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Specifier:	Mitja ŽNIDARIČ	Project:	Ograja ŠRC Radenci 1
Address:	Lackova ulica 23	Fastening Point:	
Phone I Fax:	|	Date:	9.2.2012
E-Mail:	mitja@progrin.si		

Specifier's comments:

1 Validation of fastenings for handrail applications in concrete

General data

Handrail construction

Handrail type	Balcony handrail
Handrail application	Installed on the top surface of the concrete
System	multi-post system
Post distance	2800 [mm]
Height of handrail from concrete	1050 [mm]
Environment	Outside/Influence of humidity
Cladding	100
Height above sea level (NN)	500,00 [m]
Building heigth from ground	10,00 [m]
Building width	10,00 [m]
Building depth	10,00 [m]
Windload zone	Zone 2: Midland

For the design below, we refer to the following documents:

- DIN 1055-4/03.2005 - Impact on civil construction - windloads
- DIN 1055-1 - Load assumptions for buildings - dead loads
- DIN 18800-1, Edition 11.90 - Steel buildings, calculation and construction
- Eurocode 1 - basics for planning of structural framework
- German guideline for steel companies, Bundesverband Metall
- ETB-Guideline - Safe constructions for fall protection

Moreover, the following has to be taken into account:

- the proof of the steel construction is not part of this calculation and must be done separately.
- For cladded handrails outside buildings, windloads according to DIN 1055-4: 03-2005 dependent on location and building height have to be considered.
- The calculation will be done for a Middle post of a multi-post system.
- The following loadcases are considered:
  - horizontal load outwards
  - horizontal load inwards
  - wind suction outwards
  - wind pressure inwards
- The results of loadcase horizontal load inwards are shown below.
- The result of loadcase horizontal load outwards is decisive.

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2 Handrail construction and input data

Basic input data

Horizontal load	0,500 [kN/m]
Dead load	0,400 [kN/m]
Vertical load	0,150 [kN/m]

Loads acting on governing post

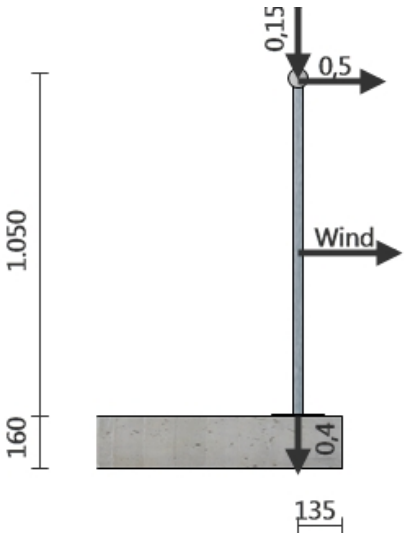
Horizontal load on post	F_H = 1,400 [kN]
Dead load on post	F_G = 1,120 [kN]
Wind load suction on post	F_{Ws} = 2,102 [kN]
Wind load pressure on post	F_{Wd} = 1,911 [kN]
Vertical load on post	F_A = 0,420 [kN]

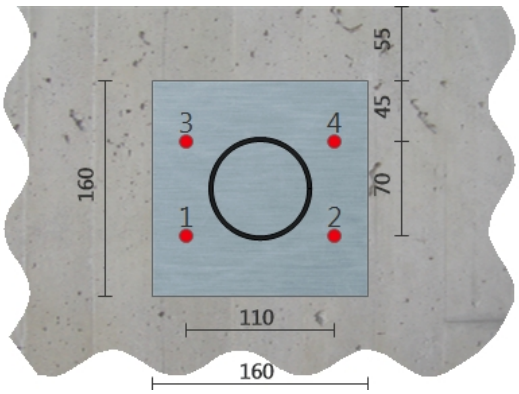
Influencing parameters

Lever arm horizontal load	e_H = 1050 [mm]
Lever arm dead load	e_G = 0 [mm]
Lever arm wind load	e_W = 525 [mm]
Lever arm vertical load	e_A = 0 [mm]
Influencing distance of post	e_p* = 2800 [mm]

Loadcase factors

Load case:	horizontal load inwards
S_d	= 0,9 * F_G - 1,5 * F_H
N_{Sd}	= -0,9 * F_G
$V_{y,Sd}$	= -1,5 * F_H
$M_{x,Sd}$	= -0,9 * F_G * e_G + 1,5 * F_H * e_H
Relevant loadcase:	horizontal load outwards





