MEMO 54

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TSS AND RVK		Last rev.:	04.02.2022	Sign.:	jb
TECHNICAL SPESIFICATIONS		Doc. nr.:	K3-10/54E	Control:	mlr@oo
DESIGN					

TSS AND RVK UNITS

TECHNICAL SPECIFICATIONS

This memo, together with memo 55, substitutes memo 52, 53, 53a, 54a-d, 55a-d, 56c-e, 57, 60 and 63.

INTENDED USE

The connection units are designed for connecting precast stairs and landing elements to the stairway shaft walls and transferring vertical shear loads between the concrete components. The connections may also be used for support of slabs mounted between walls for other purposes. Standard units are used indoor in dry conditions. Connections made of hot dip galvanized steel may be used for external exposure according to the requirements for the individual projects.

The TSS unit is specially designed to connect precast stair- and landing elements where the final surface finish of the elements are made in the factory, for example terrazzo. A unit specially designed to reduce impact sound transmission is also available.

The working life of the connection units for the intended use is assumed to be at least 50 years when installed in the works, provided that the units are subject to appropriate design and installation based upon the current state of art and the available knowledge and experience.

HOW IT WORKS

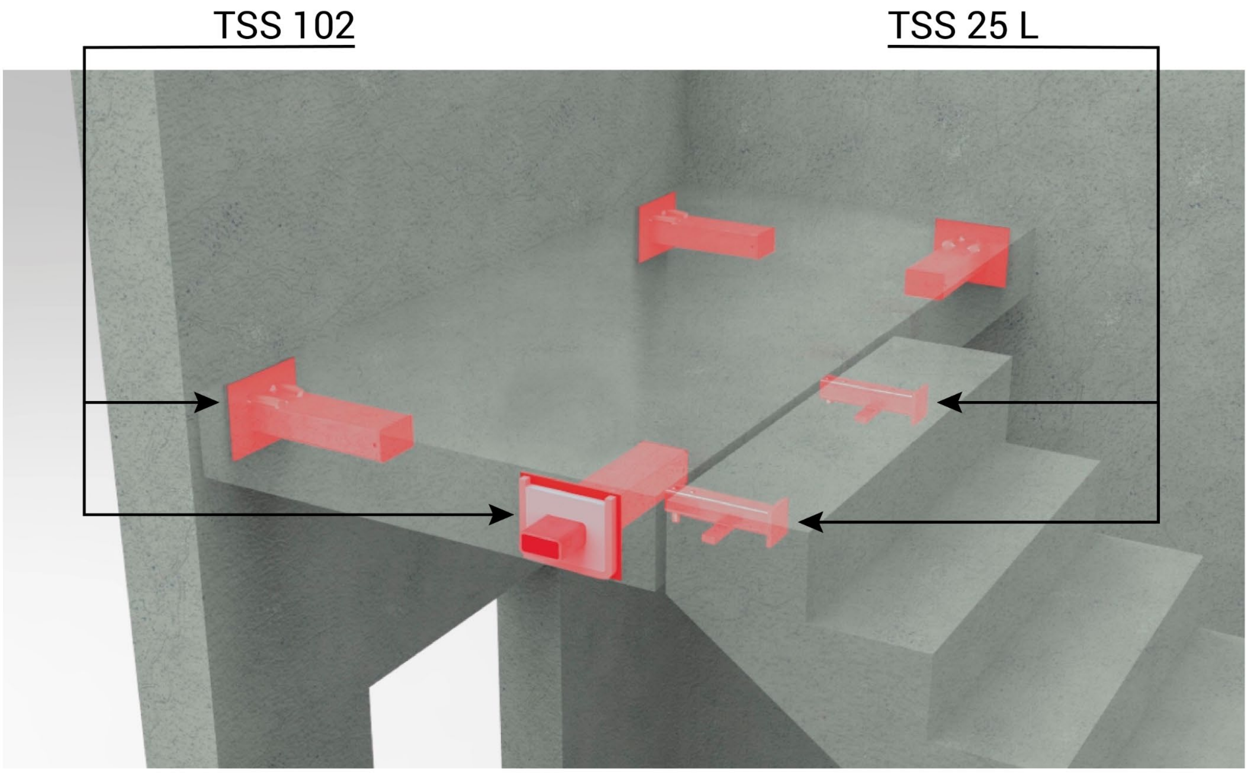

Figure 1: Illustration of unit

RVK and TSS staircase connections consist of double, extendable, hollow rectangular steel tubes type RHS made of cold worked structural steel to be cast into prefabricated concrete staircase and landing elements. The smaller tube is sliding inside the other one, and form load carrying connections to stairwell walls.

