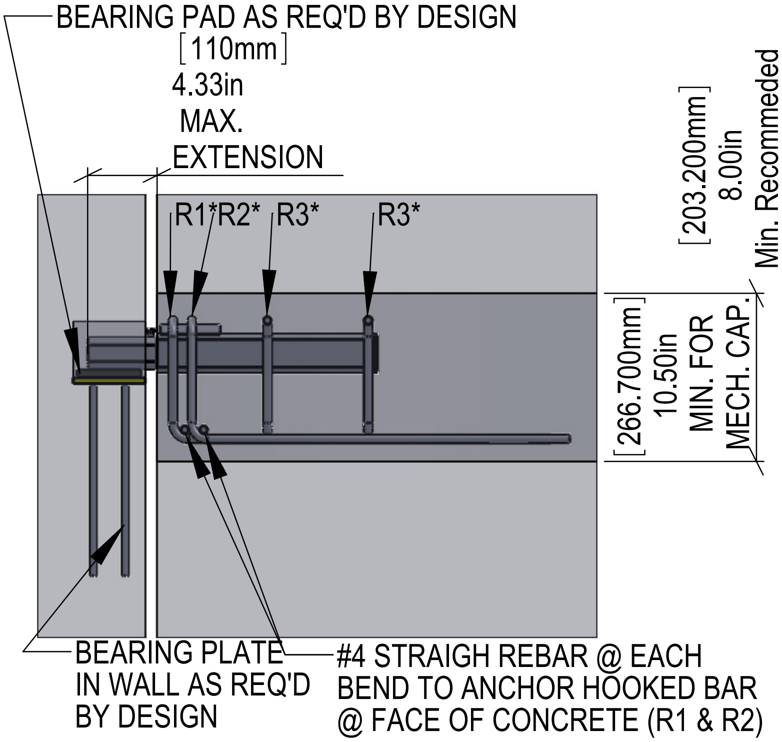
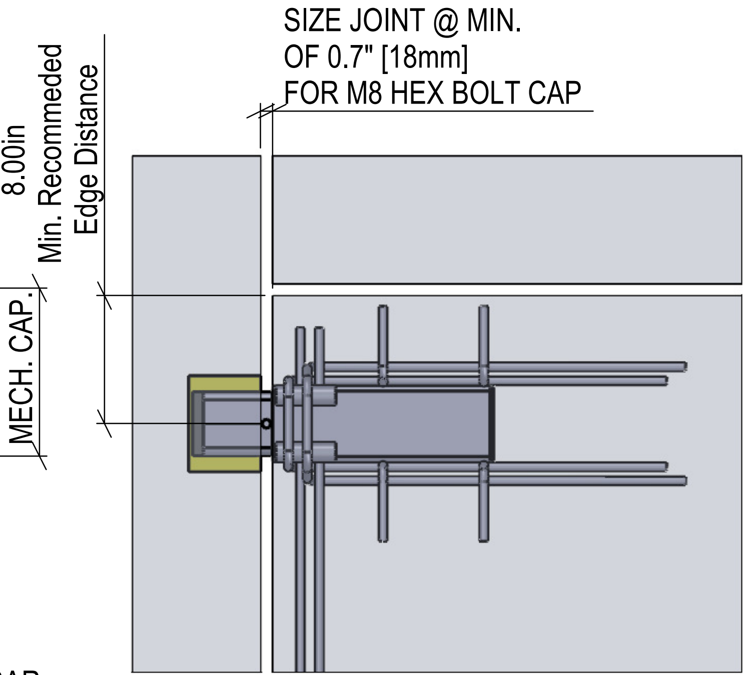
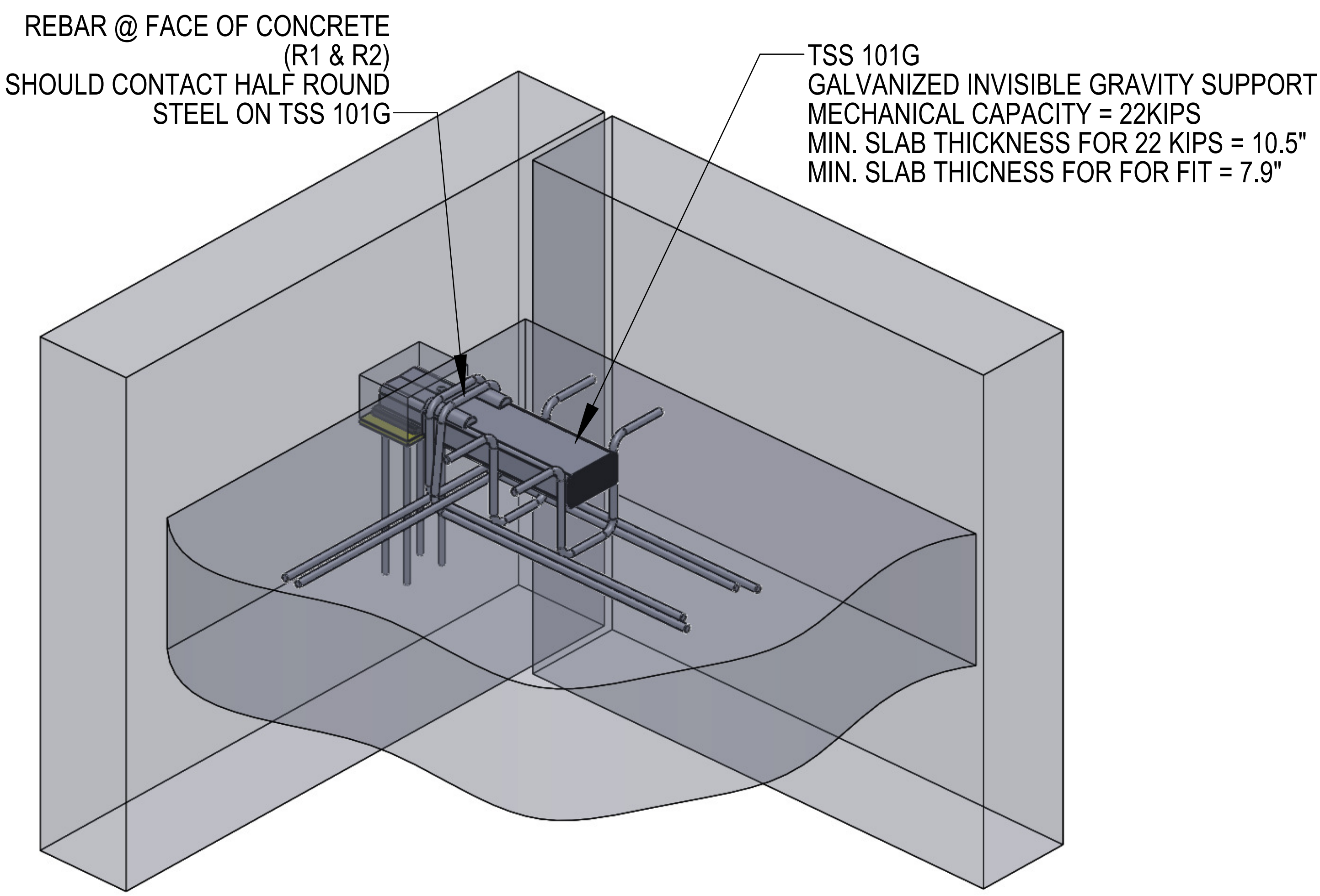


SECTION VIEW



TOP VIEW



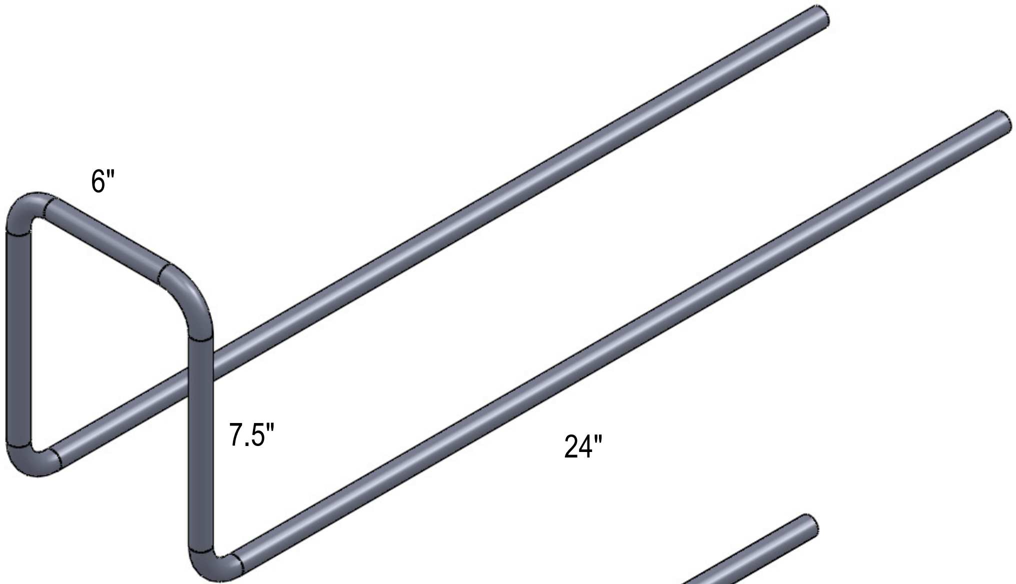
*SEE REBAR BEND SHEET FOR REBAR SIZE AND DIMENSIONS

JVI
7131 North Ridgeway Avenue
Lincolnwood, Illnois 60712 USA
Tel. 847/675-1560 - Fax 847/675-0083

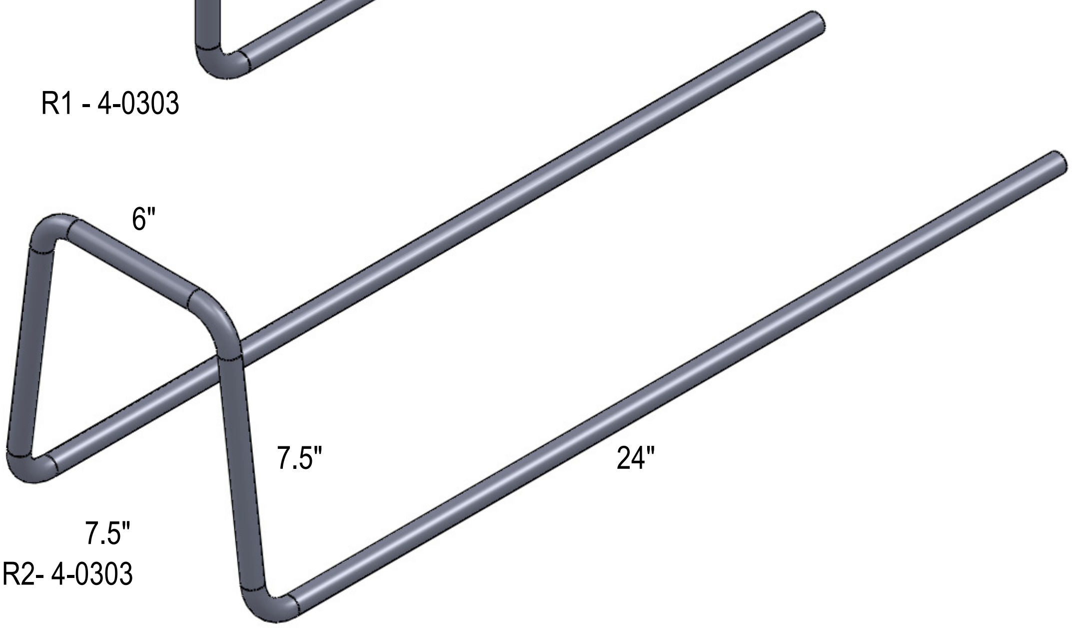
DATE	DRAWN	CHECKED	SCALE
04.14.2015	JVI	___	1" = 1'-0"

TSS 101G DETAILING

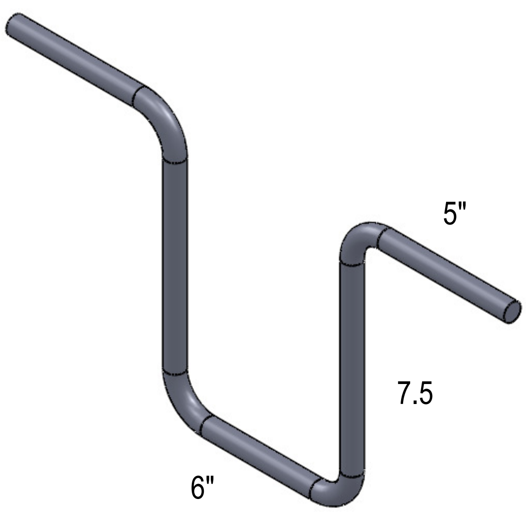
EXAMPLE TSS 101G DETAILING
NOT FOR CONSTRUCTION



R1 - 4-0303



R2- 4-0303



R3 - 4-0207

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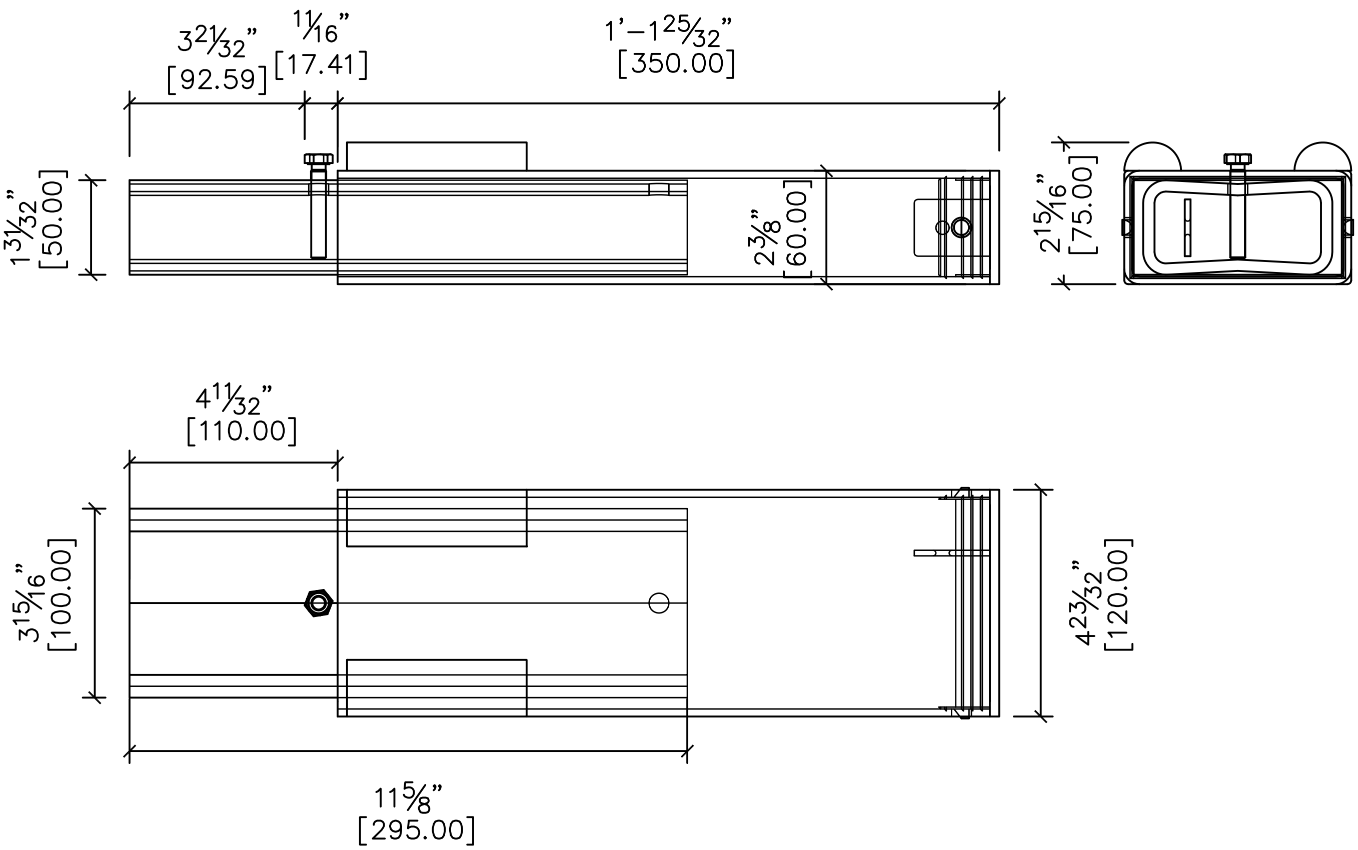
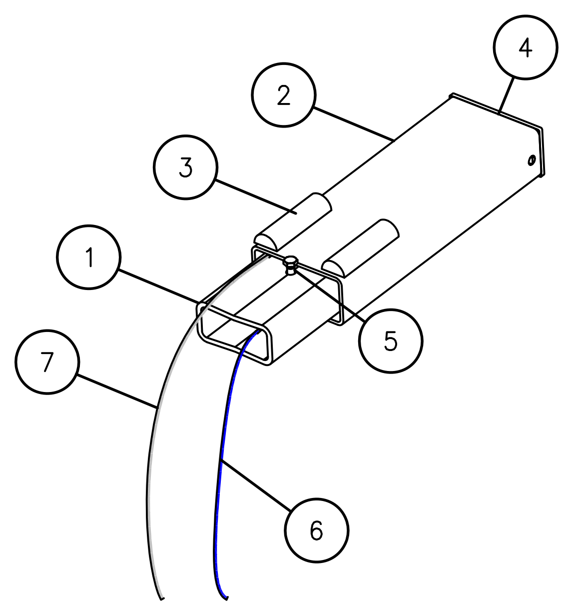
Lincolnwood, Illnois 60712 USA
Tel. 847/675-1560 - Fax 847/675-0083

