RSTEEL®

Technical Manual

Technical changes and errors reserved

Version 22.3.2018

RVL Single Wire Loop Box

Design According to Eurocodes

AAA®
Highest Creditworthiness
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THE STRONGEST IN FINLAND
2017
R-Group Finland OY
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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.

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

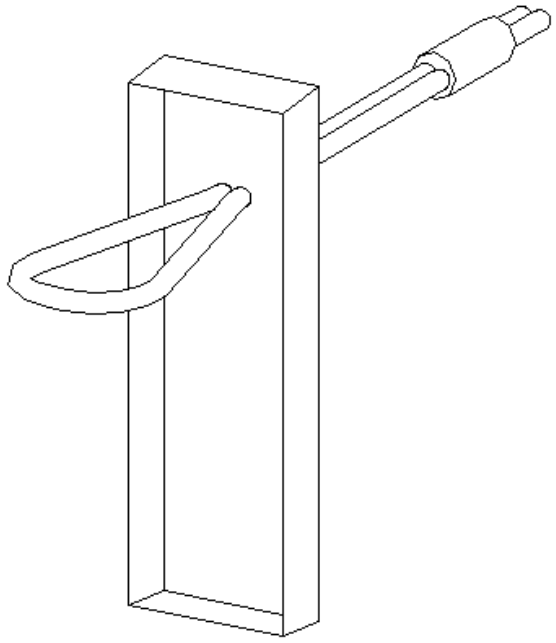

Figure 1. RVL wire rope loop

2. Dimensions and Materials

2.1 Dimensions and tolerances

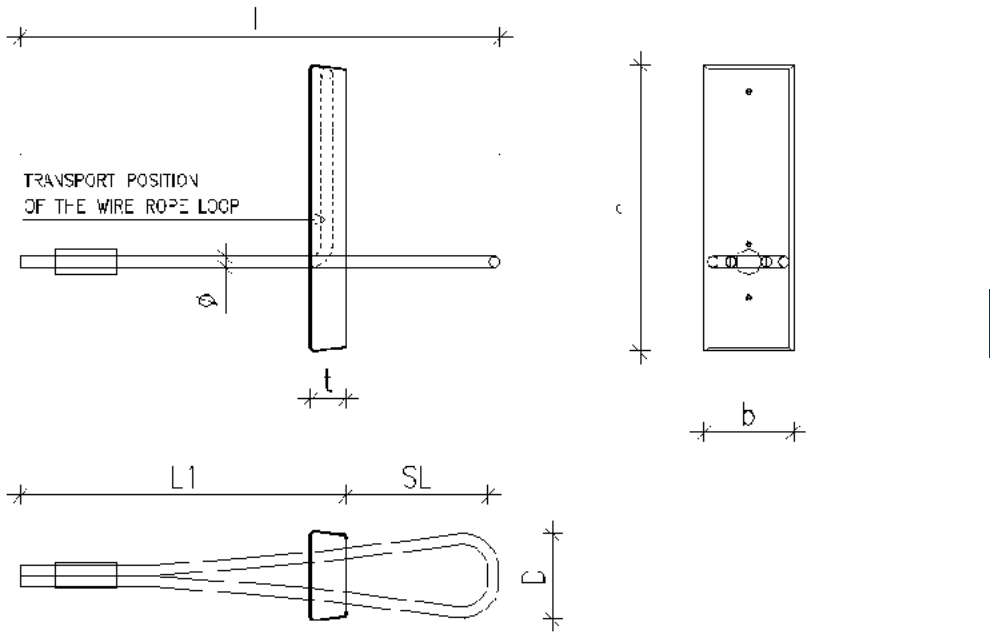

Figure 2. Dimensions of the RVL wire rope loop

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

Wire rope loop	SL [mm] ±10	L [mm] ±20	L1 [mm] ±10	h [mm] ±2	b [mm] ±2	t [mm] ±2	Ø [mm] 1)	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-140	140	528	370	200	70	30	8	100

1) according to EN 12385.

