RVL WIRE LOOP MANUAL

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1. DESCRIPTION OF THE SYSTEM

RVL wire rope loops manufactured by R-Group Finland Oy are steel parts consisting of a high strength steel wire and a steel box. RVL wire rope loops are installed to concrete elements before casting. RVL wire rope loops transfer loads in pre-cast concrete wall joints.

When the joint between concrete wall elements is loaded, the longitudinal shear force in the joint is divided to an angled compression component and a horizontal pull component at the indented joint. RVL wire rope loop transfers the shear forces acting in the joint between concrete wall elements by the pull component of the wire rope and the compression component formed by the steel boxes and the seam.

RVL wire rope loops have various advantages mainly

Easy to install through nailing or using magnet

Tapered profile of box edged ensures secure fixing in concrete

Since wire rope loops are flexible, they can easily be bent straight in position

The compression sleeve transfers the load to concrete easily

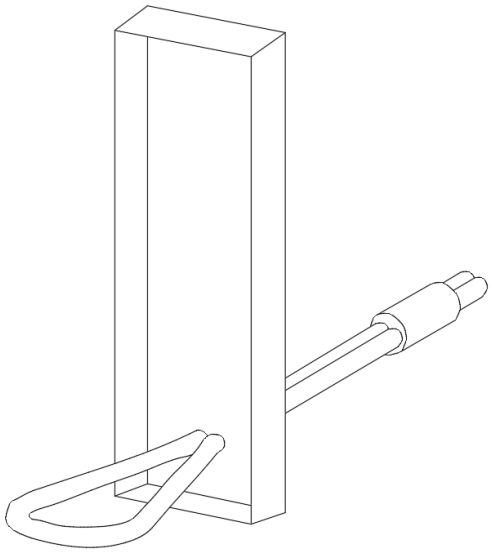

Figure 1. RVL wire rope loop

2. DIMENSIONS AND MATERIALS

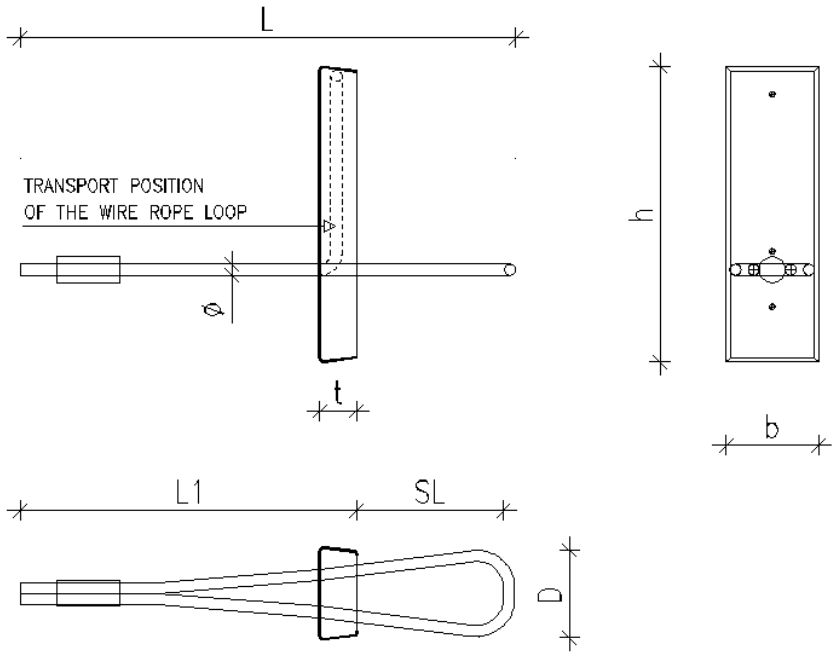

Figure 2. Dimensions of the RVL wire rope loop

Table 1. Dimensions and tolerances of the RVL wire rope loop

RVL wire rope loop	SL [mm] ±10	L [mm] ±20	L1 [mm] ±10	H [mm] ±2	B [mm] ±2	T [mm] ±2	Ø* [mm]	D [mm]
RVL-60	60	276	210	160	50	20	6	60
RVL-80	80	296	210	160	50	20	6	60
RVL-100	100	316	210	160	50	20	6	65
RVL-120	120	336	210	160	50	20	6	70
RVL-80/9	80	356	280	120	70	30	9	100
RVL-140/8	140	528	380	200	70	30	8	100
RVL-140/9	140	428	280	200	70	30	9	100

*According to EN 12385 or GB/T 20118-2006.