TSS101G EXAMPLE REBAR BEND SHEET

REBAR DEFINITION FOR EXAMPLE TSS 101G DETAIL
NOT FOR CONSTRUCTION

DATE	DRAWN	CHECKED	SCALE
04.14.2015	JVI	__ __ __	3"=1'-0"





Part No.	Description	QTY.
1	INNER TUBE	1
2	OUTER TUBE	1
3	HALF ROUND STEEL	2
4	PLASTIC LID	1
5	LOCKING SCREW	1
6	PULL IN ROPE	1
7	PULL OUT WIRE	1

JVI INC.
7131 North Ridgeway Avenue
Lincolnwood, Illinois 60712 USA
TEL. 1-800-742-8127 - FAX 847-675-0083

DATE	DRAWN	CHECKED	SCALE
06.30.2014	JVI	___	3"=1'

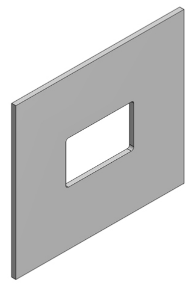
TSS 101

STAIR AND FLAT SLAB CONNECTION

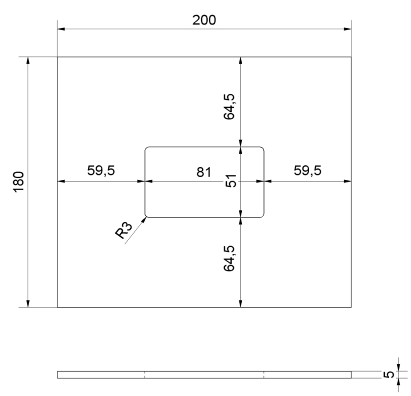
Additional products RVK and TSS

Rubber flange for RVK/TSS 41, 101 and TSS 102

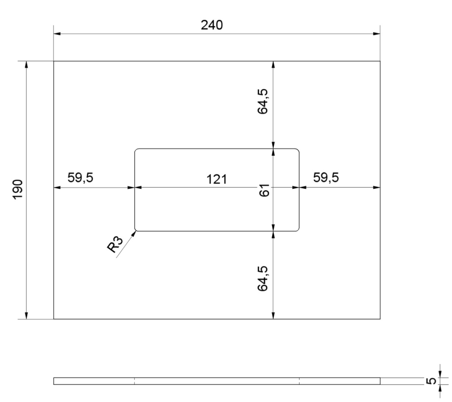
The flange is made of rubber elastomer. Hardness = 60 shore. The flange is suitable for impact sound insulation, when it is embedded in the landing.



Flange dimensions for RVK/TSS 41

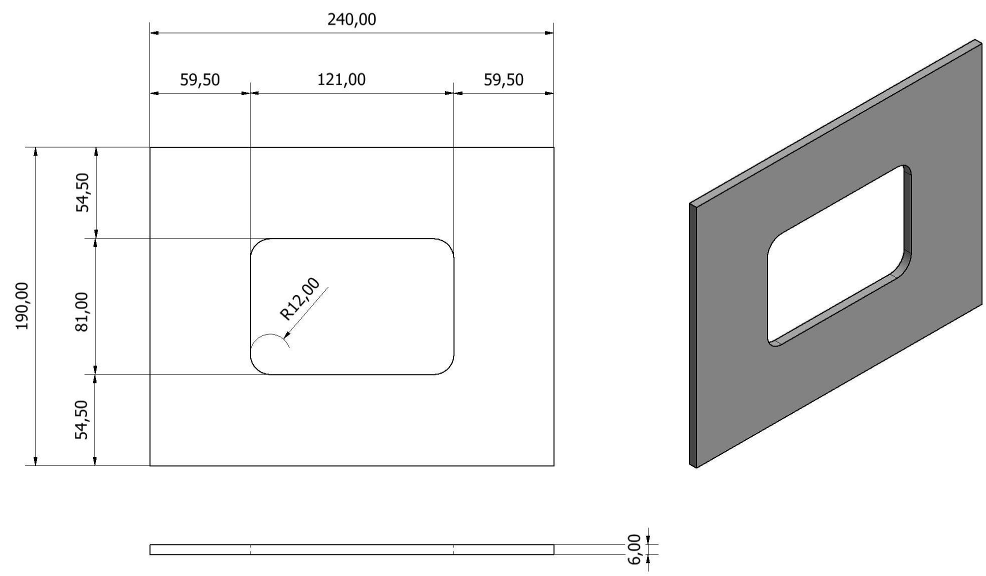


Flange dimensions for RVK/TSS 101



Additional products RVK and TSS

Flange dimensions for TSS 102

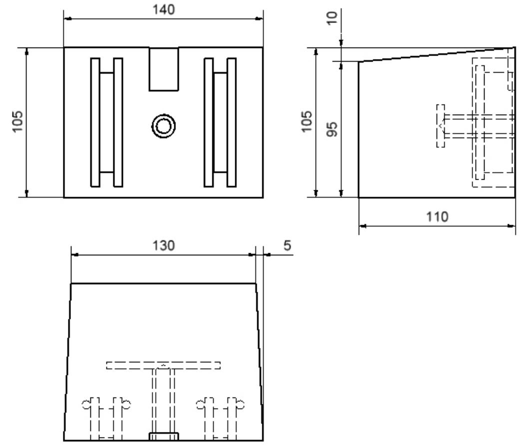


Form box for recess for RVK/TSS 40 og 100

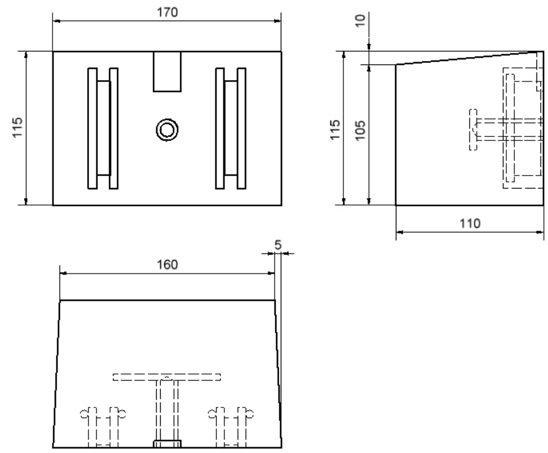
The box is made of rubber elastomers. Hardness = 60 shore.
It can be delivered with or without magnets.
The unit **must** be lubricated with surface retarder before casting.

Additional products RVK and TSS

Typical dimension for the form box for RVK/TSS 41



Typical dimension for the form box for RVK/TSS 101 and 102

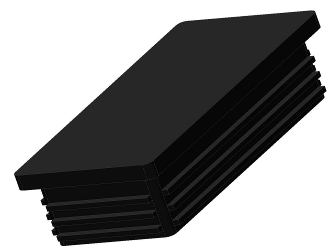


Additional products RVK and TSS

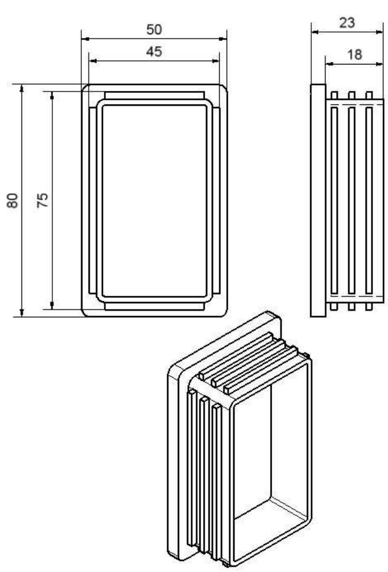
Guiding piece/ lid for TSS and RVK

The guiding pieces are made of polyethylene PE. And can also be used as a lid for the TSS/ RVK units when they are stored outside.

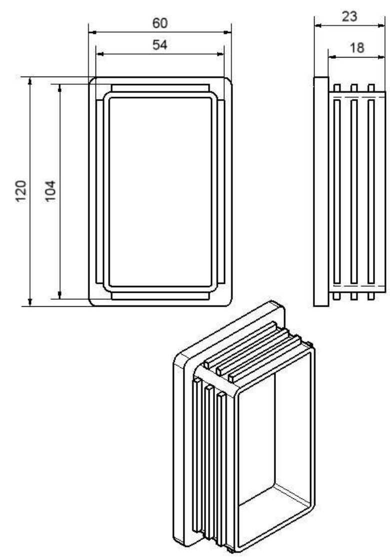
Article no.	Description
Lokk 40	Lokk 80x50x4 PE
Lokk 100	Lokk 120x60x4 PE



Lokk 40



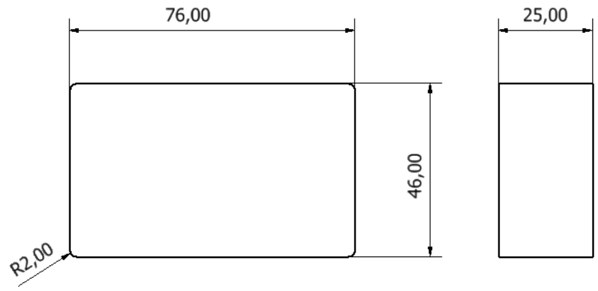
Lokk 100



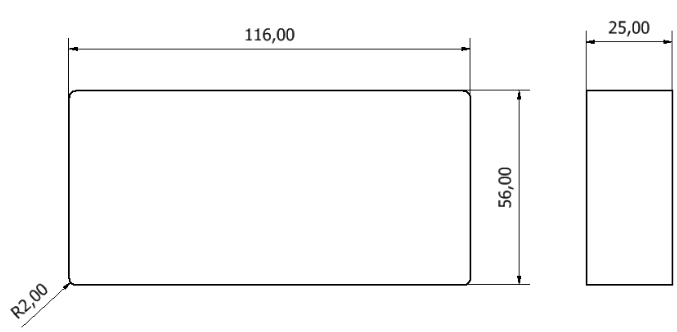
Winter storage.

This product is used to prevent water and snow entering the RVK/TSS device when the landing is stored outside, especially in winter.

The product is made of EPDM POS 300/60, this fabric is water repellent.



Seal 40



Seal 100

Production procedure using TSS

GENERAL

The TSS units were developed as a connection detail between precast landings or stairs and walls in stairways, where the precast elements are given the final surface in the factory. It provides a hidden connection, the erection is quick, and no site work is necessary with bolts, welding or mortar. It is important to provide a rubber pad at the support in order to reduce transfer of impact sound between the landing and the wall.

Since there normally is not a connection that can transfer tensile forces between the TSS unit and the wall, the supported concrete element must be locked in position connection details at least at three sides. Otherwise a steel plate can be embedded in the bottom of the recess in the wall, and a welded connection can be established.
This is not recommended for sound insulation purposes, though.

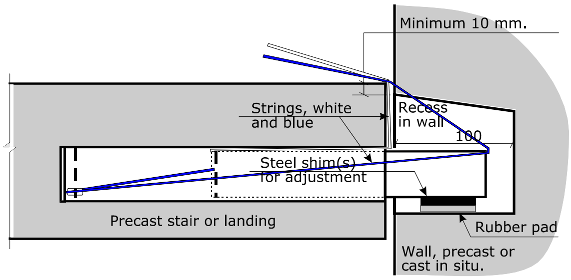


Figure 32.1. Typical connection between landing and wall.

CASTING PROCEDURE

The type of elements suited for the use of TSS units are normally cast on flat tables, either right side up or upside down, depending upon the requirements to the surfaces. Either way, the method of fixing the unit in the form is similar.

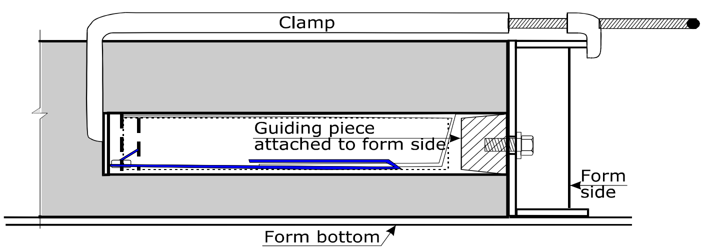


Figure 32.2. Fixing with the guiding piece.

The inner steel tube of the TSS is shorter than the outer tube. A tapered guiding piece (as shown in figure 32.2, 32.3 and described in memo 41 additional equipment) The guiding piece can be made of timber, steel, rubber or plastic. The outer maximum dimensions of the guiding piece shall be made so that the outer steel tube fits tightly when it is pressed on to the guiding piece.

Production procedure using TSS

During casting the TSS unit is normally kept in place with a clamp as shown in figure 32.2. After vibration of the concrete the clamp is removed, and the hole in the wet concrete is patched. The unit can also be tied to the reinforcement to keep it in its place during casting, or fasten with a threaded bar a shown in figure 32.3. During casting the strings are bundled up within the tubes.