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	1.0330	EN 10130
Wire rope	high strength steel wire rope SE-Zn	EN 12385
Compression sleeve	1.0046	EN 10025

The steel box and the wire rope are zinc coated. Zinced products are passivated with min. 1 month of storage.

3. Manufacturing

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 N 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.

4. Resistances

4.1 Calculation principles

The longitudinal shear capacities of the RVL wire rope loops are calculated according to wire rope loop joint calculation method presented in Henrik Brøner Jørgensen, Strength of Loop Connections between Precast Concrete Elements, 2014. Capacities are calculated for static loads with the joint width presented in figure 2. The calculations do not take into account cracks or deformations in the joint.

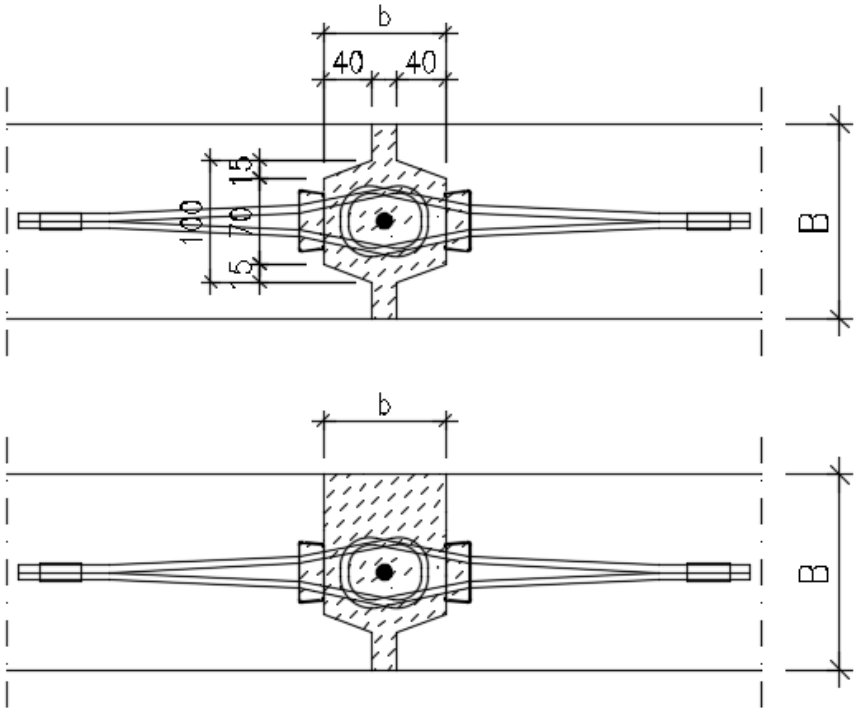

Figure 3. Indented joint dimensions used in calculations

Recommended and maximum seam thicknesses for RVL wire rope loops see chapter 5.1.2.

