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REINFORCEMENT DESIGN	Dok. nr.:	K3-10/65E	Control:	ps
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REINFORCEMENT DESIGN FOR TSS 20 FA

CONTENTS

PART 1 – BASIC ASSUMTIONS

GENERAL

The following calculations of anchorage of the units and the corresponding reinforcement must be considered as an example illustrating the design model.

It must always be checked that the forces from the anchorage reinforcement can be transferred to the main reinforcement of the concrete components. The recommended reinforcement includes only the reinforcement necessary to anchor the unit to the concrete.

In the vicinity of the unit the element must be designed for the force R_1.

STANDARDS

The calculations are carried out in accordance with:

- Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings.
- Eurocode 3: Design of steel structures. Part 1-1: General rules and rules for buildings.
- Eurocode 3: Design of steel structures. Part 1-8: Design of joints.
- EN 10080: Steel for the reinforcement of concrete. Weldable reinforcing steel. General.

The selected values for the NDP's in the following calculations are:

Parameter	γ_c	γ_s	$\gamma_{s,red2}$ 1)	α_{cc}	α_{ct}
Value	1,5	1,15	1,1	0,85	0,85

1) According to Clause A2.2, the benefit of a reduced material factor, $\gamma_{s,red2}$, can be taken in to account when the reaction forces are calculated based on the most unfavorable location of the anchoring reinforcement.

Table 1: NDP-s in EC2.

Parameter	γ_{M0}	γ_{M1}	γ_{M2}
Value	1,05	1,05	1,25

Table 2: NDP-s in EC3.

QUALITIES

Concrete B35/45:	f_{ck} = 35,0 MPa	EC2, Table 3.1
	$f_{cd} = \alpha_{cc} \times f_{ck}/\gamma_c$ = 0,85×35/1,5 = 19,8 MPa	EC2, Clause 3.1.6
	$f_{ctd} = \alpha_{ct} \times f_{ctk,0,05}/\gamma_c$ = 0,85×2,2/1,5 = 1,24 MPa	EC2, Clause 3.1.6
	$f_{bd} = 2{,}25 \times \eta_1 \times \eta_2 \times f_{ctd}$ = 2,25×1,0×1,0×1,24 = 2,79 MPa	EC2, Clause 8.4.2

Reinforcement 500C (EN 1992-1-1, Annex C):

	$f_{yd} = f_{yk}/\gamma_s$ = 500/1,15 = 435 MPa	EC2, Clause 3.2.7
	$f_{yd2} = f_{yk}/\gamma_{s,red2}$ = 500/1,1 = 454 MPa	EC2, Clause A.2.2

Note: *Reinforcement steel of different ductility grade may be chosen provided that the bendability is sufficient for fitting the vertical suspension reinforcement to the unit.*

Steel Sxxx (EN 10025-2):

S355:	Tension:	$f_{yd} = f_y/\gamma_{M0}$ = 355/1,05 = 338 MPa
	Compression:	$f_{yd} = f_y/\gamma_{M0}$ = 355/1,05 = 338 MPa
	Shear:	$f_{sd} = f_y/(\gamma_{M0} \times \sqrt{3})$ = 355/(1,05×√3) = 195 MPa

DIMENSIONS

Tube: CFRHS 40x40x4, L=215mm. Cold formed, S355

Plastic section modulus: $W_{pl}=7010mm^3$
Total area: $A=535mm^2$

LOADS

Vertical ultimate limit state load: $F_{V,Ed}$ = 20kN
Horizontal ultimate limit state load (friction force): $H_{Ed} = 0{,}2 \times F_{V,Ed}$ =0,2×20kN=4kN.

The horizontal load (H_{Ed}) is an assumed friction force at support, included in design of the unit, and in the calculation of the vertical equilibrium reaction forces. It is not a capacity that can be utilized for transfer of forces in design purpose.