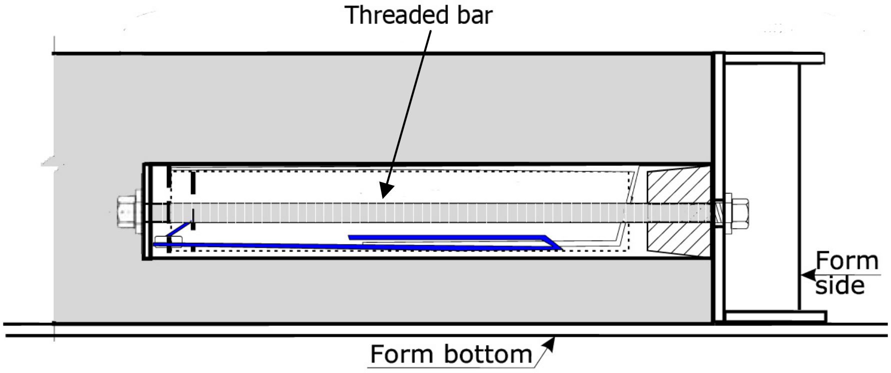


Figure 32.3 TSS fasten with a threaded bar

Capacities and main dimensions TSS 41/TSS 101

The TSS-unit is the same as the RVK-units, but without the access slot from the surface of the concrete. The smallest tube is sliding within the other, and is pulled out with a white string attached to the inner tube. If the need to retract the inner tube should arise, this can be done by means of a blue string. The TSS units are designed especially to be used to connect precast stairs and landings to the walls in the shafts, where the final surface finishes of the elements are provided in the factory.

The units are embedded in the precast stair or landing, and all that is required in the wall is a recess. During erection the inner tube is retracted into the unit, to be pulled out into the recess when the precast element is in the correct position. A safety stop will prevent the inner tube from excess protrusion.

The capacity of the steel unit itself depends only on the position of the global loading, and the anchoring reinforcement, as the anchoring stirrups serve as internal supports for the steel unit. The assumed conditions for the equilibrium and corresponding steel capacity are given in memo 54c and 54d.

The concrete elements capacity due to local punching shear may in some situations limit the applicable utilization of the steel unit. The punching shear capacity does not only depend on the capacity of the stirrups anchoring the unit, but also the reinforcement pattern in the vicinity of the unit. Important parameters are the units distance to the edge, as well as the thickness of the element. When the unit is located close to the corner, the reinforcement layout of the whole corner will influence on the local punching shear capacity. Detailing of the reinforcement will be of major importance when the concrete is governing the capacity. As the manufactures may have various solutions with respect to reinforcement layout, the final design of the elements and evaluation of punching shear capacity should be carried out under the supervision of structural engineer with knowledge about the behaviour of reinforced concrete.

The different recommended reinforcement patterns given in Memos 55c and 55d are in accordance with the reinforcement patterns in precast elements subjected to tests at Sintef, Norway in 2011. Only the local reinforcement in the vicinity of the unit is illustrated in the Memos. The recommended load reductions, due to concrete failure, as given in Figure 2 and Figure 3, are established based on results from the tests. Minimum requirements to location and slab thickness can be found in Table 5 and Table 10. The minimum concrete grade to make use of the test results are C35/45.

Based on the test results, the TSS 41 units may be fully utilized when the slab thickness is above 150mm, and the edge distance is above 240mm, see Figure 2. At slab thicknesses less than t=200mm, and corner distances between 160mm to 240mm, reduced ultimate limit load is recommended if not shear reinforcement is introduced.

The TSS 101 units require a slab thickness of 265mm to be fully utilized with the standard reinforcement pattern. Reduced ultimate limit load is recommended when the slab thickness is less than 265mm, see Figure 3. When the TSS 101 units is used in thinner slabs than 265mm, and located closer to the corner than 300mm, shear reinforcement may be used to increase the concrete capacity.

Capacities and main dimensions TSS 41/TSS 101

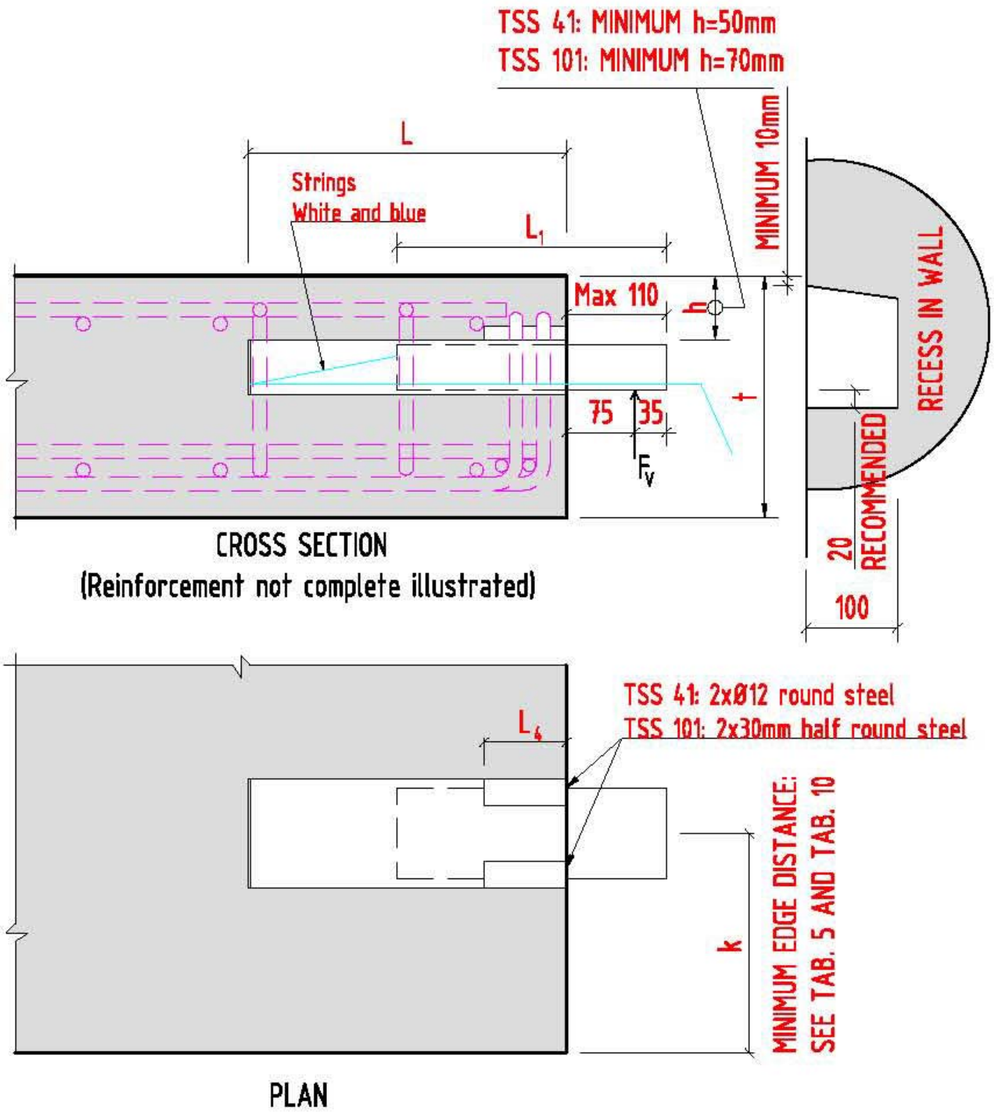


Figure 1: TSS dimensions.

Capacities and main dimensions TSS 41/TSS 101

TSS 41

Unit	Outer tube b/h/t	Inner tube b/h/t	Clearances between tubes	
			Vertically	Horizontally
mm	80/50/4	70/40/4	2	2

Table 1: Tube dimensions.

Unit	L	L_1	L_4
mm	320	275	80
in	12.6	10.8	3.2

Table 2: Dimensions.

Unit	Vertical load F_V
kN	40
kips	9

Table 3: Maximum capacity of the steel unit.

Unit	Minimum slab thickness - due to available space (t)
mm	150
in	5.9

Table 4: Minimum slab thickness – due to available space.

Unit	Slab thickness (t)	Minimum edge distance[1)] (k)
mm	150	160
in	5.9	6.3
[1)] Special requirements to the reinforcement pattern in the corner, see Memo 55c		

Table 5: Recommended minimum slab thickness to take advantage of the steel unit capacity, see Figure 1 and Figure 2.

Planning MEMO 53

Capacities and main dimensions TSS 41/TSS 101

TSS 101

Unit	Outer tube b/h/t	Inner tube b/h/t	Clearances between tubes	
			Vertically	Horizontally
mm	120/60/4	100/50/6	2	12

Table 6: Tube dimensions.

Unit	L	L_1	L_4
mm	345	295	90
in	13.6	11.6	3.5

Table 7: Dimensions.

Unit	Vertical load F_V
kN	100
kips	22

Table 8: Maximum capacity of the steel unit.

Unit	Minimum slab thickness- due to available space (t)
mm	200
in	7.9

Table 9: Minimum slab thickness – due to available space.

Unit	Slab thickness (t)	Minimum edge distance[1)] (k)
mm	265	180
in	10.4	7.1
[1)] Special requirements to the reinforcement pattern in the corner, see Memo 55d		

Table 10: Recommended minimum slab thickness to take advantage of the steel unit capacity, see Figure 1 and Figure 3.

Capacities and main dimensions TSS 41/TSS 101

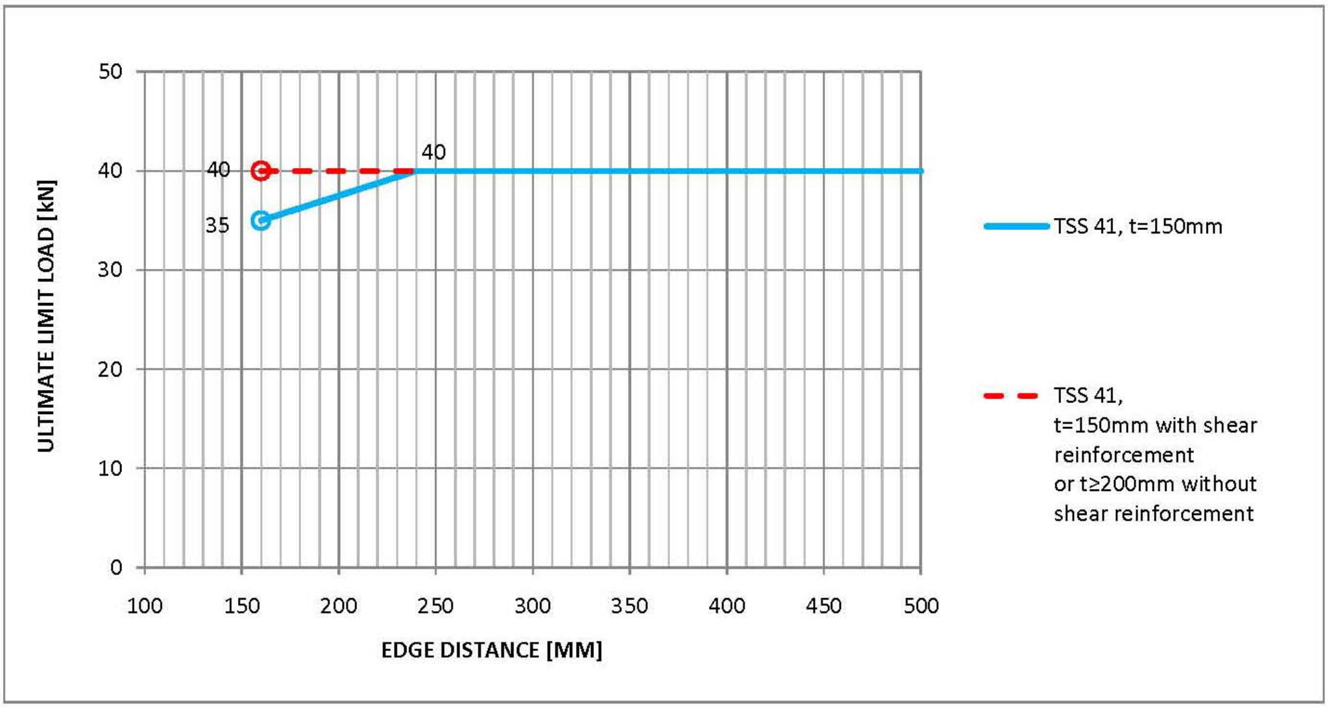


Figure 2: Recommended ultimate limit load when using TSS 41 with slab thicknesses t≥150mm.

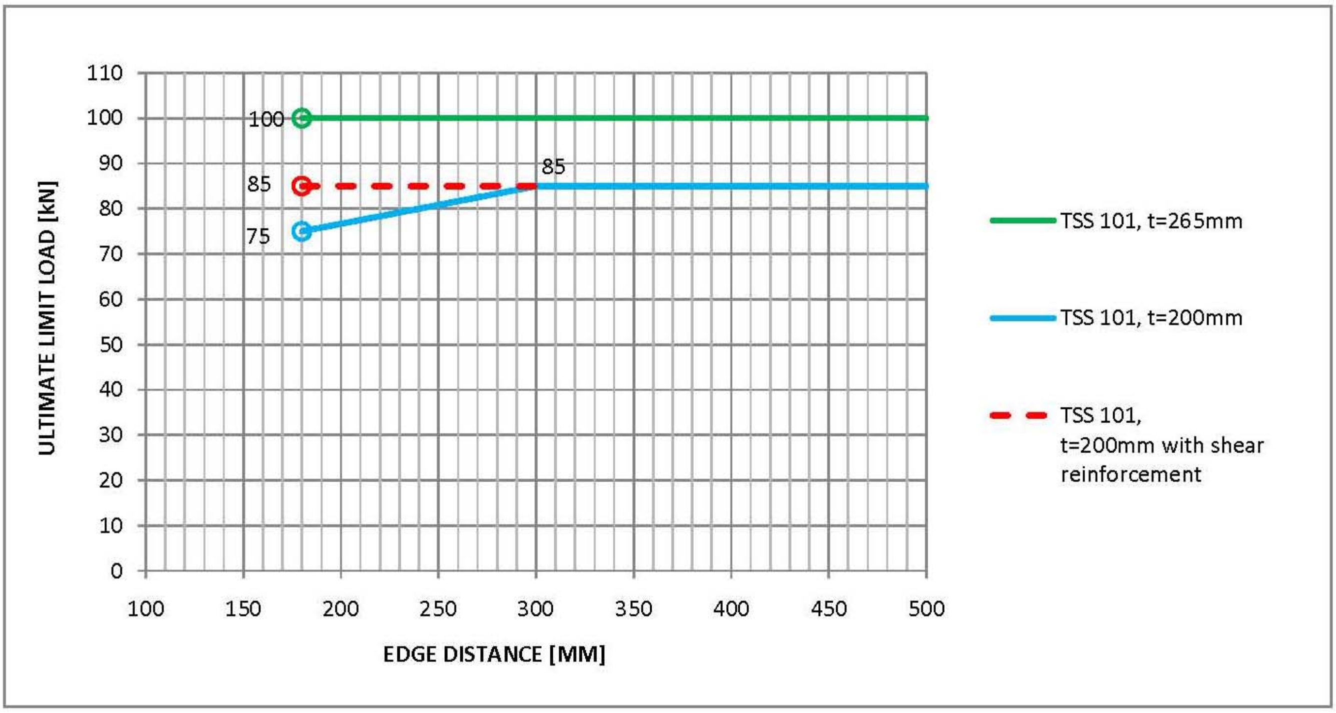


Figure 3: Recommended ultimate limit load when using TSS 101 with slab thicknesses t=200mm-265mm.

Design
MEMO 54c
Reinforcement design for TSS 41

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.

For all NDPs (Nationally Determined Parameter) in the Eurocodes the recommended values are used.

NDP's are as follows:

Parameter	γ_c	γ_s	α_{cc}	α_{ct}	$C_{Rd,c}$	v_{min}	k_1
Recommended value	1.5	1.15	1.0	1.0	0.12	$0.035k^{1/3} \cdot f_{ck}^{1/2}$	0.15

Table 1: NDP-s in EC-2.

Parameter	γ_{M0}	γ_{M1}	γ_{M2}
Recommended value	1.0	1.0	1.25

Table 2: NDP-s in EC-3.