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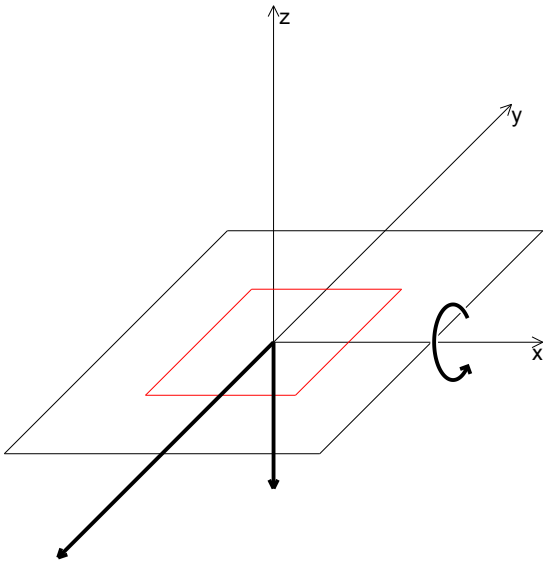
3 Input data

Anchor type and size:	**HST-HCR M16**
Effective embedment depth:	h_{ef} = 82 mm, h_{nom} = 115 mm
Material:	HCR
Approval No.:	ETA 98/0001
Issued I Valid:	17.6.2011 | 19.2.2013
Proof:	design method ETAG No. 001 Annex C(2010)
Stand-off installation:	e_b = 0 mm (no stand-off); t = 8 mm
Anchor plate:	l_x x l_y x t = 160 mm x 160 mm x 8 mm; (Recommended plate thickness: not calculated)
Profile:	Pipe; (L x W x T) = 76 mm x 76 mm x 3 mm
Base material:	cracked concrete, C25/30, f_{cc} = 30,00 N/mm^2; h = 160 mm
Reinforcement:	No reinforcement or Reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm) with longitudinal edge reinforcement d >= 12

Geometry [mm] & Loading [kN, kNm]



Design loads

	Loading
N	1,008
V_x	0,000
V_y	2,100
M_z	0,000
M_x	2,205
M_y	0,000

Eccentricity (structural section) [mm]
e_x = 0; e_y = 0

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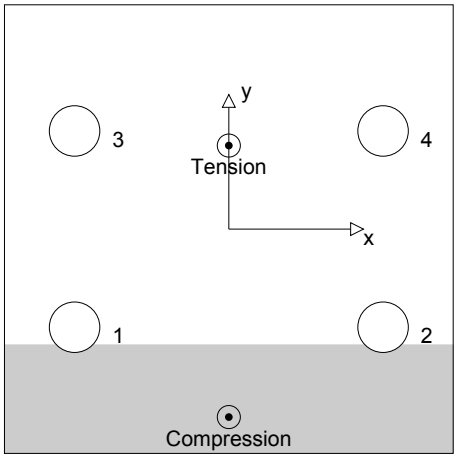
4 Load case/Resulting anchor forces

Load case: Design loads



Anchor reactions [kN]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0,821	0,525	0,000	-0,525
2	0,821	0,525	0,000	-0,525
3	10,216	0,525	0,000	-0,525
4	10,216	0,525	0,000	-0,525

max. concrete compressive strain: 0,25 [‰]
max. concrete compressive stress: 7,42 [N/mm^2]
resulting tension force in (x/y)=(0/30): 22,073 [kN]
resulting compression force in (x/y)=(0/-67): 23,081 [kN]

5 Tension load (ETAG, Annex C, Section 5.2.2)

	Load [kN]	Capacity [kN]	Utilisation β_N [%]	Status
Steel failure*	10,216	56,333	19	OK
Pull-out failure*	10,216	18,257	56	OK
Concrete cone failure**	22,073	25,568	87	OK
Splitting failure**	22,073	25,568	87	OK

* most unfavourable anchor **anchor group (anchors in tension)

5.1 Steel failure

$N_{Rk,s}$ [kN]	$\gamma_{M,s}$	$N_{Rd,s}$ [kN]	N_{Sd} [kN]
84,500	1,500	56,333	10,216

5.2 Pull-out failure

$N_{Rk,p}$ [kN]	ψ_c	$\gamma_{M,p}$	$N_{Rd,p}$ [kN]	N_{Sd} [kN]
25,000	1,095	1,500	18,257	10,216