PART 2 – EXAMPLE: ANCHORING REINFORCEMENT IN STAIR

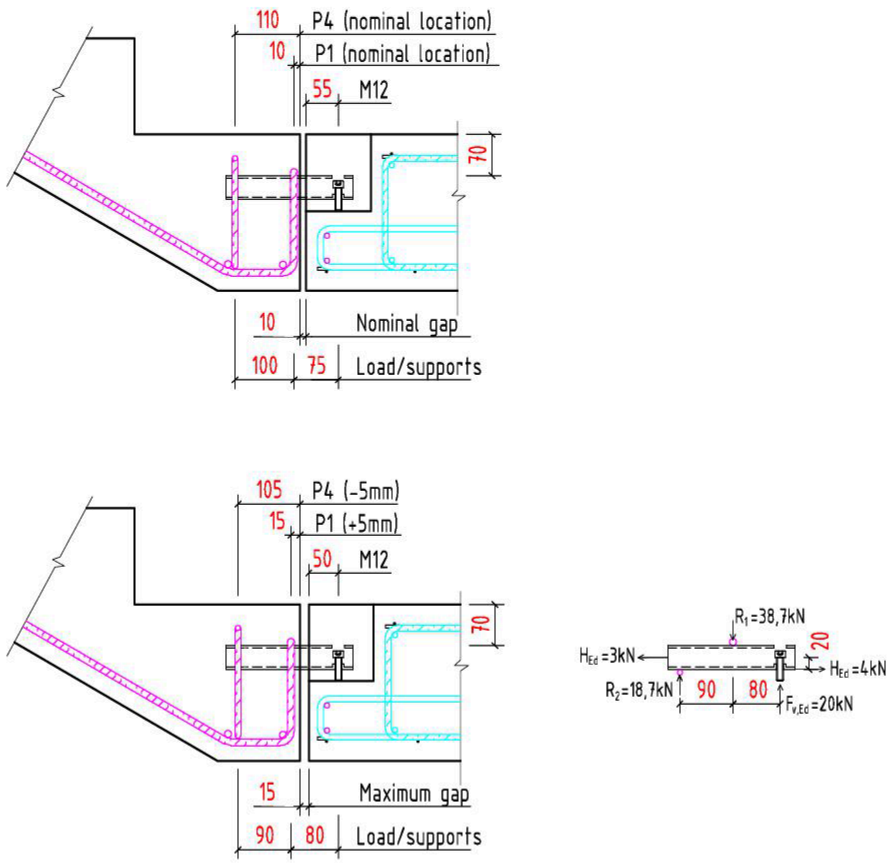

Figure 1: Forces acting on the unit.

$F_{V,Ed}$ = External vertical design force on the tube.

H_{Ed}= 0,2 × $F_{V,Ed}$ Horizontal friction force accounted for in design of tube.

R_1, R_2 = Support reaction forces.

Capacity is documented based on unfavorable location of the anchoring reinforcement, and maximum gap between stair and landing. Tolerances on positioning of reinforcement: =±5mm

Equilibrium:

R_2= ($F_{v,Ed}$ × 80mm+H_{Ed} × 20mm)/90mm= (20kN×80mm+4kN×20mm)/90mm= 18,7kN

R_1=$F_{v,Ed}$ + R_2 = 20kN+18,7kN=38,7kN

Reinforcement is to be located at the assumed attack point for support reactions.

Reinforcement necessary to anchor the unit to the concrete for R_1 and R_2:

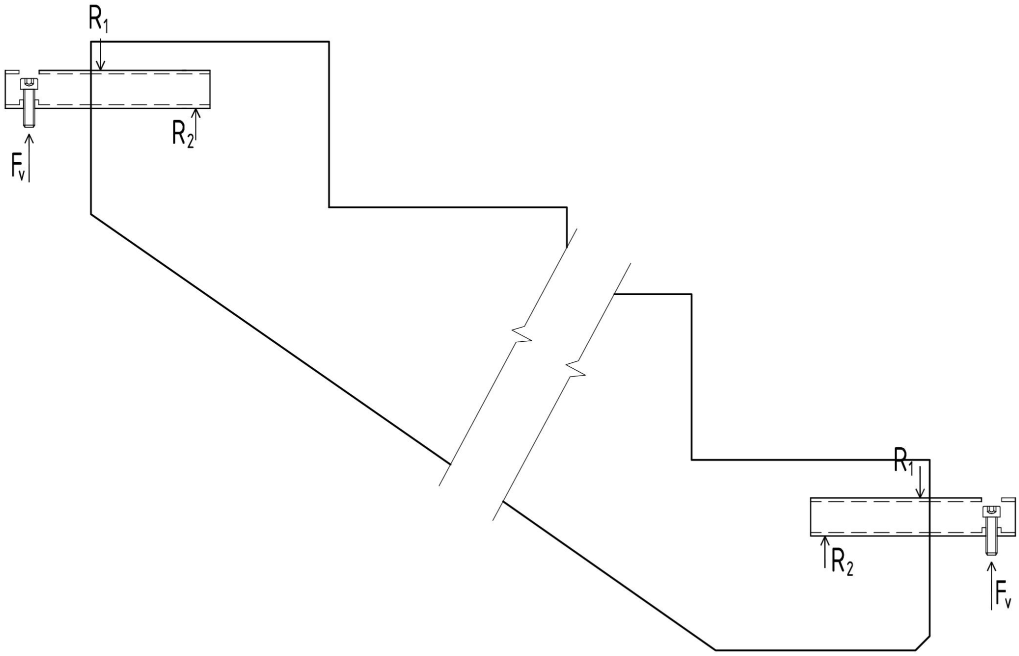

Figure 2: Forces.

Reinforcement R_1: A_{s1} = R_1/f_{yd2} = 38,7kN/454Mpa =85 mm^2
Select 1-Ø10 = 2×78 mm^2 =156 mm^2
Capacity selected reinforcement: R=156 mm^2 ·454MPa=70,8kN

Reinforcement R_2: A_{s2} = A_{s2} = R_2/f_{yd2} = 18,7kN/454MPa =41 mm^2
Select 1-Ø8 = 1×2×50 mm^2 = 100mm^2
Capacity selected reinforcement: R=100 mm^2 ·454MPa=45,4kN