QUALITIES

Concrete grade C35/45:

$f_{ck} = 35{,}0$ MPa	EC2, Table 3.1
$f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 1 \cdot 35/1{,}5 = 23{,}3$ MPa	EC2, Pt.3.15
$f_{ctd} = \alpha_{ct} \cdot f_{ctk,0,05}/\gamma_c = 1 \cdot 2{,}20/1{,}5 = 1{,}46$ MPa	EC2, Pt.3.16
$f_{bd} = 2{,}25 \cdot \eta_1 \cdot \eta_2 \cdot f_{ctd} = 2{,}25 \cdot 0{,}7 \cdot 1{,}0 \cdot 1{,}46 = 2{,}3$ MPa	EC2, Pt.8.4.2

Reinforcement B500C:

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

Structural steel S355:

Tension: $f_{yd} = f_y/\ \gamma_{M0} = 355/1{,}0 = 355$ MPa
Compression: $f_{yd} = f_y/\ \gamma_{M0} = 355/1{,}0 = 355$ MPa
Shear: $f_{sd} = f_y/(\gamma_{M0} \cdot \sqrt{3}) = 355/(1{,}0 \cdot \sqrt{3}) = 205$ MPa

DIMENSIONS

Inner tube: HUP 70x40x4, Cold formed, S355
Outer tube: HUP 80x50x4, Cold formed, S355

LOADS

Vertical ultimate limit state load = F_V = 40kN.

PART 2 - REINFORCEMENT

EQUILIBRIUM

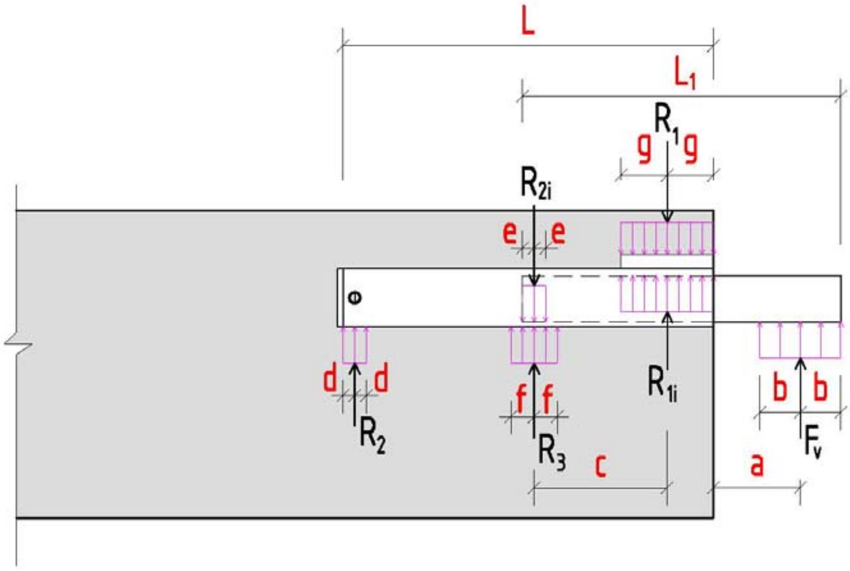


Figure 1: Forces acting on the unit.

F_V = External force on the inner tube

R_{1i}, R_{2i} = Internal forces between the inner and the outer tubes.
R_1, R_2, R_3 = Support reaction forces of the outer tube.

g= distance to the middle plane of the anchoring stirrups in front of the unit.

I) Equilibrium inner tube:

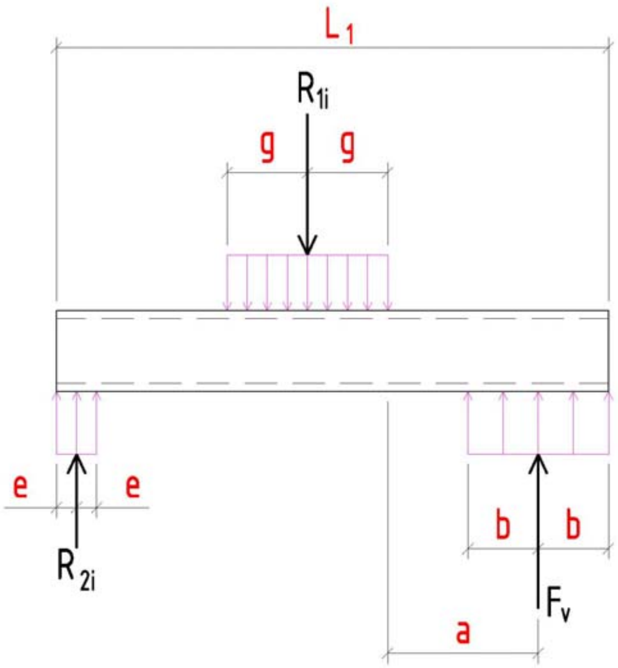


Figure 2: Forces acting on the inner tube.

Equilibrium equations of the inner tube:

1): $\sum M=0$: $F_v \cdot (L_1-b-e) - R_{1i} \cdot (L_1-b-a-g-e)=0$ (1)
2): $\sum F_y=0$: $F_v-R_{1i}+R_{2i}=0$ (2)

Assuming nominal values:
L_1=275mm, a=75mm, b=35mm, g=35mm, e=10mm

Solving R_{1i} from eq. 1:

$$R_{1i} = \frac{F_v \cdot (L_1 - b - e)}{(L_1 - b - a - g - e)} \qquad (3)$$

Solving R_{2i} from eq. 2:

$R_{2i}= R_{1i}-F_v$ (4)

Results:

$$R_{1i} = \frac{40kN \cdot (275-35-10)mm}{(275-35-75-35-10)mm} = 76.7kN$$

$$R_{2i} = 76.7kN - 40kN = 36.7kN$$

II) Equilibrium outer tube:

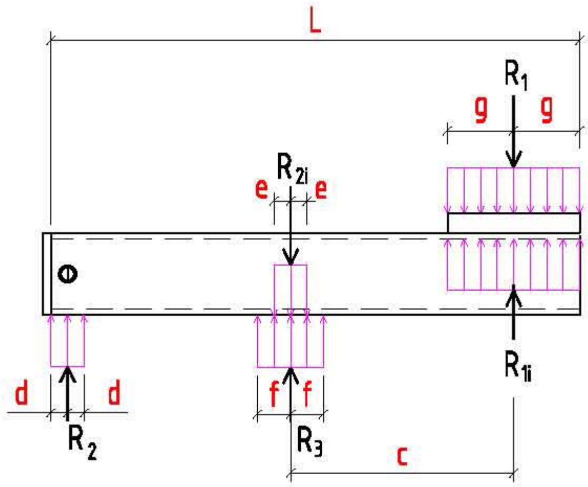


Figure 3: Forces acting on the outer tube.

Exact distribution of forces depends highly on the behavior of the outer tube. Both longitudinal bending stiffness and local transverse bending stiffness in the contact points between the inner and the outer tubes affects the equilibrium. Two situations are considered:

1) Rigid outer tube.

Outer tube rotates as a stiff body. This assumption gives minimum reaction force at R_1, and maximum reaction force at R_2. R_3 is assumed zero. (The force R_3 will actually be negative, but since no reinforcement to take the negative forces is included at this position, it is assumed to be zero.)

Equilibrium equations of the outer tube:

1): $\sum M=0$: $(R_{1i}-R_1)\cdot(L-3-g-d) - (R_{2i}-R_3)\cdot(L-3-g-c-d)=0$ (5)

2): $\sum F_y=0$: $R_2+R_3+R_{1i}- R_{2i}-R_1=0$ (6)

Assuming nominal values:
L=320mm, c=120mm, g=35mm, e=10mm, d=10mm; ($c=L_1$-b-a-g-e=275-35-75-35-10=120mm)

Solving $R_1$from eq. 5:

$$(R_{1i}-R_1)\cdot(L-g-d)-(R_{2i}-R_3)\cdot(L-g-c-d)=0$$

$$(76.7-R_1)\cdot(320-35-10)-(36.7-0)\cdot(320-35-120-10)=0$$

$$21092-275R_1-5688=0$$

$$R_1=\frac{15404}{275}=56.0kN$$

Solving $R_2$from eq. 6:

$$R_2=R_1+R_{2i}-R_{1i}=56.0+36.7-76.7=16.0kN$$

2) Outer tube without bending stiffness. No forces transferred to outer tube at the back of inner tube.

This assumption gives maximum reaction forces R_1 and R_3. R_2 becomes zero. The forces follow directly from the assumption: $R_1 = R_{1i}$ $R_3 = R_{2i}$ and $R_2=0$

$$R_1 = 76.7kN$$
$$R_2 = 0kN$$
$$R_3 = 36.7kN$$

The magnitude of the forces will be somewhere in between the two limits, and the prescribed reinforcement ensures integrity for both situations. Reinforcement is to be located at the assumed attack point for support reactions.

Reinforcement for R_1, R_2 and R_3:

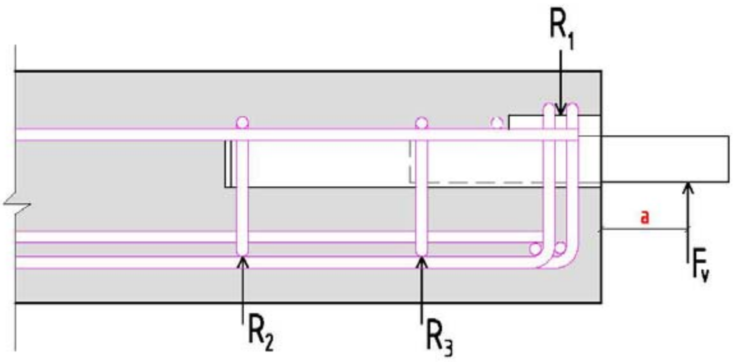


Figure 4: Forces.

Reinforcement necessary to anchor the unit to the concrete:

Reinforcement R_1: $A_{s1} = R_1/f_{sd}$ 76.7kN/435Mpa =176 mm^2
Select 2-Ø8 = 2×2×50 =200 mm^2
Capacity selected reinforcement: R=200 mm^2 ·435MPa=87kN

Reinforcement R_3: $A_{s3} = R_3/f_{sd}$ = 36.7kN/435MPa =84 mm^2
Select 1-Ø8 = 1×2×50 = 100mm^2
Capacity selected reinforcement: R=100 mm^2 ·435MPa=43.5kN

Reinforcement R_2: $A_{s2} = R_2/f_{sd}$ = 16.0kN/435MPa =37 mm^2
Select 1-Ø8 = 1×2×50 = 100mm^2
Capacity selected reinforcement: R=100 mm^2 ·435MPa=43.5kN

Tolerances on the positioning of the reinforcement:

Due to the small internal distances, the magnitude of the forces will change when changing the position of the reinforcement. Thus, strict tolerances are required.

Alt 1)

Assume:
L_1=275mm, a=75mm, b=35mm, g=35+5=40mm, e=10mm

Gives:

$$R_1 = \frac{40kN \cdot (275 - 35 - 10)mm}{(275 - 35 - 75 - 40 - 10)mm} = 80.0kN$$
$$R_2 = 80.0kN - 40kN = 40.0kN$$

Alt 2)

Assume:
L_1=275mm, a=75mm, b=35mm, g=35+5=40mm, e=10+5mm,

Gives:

$$R_1 = \frac{40kN \cdot (275 - 35 - 15)mm}{(275 - 35 - 75 - 40 - 15)mm} = 81.8kN$$
$$R_2 = 81.8kN - 40kN = 41.8kN$$

Conclusion tolerances: Alt 2 represents the most unfavorable position of reinforcement allowed without exceeding the reinforcement capacity. Thus, the assembling tolerances for P1, P2 and P4 should be ±5mm. For recommended reinforcement pattern, see Memo 55c.

Transverse reinforcement:

- One transverse bar with the same diameter as the anchorage bar to be placed in the bend of every anchoring bar.

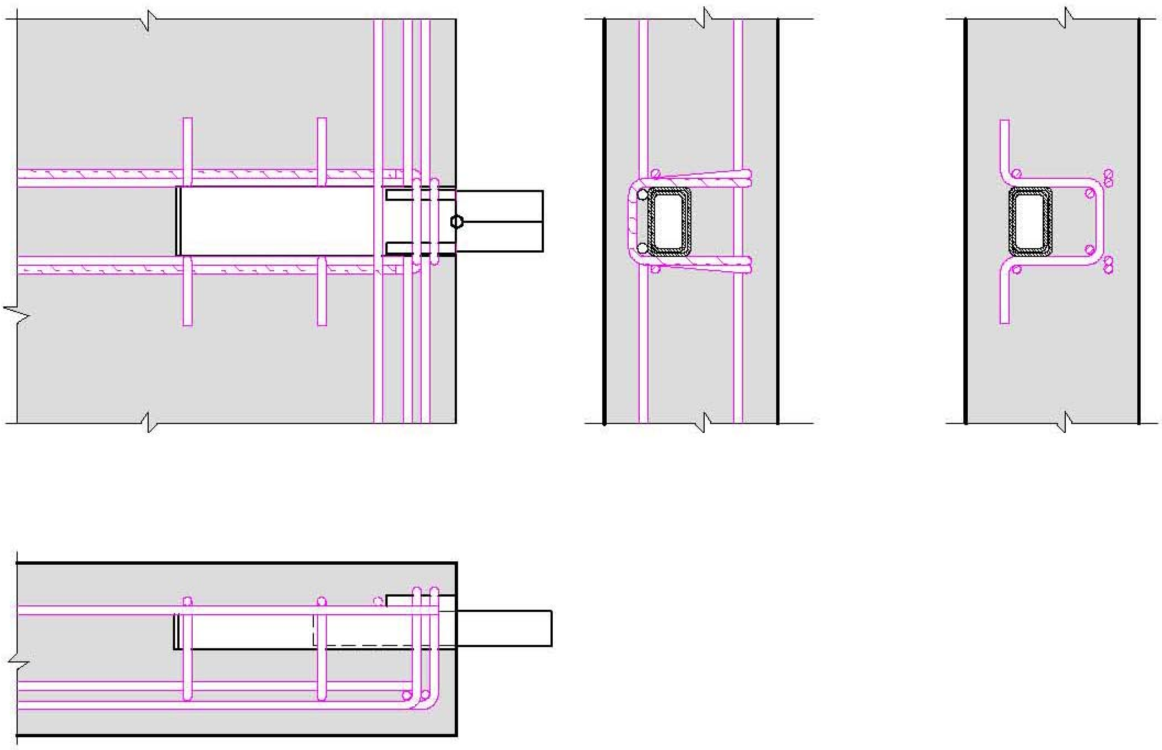


Figure 5: Anchoring reinforcement.

Design
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Reinforcement design for TSS 101

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.

For all NDPs (Nationally Determined Parameter) in the Eurocodes the recommended values are used.

NDP’s are as follows:

Parameter	γ_c	γ_s	α_{cc}	α_{ct}	$C_{Rd,c}$	v_{min}	k_1
Recommended value	1.5	1.15	1.0	1.0	0.12	$0.035k^{1/3}\cdot f_{ck}^{1/2}$	0.15

Table 1: NDP-s in EC-2.

Parameter	γ_{M0}	γ_{M1}	γ_{M2}
Recommended value	1.0	1.0	1.25

Table 2: NDP-s in EC-3.

