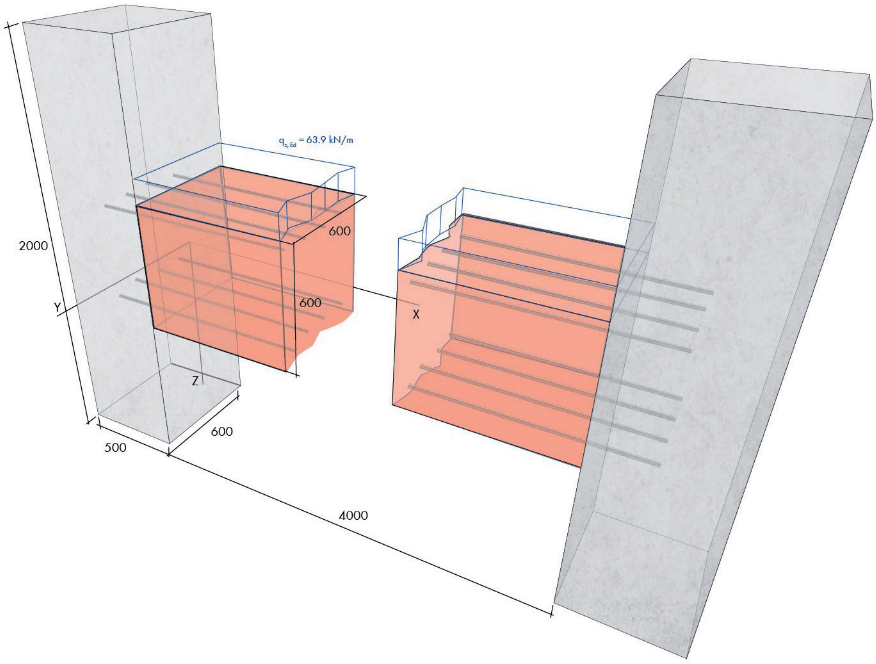
DESIGN EXAMPLE - BEAM BETWEEN TWO COLUMNS



Base material of existing & new				
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cube}$ =	25	N/mm²	
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cyl}$ =	30	N/mm²	
Cracked concrete	✔	**Non-cracked concrete**		
Roughness of joint	=	rough		

Geometry			
Existing structure:			
Height	H =	2000	mm
Width	W =	600	mm
Depth	D =	500	mm
New structure:			
Height	H =	600	mm
Width	W =	600	mm
Span length	L =	4000	mm
Effective span length	L_{ef} =	4500	mm

Reinforcement			
Injection Anchor		WIT-UH 300	
Top reinforcement diameter	Ø =	16	mm
Bottom reinforcement diameter	Ø =	16	mm
Top reinforcement:			
Number of bars	n_{Top}	4	
Anchorage length	$l_{bd,1}$	193	mm
Drill hole depth	l_{v1}	250	mm
Drill diameter	d_0	20	mm
Bottom reinforcement:			
Number of bars	n_{Bot}	4	
Anchorage length	$l_{bd,2}$	196	mm
Drill hole depth	l_{v2}	250	mm
Drill diameter	d_0	20	mm

Actions
Beam self-weight = 25 * (0.6*0.6) * 1.35 = 12.15 kN/m
Slab self-weight = 25 * 0.25* 4 m * 1.35 = 33.75 kN/m
=> Dead load = 12.15 + 33.75 = 45.9 kN/m
Imposed load = 3 kN/m² (Category B - Office)
=> Live load = 3 * 4 m * 1.5 = 18 kN/m

A - Determination of the additional normal force due to shear loading			
F_{Ed}	=	max(| $V_{z,ed}$ | ·a_l/z; 0.5 · | $V_{z,ed}$ |)	EN 1992-1-1: 9.2.1.4 (9.3); NCI 9.3DE
$V_{z,ed}$	=	143.775 kN	
F_{Ed}	=	159.75 kN	

B - Verification of steel			
Bottom reinforcement (new)			
$\beta_{sb,2}$	=	σ_{Ed} / σ_{Rd}	degree of capacity utilisation
σ_{Ed}	=	N_{Ed}/A = 159.74 / 4 (π x 16^2/4) = 198.63 N/mm²	Design value of the actions
σ_R	=	f_{yk} / γ_{Ms} = 500 / 1.15 = 434.78 N/mm²	
$\beta_{sb,2}$	=	σ_{Ed} / σ_{Rd} = 198.63 / 434.78 = **0.46**	degree of capacity utilisation

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C - Verification of concrete

Bottom reinforcement (anchorage)

l_{bd}	=	$\max(\alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_5 \cdot l_{b,rqd}; l_{b,min})$		EN 1992-1-1: 8.4.4 (8.4)
$l_{b,rqd}$	=	$(d/4) \cdot (\sigma_{sd} / f_{bd})$ = (16/4) x (198.63 / 2.7) = 294 mm		EN 1992-1-1: 8.4.3 (8.3)
$l_{b,min}$	=	$\max(0.3 \cdot \alpha_1 \cdot \alpha_4 \cdot l_{b,rqd,min}; 2/3 \cdot 10 \cdot d; 2/3 \cdot 100 \text{ mm}) \cdot 1.0$		EN 1992-1-1: 8.4.4 (8.6)
$l_{b,rqd,min}$	=	$(d/4) \cdot (f_{yd} / f_{bd})$ = (16/4) x (500/1.15/2.7) = 644 mm		EN 1992-1-1: 8.4.3 (8.3)
$l_{b,min}$	=	max (0,3 x 1 x 1 x 644 ; 2/3 x 10 x 16; 2/3 x 100) = 193.2 mm		
l_{bd}	=	max (1 x 1 x 1x 1x 0.67 x 294 ; 193.2) = 196.9 mm		
l_v	=	250	mm	9.2.1.4 (3) extension to the calculated support position (effective span), which is in this case in the middle of the column (Commentary of the German National Annex)

Shear at the joint

β_{joint}	=	V_{Edi} / V_{Rdi}	degree of capacity utilisation
V_{Edi}	=	$\beta \cdot V_{Ed} / (z \cdot bi)$ = 1 x 143.775 / (600 x 600) = 0.399 N/mm²	EN 1992-1-1: 6.2.5 (6.24)
V_{Rdi}	=	$M_{in} (V_{Rdic}; V_{Rc,max})$	EN 1992-1-1: 6.2.5 (1)
V_{Rdic}	=	$c \cdot f_{ctd} + (\mu \cdot \sigma_D + \mu \cdot \sigma_z)$ = 0.4 x 1.0174 + (0.7 x 0 + 0.7 x 0) = 0.407 N/mm²	EN 1992-1-1: 6.2.5 (6.25)
$V_{Rc,max}$	=	$0.5 \cdot v \cdot f_{cd}$	EN 1992-1-1: 6.2.5 (6.25)
f_{cd}	=	$a_{cc} \cdot f_{ck} / \gamma_c$ = 0.85 x 20/1.5 = 14.17 N/mm²	EN 1992-1-1: 3.1.6 (3.15)
$V_{Rc,max}$	=	$0.5 \cdot v \cdot f_{cd}$ = 0.5 x 0.5 x 14.17 = 3.54 N/mm²	EN 1992-1-1: 6.2.5 (6.25)
β_{joint}	=	V_{Edi} / V_{rdi} = 0.399/0.407 = 0.98	Degree of capacity utilisation