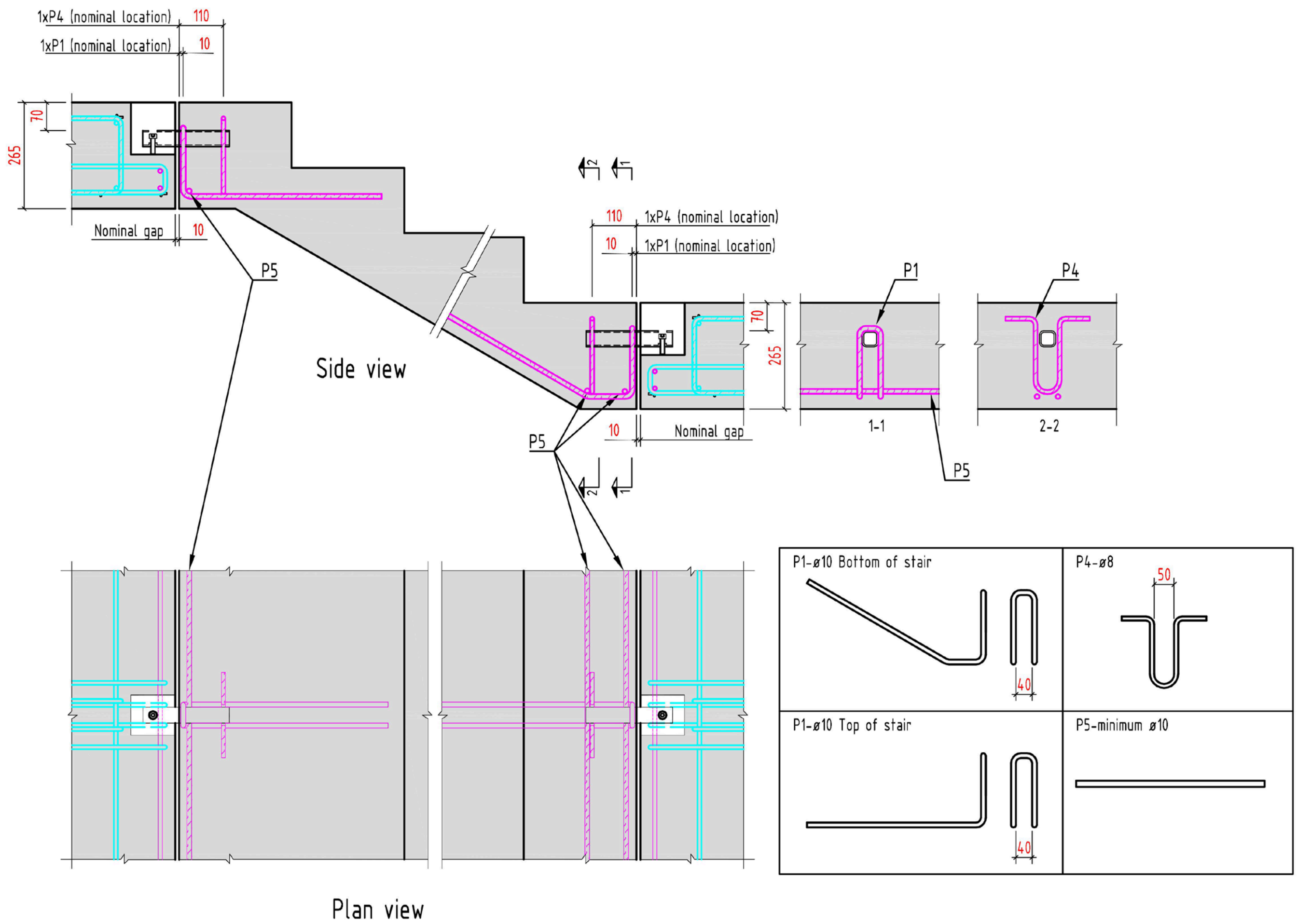

Figure 3: Anchoring reinforcement in stair.

Note:

- The P5 bars is to be located in the bends of the P1 bar.

Tolerances on the positioning of the reinforcement:

- The assembling tolerances for P1 and P4 should be ±5mm.

PART 3 – EXAMPLE: LOCAL REINFORCEMENT AROUND RECESS IN LANDING

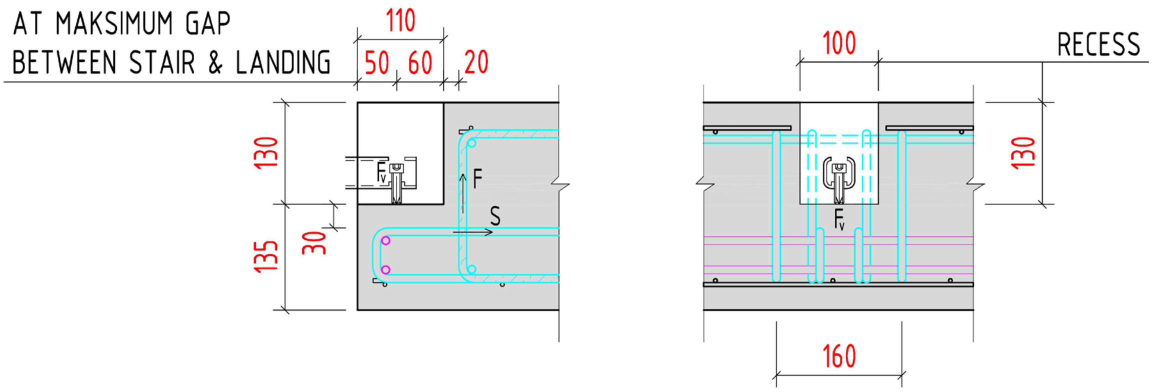

Figure 4: Forces acting on the landing.