QUALITIES

Concrete grade C35/45:

$f_{ck} = 35{,}0$ MPa	EC2, Table 3.1
$f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 1 \cdot 35/1{,}5 = 23{,}3$ MPa	EC2, Pt.3.15
$f_{ctd} = \alpha_{ct} \cdot f_{ctk,0,05}/\gamma_c = 1 \cdot 2{,}20/1{,}5 = 1{,}46$ MPa	EC2, Pt.3.16
$f_{bd} = 2{,}25 \cdot \eta_1 \cdot \eta_2 \cdot f_{ctd} = 2{,}25 \cdot 0{,}7 \cdot 1{,}0 \cdot 1{,}46 = 2{,}3$ MPa	EC2, Pt.8.4.2

Reinforcement B500C:

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

Structural steel S355:

Tension: $f_{yd} = f_y/\ \gamma_{M0} = 355/1{,}0 = 355$ MPa
Compression: $f_{yd} = f_y/\ \gamma_{M0} = 355/1{,}0 = 355$ MPa
Shear: $f_{sd} = f_y/(\gamma_{M0} \cdot \sqrt{3}) = 355/(1{,}0 \cdot \sqrt{3}) = 205$ MPa

DIMENSIONS

Inner tube: HUP 100x50x6, Cold formed, S355
Outer tube: HUP 120x60x4, Cold formed, S355

LOADS

Vertical ultimate limit state load = F_V = 100kN.

PART 2 - REINFORCEMENT

EQUILIBRIUM

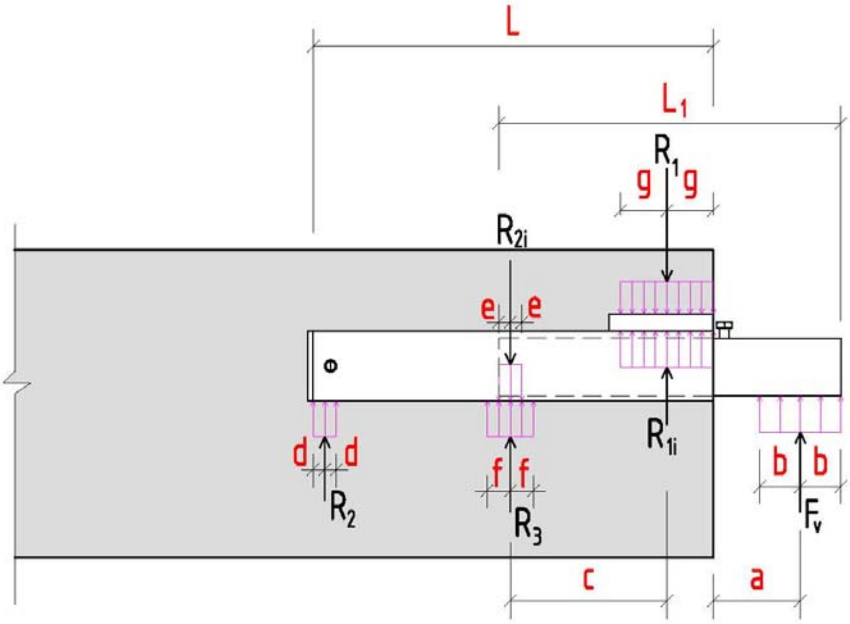


Figure 1: Forces acting on the unit.

F_V = External force on the inner tube

R_{1i}, R_{2i} = Internal forces between the inner and outer tubes.
R_1, R_2, R_3 = Support reaction forces the outer tube.

g= distance to the middle plane of the anchoring stirrups in front of the unit.

I) Equilibrium inner tube:

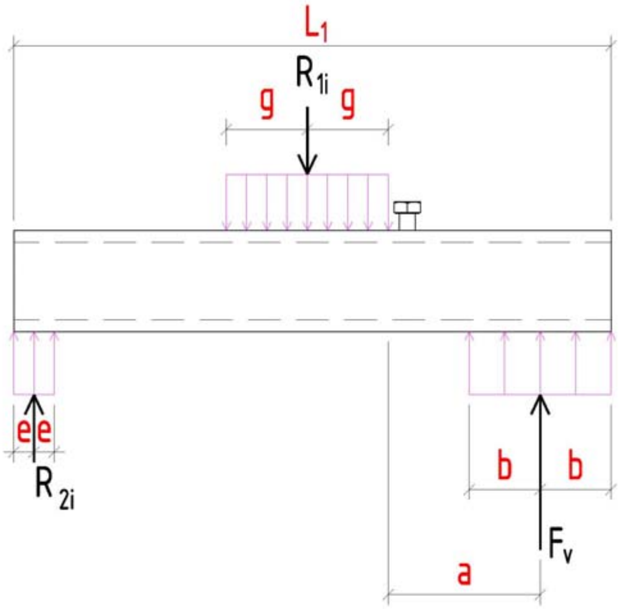


Figure 2: Forces acting on the inner tube.

Equilibrium equations of the inner tube:

1): $\sum M=0$: $F_v \cdot (L_1-b-e) - R_{1i} \cdot (L_1-b-a-g-e)=0$ (1)
2): $\sum F_y=0$: $F_v-R_{1i}+R_{2i}=0$ (2)

Assuming nominal values:
L_1=295mm, a=75mm, b=35mm, g=40mm, e=10mm

Solving R_{1i} from eq. 1:

$$R_{1i} = \frac{F_v \cdot (L_1 - b - e)}{(L_1 - b - a - g - e)} \quad (3)$$

Solving R_{2i} from eq. 2:

$R_{2i}= R_{1i}-F_v$ (4)

Results:

$$R_{1i} = \frac{100kN \cdot (295-35-10)mm}{(295-35-75-40-10)mm} = 185.2kN$$

$$R_{2i} = 185.2kN - 100kN = 85.2kN$$

II) Equilibrium outer tube:

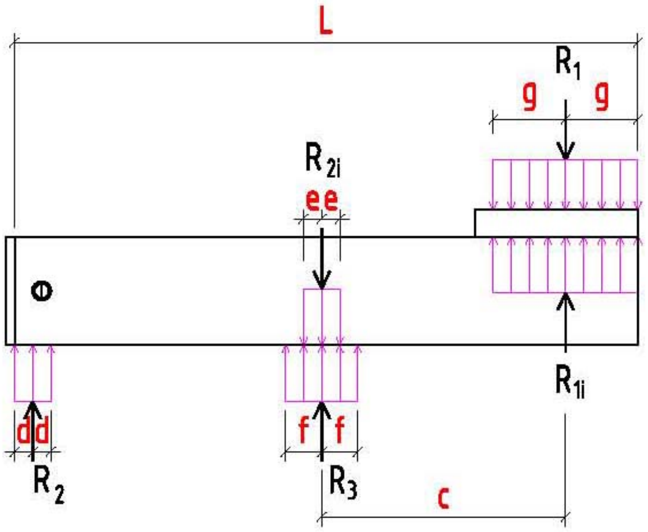


Figure 3: Forces acting on the outer tube.

Exact distribution of forces depends highly on the behavior of the outer tube. Both longitudinal bending stiffness and local transverse bending stiffness in the contact points between the inner and the outer tubes affects the equilibrium. Two situations are considered:

1) Rigid outer tube.

Outer tube rotates as a stiff body. This assumption gives minimum reaction force at R_1, and maximum reaction force at R_2. R_3 becomes zero. (The force R_3 will actually be negative, but since no reinforcement to take the negative forces is included at this position, it is assumed to be zero.)

Equilibrium equations of the outer tube:

1): $\sum M=0$: $(R_{1i}-R_1)\cdot(L-g-d) - (R_{2i}-R_3)\cdot(L-g-c-d)=0$ (5)

2): $\sum F_y=0$: $R_2+R_3+R_{1i}- R_{2i}-R_1=0$ (6)

Assuming nominal values:
L=345mm, c=135mm, g=40mm, e=10mm, d=10mm ; ($c=L_1$-b-a-g-e=295-35-75-40-10=135mm, see Figure 1)

Solving R_1 from eq. 5:

$$(R_{1i}-R_1)\cdot(L-g-d)-(R_{2i}-R_3)\cdot(L-g-c-d)=0$$

$$(185.2-R_1)\cdot(345-40-10)-(85.2-0)\cdot(345-40-135-10)=0$$

$$54634-295R_1-13632=0$$

$$R_1=\frac{41002}{295}=139kN$$

Solving R_2 from eq. 6:

$$R_2 = R_1 + R_{2i} - R_{1i} - R_3 = 139 + 85.2 - 185.2 = 39kN$$

2) Outer tube without bending stiffness. No forces transferred to outer tube at the back of inner tube.

This assumption gives maximum reaction forces R_1 and R_3. R_2 becomes zero. The forces follow directly from the assumption: R_1= R_{1i} R_3= R_{2i} and R_2=0

$$R_1 = 185.2kN$$
$$R_2 = 0kN$$
$$R_3 = 85.2kN$$

The magnitude of the forces will be somewhere in between the two limits, and the prescribed reinforcement ensures integrity for both situations. Reinforcement is to be located at the assumed attack point for support reactions.

Reinforcement for R_1, R_2 and R_3:

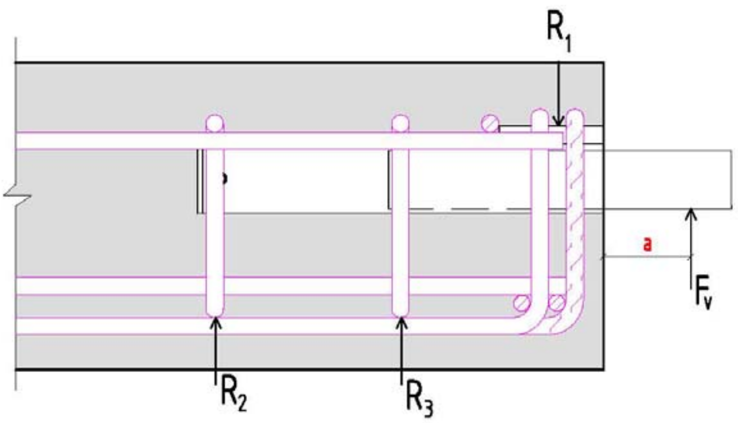


Figure 4: Forces.

Reinforcement necessary to anchor the unit to the concrete:

Reinforcement R_1: $A_{s1} = R_1/f_{sd}$ = 185.2kN/435Mpa =426 mm^2
Select 2-Ø12 = 2×2×113 =452 mm^2
Capacity selected reinforcement: R=452 mm^2 ·435MPa=196.6kN

Reinforcement R_3: $A_{s3} = R_3/f_{sd}$ = 85.2kN/435MPa =196 mm^2
Select 1-Ø12 = 1×2×113 = 226 mm^2
Capacity selected reinforcement: R=226 mm^2 ·435MPa=98.3kN

Reinforcement R_2: $A_{s2} = R_2/f_{sd}$ = 39kN/435MPa =89 mm^2
Select 1-Ø12 = 1×2×113 = 226mm^2
Capacity selected reinforcement: R=226 mm^2 ·435MPa=98.3kN

Tolerances on the positioning of the reinforcement:

Due to the small internal distances, the magnitude of the forces will change when changing the position of the reinforcement. Thus, strict tolerances are required.

Alt 1) Assume:
L_1=295mm, a=75mm, b=35mm, g=40+5=45mm, e=10mm

Gives:

$$R_1 = \frac{100kN \cdot (295-35-10)mm}{(295-35-75-45-10)mm} = 192.3kN$$

$$R_2 = 192.3kN - 100kN = 92.3kN$$

Alt 2) Assume:
L_1=295mm, a=75mm, b=35mm, g=40-5=35mm, e=10mm

Gives:

$$R_1 = \frac{100kN \cdot (295-35-10)mm}{(295-35-75-35-10)mm} = 178.6kN$$

$$R_2 = 178.6kN - 100kN = 178.6kN$$

Alt 3) Assume:
L_1=295mm, a=75mm, b=35mm, g=40mm, e=10-5=5mm

Gives:

$$R_1 = \frac{100kN \cdot (295-35-5)mm}{(295-35-75-40-5)mm} = 182.1kN$$

$$R_2 = 182.1kN - 100kN = 82.1kN$$

Alt 4) Assume:
L_1=295mm, a=75mm, b=35mm, g=40mm, e=10+5=15mm

Gives:

$$R_1 = \frac{100kN \cdot (295-35-15)mm}{(295-35-75-40-15)mm} = 188.5kN$$

$$R_2 = 188.5kN - 100kN = 88.5kN$$

Design MEMO 54d

Reinforcement design for TSS 101

Alt 5) Assume:
L_1=295mm, a=75mm, b=35mm, g=40+5=45mm, e=10+5=15mm

Gives:

$$R_1 = \frac{100kN \cdot (295-35-15)mm}{(295-35-75-45-15)mm} = 196kN$$

$$R_2 = 196kN - 100kN = 96kN$$

Conclusion tolerances: Alt 5 represents the most unfavorable position of reinforcement allowed without exceeding the reinforcement capacity. Thus, the assembling tolerances for P1, P2 and P4 should be ±5mm. For recommended reinforcement pattern, see Memo 55d.

Transverse reinforcement:

- One transverse bar with the same diameter as the anchorage bar to be placed in the bend of every anchoring bar.

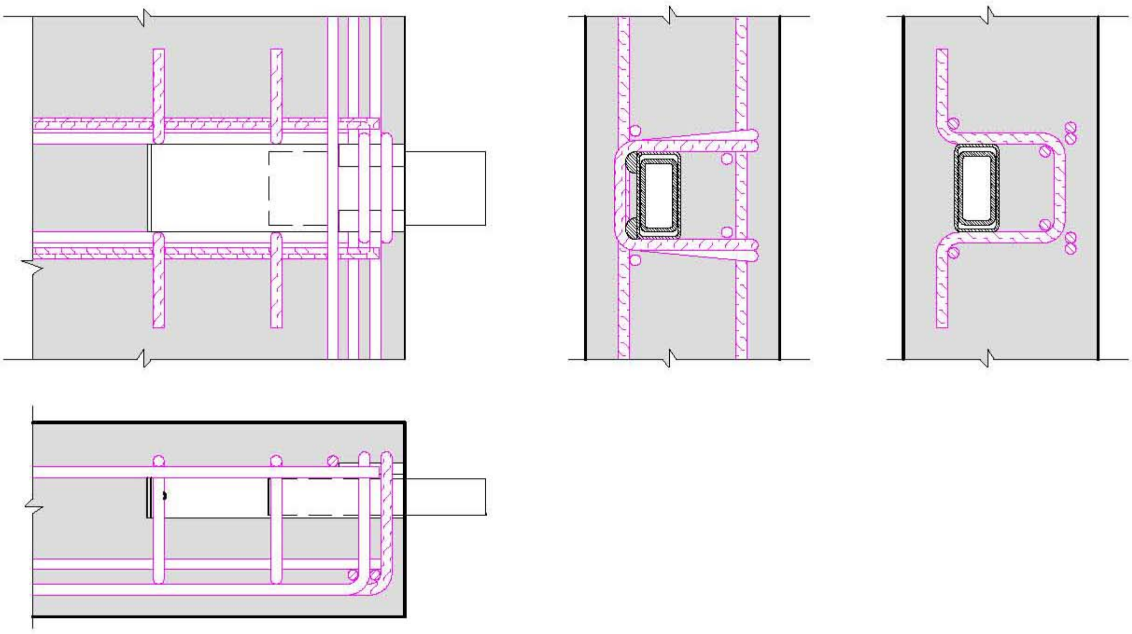


Figure 5: Anchoring reinforcement.