Thickness of the steel plate of the box is 0,5…0,7 mm.

2.2. Materials and standards

Table 2. Materials and standards

Part	Material	Standard
Steel box	SGCC	JIS G3302
Wire rope	High strength steel wire rope (fu = 1770 MPa)	GB/T 20118-2006
	7x7	EN 12385-2
	R-wire	R-wire
Ferrule (socket)	Q195	GB/T 701-2008

The steel box and the wire rope are zinc coated.

Zinced products are passivated with min. 1 month of storage.

3. MANUFACTURING

3.1. Manufacturing method

The steel is box is mechanically cut and bent to shape. The open wire rope is installed to the steel box and attached by the compression sleeve to form a loop. The wire rope is bent in to the steel box and the open part of the steel box is closed by tape to protect from casting concrete.

3.2. Manufacturing markings

Product package is equipped with an R-Steel –sticker, which contains the following information: product type, product name, quantity, ISO9001 and ISO14001 quality and environment system markings, FI marking and product picture.

Products are delivered in cardboard boxes on a truck palette. Cardboard boxes are marked with FI and BY (Concrete Association of Finland) logo and the number of certified product declaration, numbers of the ISO-certificates and the product type and name.

3.3. Quality control

Quality control of the wire rope loops is done according to EN 1090-2 and the instructions according to quality and environment system of the R-Group Finland Oy (ISO9001 and ISO14001). R-Group Finland Oy has a quality control contract with Inspecta Sertifiointi Oy.

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4. RESISTANCES

4.1 Calculation principles

RVL wire rope loops resistances are calculated according to truss model in EN 1992-1-1. Calculations do not consider cracks or deformations in the joint. Resistances are calculated for static loads.

4.2 Design values of resistance for longitudinal shear force

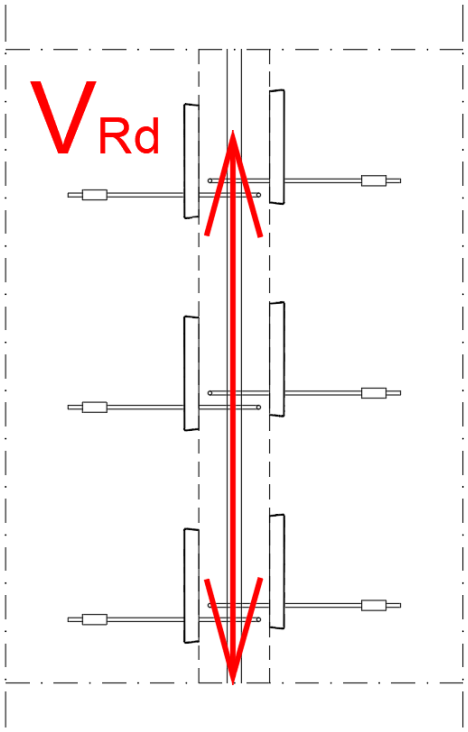

Figure 3. Direction of longitudinal shear force in joint

Design values of resistance presented in table 3 are resistances in ultimate limit state. The resistance is defined by the weakest concrete in the joint (element/joint concrete).

Table 3. Resistances of longitudinal shear force per one pair of wire rope loops

RVL wire rope loop	Wall thickness B (mm)	Shear resistance of one pair of wire rope loops VRd [kN]					
		C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
RVL-60…120	≥ 80	13,0	15,4	17,6	20,0	22,0	23,8
RVL-80/9	≥ 150	28,1	33,0	37,6	42,0	45,2	47,0
RVL-140/8	≥ 150	18,2	21,2	24,2	27,1	29,9	32,8
RVL-140/9	≥ 150	28,1	33,0	37,6	42,0	45,2	47,0

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Resistances in table 3 are per one pair of wire rope loops.

Total resistance of joint (kN/m) is calculated as follows:

$V_{Rd.joint} = n_{RVL} \times V_{Rd}$ (kN/m)

nRVL = number of RVL wire rope loops / meter.

For example: RVL-60 -wire rope loops c/c250, concrete C30/37.