Figure 1 illustrates the principle of the staircase connections. The position of the inner tube of the RVK unit is adjusted through a slot in the surface of the staircase element. The units have a safety stop at the rear end of the inner tube to prevent overextension. The TSS unit is identical to the RVK unit except that the TSS unit has no opening to the upper surface. The position of the inner tube is instead adjusted by two strings with different colour. The units have a control line marking the correct position of the sliding tube, and a hole for a locking bolt.

RVK 60 P and TSS 60P is variants with the outer tube made of plastic.

TSS 102 is a variant specially designed to reduce impact sound transmission. A rubber layer is glued to the inner tube and the dimension of the outer tube is increased in order to make enough space for the rubber.

As additional products the manufacturer also provides “IC box” and “IC box SRU” (sound reduction unit) used to make recesses in the walls. The “IC box SRU” can be used in combination with a vertical rubber flange towards the slab edge, in order to achieve reduced impact sound transmission for all units.

MATERIALS

All structural parts are made from steel. For the units with the outer tube made of plastic, the outer tube is not a load carrying part.

PRODUCT SERIES [1,2]		**RVK 60 P**	**TSS 60 P**	**TSS 101 TSS 101 G**	**RVK 101 RVK 101 G**	**TSS 102 TSS 102 G**
f_y [MPa] f_u [MPa]	Nominal values of the yield strength, f_y, and the ultimate tensile strength, f_u, corresponding to *EN 1993-1-1* or *EN 1993-1-4*.	355 470				
γ_{M1}	Material safety factor	1,05				

[1] An additional letter G indicate hot dip galvanized version.

[2] An additional letter P indicate outer tube made of plastic

Table 1: Material properties.

PERFORMANCE OF UNITS

The units are designed to carry vertical static and quasi static loads. The load bearing capacity for the steel unit is given for two different load categories, see Table 2:

Load category a) - **Without** simultaneously acting horizontal design support reaction.

Load category b) - **With** simultaneously acting horizontal design support reaction.

Load category b) is relevant in the typical case where concrete elements with moderate dimension are mounted between stable walls, the potential imposed deformation due to shrinkage and temperature differences may result in a sliding movement at the supports estimated to be less than 2 mm.

Estimated shrinkage:

$$\Delta L = \varepsilon \times L = 0{,}04\% \times 4m \approx 1{,}6mm$$

Estimated temperature effect:

$$\Delta L = \alpha \times \Delta T \times L = 1{,}2 \times 10^{-5} \times 20 \times 4m \approx 1mm$$

Due to friction on support, this sliding movement may cause axial load on the inner tube. The horizontal load (H_{Ed}) is included in design of the unit, and in the calculation of the vertical reaction forces R_1, R_2 and R_3.

Note: The horizontal force H_{Ed} is not a capacity that can be utilized for transfer of horizontal forces in the structure for design purpose.

PERFORMANCE OF UNITS							
The load categories a) and b) corresponds to the permittet vertical design reaction force (support reaction), $F_{V,Ed}$, in ULS, on the steel bridge element itself. Cantilever and lever arms according to Table 3.							
PRODUCT SERIES			**RVK 60 P**	**TSS 60 P**	**TSS 101 TSS 101 G**	**RVK 101 RVK 101 G**	**TSS 102 TSS 102 G**
Load category a) - without *simultaniously acting horizontal design support reaction.* H_{Ed}							
$F_{V,Ed}$	[kN]		**60**	**60**	**100**	**100**	**100**
Load category b) - with *permitted simultaniously acting horizontal design support reaction,* H_{Ed}							
$F_{V,Ed}$	[kN]		**60**	**60**	**94**	**94**	**90**
μ	[-]	Friction factor at support	0,2	0,2	0,2	0,2	0,2
$H_{Ed}=\mu \cdot F_{V,Ed}$	[kN]		12	12	18,8	18,8	18

Table 2: Steel unit- Load bearing capacity for load categories a) and b).