Recommended reinforcement pattern TSS 41

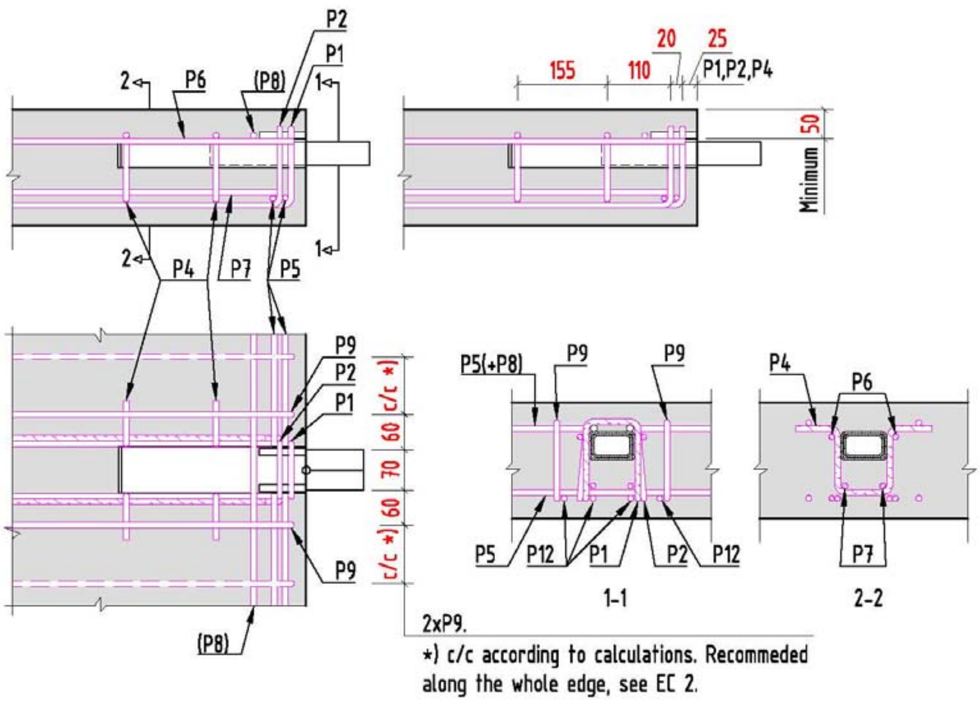


Figure 1: Recommended reinforcement pattern for TSS 41 units. Edge distance k>300mm.

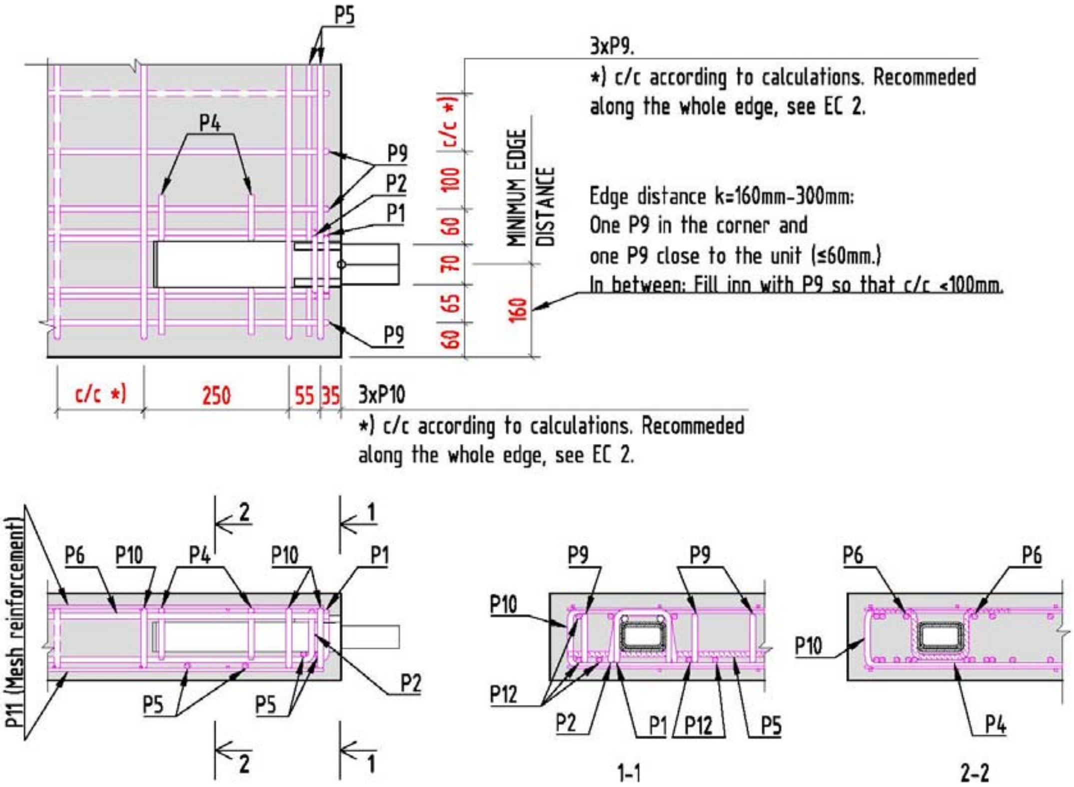


Figure 2: Recommended reinforcement pattern for TSS 41 units. Edge distance 160mm≤k≤300mm. Ultimate limit load according to Figure 5.

Recommended reinforcement pattern TSS 41

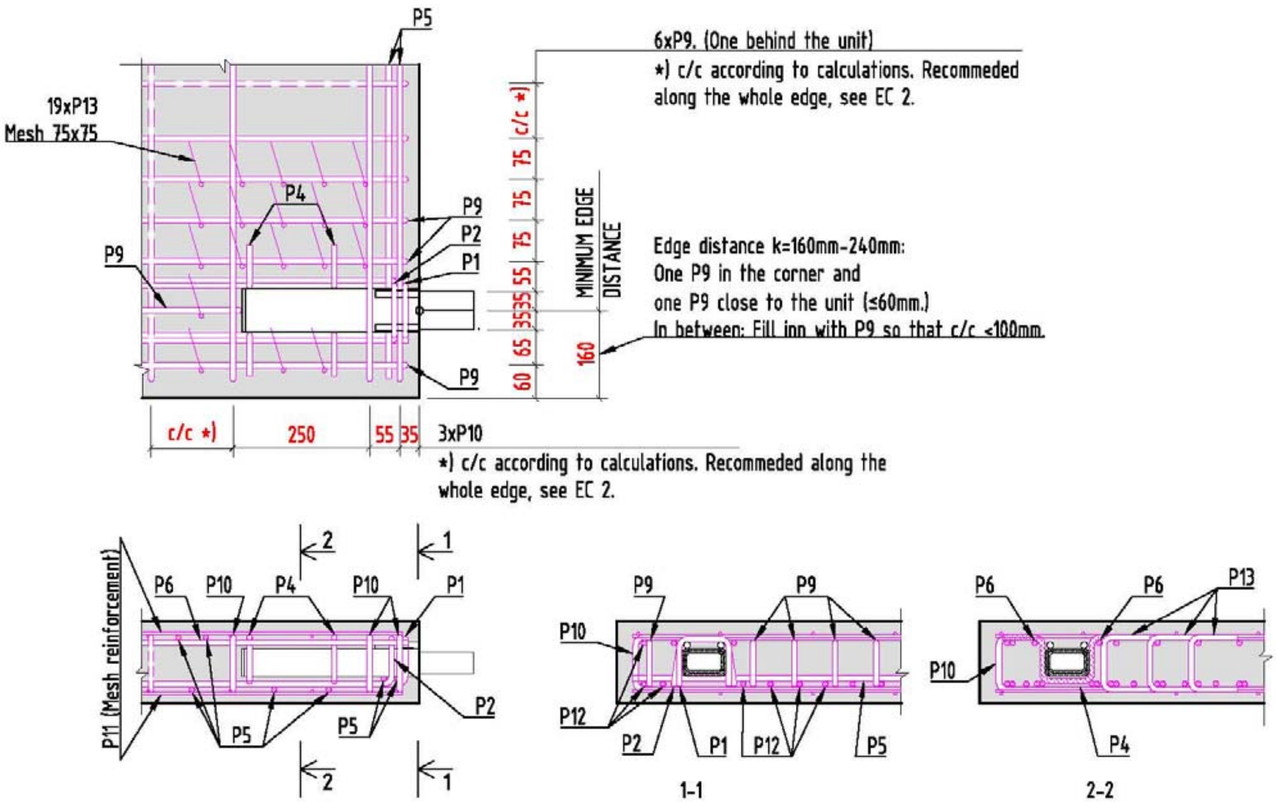


Figure 3: Recommended reinforcement pattern TSS 41. Slab thickness t<200mm and edge distance 160mm≤k≤240mm. Ultimate limit load according to Figure 5.

The following comments can be made in connection with the recommended reinforcement pattern shown in Figure 1:

- Reinforcement is illustrated in a slab with thickness 200mm, concrete cover 30mm and large edge distance.
- In the area marked "c/c*)", the tested elements (thickness t=150mm) were reinforced with P9 c/c 100mm along the whole edge.
- Two stirrups P9 to be placed closed to the unit. One on each side. Edge reinforcement P9 beyond the prescribed locations should be in accordance with calculations. However, according to EC 2 clauses 6.4.2(5) and 9.3.1.4, stirrups continuously along the edge are always recommended.
- Transverse reinforcement P5 in the bends of P9. When the concrete cover is 20mm, or less, the upper P5 bar can run above the 12mm round steel in front of the unit. With 30mm concrete cover, the upper P5 bar may have to be cut. Then, a straight bar P8 is to be placed transverse of the unit as illustrated, in overlap with P5. If possible, the P5 bar should be made continuously, and to achieve this, it is preferable to lower the unit below the minimum value of 50mm from the top.
- The illustrated reinforcement is the necessary reinforcement required to transfer the forces in the unit to the concrete. It is not to be understood as the complete slab reinforcement. The main reinforcement for the slab/landings, inclusive edge reinforcement must be calculated in each case.

Recommended reinforcement pattern TSS 41

The following comments can be made in connection with the recommended reinforcement pattern shown in Figure 2:

- Reinforcement is illustrated in a slab with thickness 150mm, concrete cover 20mm and edge distance 160mm. Notice the reduction in load in this case, see Figure 5.
- In the areas marked "c/c*)", the tested elements (thickness t=150mm) were reinforced with P10 c/c 150mm and P9 c/c 100mm along the two edges.
- Mesh reinforcement with transverse reinforcement P10 (closed bars) below. P10 runs above the unit, and below P1/P2. The mesh reinforcement may be replaced with straight bars with corresponding cross section area and c/c distance.
- When the unit is located at 300mm, or closer to the corner than 300mm, stirrups **shall always** be used along both edges as prescribed (P9/P10). The stirrups anchor the main reinforcement, and will in addition function as shear reinforcement in the slab. Edge reinforcement P9/P10 beyond the prescribed locations should be in accordance with calculations. However, according to EC 2 clauses 6.4.2(5) and 9.3.1.4, stirrups continuously along the edge are always recommended.
- P10 may be replaced with u-shaped stirrups in overlap with straight bars.
- The illustrated reinforcement is to be understood as a minimum of reinforcement which always should be found when the unit is located close to the corner. It is not to be understood as the complete slab reinforcement. The main reinforcement for the slab/landings, inclusive edge reinforcement must be calculated in each case.

The following comments can be made in connection with the recommended reinforcement pattern shown in Figure 3:

- Reinforcement is illustrated in a slab with thickness 150mm, concrete cover 20mm and edge distance 160mm.
- In the areas marked "c/c*)", the tested elements (thickness t=150mm) were reinforced with P10 c/c 150mm and P9 c/c 150mm along the two edges.
- Mesh reinforcement with transverse reinforcement P10 (closed bars) below. P10 runs above the unit, and below P1/P2. The mesh reinforcement may be replaced with straight bars with corresponding cross section area and c/c distance.
- When the unit is located at 240mm, or closer to the corner than 240mm, stirrups P13 **shall always** be used in the corner area if utilizing the full unit capacity in slabs with thickness less than t=200mm.
- Transverse reinforcement 3Ø8 P5 behind the unit as illustrated.
- The illustrated reinforcement is to be understood as a minimum of reinforcement which always should be found. It is not to be understood as the complete slab reinforcement. The main reinforcement for the slab/landings, inclusive edge reinforcement must be calculated in each case.

Recommended reinforcement pattern TSS 41

General comments in connection with both reinforcement patterns:

- Minimum slab thickness: t=150mm. Notice the reduction in load when the slab thickness is less than 200mm, the unit is located closer to the corner than 240mm and no additional shear reinforcement is introduced, see Figure 5.

- Minimum concrete cover TSS: 50mm (top flange of the outer tube).

- P1 and P2 to be placed directly onto the top of the unit, with the 12mm round steel positioned in the bend of P1/P2. It is recommended to spot weld P1 and P2 to the unit in order to ensure the correct position.

- Position, shape and anchorage of the stirrups P1 and P2 in the front is the governing factor concerning force transfer from the unit to the slab. Exact and careful detailing is therefore important. Inaccuracy may cause minor concrete cracks to develop before activating the reinforcement as assumed.

- Transverse reinforcement in the bend of P1/P2 (P5). P5 shall have the same diameter as P1/P2 and should run along the whole width of the slab.

- The transverse reinforcement P5 may be a part of the main transverse reinforcement and should have proper anchoring on the outside of the unit on both sides, especially towards the edge. This may require anchoring of P5 with an upward bend, or u-shaped bars. The required anchoring must be evaluated in every case.

- P1 and P2 should be anchored to the maximum depth, depending on the slab thickness.

- The inner width of the stirrups P1 and P2 should correspond to the width of the outer tube. This in order to have the most direct transfer of forces from the outer tube to the vertical legs of the stirrups.

- The main reinforcement of the slab should have sufficient overlap with P1 and P2. This is illustrated with four straight bars P12. The total amount of main reinforcement must be calculated in each case.

- All recommended reinforcement assumed to continue beyond the boundary of the illustrated area shall have a proper anchoring on the outside of the area. Thus, the reinforcement should continue at least one anchoring length outside the illustrated area, or be anchored by hooks.

- Shear reinforcement due to punching shear according to EC 2, clause 6.4.3.

Recommended reinforcement pattern TSS 41

Tolerances on location of anchoring bars:

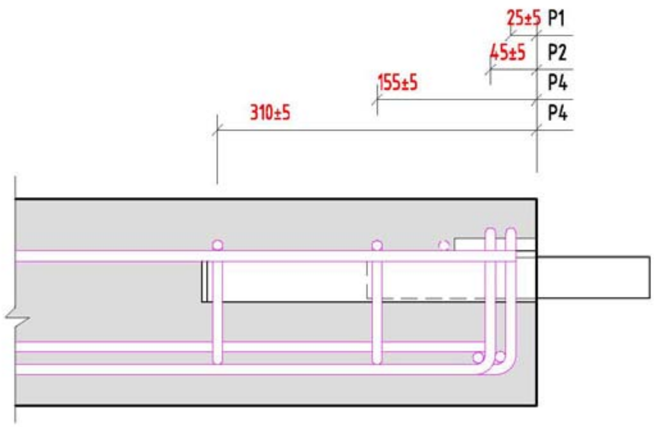


Figure 4: Tolerances P1, P2 and P4.

