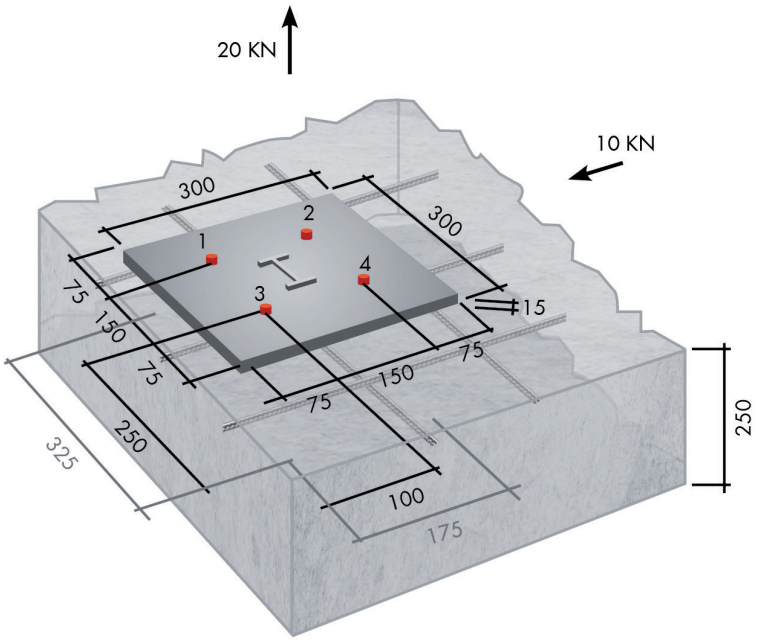
DESIGN EXAMPLES – BONDED ANCHORS



Actions			
Design value of tensile load	N^g_{ed} =	20	kN
Number of anchors in the group loaded with tension	n =	4	
Design value of tensile load acting on a single anchor	$N^h_{ed} = N^g_{ed}/n$ =	5	kN
Percent of sustained load from total load	a_{sus}	70	%
Design value of shear load	V^g_{Sd} =	10	kN
Number of anchors in the group loaded with shear	n =	4	
Design value of shear load acting on a single anchor	$V^h_{ed} = V^g_{ed}/n$ =	2.5	kN
Anchor data			
Anchor type		WIT-UH 300 + W-VD-A/S M12	
Steel grade		5.8	
Anchor diameter	M	12	
Anchorage depth	h_{ef} =	110	
Base material			
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cube}$ =	25	N/mm²
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cyl}$ =	20	N/mm²
Cracked concrete		**Non-cracked concrete**	✔

Structural verification			
Tension		**Shear**	
$\beta_{N,s}$ =	$N^h_{Ed} / N_{Rd,s}$	$\beta_{V,s}$ =	$V^h_{Ed} / V_{Rd,s}$
$\beta_{N,s}$ =	18 %	$\beta_{V,s}$ =	12 %
$\beta_{N,p}$ =	$N^h_{Ed} / N_{Rd,p}$	$\beta_{V,cp}$ =	$V^h_{Ed} / V_{Rd,cp}$
$\beta_{N,p}$ =	30 %	$\beta_{V,cp}$ =	9 %
$\beta_{N,c}$ =	$N^h_{Ed} / N_{Rd,c}$	$\beta_{V,c}$ =	$V^h_{Ed} / V_{Rd,c}$
$\beta_{N,c}$ =	35 %	$\beta_{V,c}$ =	55 %
$\beta_{N,sp}$ =	$N^h_{Ed} / N_{Rd,sp}$		
$\beta_{N,sp}$ =	13 %		

I - Required verification of post-installed anchor in combined tension and shear load:		
Assessment of steel failure only		
	Utilization	**Verification**
Tension	18 %	$\beta_{N,max} \leq 1.00$
Shear	12 %	$\beta_{V,max} \leq 1.00$
Tension/shear combination	5 %	$\beta_{N,max}^{2.0} + \beta_{V,max}^{2.0} \leq 1.00$
II - Required verification of post-installed anchor in combined tension and shear load:		
Assessment of failure modes other than steel		
	Utilization	**Verification**
Tension	35 %	$\beta_{N,max} \leq 1.00$
Shear	55 %	$\beta_{V,max} \leq 1.00$
Tension/shear combination	62 %	$\beta_{N,max}^{1.5} + \beta_{V,max}^{1.5} \leq 1.00$

A. Required verification of post-installed anchor in tension				
1. Steel failure				
$N_{Rd,s}$	=	28.1	kN	
$\beta_{N,s}$	=	0.18		
2. Combined pull-out and concrete failure				
$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$				
$N^0_{Rd,p}$	=	44.2	kN	
a. Influence of concrete strength				
$f_{b,N}$	=	1.0		
b. Influence of embedment depth				
f_{hef}	=	1.0		

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c. Influence of spacing										
$s_{cr,Np}$	=	330	mm							
s_x	=	150	mm	$s_x / s_{cr,p}$	=	0.45	$f_{sx,p}$	=	0.73
s_y	=	150	mm	$s_y / s_{cr,p}$	=	0.45	$f_{sy,p}$	=	0.73
d. Influence of edge distance										
$c_{cr,Np}$	=	165	mm							
c_x	=	100	mm	$c_x / c_{cr,p}$	=	0.61	$f_{cx,1,p}$	=	0.88
							$f_{cx,2,p}$	=	0.81
c_y	=	250	mm	$c_y / c_{cr,p}$	=	1.52	$f_{cy,p}$	=	1.00
e. Influence of sustained loading										
f_{sus}	=	1.0								
$N_{Rd,p}$	=	16.79	kN							
$\beta_{N,p}$	=	0.3								