MAIN DIMENSIONS AND DESIGN PRINCIPLES

When deployed, the sliding inner tube cantilevers from the slab into the wall. It is supported on a shim in the recess at the free end, which induces rotation of the tube. This is resisted by bearing against reinforcement.

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

The anchorage reinforcement works as support points for the steel unit, and correct positioning of this reinforcement, within the specified tolerances, is of major importance to achieve the specified load bearing capacity for the steel-unit itself. Nominal position of the anchorage reinforcement, and tolerances, are illustrated in Figure 2, and listed in Table 3.

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

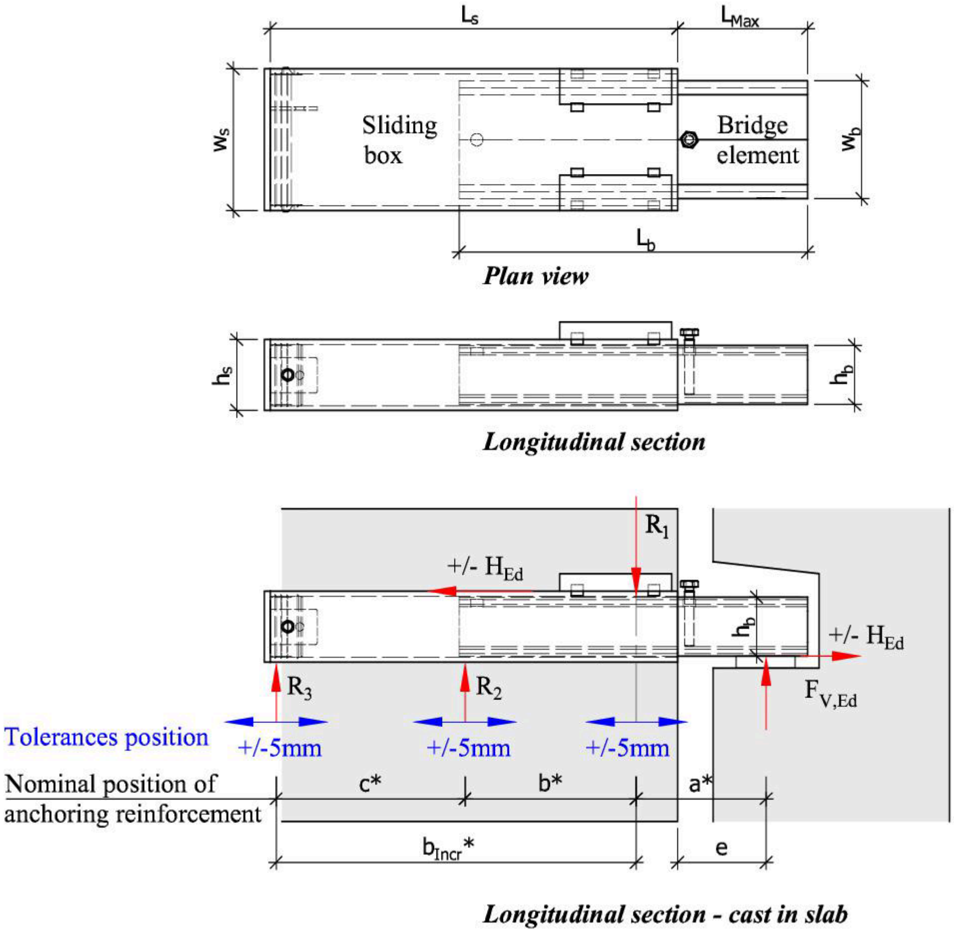

Figure 2: Principal equilibrium figure for TSS and RVK units. Illustrated with a TSS unit.