$V_{Rd.joint}$ = 1000 mm / 250 mm x 15,4 kN = 4 x 15,4 kN = 61,6 kN/m

4.3 Design value of resistance for tensile force

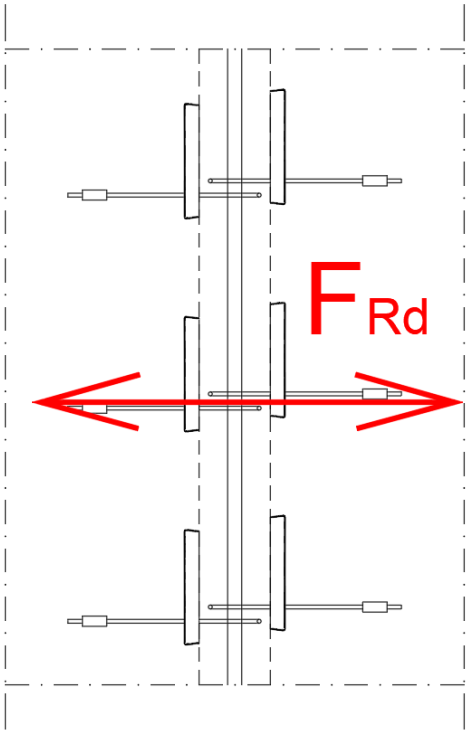

Figure 4. Direction of tensile force

Design values of resistance presented in table 4 are resistances in ultimate limit state. The resistance is defined by the weakest concrete in the joint (element/joint concrete).

Table 4. Design value of resistance for tensile force for one pair of wire rope loops

RVL wire rope loop	Wall thickness B (mm)	Tensile force resistance of one pair of wire rope loops FRd [kN]					
		C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
RVL-60…120	≥ 80	9,5	11,2	12,8	14,5	16,1	17,7
RVL-80/9	≥ 150	22,0	26,2	30,1	34,0	36,3	36,3
RVL-140/8	≥ 150	12,5	14,6	16,6	18,6	20,6	22,6
RVL-140/9	≥ 150	22,0	26,2	30,1	34,0	36,3	36,3

Resistances in table 4 are per one pair of wire rope loops.

Wall thickness B in table 4 is applicable for RVL wire rope loops with anchor reinforcement. For RVL wire rope loops without anchor reinforcement wall thickness B must be ≥ 100 mm for RVL-60…120 and ≥ 170 mm for RVL-80/9, -140/8 and -140/9.

Total resistance of joint (kN/m) is calculated as follows:

$F_{Rd.joint} = n_{RVL} \times F_{Rd}$ (kN/m)

nRVL = number of RVL wire rope loops / meter.

For example: RVL-60 -wire rope loops c/c250, concrete C30/37.

$F_{Rd.joint}$ = 1000 mm / 250 mm x 11,2 kN = 4 x 11,2 kN = 44,8 kN/m

4.4 Design values of resistance for transversal shear

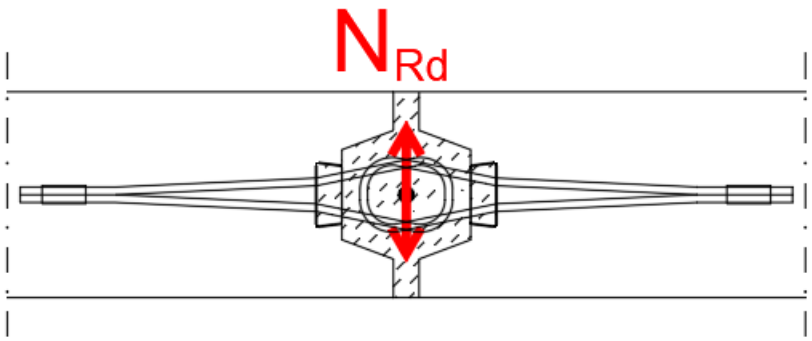

Figure 5. Direction of transversal shear

4.4.1 Intended joint

Design values of resistance for transversal shear in table 5 are per one meter of joint length. Dimensions of intended joint must be according to figure 6.

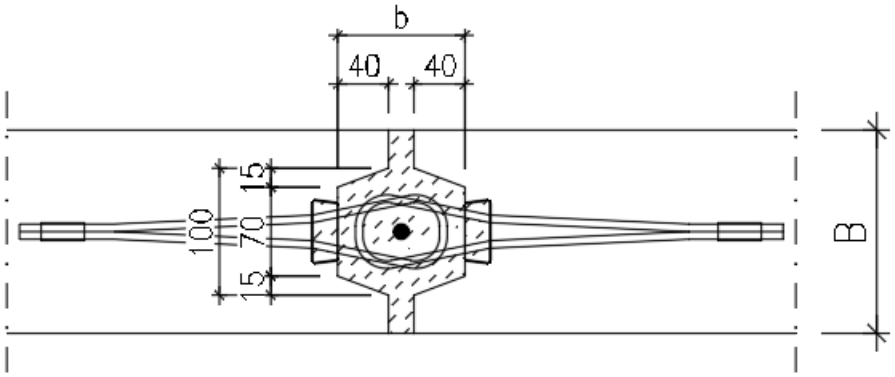

Figure 6. Joint dimensions and shape for resistances in table 5

Design values of resistance presented in table 5 are resistances in ultimate limit state. The resistance is defined by the weakest concrete in the joint (element/joint concrete).