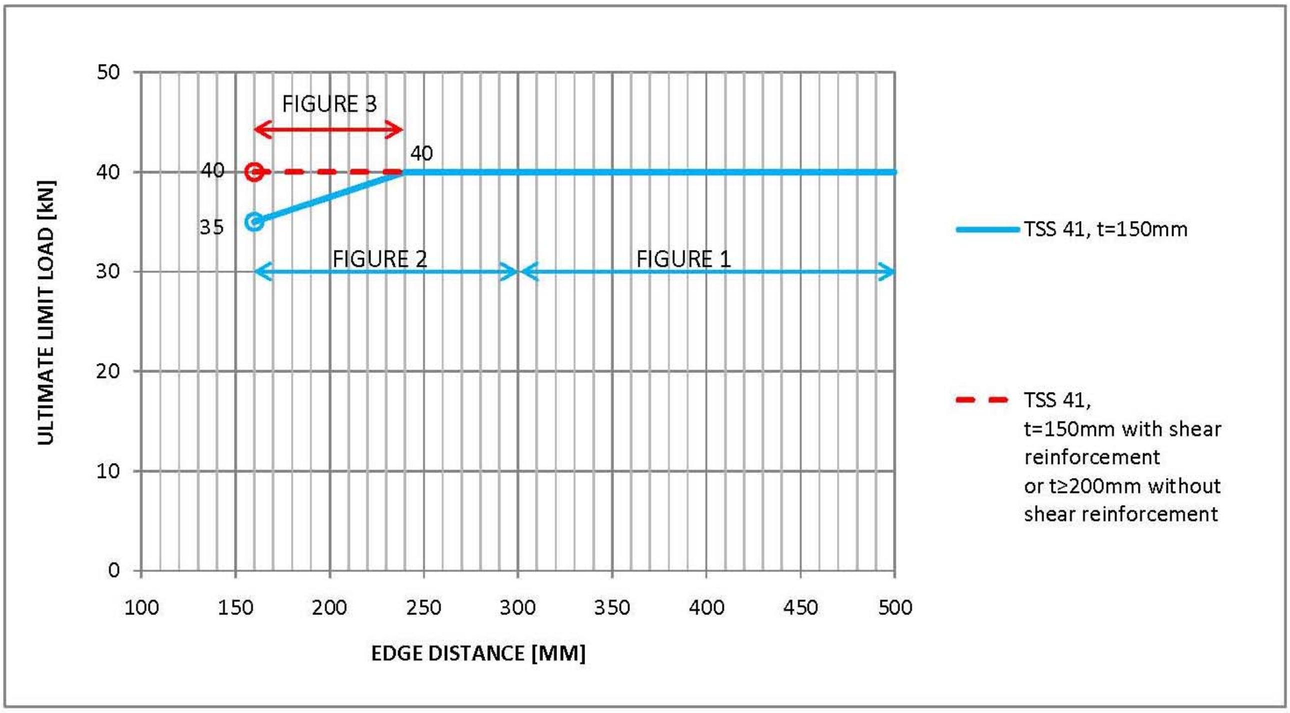
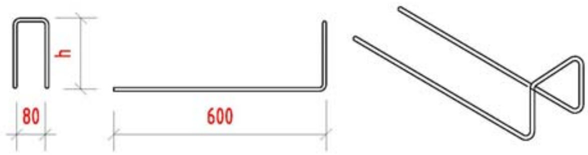
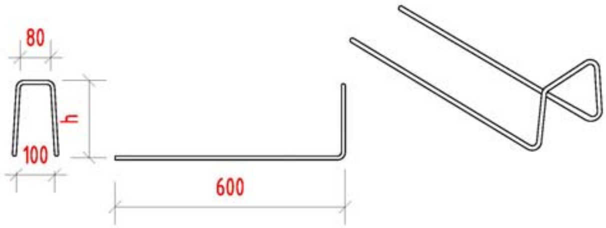
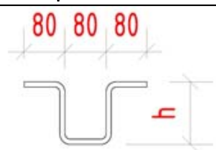


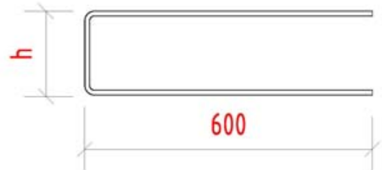
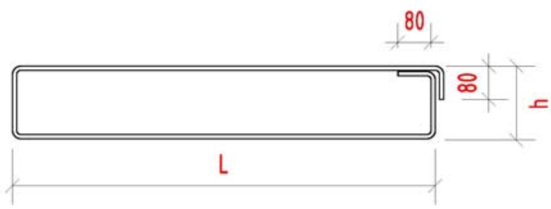
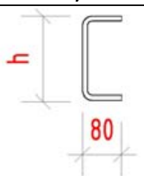
Figure 5: Slab thickness and load limitations. The coloured arrows refer to the recommended reinforcement patterns at different edge distances, as given in above Figures. The colour of the arrow giving the recommended reinforcement pattern corresponds to the colour of the line giving the load limitation. (In Memo 53, Figure 2, the load limitation is illustrated alone, without the arrows and references to reinforcement pattern)

Design MEMO 55c

Recommended reinforcement pattern TSS 41

Pos	Diameter	Cutting length	Nr. Pr unit	Bar schedule	Grade
P1	8		1	 Mandrel diameter=20mm (if this is in accordance with national regulations.) h=Decided locally, but as deep as possible. Normally: Slab thickness - 30mm - national rules for concrete cover. If the mandrel diameter is 4xØ (in accordance with EC-2) the width should be increased to 84mm to ensure good contact between the stirrups and the round steel. The contact point should be in approximate 45degrees from the centre of the round steel, and in the middle of the curved part of the stirrup.	B500C
P2	8		1	 Mandrel diameter=20mm (if this is in accordance with national regulations.) h=Decided locally, but as deep as possible. Normally: Slab thickness - 30mm - national rules for concrete cover. If the mandrel diameter is 4xØ (in accordance with EC-2) the widths should be increased to respectively 84mm and 104 mm to ensure good contact between the stirrups and the round steel. The contact point should be in approximate 45degrees from the centre of the round steel, and in the middle of the curved part of the stirrup.	B500C
P4	8		2	 h= Decided locally. Normally: Slab thickness – 20mm – 2 x national rules for concrete cover.	B500C
P5	8		3 + 4[1)] + 7[2)] +	 Normally: Width of slab – 2 x national rules for concrete cover.	B500C
P6	8	600	2		B500C

Recommended reinforcement pattern TSS 41

Pos	Diameter	Cutting length	Nr. Pr unit	Bar schedule	Grade
P7	8	600	2	 Slab thickness t=150mm: There is not enough space for the bars, and they don't need to be used.	B500C
P8	8		1	 Normally: Width of slab – 2 x national rules for concrete cover. Alternatively u-shaped or closed stirrups may be used.	B500C
P9	8		2+ 3[1)]+ 6[2)]+	 h= Decided locally. Normally: Slab thickness –30mm – 2 x national rules for concrete cover. Recommended along whole edge.	B500C
P10	8		3[1), 2)]+	 h= Decided locally. Normally: Slab thickness – 2 x national rules for concrete cover – thickness of mesh reinforcement.	B500C
P11				Minimum mesh reinforcement K131, or main reinforcement in both directions with corresponding cross section area and c/c.	B500C
P12	8		4 + 5[1)] + 6[2)] +	 The amount of main reinforcement must be according to calculations in each case. Minimum 4xØ8 in overlap with P1/P2 as illustrated. Normally: Length of slab – 2 x national rules for concrete cover	B500C
P13	8		19[2)]	 h= Decided locally. Normally: Slab thickness – 2 x national rules for concrete cover – thickness of mesh reinforcement.	B500C

[1)] *Edge distance ≤300mm*
[2)] *Edge distance ≤240mm, slab thickness t<200mm.*

Table 1: List of reinforcement TSS 41.

Invisible connections™

Design MEMO 55d

Recommended reinforcement pattern TSS 101

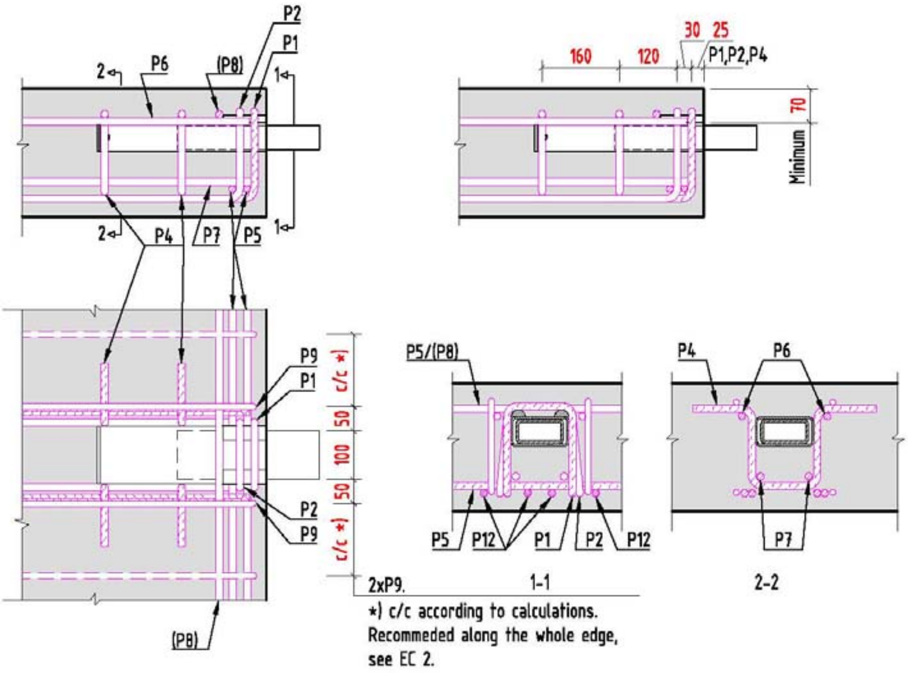


Figure 1: Recommended reinforcement pattern for TSS 101 units. Slab thickness t=265mm and edge distance k>450mm. Slab thickness t=200mm and edge distance k>400mm.

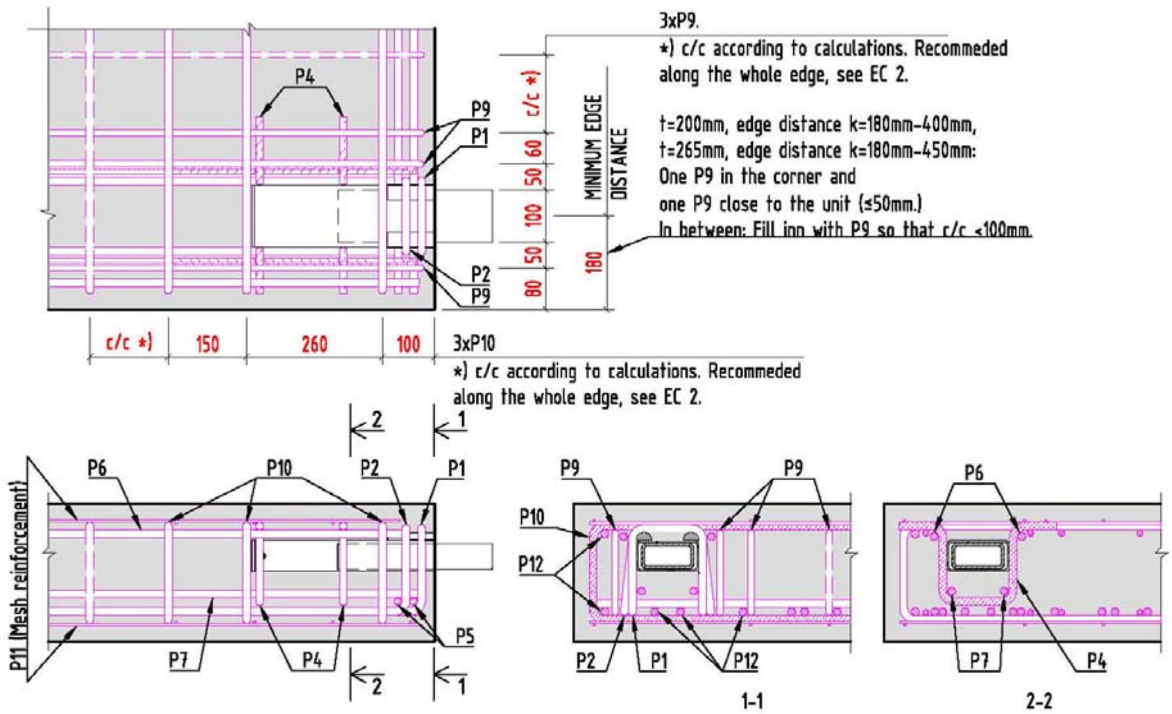


Figure 2: Recommended reinforcement pattern for TSS 101 units. Slab thickness t=265mm and edge distance 180mm≤k≤450mm. Slab thickness t=200mm and edge distance 180mm≤k≤400mm. Ultimate limit load according to Figure 5.

Recommended reinforcement pattern TSS 101

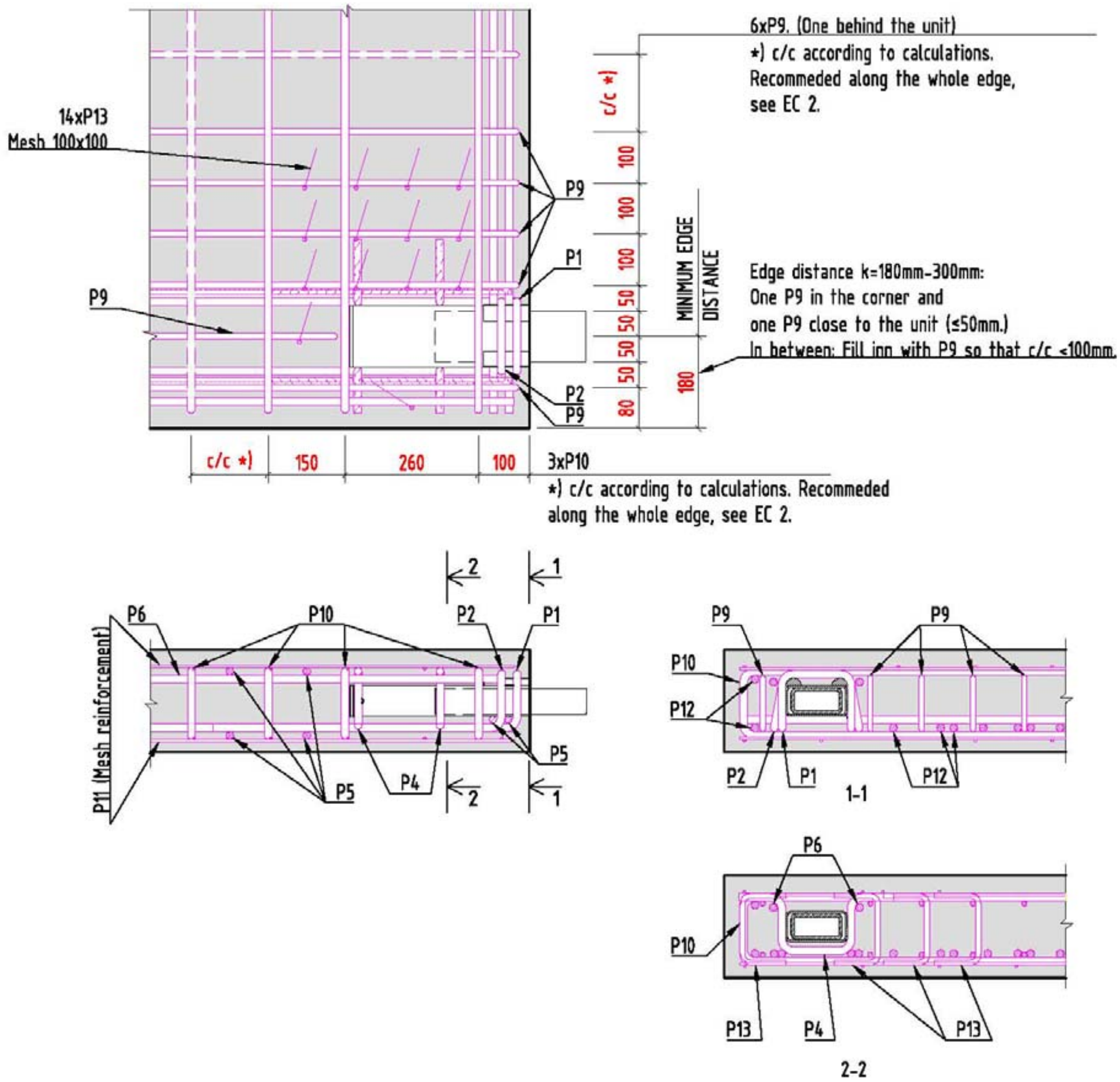


Figure 3: Recommended reinforcement pattern for TSS 101 units. Slab thickness t<265mm and edge distance 180mm≤k<300mm. Ultimate limit load according to Figure 5.