5.3 Concrete cone failure

$A_{c,N}$ [mm^2]	$A^0_{c,N}$ [mm^2]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]
104308	60516	123	246

$e_{c1,N}$ [mm]	$\psi_{ec1,N}$	$e_{c2,N}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0	1,000	30	0,805	0,944	1,000	7,200

$N^0_{Rk,c}$ [kN]	$\gamma_{M,c}$	$N_{Rd,c}$ [kN]	N_{Sd} [kN]
29,283	1,500	25,568	22,073

5.4 Splitting failure

$A_{c,N}$ [mm^2]	$A^0_{c,N}$ [mm^2]	$c_{cr,sp}$ [mm]	$s_{cr,sp}$ [mm]	$\psi_{h,sp}$
104308	60516	123	246	1,000

$e_{c1,N}$ [mm]	$\psi_{ec1,N}$	$e_{c2,N}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	k_1
0	1,000	30	0,805	0,944	1,000	7,200

$N^0_{Rk,c}$ [kN]	$\gamma_{M,sp}$	$N_{Rd,sp}$ [kN]	N_{Sd} [kN]
29,283	1,500	25,568	22,073

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6 Shear load (ETAG, Annex C, Section 5.2.3)

	Load [kN]	Capacity [kN]	Utilisation β_V [%]	Status
Steel failure (without lever arm)*	0,525	44,000	2	OK
Steel failure (with lever arm)	N/A	N/A	N/A	N/A
Pryout failure**	2,100	79,403	3	OK
Concrete edge failure in direction	N/A	N/A	N/A	N/A

* most unfavourable anchor **anchor group (relevant anchors)

6.1 Steel failure (without lever arm)

$V_{Rk,s}$ [kN]	$\gamma_{M,s}$	$V_{Rd,s}$ [kN]	V_{Sd} [kN]
55,000	1,250	44,000	0,525

6.2 Pryout failure

$A_{c,N}$ [mm²]	$A^0_{c,N}$ [mm²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k-factor
104308	60516	123	246	2,500

$e_{c1,V}$ [mm]	$\psi_{ec1,N}$	$e_{c2,V}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$
0	1,000	0	1,000	0,944	1,000

$N^0_{Rk,c}$ [kN]	$\gamma_{M,c,p}$	$V_{Rd,c1}$ [kN]	V_{Sd} [kN]
29,283	1,500	79,403	2,100

7 Combined tension and shear loads (ETAG, Annex C, Section 5.2.4)

β_N	β_V	α	Utilisation $\beta_{N,V}$ [%]	Status
0,863	0,026	1,000	75	OK

$(\beta_N + \beta_V) / 1.2 <= 1$

8 Displacements (highest loaded anchor)

Short term loading:

N_{Sk} = 7,567 [kN]
V_{Sk} = 0,389 [kN]

δ_N = 0,636 [mm]
δ_V = 0,031 [mm]
δ_{NV} = 0,637 [mm]

Long term loading:

N_{Sk} = 7,567 [kN]
V_{Sk} = 0,389 [kN]

δ_N = 0,763 [mm]
δ_V = 0,047 [mm]
δ_{NV} = 0,765 [mm]

Comments: Tension displacements are valid with half of the required installation torque moment for uncracked concrete! Shear displacements are valid without friction between the concrete and the anchor plate! The gap due to the drilled hole and clearance hole tolerances are not included in this calculation!

The acceptable anchor displacements depend on the fastened construction and must be defined by the designer!

9 Warnings

- The anchor plate is assumed to be sufficiently stiff in order to be not deformed when subjected to the actions!
- Checking the transfer of loads into the base material is required in accordance with ETAG 001, Annex C(2010)Section 7! The software considers that the grout is installed under the anchor plate without creating air voids and before application of the loads.
- The design is only valid if the clearance hole in the fixture is not larger than the value given in Table 4.1 of ETAG 001, Annex C! For larger diameters of the clearance hole see Chapter 1.1. of ETAG 001, Annex C!

Fastening meets the design criteria!