Table 5. Design values of resistance for transversal shear for RVL wire rope loop joint, joint shape and dimensions according to figure 6

RVL wire rope loop	Wall thickness B (mm)	Design values of resistance for transversal shear for intended RVL wire rope loop joint NRd [kN/m]					
		C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
RVL-60…120	120	14,8	16,3	17,6	18,8	19,9	21,0
	≥ 140	19,8	21,7	23,4	25,0	26,6	28,0
RVL-80/9	150	17,3	19,0	20,5	21,9	23,2	24,5
	≥ 160	19,8	21,7	23,4	25,0	26,6	28,0
RVL-140/8	150	17,3	19,0	20,5	21,9	23,2	24,5
	≥ 160	19,8	21,7	23,4	25,0	26,6	28,0
RVL-140/9	150	17,3	19,0	20,5	21,9	23,2	24,5
	≥ 160	19,8	21,7	23,4	25,0	26,6	28,0

Design values of resistance for transversal shear in table 5 are per one meter of joint length.

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4.4.2 Smooth joint

Design values of resistance for transversal shear in table 6 are per one pair of wire rope loops. Dimensions of joint must be according to figure 6.

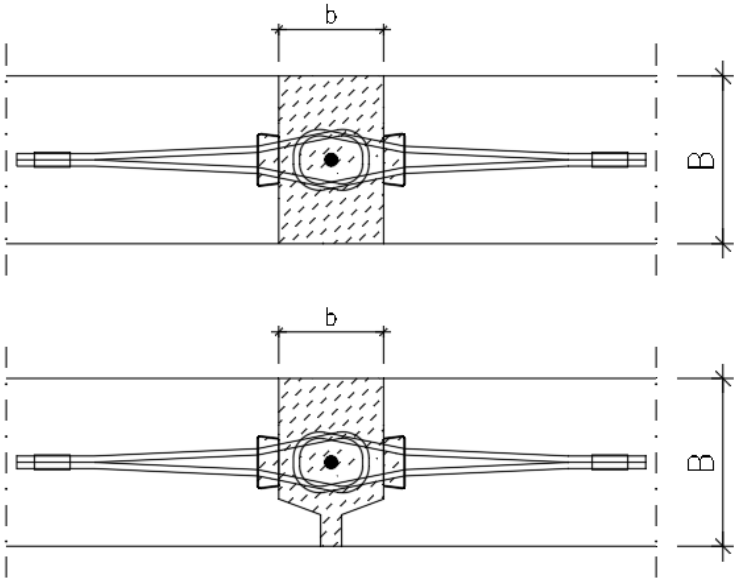

Figure 7. Joint dimensions and shape for resistances in table 6

Design values of resistance presented in table 6 are resistances in ultimate limit state. The resistance is defined by the weakest concrete in the joint (element/joint concrete).

Table 6. Design values of resistance for transversal shear for RVL wire rope loop joint, joint shape and dimensions according to figure 7

RVL wire rope loop	Wall thickness B (mm)	Design values of resistance for transversal shear for smooth RVL wire rope loop joint NRd [kN]					
		C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
RVL-60…120	≥120	2,8	3,0	3,3	3,5	3,7	3,9
RVL-80/9	≥ 150	3,2	3,5	3,7	4,0	4,3	4,5
RVL-140/8	≥ 150	4,0	4,3	4,7	5,0	5,3	5,6
RVL-140/9	≥ 150	4,0	4,3	4,7	5,0	5,3	5,6

Resistances in table 6 are per one pair of wire rope loops.

Total resistance of joint (kN/m) is calculated as follows:

$N_{Rd,joint} = n_{RVL} \times N_{Rd}$ (kN/m)

nRVL = number of RVL wire rope loops / meter.

For example: RVL-60 -wire rope loops c/c250, concrete C30/37.