3. Concrete cone failure

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

$N^0_{Rd,c}$	=	37.8	kN							
a. Influence of concrete strength										
$f_{b,N}$	=	1.0								
b. Influence of embedment depth										
f_{hef}	=	1.0								
c. Influence of spacing										
$s_{cr,N}$	=	330	mm							
s_x	=	150	mm	$s_x / s_{cr,N}$	=	0.45	f_{sx}	=	0.73
s_y	=	150	mm	$s_y / s_{cr,N}$	=	0.45	f_{sy}	=	0.73
d. Influence of edge distance										
$c_{cr,N}$	=	165	mm							
c_x	=	100	mm	$c_x / c_{cr,N}$	=	0.61	$f_{cx,1}$	=	0.88
							$f_{cx,2}$	=	0.81
c_y	=	250	mm	$c_y / c_{cr,N}$	=	1.52	f_{cy}	=	1.00
$N_{Rd,c}$	=	14.36	kN							
$\beta_{N,c}$	=	0.35								

4. Splitting failure

No verification is required if at least one of the following conditions is fulfilled.

a. The edge distance in all directions is $c \geq 1.0\ c_{cr,sp,}$ for single fasteners and $c \geq 1.2\ c_{cr,sp,}$ for groups of fasteners and the member depth is $h \geq h_{min}$ in both cases, with h_{min} corresponding to $c_{cr,sp}$.

b. The characteristic resistances for concrete cone failure and pull-out failure or combined pull-out and concrete failure (bonded fasteners) are calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to wk ≈ 0.3 mm.

$$N_{Rd,sp} = N^{0}_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_{h}$$

								Verification			
c_x	=	100	mm	$c_{cr,sp}$	=	264	mm	$c_x \geq c_{cr,sp}$	check required		
				$1.2\ c_{cr,sp}$	=	316.8	mm	$c_x \geq 1.2\ c_{cr,sp}$	check required		
c_y	=	250	mm	$c_{cr,sp}$	=	264	mm	$c_y \geq c_{cr,sp}$	check required		
				$1.2\ c_{cr,sp}$	=	316.8	mm	$c_y \geq 1.2\ c_{cr,sp}$	check required		
h	=	250	mm	h_{min}	=	140	mm	$h \geq h_{min}$	✔		
$N^{0}_{Rd,sp}$	=	37.8	kN								
a. Influence of concrete strength											
$f_{b,N}$	=	1.00									
b. Influence of embedment depth											
f_{hef}	=	1.00									
c. Influence of Spacing											
$s_{cr,sp}$	=	220	mm								
s_x	=	150	mm	$s_x / s_{cr,sp}$	=	0.68		$f_{sx,sp}$	=	0.85	
s_y	=	150	mm	$s_y / s_{cr,sp}$	=	0.68		$f_{sy,sp}$	=	0.85	
d. Influence of edge distance											
$c_{cr,sp}$	=	110	mm								
c_x	=	100	mm	$c_x / c_{cr,sp}$	=	0.91		$f_{cx,1,sp}$	=	0.98	
c_y	=	250	mm	$c_y / c_{cr,sp}$	=	2.27		$f_{cx,2,sp}$	=	1	
								$f_{cy,sp}$	=	1	
e. Influence of concrete member thickness											
h	=	250	mm	h_{min}	=	140		h/h_{min}	=	1.79	
f_h	=	1.48									
$N_{Rd,sp}$	=	39.6	kN								
$\beta_{N,sp}$	=	0.13									

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B. Required verification of post-installed anchor in shear

1. Steel failure, shear load without lever arm

$V_{Rd,s}$	=	20.2	kN	
$\beta_{V,s}$	=	0.12		

2. Concrete pry-out

$V_{Rd,c}$	=	$k \cdot \min(N_{Rd,p;} N_{Rd,c})$		
$N_{Rd,c}$	=	14.36	kN	
k	=	2		
$V_{Rd,cp}$	=	28.72	kN	
$\beta_{V,cp}$	=	0.09		

3. Concrete edge breakout

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max(10\ h_{ef}\ ;\ 60\ d)$.

For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

$V_{Rd,c}$	=	$V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$		
$V^0_{Rk,c}$	=	4.6	kN	

a. Influence of concrete strength

$f_{b,N}$	=	1.00		

b. Influence of embedment depth

$f_{hef,V}$	=	1.04		

c. Influence of spacing

In groups loaded perpendicular to the edge, only two adjacent anchors closest and parallel to the edge carry the load. The same spacing should be used for the verification.

s	=	150	mm	c_1	=	100	s/c_1	=	1.5	$f_{s,v}$	=	1.5

d. Influence of edge distance c_1

c_1	=	100	mm	d	=	12	c_1/d	=	8.33	$f_{c1,v}$	=	1.26

e. Influence of edge distance c_2

c_2	=	250	mm	c_1	=	100	c_2/c_1	=	2.50	$f_{c2,v}$	=	1

f. Influence on load direction

a	=	0	°	
f_a	=	1		

g. Influence on member thickness

h	=	250	mm	c_1	=	100	h/c_1	=	2.50			
f_h	=	1										
$V_{Rd,c}$	=	9.04	kN	for a single anchor								
$\beta_{V,c}$	=	0.55										