

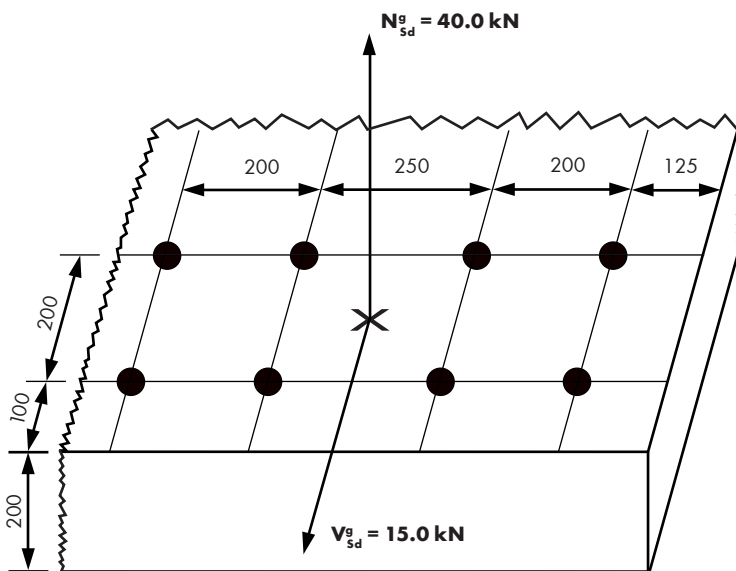
## DESIGN EXAMPLE – METAL ANCHORS

### Design Example

Anchor design according to Würth Simplified Anchor Design Method

Given Data:

- Concrete C30/37
- Cracked concrete
- Thickness of concrete component  $h = 200\text{mm}$



CALCULATION EXAMPLES

Selected anchor: W-FAZ M20

<b>Actions</b>			
<b>Design value of tensile load</b>	$N_{sd}^g =$	40.0	kN
Number of anchors in the group loaded with tension	$n =$	8	
Design value of tensile load acting on a single anchor	$N_{sd}^h = \frac{N_{sd}^g}{n} =$	5.0	kN
<b>Design value of shear load</b>	$V_{sd}^g =$	15.0	kN
Number of anchors in the group loaded with shear	$n =$	8	
Design value of shear load acting on a single anchor	$V_{sd}^h = \frac{V_{sd}^g}{n} =$	1.88	kN
<b>Anchor data</b>			
Anchor type		W-FAZ/S M20	
Anchor diameter	M	20	
Anchorage depth	$h_{ef} =$	100	mm
<b>Base material</b>			
Compressive strength class of concrete			
Characteristic compressive cube strength of concrete at 28days	$f_{ck,cube} =$	37	N/mm <sup>2</sup>
Characteristic compressive cylinder strength of concrete at 28days	$f_{ck,cyl} =$	30	N/mm <sup>2</sup>
<b>Cracked concrete</b>	✓	<b>Non-cracked concrete</b>	
<b>Structural verification</b>			
	$\beta_N = \max(\beta_{N,s}; \beta_{N,p}; \beta_{N,c}; \beta_{N,sp}) =$	0.405	
	$\beta_N \leq 1$	✓	
	$\beta_V = \max(\beta_{V,s}; \beta_{V,cp}; \beta_{V,c}) =$	0.787	
	$\beta_V \leq 1$	✓	
	$\beta_N + \beta_V = 0.405 + 0.787 =$	1.192	
	$\beta_N + \beta_V \leq 1.2$	✓	

## DESIGN EXAMPLE – METAL ANCHORS

<b>Resistances</b>											
Calculation of Design values of resistance to <b>tension loads</b>											
<b>In case of steel failure</b>											
Design value							$N_{Rd,s} =$		53.8	kN	
Ratio between design action and design resistance							$\beta_{N,s} = N_{sd}^h / N_{Rd,s} = \frac{5}{53.8} =$		0.093		
<b>In case of pull-out/pull-through failure</b>											
Basic design value							$N_{Rd,p}^0 =$		24.0	kN	
Influence of compressive strength of concrete							$f_{b,N} =$		1.22		
							$N_{Rd,p} = N_{Rd,p}^0 \cdot f_{b,N}$				
Design value							$N_{Rd,p} =$		29.28	kN	
Ratio between design action and design resistance							$\beta_{N,p} = N_{sd}^h / N_{Rd,p} = \frac{5}{29.28} =$		0.171		
<b>In case of concrete cone failure</b>											
Basic design value							$N_{Rd,c}^0 =$		24.0	kN	
Influence of compressive strength of concrete							$f_{b,N} =$		1.22		
Influence of spacing											
$s_x =$	200	mm	$s_{cr,N} =$	300	mm	$s_x / s_{cr,N} =$	0.66	$f_{sx} =$	0.74		
$n_x =$	4					$s_y / s_{cr,N} =$	0.83	$f_{sy} =$	0.92		
$s_y =$	200	mm									
$n_y =$	2										
Influence of edge distance											
$c_x =$	100	mm	$c_{cr,N} =$	150	mm	$c_x / c_{cr,N} =$	0.66	$f_{cx,1} =$	0.90		
						$c_y / c_{cr,N} =$	0.83	$f_{cx,2} =$	0.83		
$c_y =$	125	mm						$f_{cy} =$	0.83		
							$N_{Rd,c} = N_{Rd,c}^0 \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$				
Design value							$N_{Rd,c} =$		12.36	kN	
Ratio between design action and design resistance							$\beta_{N,c} = N_{sd}^h / N_{Rd,c} = \frac{5}{12.36} =$		0.405		