$N_{Rd,joint}$ = 1000 mm / 250 mm x 3,0 kN = 4 x 3,0 kN = 12,0 kN/m

4.5 Resistance for combined forces

Resistance of RVL wire rope loop joint for combined forces may be calculated according to equation

$$\frac{V_{Ed}}{V_{Rd}} + \frac{N_{Ed}}{N_{Rd}} + \frac{F_{Ed}}{F_{Rd}} \leq 1$$

in which

V_{Ed} = design value of longitudinal shear force

V_{Rd} = design value of resistance for longitudinal shear force

N_{Ed} = design value of transversal shear force

N_{Rd} = design value of resistance for transversal shear force

F_{Ed} = design value for tensile force

F_{Rd} = design value of resistance for tensile force

4.6 Resistance in fire

Critical temperature of RVL wire rope loops in fire is θ_{cr} = 350 °C. In fire design sufficient concrete cover according to EN 1992-1-2 must be designed to ensure that the critical temperature of wire rope loops is not exceeded. Also, sufficient thickness of the concrete wall and the joint between walls must be designed for the required fire class.

5. APPLICATION

5.1 Limitations for application

Resistances presented in tables 3…6 are calculated for static loads. RVL wire rope loops are not designed to be used for lifting or as lifting loops.

Resistance of the RVL wire rope loop is defined by the weakest concrete in the joint (element/joint concrete). The resistance calculations do not take into account cracks or deformations in the joint.

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Resistances of the RVL wire rope loops are calculated for a joint in which the steel boxes and the seam are assumed to be fully filled with concrete.

RVL wire rope loops may be used for forces in all directions (N_{Rd}, V_{Rd} and F_{Rd}) when they are used with anchor reinforcement in chapter 5.2.2. Without anchor reinforcement RVL wire rope loops may be used only for forces V_{Rd} and N_{Rd}, tensile force F_{Rd} is not allowed in this application (see also section 5.2).

When using RVL wire rope loops without anchor reinforcement for load transfer in the seam concrete in the RVL region must be uncracked. Structural designer must verify the condition of concrete according to EN 1992-4 section 4.7.

5.1.1 Minimum edge and center distances

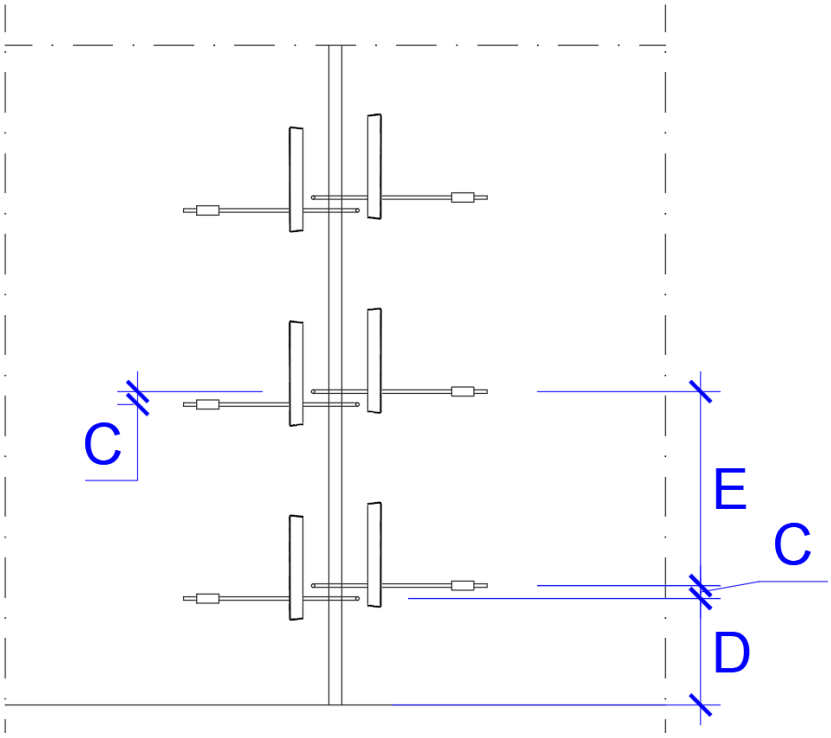

Figure 8. Distances of the RVL wire rope loops

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Table 7. Minimum distances of RVL wire rope loops with anchor reinforcement

RVL wire rope loop	center to center Emin [mm]	edge distance Dmin [mm]	center to center Cmax [mm]	minimum width Bmin [mm]
RVL-60…120	250	150	20	80
RVL-80/9	250	200	25	150
RVL-140/8 RVL-140/9	350	200	25	150

Table 8. Minimum distances of RVL wire rope loops without anchor reinforcement

RVL wire rope loop	center to center Emin [mm]	edge distance Dmin [mm]	center to center Cmax [mm]	minimum width Bmin [mm]
RVL-60…120	600	400	20	80
RVL-80/9	800	400	25	150
RVL-140/8 RVL-140/9	800	400	25	150

Center to center E_{min} = minimum distance between wire rope loops at the same side of the joint.