4.2 Design values of resistance for longitudinal shear force

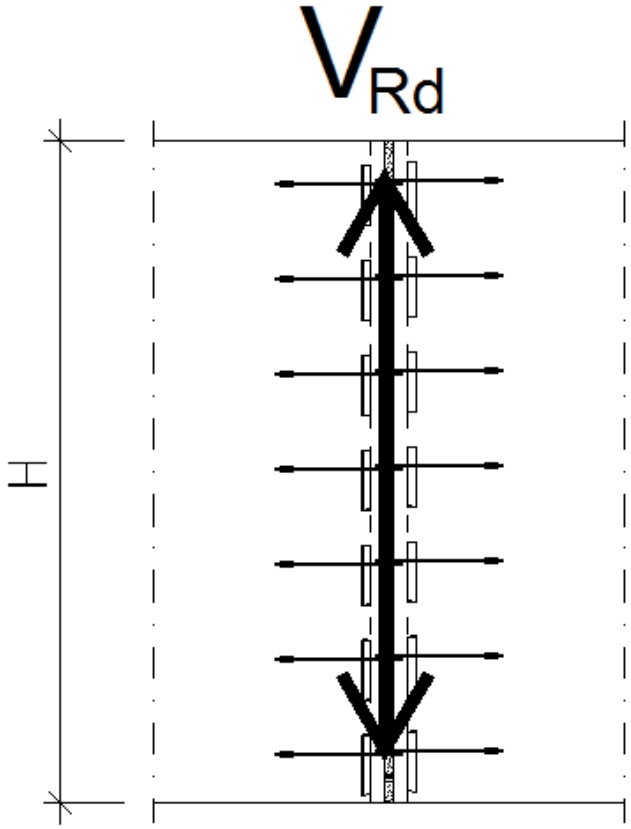

Figure 4. Direction of longitudinal shear force in joint

Design values of resistance presented in the tables are resistances in ultimate limit state. The resistance is defined by the weakest concrete in the joint (element/joint concrete). Resistances are calculated for concrete classes C25/30, C30/37 and C40/50.

Resistances are calculated for two different wall heights and for certain number of RVL wire rope loop boxes in joint. Number of wire rope loop boxes given in resistance tables is the number of wire rope loop boxes in one side of the joint. E.g. in the joint in figure 3 there is seven boxes.

Table 3. Design values of resistance for longitudinal shear force for RVL-60 wire rope loop, wall width B ≥ 80 mm

Number of RVL boxes [n]	V_{Rd} [kN/m] (wall width B ≥ 80 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	60	67	78
13	-	-	-	57	63	74
12	-	-	-	54	60	70
11	-	-	-	49	56	66
10	60	70	82	45	52	61
9	54	63	76	40	47	57
8	48	56	70	36	42	52
7	42	49	62	31	37	46
6	36	42	53	27	31	40
5	30	35	44	-	-	-
4	24	28	35	-	-	-

Table 4. Design values of resistance for longitudinal shear force for RVL-60 wire rope loop, wall width B ≥ 120 mm

Number of RVL boxes [n]	V_{Rd} [kN/m] (wall width B ≥ 120 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	63	71	84
13	-	-	-	58	68	79
12	-	-	-	54	63	75
11	-	-	-	49	57	71
10	60	70	88	45	52	66
9	54	63	79	40	47	59
8	48	56	70	36	42	53
7	42	49	62	31	37	46
6	36	42	53	27	31	40
5	30	35	44	-	-	-
4	24	28	35	-	-	-

Table 5. Design values of resistance for longitudinal shear force for RVL-80 wire rope loop, wall width B ≥ 80 mm

Number of RVL boxes [n]	V_{Rd} [kN/m] (wall width B ≥ 80 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	77	86	102
13	-	-	-	73	81	96
12	-	-	-	68	76	90
11	-	-	-	64	71	84
10	79	88	103	59	66	77
9	73	81	95	55	61	71
8	67	74	87	50	55	65
7	61	67	78	46	50	58
6	55	60	69	41	45	52
5	48	53	60	-	-	-
4	39	43	49	-	-	-

Table 6. Design values of resistance for longitudinal shear force for RVL-80 wire rope loop, wall width B ≥ 120 mm

Number of RVL boxes [n]	V_{Rd} [kN/m] (wall width B ≥ 120 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	81	90	107
13	-	-	-	76	85	100
12	-	-	-	72	80	94
11	-	-	-	67	75	88
10	84	93	109	63	69	82
9	78	86	100	58	64	75
8	71	79	92	54	59	69
7	65	71	83	49	54	62
6	59	64	74	44	48	55
5	49	54	62	-	-	-
4	39	43	49	-	-	-

Table 7. Design values of resistance for longitudinal shear force for RVL-100 wire rope loop, wall width B ≥ 80 mm

Number of RVL boxes [n]	VRd [kN/m] (wall width B ≥ 80 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	82	91	109
13	-	-	-	77	86	102
12	-	-	-	72	80	96
11	-	-	-	68	75	89
10	84	93	109	63	69	82
9	77	85	100	58	64	75
8	71	78	91	53	58	68
7	64	70	82	48	53	61
6	57	62	72	43	47	54
5	48	53	62	-	-	-
4	39	43	49	-	-	-