Recommended reinforcement pattern TSS 101

The following comments can be made in connection with the recommended reinforcement pattern shown in Figure 1:

- Reinforcement is illustrated in a slab with thickness 265mm, concrete cover 30mm and large edge distance.
- In the area marked "c/c*)", the tested elements (thickness t=265mm) were reinforced with P9 c/c 150mm along the whole edge.
- Two stirrups P9 to be placed closed to the unit. One on each side. Edge reinforcement P9 beyond the prescribed locations should be in accordance with calculations. However, according to EC 2 clauses 6.4.2(5) and 9.3.1.4, stirrups continuously along the edge are always recommended.
- Transverse reinforcement P5 in the bends of P9. When the concrete cover is 25mm, or less, the upper P5 bar can run above the half round steel in front of the unit. With 30mm concrete cover, the upper P5 bar may have to be cut. Then, a straight bar P8 is to be placed transverse of the unit as illustrated, in overlap with P5. If possible, the P5 bar should be made continuously, and to achieve this, it is preferable to lower the unit below the minimum value of 70mm from the top.
- The illustrated reinforcement is the necessary reinforcement required to transfer the forces in the unit to the concrete. It is not to be understood as the complete slab reinforcement. The main reinforcement for the slab/landings, inclusive edge reinforcement must be calculated in each case.

The following comments can be made in connection with the recommended reinforcement pattern shown in Figure 2:

- Reinforcement is illustrated in a slab with thickness 265mm, concrete cover 30mm and edge distance 180mm.
- In the areas marked "c/c*)", the tested elements (thickness t=265mm) were reinforced with P10 c/c 150mm and P9 c/c 150mm along the two edges.
- Mesh reinforcement with transverse reinforcement P10 (closed bars) below. P10 runs above the unit, and below P1/P2. The mesh reinforcement may be replaced with straight bars with corresponding cross section area and c/c distance.
- Slab thickness t=200mm: When the unit is located at 400mm, or closer to the corner than 400mm, stirrups **shall always** be used along both edges as prescribed (P9/P10).
  Slab thickness t=265mm: When the unit is located at 450mm, or closer to the corner than 450mm, stirrups **shall always** be used along both edges as prescribed (P9/P10).
  These stirrups anchor the main reinforcement, and will in addition function as shear reinforcement in the slab. Edge reinforcement P9/P10 beyond the prescribed locations should be in accordance with calculations. However, according to EC 2 clauses 6.4.2(5) and 9.3.1.4, stirrups continuously along the edge are always recommended.
- P10 may be replaced with u-shaped stirrups in overlap with straight bars.
- The illustrated reinforcement is to be understood as a minimum of reinforcement which always should be found when the unit is located close to the corner. It is not to be understood as the complete slab

reinforcement. The main reinforcement for the slab/landings, inclusive edge reinforcement must be calculated in each case.

The following comments can be made in connection with the recommended reinforcement pattern shown in Figure 3:

- Reinforcement is illustrated in a slab with thickness 200mm, concrete cover 30mm and edge distance 180mm. Notice the reduction in load in this case, see Figure 5.
- In the areas marked "c/c*)", the tested elements (thickness t=200mm) were reinforced with P10 c/c 150mm and P9 c/c 100mm along the two edges.
- Mesh reinforcement with transverse reinforcement P10 (closed bars) below. P10 runs above the unit, and below P1/P2. The mesh reinforcement may be replaced with straight bars with corresponding cross section area and c/c distance.
- Slab thickness t=200mm: When the unit is located at 400mm, or closer to the corner than 400mm, stirrups **shall always** be used along both edges as prescribed (P9/P10).
  Slab thickness t=265mm: When the unit is located at 450mm, or closer to the corner than 450mm, stirrups **shall always** be used along both edges as prescribed (P9/P10).
  These stirrups anchor the main reinforcement, and will in addition function as shear reinforcement in the slab. Edge reinforcement P9/P10 beyond the prescribed locations should be in accordance with calculations. However, according to EC 2 clauses 6.4.2(5) and 9.3.1.4, stirrups continuously along the edge are always recommended.
- When the slab thickness is less than 265mm, and the unit is located closer to the corner than 300mm, stirrups P13 (shear reinforcement) may be used in the corner area, as illustrated, to increase the concrete capacity, see Figure 5.
- P10 may be replaced with u-shaped stirrups in overlap with straight bars.
- Transverse reinforcement 4Ø12 –P5 behind the unit as illustrated.
- The illustrated reinforcement is to be understood as a minimum of reinforcement which always should be found when the unit is located close to the corner. However, it is not to be understood as the complete slab reinforcement. The main reinforcement for the slab/landings, inclusive edge reinforcement must be calculated in each case.

General comments in connection with both reinforcement patterns:

- Minimum slab thickness: t=200mm. Notice the reduction in load, see Figure 5.
- Minimum concrete cover TSS: 70mm (top flange of the outer tube).
- P1 and P2 to be placed directly onto the unit, with the half round steel positioned in the bend of P1/P2. It is recommended to spot weld P1 and P2 to the unit in order to ensure the correct position.

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- Position, shape and anchorage of the stirrups P1 and P2 in the front is the governing factor concerning force transfer from the unit to the slab. Exact and careful detailing is therefore important. Inaccuracy may cause minor concrete cracks to develop before activating the reinforcement as assumed.

- Transverse reinforcement in the bend of P1/P2 (P5). P5 shall have the same diameter as P1/P2 and should run along the whole width of the slab.

- The transverse reinforcement P5 may be a part of the main transverse reinforcement and should have proper anchoring on the outside of the unit on both sides, especially towards the edge. This may require anchoring of P5 with an upward bend, or u-shaped bars. The required anchoring must be evaluated in every case.

- P1 and P2 should be anchored to the maximum depth, depending on the slab thickness.

- The inner width of the stirrups P1 and P2 should correspond to the width of the outer tube. This in order to have the most direct transfer of forces from the outer tube to the vertical legs of the stirrups.

- The main reinforcement of the slab should have sufficient overlap with P1 and P2. This is illustrated with four straight bars P12. The total amount of main reinforcement must be calculated in each case.

- All recommended reinforcement assumed to continue beyond the boundary of the illustrated area shall have a proper anchoring on the outside of the area. Thus, the reinforcement should continue at least one anchoring length outside the illustrated area, or be anchored by hooks.

- Shear reinforcement due to punching shear according to EC 2, clause 6.4.3.

Tolerances on location of anchoring bars:

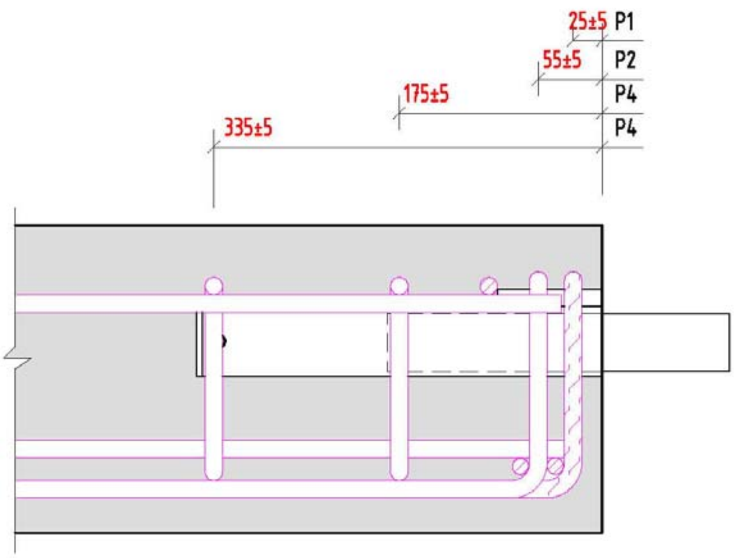

Figure 4: Tolerances P1, P2 and P4.

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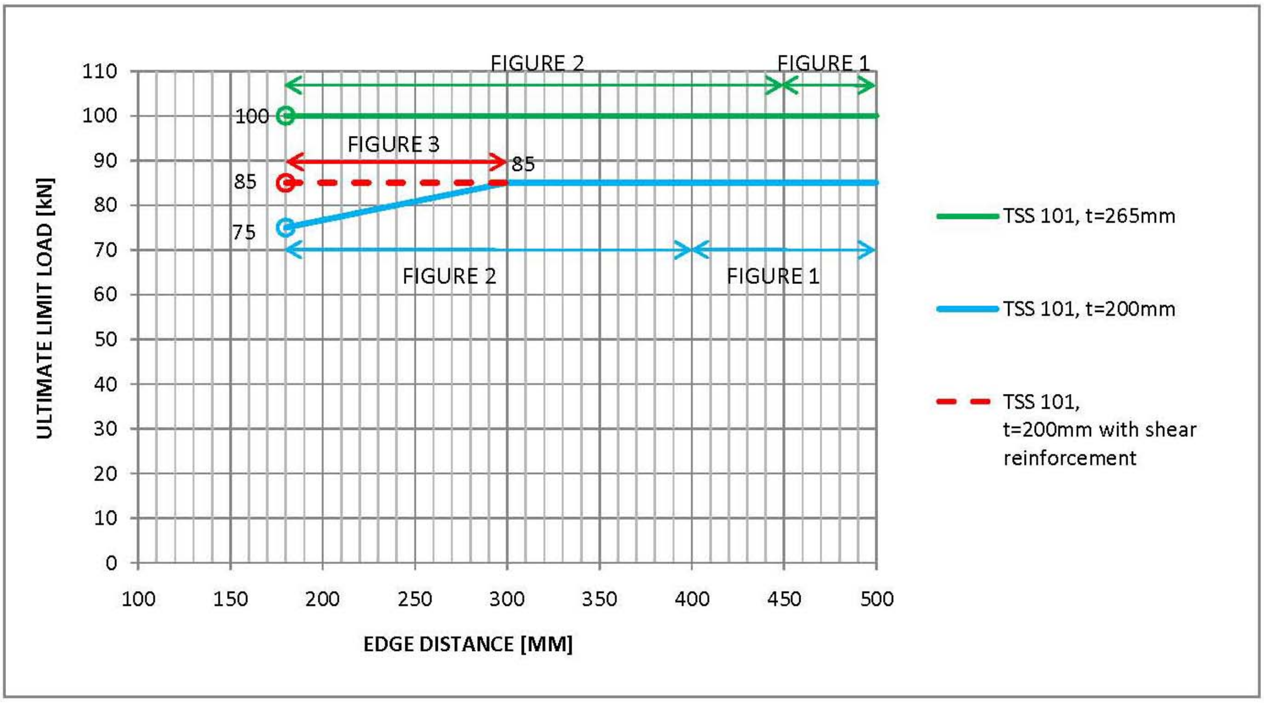

Figure 5: Slab thickness, recommended reinforcement pattern and load limitations. The coloured arrows refer to the recommended reinforcement patterns, as given in above Figures. The colour of the arrow giving the recommended reinforcement pattern corresponds to the colour of the line giving the load limitation. (In Memo 53, Figure 3, the load limitation is illustrated alone, without the arrows and references to reinforcement pattern)

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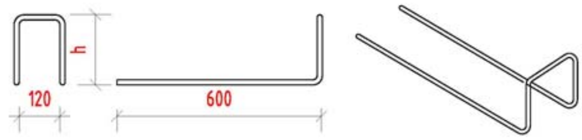
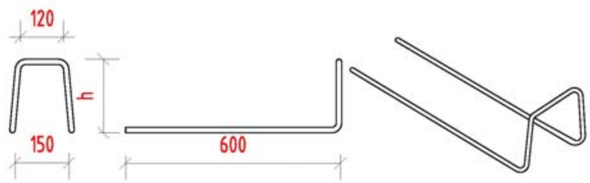
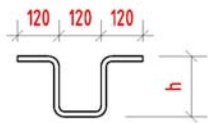
Pos	Diameter	Cutting length	Nr. Pr unit	Bar schedule	Grade
P1	12		1	 Mandrel diameter=32mm (if this is in accordance with national regulations.) h=Decided locally, but as deep as possible. Normally: Slab thickness - 40mm - national rules for concrete cover. If the mandrel diameter is 4xØ (in accordance with EC-2) the width should be increased to 130mm to ensure good contact between the stirrups and the round steel.	B500C
P2	12		1	 Mandrel diameter=32mm (if this is in accordance with national regulations.) h=Decided locally, but as deep as possible. Normally: Slab thickness - 40mm - national rules for concrete cover. If the mandrel diameter is 4xØ (in accordance with EC-2) the widths should be increased to respectively 130mm and 160 mm to ensure good contact between the stirrups and the round steel.	B500C
P4	12		2	 h= Decided locally. Normally: Slab thickness – 30mm – 2 x national rules for concrete cover.	B500C
P5	12		2 6[2)]	 Normally: Width of slab – 2 x national rules for concrete cover.	B500C
P6	12	1000	2		B500C
P7	12	1000	2	 Slab thickness t=200mm: There is not enough space for the bars, and they don't need to be used.	B500C

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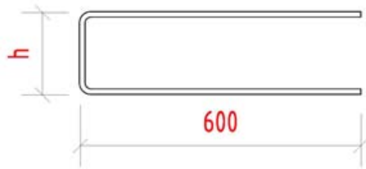
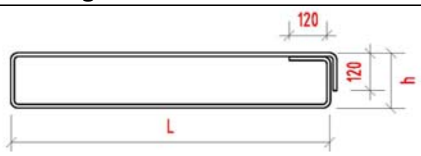
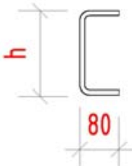
Pos	Diameter	Cutting length	Nr. Pr unit	Bar schedule	Grade
P8	12		1	 Normally: Width of slab – 2 x national rules for concrete cover. Alternatively u-shaped or closed stirrups may be used.	B500C
P9	10		2 + 3[1)] + 6[2)] +	 h= Decided locally. Normally: Slab thickness –30mm – 2 x national rules for concrete cover. Recommended along whole edge.	B500C
P10	12		3[1),2)] +	 h= Decided locally. Normally: Slab thickness – 2 x national rules for concrete cover – thickness of mesh reinforcement.	B500C
P11				Minimum mesh reinforcement K131, or main reinforcement in both directions with corresponding cross section area and c/c.	B500C
P12	12		4 + 5[1),2)] +	 The amount of main reinforcement must be according to calculations in each case. Minimum 4xØ12 in overlap with P1/P2 as illustrated. Normally: Length of slab – 2 x national rules for concrete cover	B500C
P13	8		14[2)]	 h= Decided locally. Normally: Slab thickness – 2 x national rules for concrete cover – thickness of mesh reinforcement.	B500C

[1)] Edge distance≤400mm. Slab thickness, t=200mm.
Edge distance≤450mm. Slab thickness, t=265mm.
[2)] Edge distance<300mm and slab thickness t<265mm

Table 1: List of reinforcement TSS 101.