In case of concrete splitting failure									
No verification of splitting is required if at least one of the conditions is fulfilled:									
a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2 \cdot c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.									
b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3\text{mm}$ .									
$c_x =$		mm	$c_{cr,sp} =$		mm	$c_x \geq c_{cr,sp}$	b) applies		
						$c_x \geq 1.2 \cdot c_{cr,sp}$	b) applies		
$c_y =$		mm	$1.2 \cdot c_{cr,sp} =$		mm	$c_y \geq c_{cr,sp}$	b) applies		
						$c_y \geq 1.2 \cdot c_{cr,sp}$	b) applies		
$h =$		mm	$h_{min} =$		mm	$h \geq h_{min}$	b) applies		
Basic design value						$N_{Rd,c(sp)}^0 =$	-	kN	
Influence of compressive strength of concrete						$f_{b,N} =$	-		
Influence of spacing									
$s_x =$		mm	$s_{cr,sp} =$		mm	$s_x / s_{cr,sp} =$	$f_{sx,sp} =$	-	
$n_x =$						$s_y / s_{cr,sp} =$	$f_{sy,sp} =$	-	
$s_y =$		mm							
$n_y =$									
Influence of edge distance									
$c_x =$		mm	$c_{cr,sp} =$		mm	$c_x / c_{cr,sp} =$	$f_{cx,1,sp} =$	-	
						$c_x / c_{cr,sp} =$	$f_{cx,2,sp} =$	-	
$c_y =$		mm				$c_y / c_{cr,sp} =$	$f_{cy,sp} =$	-	
$h =$		mm	$h_{min} =$		mm	$h / h_{min} =$	$f_h =$	-	
$N_{Rd,sp} = N_{Rd,c(sp)}^0 \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$									
Design value						$N_{Rd,sp} =$	-	kN	
Ratio between design action and design resistance						$\beta_{N,sp} = N_{Sd}^h / N_{Rd,sp} =$	-		

## DESIGN EXAMPLE – METAL ANCHORS

<b>Resistances</b>	
Calculation of Design values of resistance to <b>shear loads</b>	
<b>In case of steel failure</b>	
Design value	$V_{Rd,s} = 51.9$ kN
Ratio between design action and design resistance	$\beta_{V,s} = \frac{V_{Sd}^h}{V_{Rd,s}} = \frac{1.88}{51.9} = 0.036$
<b>In case of pry-out failure</b>	
	$N_{Rd,c} = 12.36$ kN
Influence of compressive strength of concrete	$k = 2$
	$V_{Rd,cp} = N_{Rd,c} \cdot k$
Design value	$V_{Rd,cp} = 24.72$ kN
Ratio between design action and design resistance	$\beta_{V,cp} = \frac{V_{Sd}^h}{V_{Rd,cp}} = \frac{1.88}{24.72} = 0.076$
<b>In case of concrete edge failure</b>	
Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c > \max(10h_{ef}; 60d)$ . For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.	
Basic design value	$V_{Rd,c}^0 = 10.7$ kN
Influence of compressive strength of concrete	$f_{b,v} = 1.22$
Influence of spacing	
In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.	
$s = 200$ mm	$c_1 = 100$ mm
	$s/c_1 = 2.0$
	$f_{s,v} = 1.67$
Influence of edge distance	
$c_2 = 125$ mm	$c_1 = 100$ mm
	$c_2/c_1 = 1.25$
	$f_{c2,v} = 0.875$
Influence of load direction	
In case of $\alpha > 90^\circ$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure.	
$\alpha = 0^\circ$	$f_\alpha = 1.0$
Influence of component thickness	
$h = 200$ mm	$c_1 = 100$ mm
	$h/c_1 = 2.0$
	$f_h = 1.0$
	$V_{Rd,c} = V_{Rd,c}^0 \cdot f_{b,v} \cdot f_{s,v} \cdot f_{c2,v} \cdot f_\alpha \cdot f_h$
Design value	$V_{Rd,c} = 19.07$ kN
Ratio between design action and design resistance	$\beta_{V,c} = \frac{V_{Sd}^g}{V_{Rd,c}} = \frac{15.0}{19.07} = 0.787$