PRODUCT SERIES		RVK 60 P	TSS 60 P	TSS 101 TSS 101 G	RVK 101 RVK 101 G	TSS 102 TSS 102 G
Bridge element (inner tube)		RHS 80×40×5,0	RHS 80×40×5,0	RHS 100×50×6,0	RHS 100×50×6,0	RHS 100×50×6,0
A_b [mm^2]	Cross-section area of the bridge element	1040	1040	1560	1560	1560
L_b [mm]	Length of the bridge element	295	295	295	300	342
L_{Max} [mm]	Max permitted extension of the bridge element (nominal value)	95	95	110	110	110
w_b [mm]	With of the bridge element	80	80	100	100	100
h_b [mm]	Hight of the bridge element	40	40	50	50	50
t_b [mm]	Thickness of the bridge element	5	5	6	6	6
Sliding box (outer tube)		Plastic	Plastic	RHS 120×60×4,0	RHS 120×60×4,0	RHS 120×80×5,0
A_b [mm^2]	Cross-section area of the sliding box	-	-	1335	1335	1836
L_s [mm]	Length of the sliding box	320	320	345	345	397
w_s [mm]	With of the sliding box	94-88	94-88	120	120	120
h_s [mm]	Hight of the sliding box	105/60	60	60	60	80
t_s [mm]	Thickness of the sliding box	Ribbed	Ribbed	4	4	*5*
Free space between bridge element and sliding box						
f_v [mm]	Free space between tubes in vertical direction	2-4	2-4	2	2	20
f_h [mm]	Free space between tubes in horizontal direction	2-8	2-8	12	12	10
Cantilever and lever arms corresponding to the intended use of the connection units						
a* [mm]	Nominal value of the cantilever arm	95	95	115	115	115
a [mm]	Cantilever arm, including unfavourable tolerances: $a = a^* + \Delta_a$	95[1)]	95[1)]	120	120	120
b* [mm]	Nominal value of the lever arm	157	157	135	135	187
b [mm]	Lever arm, including unfavourable tolerances: $b = b^* - (\Delta_a + \Delta_b)$	157[1)]	157[1)]	125	125	177
c* [mm]	Nominal distance between R_2 and R_3	109	109	160	160	160
b_{Incr}^* [mm]	Nominal value of the lever arm: $b_{Incr}^* = b^* + c^*$	266	266	295	295	347
b_{Incr} [mm]	Lever arm, including unfavourable tolerances: $b_{Incr} = b_{Incr}^* - (\Delta_a + \Delta_{b,Incr})$	266[1)]	266[1)]	**285**	**285**	**337**
e [mm]	Nominal value of the cantilever arm from the concrete slab edge to the centre of the support area	60	60	75	75	75

[1)] The plastic outer tube is made with snap-on slots to ensure correct positioning of the anchoring reinforcement.

Table 3: Main dimensions.

VERTICAL FORCES AND ANCHORAGE REINFORCEMENT

The internal design reaction forces are calculated for the two load categories, a) and b). Maximum cantilevering of the bridge element in combination with the most unfavourable location of the front and rear reinforcement shall be included when calculating the reaction forces. For each of the load categories, two different assumptions are considered in order to find the value of the forces R_1, R_2 and R_3.

Assumption 1: Outer tube without bending stiffness: No forces transferred to outer tube at the back of inner tube. The force from the inner tube is transferred directly through the flanges of the outer tube and into the anchorage reinforcement at the rear of in the inner tube.
Assumption 2: Rigid outer tube: The outer and inner tube rotates together as one stiff body. Note on TSS 60 P/RVK 60 P: Although the outer tube is not load bearing, the forces are calculated for consistency.