Table 8. Design values of resistance for longitudinal shear force for RVL-100 wire rope loop, wall width B ≥ 120 mm

Number of RVL boxes [n]	VRd [kN/m] (wall width B ≥ 120 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	85	95	113
13	-	-	-	80	89	106
12	-	-	-	76	84	99
11	-	-	-	71	78	93
10	88	97	114	66	73	86
9	81	90	105	61	67	79
8	74	82	96	56	61	72
7	68	74	86	51	56	65
6	58	64	74	43	48	55
5	48	53	62	-	-	-
4	39	43	49	-	-	-

Table 9. Design values of resistance for longitudinal shear force for RVL-120 wire rope loop, wall width B ≥ 80 mm

Number of RVL boxes [n]	V_{Rd} [kN/m] (wall width B ≥ 80 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	82	92	109
13	-	-	-	77	86	102
12	-	-	-	73	81	95
11	-	-	-	68	75	89
10	84	93	109	63	70	82
9	77	85	100	58	64	75
8	71	78	91	53	58	68
7	64	70	81	48	53	61
6	57	62	72	43	47	54
5	48	53	62	-	-	-
4	39	43	49	-	-	-

Table 10. Design values of resistance for longitudinal shear force for RVL-120 wire rope loop, wall width B ≥ 120 mm

Number of RVL boxes [n]	V_{Rd} [kN/m] (wall width B ≥ 120 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	86	95	113
13	-	-	-	81	89	106
12	-	-	-	76	84	99
11	-	-	-	71	78	92
10	88	97	114	66	73	85
9	81	89	104	61	67	78
8	74	82	95	56	61	71
7	67	74	85	51	55	64
6	58	64	74	43	48	55
5	48	53	62	-	-	-
4	39	43	49	-	-	-

Table 11. Design values of resistance for longitudinal shear force for RVL-140 wire rope loop, wall width B ≥ 150 mm

Number of RVL boxes [n]	V_{Rd} [kN/m] (wall width B ≥ 150 mm)					
	Wall height H = 3 m			Wall height H = 4 m		
	C25/30	C30/37	C40/50	C25/30	C30/37	C40/50
14	-	-	-	113	125	147
13	-	-	-	105	118	138
12	-	-	-	97	110	128
11	-	-	-	89	101	117
10	108	122	142	81	92	106
9	97	110	128	73	83	96
8	86	98	113	65	73	85
7	75	86	99	56	64	74
6	65	73	85	48	55	64
5	54	61	71	-	-	-
4	43	49	57	-	-	-

4.3 Design values of resistance for transversal shear force

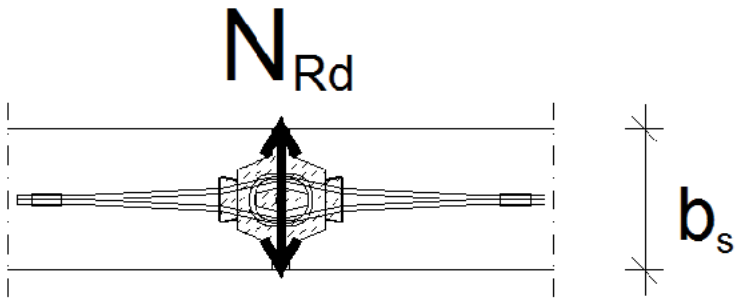

Figure 5. Direction of transversal shear force

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

Design values for transversal shear force apply for one pair of RVL wire rope loops (one on each side of the joint). Distance between wire rope loop pairs must be according to section 5.1.1. and RVL seam dimensions according to figure 2.

