MEMO 802

MEMO 802 DTF 120 / DTS 120 REINFORCEMENT DESIGN DESIGN	Dato: 07.06.2012 Siste rev.: 25.05.2016 Dok. nr.: K4-10/2E	Sign.: sss Sign.: sss Control: ps

REINFORCEMENT DESIGN DTF 120 / DTS 120

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. The calculations give the reaction forces from the unit to the element, and the recommended reinforcement includes only the reinforcement necessary to anchor these forces to the concrete. The unit may be used in DT-elements with various cross-sections. Thus, no recommendations on the reinforcement layout of the element are given, as this cannot be generalized. The DT-element must be designed for the forces R_1 and R_2 and it must always be checked that the forces from the anchorage reinforcement can be transferred to the main reinforcement of the concrete element.

The information found here and in the memos assumes that the design of the elements and the use of the units in structural elements are carried out under the supervision of a structural engineer with knowledge about the behaviour of concrete structures. Be aware of the increase in shear force (R_1) in the end of the element, compared to the situation with underlying support where the shear force equals the support reaction force.

To ensure structural integrity of the steel unit itself the position of the anchoring reinforcement relative to the unit shall be as illustrated in Figure 3.

STANDARDS

The calculations are carried out in accordance with:

- Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings.

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

Parameter	γ_c	γ_s	α_{cc}	α_{ct}
Value	1,5	1,15	0,85	0,85

Table 1: NDP’s in EC2.

QUALITIES

Concrete grade C30/37:

f_{ck} = 30,0 MPa — EC2, Table 3.1

$f_{cd} = \alpha_{cc} \times f_{ck}/\gamma_c$ = 0,85×30/1,5 = 17,0 MPa — EC2, Pt.3.15

$f_{ctd} = \alpha_{ct} \times f_{ctk,0,05}/\gamma_c$ = 0,85×2,00/1,5 = 1,13 MPa — EC2, Pt.3.16

$f_{bd} = 2,25 \times \eta_1 \times \eta_2 \times f_{ctd}$ = 2,25×0,7×1,0×1,13 = 1,78 MPa — EC2, Pt.8.4.2

Reinforcement 500C (EN 1992-1-1, Annex C): Note: *Reinforcement steel of different qualities may be chosen provided that the calculations take into account the actual yield strength ($f_y \leq 500$ MPa) and that the bendability is sufficient for fitting the vertical suspension reinforcement to the half round steel in front of the unit.*

$f_{yd} = f_{yk}/\gamma_s$ = 500/1,15 = 435 MPa — EC2, Pt.3.2.7

LOADS

Maximum cantilever (load location): 75mm

Vertical ultimate limit state load: F_V = 120kN.
Horizontal ultimate limit state load in axial direction: F_H = 0kN.
Horizontal ultimate limit state load in transverse direction: F_T=0kN.

PART 2 - REINFORCEMENT

EQUILIBRIUM

For evaluation of the reaction forces from the unit, the following geometry may be used. The assumed location of the reaction forces represents a conservative simplification with rounded values compared to the assumptions used when designing the unit. The geometry accounts for approximately 5mm tolerances on the location of the front reinforcement. However, the nominal planned location of anchoring reinforcement is equal for the DTS and DTF units and shall always be as illustrated in Figure 3.

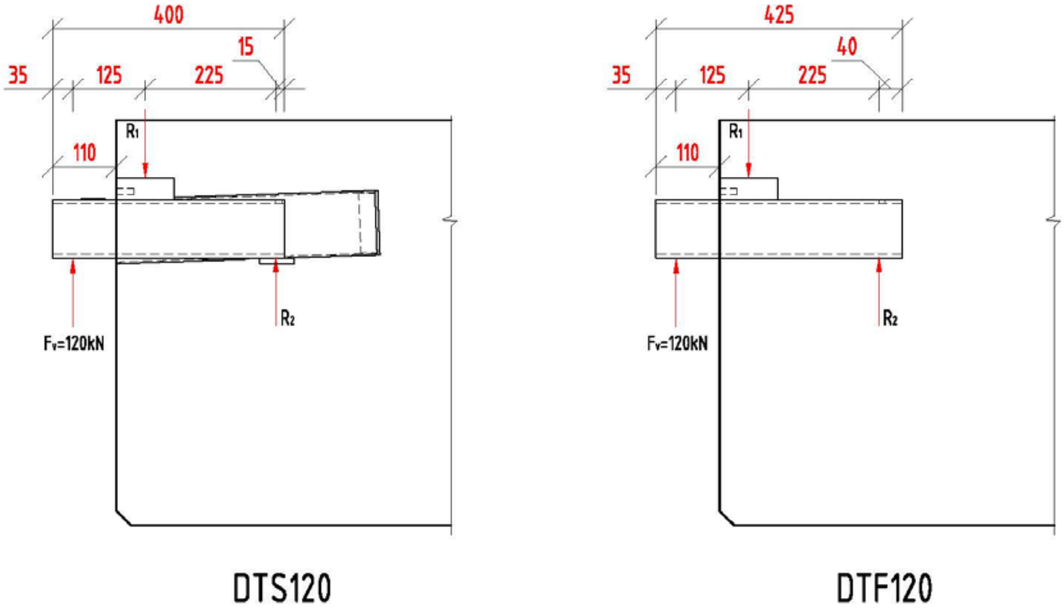

Figure 1: Forces acting on the unit.