Reinforcement below the recess:

$$A_s = \frac{S}{f_{yd}} = \frac{\frac{F_v \cdot (60mm+20mm+5mm)}{z}}{f_{yd}} = \frac{\frac{F_v \cdot (60mm+20mm+5mm)}{0{,}8 \cdot (135mm-30mm-5mm)}}{f_{yd}} = \frac{\frac{20000N \cdot 85mm}{80mm}}{435MPa} = 49mm^2$$

Select 2-Ø8 stirrups = 100 mm²
Capacity selected reinforcement: R=100mm² ·435MPa=43,5kN

Reinforcement behind the recess:

$$A_s = \frac{F}{f_{yd}} = \frac{20kN}{435MPa} = 46mm^2$$

Select 2-Ø8 stirrups = 100 mm²
Capacity selected reinforcement: R=100mm² ·435MPa=43,5kN

Reinforcement at the sides of the recess:

$$A_s = \frac{F}{f_{yd}} = \frac{20kN}{435MPa} = 46mm^2$$

Select 1-Ø8 stirrup at each side = totally 100 mm²
Capacity selected reinforcement: R=100mm² ·435MPa=43,5kN

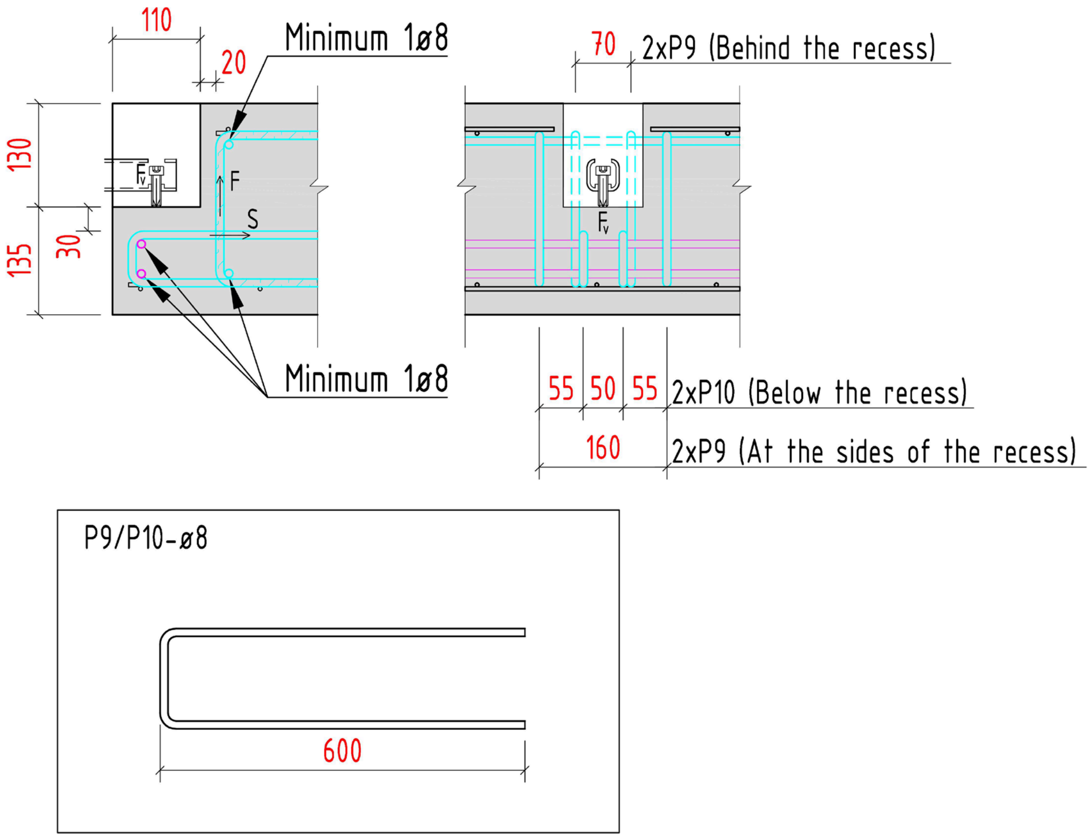

Figure 5: Possible local reinforcement in landing t=265mm.

If the landing is too thin to have reinforcement below the recess (-P10), a wide steel plate may be introduced. This steel plate should be thick enough to receive the load from the M12 bolt and transfer it sideways into the supporting P9 bars at the sides of the recess.

REVISION HISTORY	
Date:	**Description:**
10.04.2015	First edition.
08.01.2016	Included note on reinforcement ductility grade.
25.05.2016	New template.
12.11.2020	Included horizontal friction force. Introduced reduced material factor $\gamma_{s,red2}$