads on fixings for balustrades as recommended in BS EN 6180:2011.

8) Standard **M12 (8.8 grade) bolts,** washers and nuts can be used where installing onto open sections (UB or UC) and where access is available to install bolts while maintaining 1.9 metres maximum post spacing.

9) In cases of blind fixings, or where connecting to hollow sections (RHS or SHS) **M14 Blind Bolts** or similar can be used while maintaining 1.9 metres maximum post spacing.

10) The 4.8mm diameter self-tapping stainless-steel screws connecting the handrail to the stainless steel angle brackets at wall and post fixings are adequate to support the design loads specified in relevant British and European Standards. The 3mm thick stainless-steel brackets are also adequate to support these loads.

(continued)

SUMMARY
(continued)

11) **Important note:** The installers and/or Engineers for the main building structure should satisfy themselves that the fixing bolts chosen are suitable to resist the design loads and moments specified in these calculations and also that the structure into which they are to be installed can safely support these loads without significant deflection or distortion. Any undue movement of the supporting structure could result in unacceptable displacement at balustrade handrail level.

12) The standard bottom rail fixing comprises 4.8mm diameter screws inserted into the balcony deck at 450mm centres. At this spacing the fixings are required to have a working load shear capacity of **0.50 kN/screw.** The installers should satisfy themselves that the screws chosen are suitable to resist this load when inserted into the deck material present on a specific project. Where the deck material is of reduced strength and/or thickness the spacing of the screws should be reduced accordingly.

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

14) A table is attached showing allowable spans and fixing loads for the system where characteristic wind loads are between **1.35 kN/m^2** and **2.0 kN/m^2**. Should the characteristic wind load for a site exceed **2.0 kN/m^2** the allowable spans and fixing loads will need to be adjusted accordingly.

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