Edge distance D_{min} = the minimum distance of the wire rope loop to the upper and lower edge of the concrete element.

Center to center C_{max} = maximum distance between wire rope loops at opposite sides of the joint.

Minimum width B_{min} = minimum total wall width.

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5.1.2 Seam width

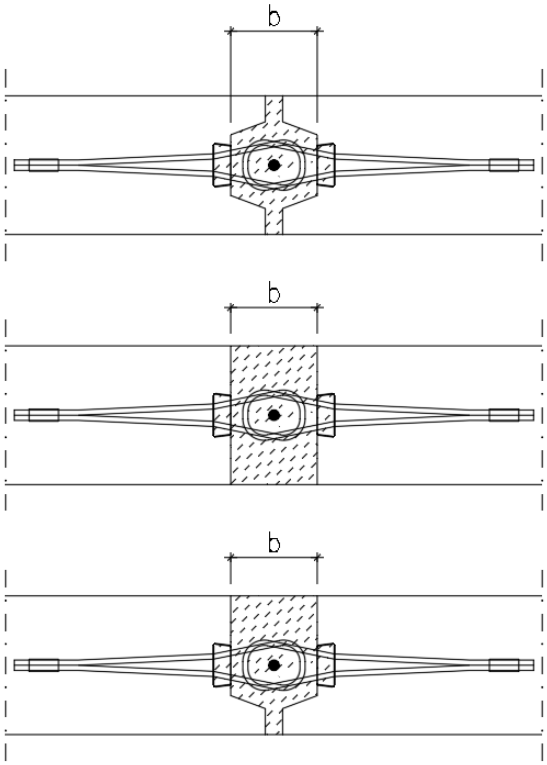

Figure 9. Seam width b

Table 9. Seam width b

RVL wire rope loop	Seam width b [mm]
RVL-60	80
RVL-80	100
RVL-100	120
RVL-120	140
RVL-80/9	100
RVL-140/8 **RVL-140/9**	160

The size of the wire rope loops must be chosen according to the width of the joint to enable the vertical ribbed steel bar in the joint to pass through the wire rope loops on both sides of the joint.

The total wall width of the concrete wall element must be chosen taking into account the width of the indented joint (figure 6), the width of the steel box of the wire rope loop (table 1) and the required concrete cover.

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5.2 Reinforcement of the concrete

5.2.1 Reinforcement of the joint

When using the RVL wire rope loops, a vertical ribbed steel bar must always be installed to the joint according to figure 10. This ribbed steel bar is installed through the wire rope loops according to figure 10.

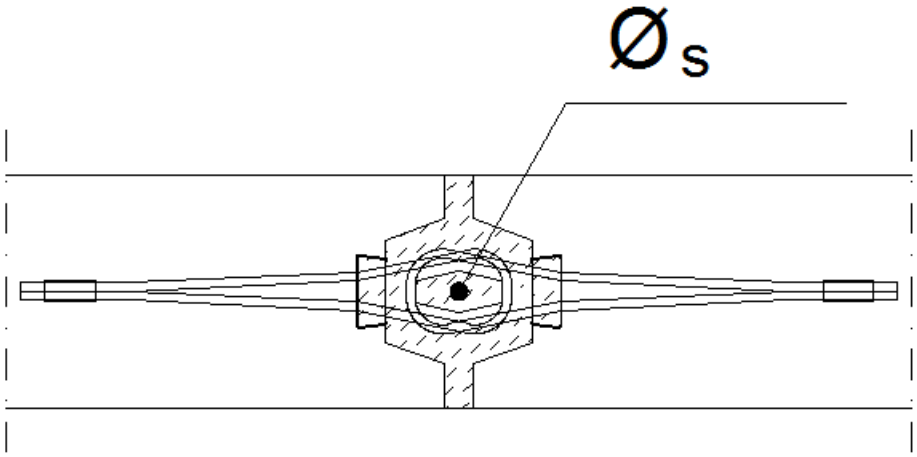

Figure 10. Ribbed steel bar in the joint

Table 10. Size of the ribbed steel bar in the joint, steel B500B

RVL wire rope loop	Diameter of the ribbed steel bar Øs [mm]
RVL-60 **RVL-80** **RVL-100** **RVL-120**	12
RVL-80/9	16
RVL-140/8 **RVL-140/9**	16

5.2.2 Anchor reinforcement

Anchor reinforcement according to figure 11 and table 11 must always be installed with RVL wire rope loop when tensile force in seam is present or distance between RVL wire rope loops is less than minimum distances in table 8.