F_V = External force on the inner tube
R_1, R_2= Support reaction forces of the inner tube.

The equilibrium equations for the inner tube become:

1): ∑M=0: $F_V \times 125 - R_2 \times 225 = 0$

2): $\sum F_y = 0$: $F_v + R_2 - R_1 = 0$

Results:

$$R_2 = \frac{120kN \times 125mm}{225mm} \approx 67kN$$

Support reaction force at front of unit:

$$R_1 = 120kN + 67kN = 187kN$$

REINFORCEMENT NECESSARY TO ANCHOR THE UNIT TO THE CONCRETE

Reinforcement R_1:

$A_{s1} = R_1 / f_{sd} = 187000/435 = 430mm^2$

Select 2Ø12 $=2\times2\times113mm^2=452mm^2$

Capacity selected reinforcement: $R=452mm^2\times435MPa=196kN$

Stress: $\sigma=187000/452=414MPa$

<u>Reinforcement R_2:</u>

$A_{s2}= R_2/f_{sd}=67000/435=154mm^2$

If the shear reinforcement in the DT is made from Ø8 bars, two additional bars ($200mm^2$) at back of the unit will be sufficient anchoring.

BENDING OF FRONT REINFORCEMENT

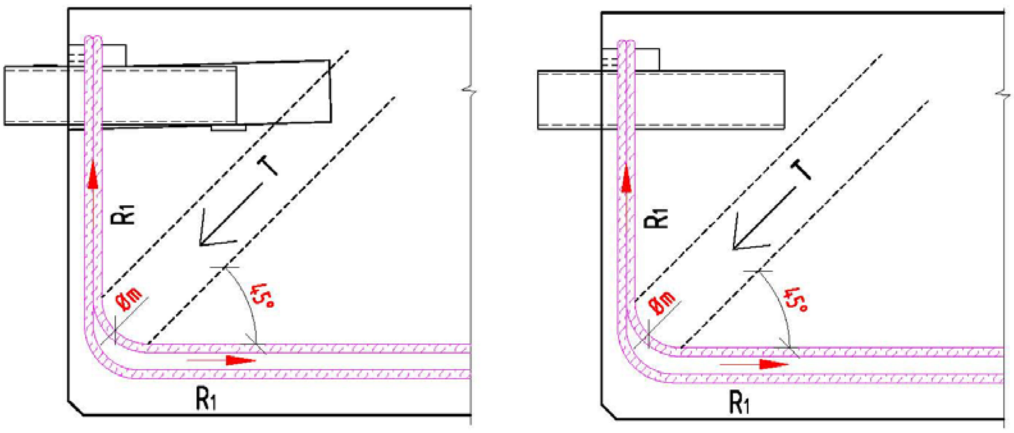

Figure 2: Compression diagonal.

Allowable concrete stress in node, EC2, clause 6.5.2:

$$f_{cd2} = 0{,}6 \times (1 - \frac{f_{ck}}{250}) \times f_{cd}$$

Concrete stress in node:

$$\sigma_c = \frac{R_1}{b \times Ø_m \times \sin\theta \times \cos\theta}$$

b =effective width of the web to transfer compression diagonal in the DT.

(if the compression diagonal crosses the unit, the width of the unit should be subtracted)

$Ø_m$= Mandrel diameter of front reinforcement

θ=assume compression diagonal in 45degrees.

Solving for $Ø_m$:

$$Ø_m = \frac{R_1}{b \times \sigma_c \times \sin 45 \times \cos 45}$$

Minimum mandrel diameter is found for the maximum concrete stress in the node:

$$Ø_{m,\min} = \frac{R_1}{b \times f_{cd2} \times 0{,}5}$$

When the effective width (b) is known, the minimum mandrel diameter may be calculated from the above formula.

ANCHORAGE

See Figure 3. According to EC2 clauses 8.4.3 and 8.4.4:

$l_{bd} = \alpha_1 \times \alpha_2 \times \alpha_3 \times \alpha_4 \times \alpha_5 \times l_{b,reqd} \geq l_{b,min}$

Ø12: $l_{b,req'd} = \frac{Ø}{4} \times \frac{\sigma_{sd}}{f_{bd}} = \frac{12}{4} \times \frac{414}{1{,}78} = 698$ mm

$l_{b,min} = \max(0{,}3 \times l_{b,reqd};\ 10 \times Ø;\ 100\text{mm}) = 209$ mm

Straight bar:

$\alpha_1 = 1{,}0$

Concrete cover:

$\alpha_2 = 1 - 0{,}15 \times (c_d - 3 \times Ø)/Ø$

Neglecting any positive effect of concrete cover, selecting $\alpha_2 = 1{,}0$

Confinement by reinforcement:

$\alpha_3 = 1 - K \times \lambda$

Neglecting any positive effect of transverse reinforcement, selecting $\alpha_3 = 1{,}0$

Confinement by welded transverse reinforcement:

α_4 = Not relevant.

