Design
MEMO 65
Reinforcement design for TSS 20 FA

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PART 1 – BASIC ASSUMPTIONS

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:

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\gamma_c$</th>
<th>$\gamma_s$</th>
<th>$\alpha_{cc}$</th>
<th>$\alpha_{ct}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1,5</td>
<td>1,15</td>
<td>0,85</td>
<td>0,85</td>
</tr>
</tbody>
</table>

*Table 1: NDP-s in EC2.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\gamma_{M0}$</th>
<th>$\gamma_{M1}$</th>
<th>$\gamma_{M2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1,05</td>
<td>1,05</td>
<td>1,25</td>
</tr>
</tbody>
</table>

*Table 2: NDP-s in EC3.*
QUALITIES

Concrete B35/45:  \( f_{ck} = 35,0 \text{ MPa} \)  
\[ f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_c = 0,85 \times 35 / 1,5 = 19,8 \text{ MPa} \]  
\[ f_{ctd} = \alpha_{ct} \times f_{ck,0.05} / \gamma_c = 0,85 \times 2,2 / 1,5 = 1,24 \text{ MPa} \]  
\[ f_{bd} = 2,25 \times \eta_1 \times \eta_2 \times f_{ctd} = 2,25 \times 1,0 \times 1,0 \times 1,24 = 2,79 \text{ MPa} \]

Reinforcement 500C (EN 1992-1-1, Annex C):  
\[ f_{yd} = f_{ys} / \gamma_s = 500 / 1,15 = 435 \text{ MPa} \]  
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:  
\[ f_{yd} = f_{ys} / \gamma_{M0} = 355 / 1,05 = 338 \text{ MPa} \]  
Compression:  
\[ f_{yd} = f_{ys} / \gamma_{M0} = 355 / 1,05 = 338 \text{ MPa} \]  
Shear:  
\[ f_{sd} = f_{ys} / (\gamma_{M0} \times \sqrt{3}) = 355 / (1,05 \times \sqrt{3}) = 195 \text{ MPa} \]

DIMENSIONS

Tube: CFRHS 40x40x4, L=215mm. Cold formed, S355  
Plastic section modulus:  \( W_{pl}=7010\text{mm}^3 \)  
Total area:  \( A=535\text{mm}^2 \)

LOADS

Vertical ultimate limit state load = \( F_V = 20\text{kN} \).
PART 2 – EXAMPLE: ANCHORING REINFORCEMENT IN STAIR

Figure 1: Forces acting on the unit.

- $F_V$ = External force.
- $R_1$, $R_2$ = Support reaction forces.

Capacity is documented based on unfavorable location of the anchoring reinforcement. Tolerances $\pm 5$mm
Equilibrium:

\[ R_2 = F_v \times 80\text{mm}/90\text{mm} = 20\text{kN} \times 80\text{mm}/90\text{mm} = 17.8\text{kN} \]

\[ R_1 = F_v + R_2 = 20\text{kN} + 17.8\text{kN} = 37.8\text{kN} \]

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 \( R_2 \):**

![Diagram of forces](image.jpg)

**Figure 2: Forces.**

Reinforcement \( R_1 \):  
\[ A_{s1} = \frac{R_1}{f_{sd}} = \frac{37.8\text{kN}}{435\text{MPa}} = 87 \text{ mm}^2 \]

Select 1-Ø10 = 2×78 mm \( = 156 \text{ mm}^2 \)

Capacity selected reinforcement:  \( R=156 \text{ mm}^2 \times 435\text{MPa} = 67.8\text{kN} \)

Reinforcement \( R_2 \):  
\[ A_{s2} = \frac{R_2}{f_{sd}} = \frac{17.8\text{kN}}{435\text{MPa}} = 41 \text{ mm}^2 \]

Select 1-Ø8 = 1×2×50 mm \( = 100 \text{ mm}^2 \)

Capacity selected reinforcement:  \( R=100 \text{ mm}^2 \times 435\text{MPa} = 43.5\text{kN} \)
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:

\[ A_s = \frac{S}{f_{sd}} = \frac{F_y \cdot (60mm + 20mm + 5mm)}{0.8 \cdot (135mm - 30mm - 5mm)} \]

Select 2-Ø8 stirrups = 100 mm\(^2\)
Capacity selected reinforcement: R=100mm\(^2\) \cdot 435MPa=43,5kN

Reinforcement behind the recess:

\[ A_s = \frac{F}{f_{sd}} = \frac{20kN}{435MPa} = 46mm^2 \]

Select 2-Ø8 stirrups = 100 mm\(^2\)
Capacity selected reinforcement: R=100mm\(^2\) \cdot 435MPa=43,5kN

Reinforcement at the sides of the recess:

\[ A_s = \frac{F}{f_{sd}} = \frac{20kN}{435MPa} = 46mm^2 \]

Select 1-Ø8 stirrup at each side = totally 100 mm\(^2\)
Capacity selected reinforcement: R=100mm\(^2\) \cdot 435MPa=43,5kN
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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.
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REVISION

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
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<tbody>
<tr>
<td>10.04.2015</td>
<td>First edition</td>
</tr>
<tr>
<td>08.01.2016</td>
<td>Included note on reinforcement ductility grade.</td>
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