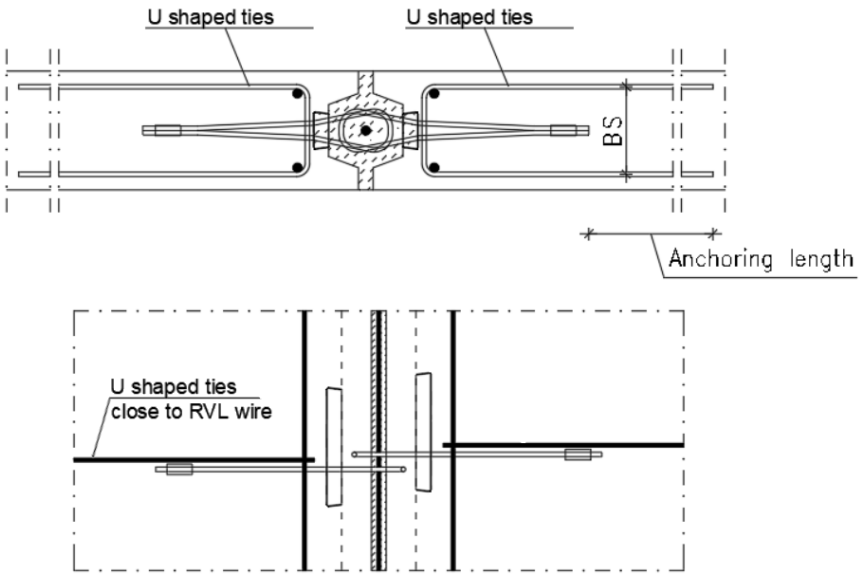

Figure 11. Anchor reinforcement

Table 11. Anchor reinforcement, steel B500B

RVL wire rope loop	Number of anchor bars / RVL wire rope loop n [pcs]	Diameter of the ribbed steel bar Øs [mm]	Maximum width of anchor bar BS [mm]
RVL-60 RVL-80	1	6	105
RVL-100 RVL-120	1	8	185
RVL-80/9	1	10	130
	1	12	205
RVL-140/8	1	8	150
	1	10	205
RVL-140/9	1	10	130
	1	12	205

Width of the anchor bar (BS in figure 11 and table 11) may not be greater than that in table 11 even if the wall width would be larger.

5.2.3 Reinforcement of the concrete element

The wall elements must be reinforced for all forces. RVL wire rope loops must be anchored with U-shaped ribbed steel bar ties, material B500B (or similar steel). These U-ties must be placed near RVL wire.

RVL wire rope loops must be secured by overlapping the wire rope loop sufficiently with the reinforcement of the concrete element. For wire rope loops RVL -60, -80, -100 and -120 the greatest design value for tensile force is F_{Rd} = 17,7 kN, for RVL-80/9 F_{Rd} = 22,6 kN and for wire rope loops RVL-80/9 and RVL-140/9 F_{Rd} = 41,7 kN. The anchorage of the wire rope loops must be designed for these forces when using design values for resistances presented in this technical manual.