Confinement by transverse pressure:

α_5 = Not relevant.

$\alpha_2 \times \alpha_3 \times \alpha_5 = 1{,}0 \times 1{,}0 \times 1{,}0 = 1{,}0 > 0{,}7$ – OK

$l_{bd} = 1{,}0 \times 1{,}0 \times 1{,}0 \times 1{,}0 \times 1{,}0 \times 698 = 698$mm

$\Rightarrow$Select l=700mm

IMPORTANT:

- It must always be checked that the beam's main reinforcement has sufficient anchorage at the end of the horizontal part of the front anchorage. This may lead to greater lengths for the horizontal part of the front anchorage than calculated here.

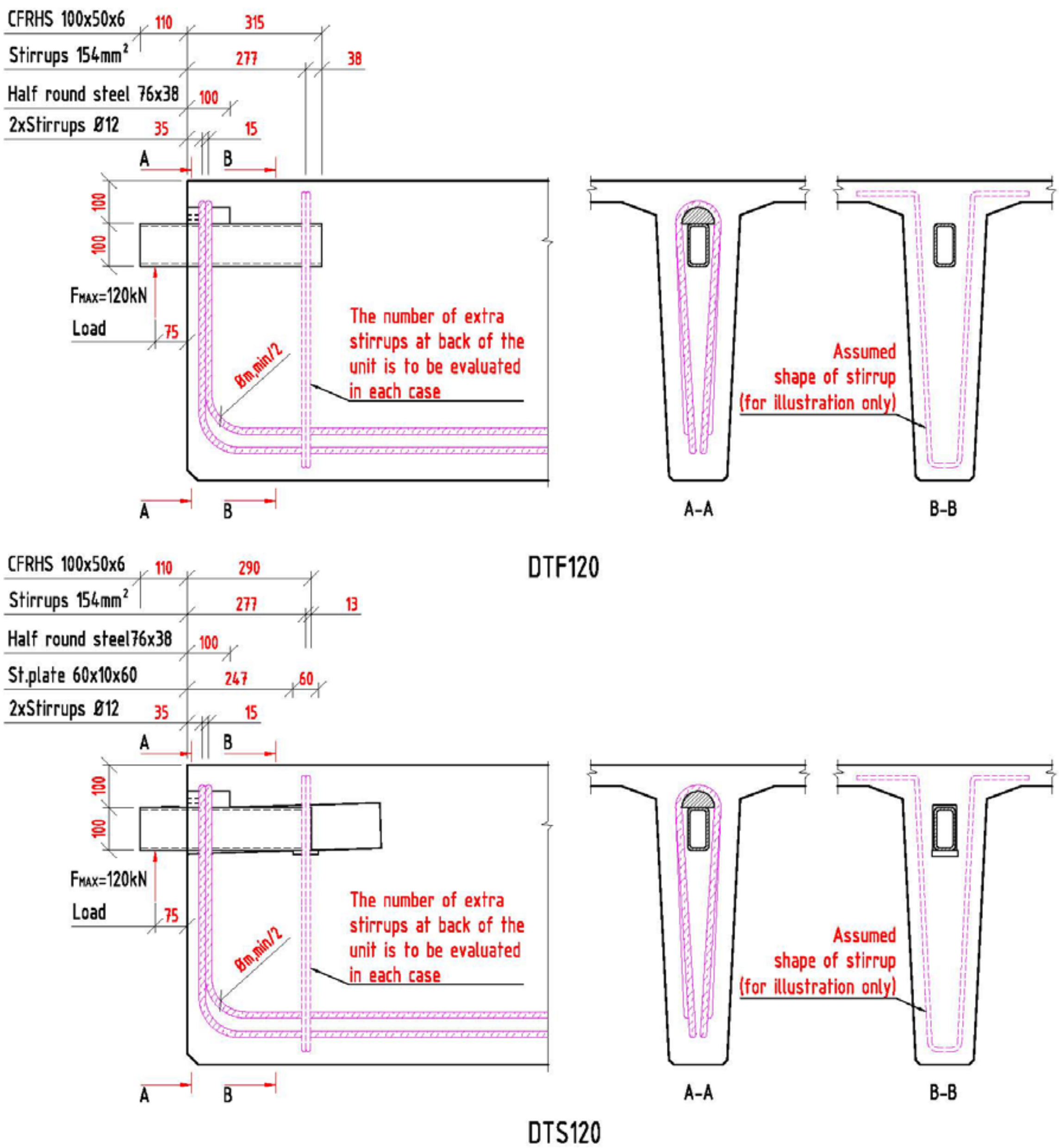

Figure 3: Anchoring reinforcement.

The integrity of the steel unit is based on the location of the reinforcement bars given in Figure 3. The position of the bars should not be changed.

REVISION HISTORY	
Date:	**Description:**
07.06.2012	First Edition.
27.03.2013	Updated
11.01.2016	Included revision history table. Included note on reinforcement quality.
25.05.2016	New template.