Load category a): Considering only $F_{v,Ed}$

$$R_{1,1} = \frac{F_{V,Ed}\times(b+a)}{b}$$

$$R_{2,1} = \frac{F_{V,Ed}\times a}{b}$$

$$R_{3,1} = \frac{F_{V,Ed}\times a}{b_{incr}}$$ (According to assumption 2, and assuming $R_{2,1}$=0. Only relevant for products with outer tube)

Load category b): Considering $F_{v,Ed}$ and H_{Ed}=0,2 $F_{v,Ed}$

$$R_{1,2} = \frac{F_{V,Ed}\times(b+a)+H_{Ed}\times h_b}{b}$$

$$R_{2,2} = \frac{F_{V,Ed}\times a+H_{Ed}\times h_b}{b}$$

$$R_{3,2} = \frac{F_{V,Ed}\times a+H_{Ed}\times h_b}{b_{incr}}$$ (According to assumption 2, and assuming $R_{2,1}$=0.)

PRODUCT SERIES		RVK 60 P	TSS 60 P	TSS 101 TSS 101 G	RVK 101 RVK 101 G	TSS 102 TSS 102 G
***Load category a) - without** simultaniously acting horizontal design support reaction. H_{Ed}*						
$F_{V,Ed}$ [kN]		**60[3)]**	**60[3)]**	**100**	**100**	**100**
$R_{1,1}$ [kN]	See illustration	96,3	96,3	**196,0**	**196,0**	**167,8**
$R_{2,1}$ [kN]		36,3	36,3	96,0	96,0	**67,8**
$R_{3,1}$ [kN]		21,4	21,4	42,1	42,1	**35,6**
***Load category b) - with** permitted simultaniously acting horizontal design support reaction, H_{Ed}*						
$F_{V,Ed}$ [kN]		**60[3)]**	**60[3)]**	**94**	**94**	**90**
μ [-]	Friction factor at support	0,2	0,2	0,2	0,2	0,2
$H_{Ed}=\mu\cdot F_{V,Ed}$ [kN]		12	12	18,8	18,8	18
$R_{1,2}$ [kN]	See illustration	**99,4**	**99,4**	191,8	191,8	156,1
$R_{2,2}$ [kN]		**39,4**	**39,4**	**97,8**	**97,8**	66,1
$R_{3,2}$ [kN]		**23,2**	**23,2**	**42,9**	**42,9**	34,7
***Required amount of anchorage reinforcement.** Based on the dimensioning reaction forces from load category a) and/or b)*						
f_y [MPa]	Grade 500C [1)]	**500**				
$\gamma_{s2,red}$ [-]	Material safety factor [2)]	**1,1**				
A_{s1} [mm²]	=MAX($R_{1,1}$; $R_{1,2}$)/($f_y\cdot\gamma_{s2,red}$)	**219[3)]**	**219[3)]**	**431**	**431**	**369**
A_{s2} [mm²]	=MAX($R_{2,1}$; $R_{2,2}$)/($f_y\cdot\gamma_{s2,red}$)	**87**	**87**	**215**	**215**	**149**
A_{s3} [mm²]	=MAX($R_{3,1}$; $R_{3,2}$)/($f_y\cdot\gamma_{s2,red}$)	**51**	**51**	**94**	**94**	**78**

[1)] Reinforcement steel of different ductility grade may be chosen provided that the bendability is sufficient for fitting the vertical suspension reinforcement to the half round steels in front of the unit.
[2)]According to EC2, section A.2.2, $\gamma_{s2,red}$ can be used, as the tolerances on location of the reinforcement are included when calculating the magnitude of the forces. The value from the Norwegian appendix NA.A.2.2 is applied
*[3)] Memo 55, Table 1, specifies 2ø8 anchoring bars =201mm². In Table 2, Memo 55, the recommended maximum ULS load is reduced to 201mm²/219mm²x60kN=55kN (load category b) and 55kN*99,4kN/ 96,3kN=57kN (load category a).*

Table 4: Vertical forces and anchorage reinforcement - calculated for the steel unit's capacity.

REVISION HISTORY	
Date:	**Description:**
31.03.2020	Preliminary
20.04.2020	Reviewed by company Dr. techn. Olav Olsen. Comments included.
08.05.2020	Updated list of substituted memos. Typing errors corrected.
10.02.2021	Changed height for sliding box , table 3.
04.02.2022	Removed TSS 41