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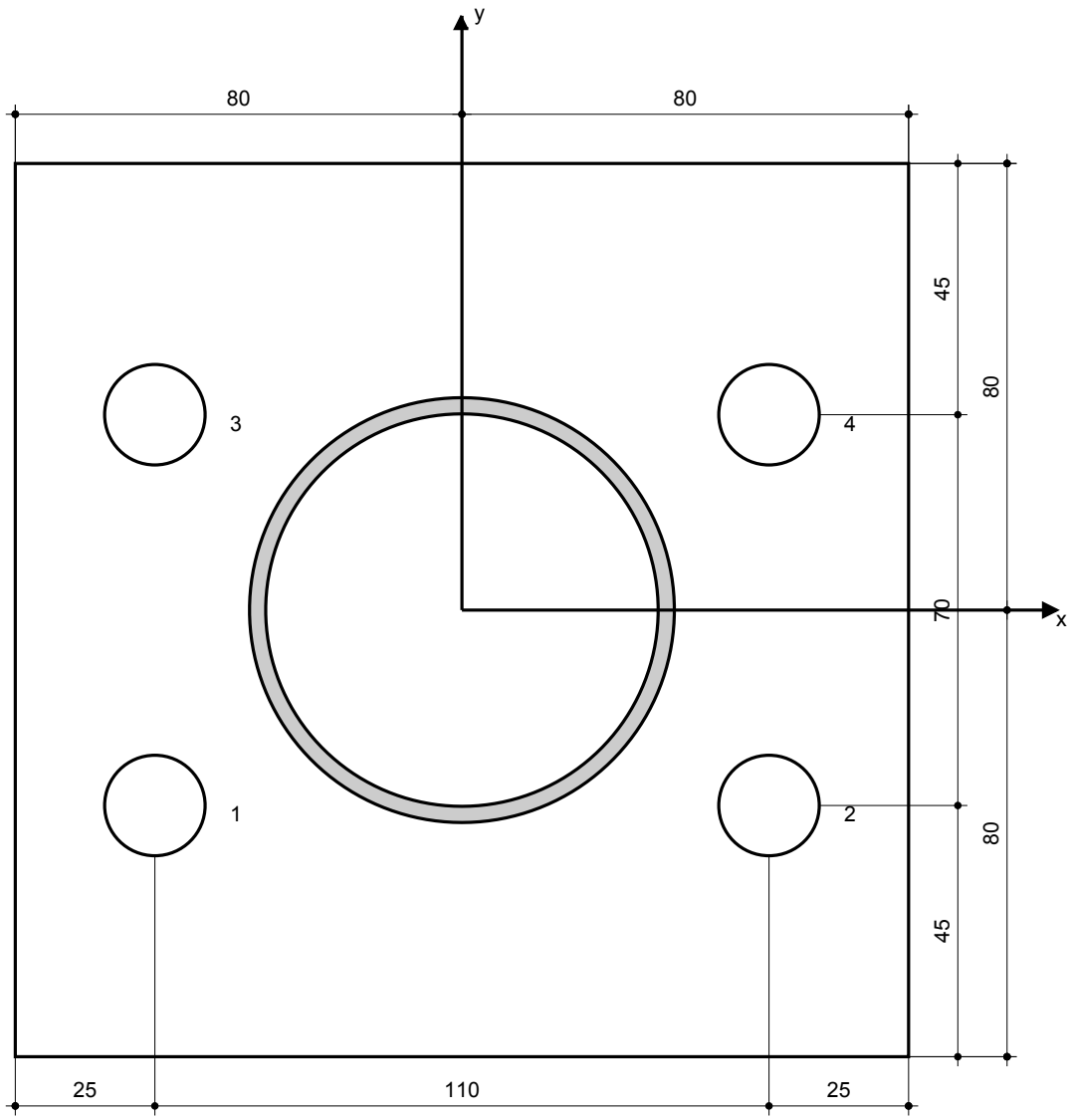
10 Installation data

Anchorplate, steel: -
Profile: Pipe; 76 x 76 x 3 mm
Hole diameter in the fixture: d_f = 18 mm
Plate thickness (input): 8 mm
Recommended plate thickness: not calculated
Anchor type and size: HST-HCR, M16
Installation torque: 0,110 kNm
Hole diameter in the base material: 16 mm
Hole depth in the base material: 115 mm
Minimum thickness of the base material: 160 mm
Cleaning: Manual cleaning of the drilled hole according to instructions for use is required.



Coordinates Anchor [mm]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-55	-35	-	-	-	170
2	55	-35	-	-	-	170
3	-55	35	-	-	-	100
4	55	35	-	-	-	100

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