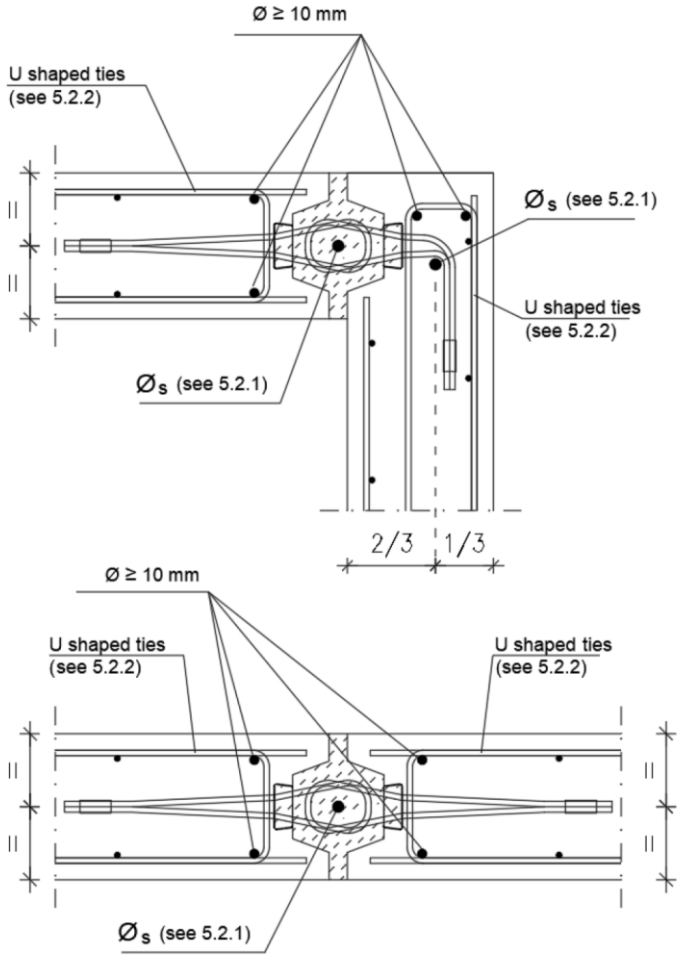

Figure 12. Additional reinforcement of RVL wire rope loop

When no anchor reinforcement of RVL wire rope loop is installed (see figure 13), only longitudinal shear force V_{Rd} and transversal shear force N_{Rd} may be transferred in the seam. No tensile force F_{Rd} is allowed. Distances for RVL edge and center distances according to 5.1.1.

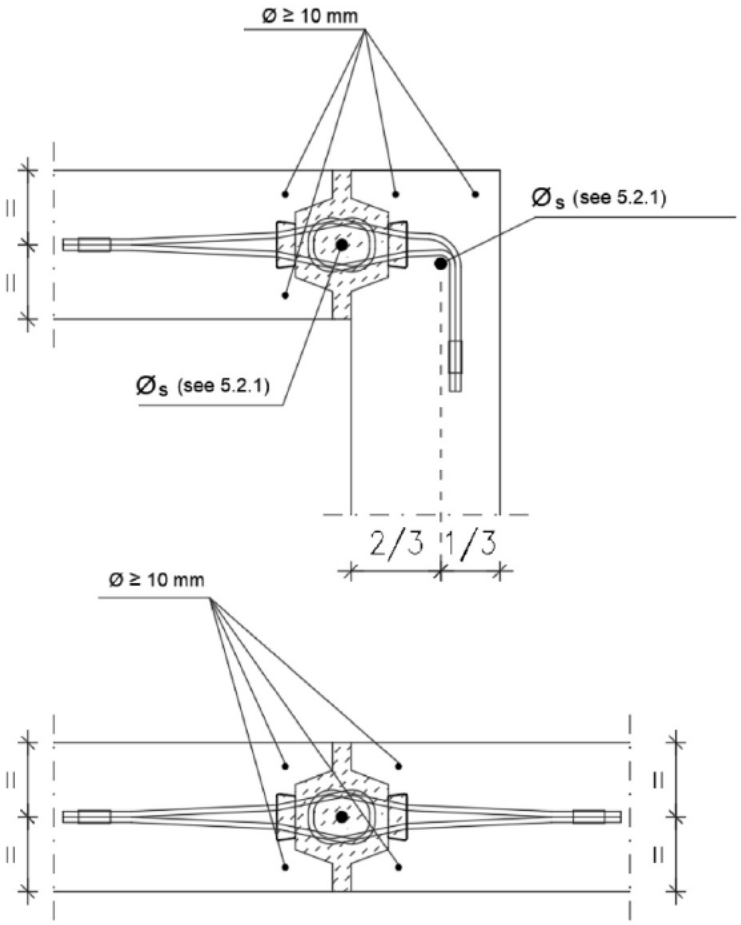

Figure 13. RVL wire rope loop additional reinforcement without anchor reinforcement

6. INSTALLATION

The RVL wire rope loop must be attached securely so it cannot move during casting of the concrete. At the RVL wire rope loop the concrete must be compressed carefully. The RVL wire rope loop cannot be vibrated.

The RVL wire rope loops may be fastened to formwork with nails or by magnets. RVL wire rope loops are installed according to structural designer's instructions and figures in technical manual. RVL wire rope loops are tied to element reinforcement.

7. SUPERVISION OF INSTALLATION

Check list before casting:

- RVL wire rope loop is in good condition

- RVL wire rope loop is according to designs and in the right place

- RVL wire rope loop is attached firmly

- the required additional reinforcement is installed

During the casting:

- RVL wire rope loop stays in the right place

- the concrete is thoroughly vibrated around the RVL wire rope loop

After the casting:

- the situation of the RVL wire rope loop is according to designs

- the tape covering the steel box is removed at the factory after the concrete is hardened.