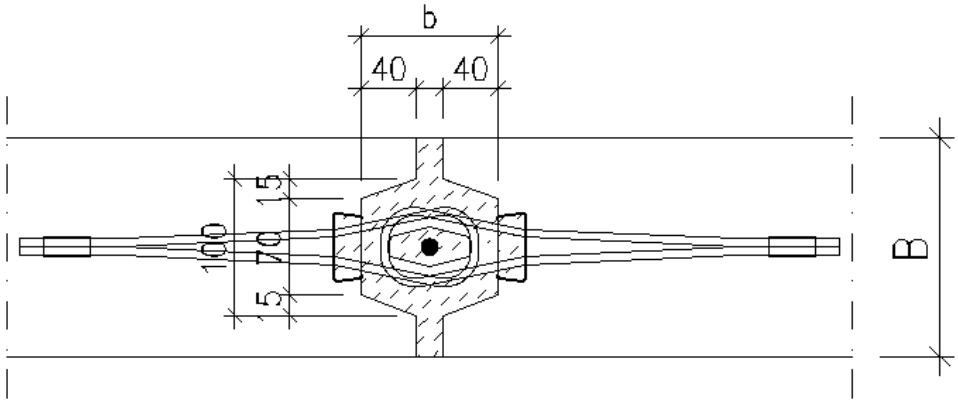

Figure 6. Indented joint dimensions used in calculations for transversal shear force resistance in table 8

Table 12. Design values of resistance for transversal shear force for RVL wire rope loop, seam type and dimensions according to figure 6

Wire rope loop	B [mm]	Design value for transversal shear force in one pair of wire rope loops N_{Rd} [kN]		
		C25/30	C30/37	C40/50
RVL-60	≥ 120	6,7	7,6	9,2
RVL-80				
RVL-100				
RVL-120				
RVL-140	≥ 150	8,4	9,5	11,5

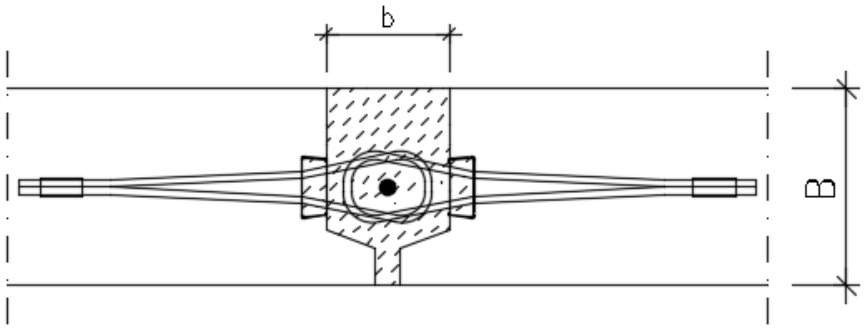

Figure 7. Indented joint dimensions used in calculations for transversal shear force resistance in table 9

Table 13. Design values of resistance for transversal shear force for RVL wire rope loop, seam type and dimensions according to figure 7

Wire rope loop	B [mm]	Design value for transversal shear force in one pair of wire rope loops N_{Rd} [kN]		
		C25/30	C30/37	C40/50
RVL-60	≥ 120	0,9	1,2	1,4
RVL-80				
RVL-100				
RVL-120				
RVL-140	≥ 150	2,8	3,4	3,6

4.4 Design value for tensile force

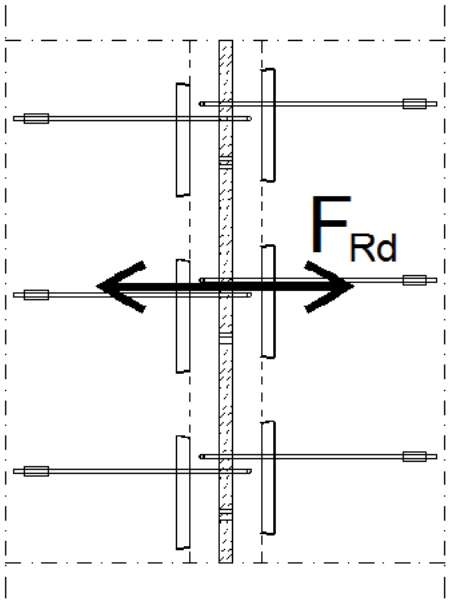

Figure 8. Direction of tensile force

Table 14. Design value for tensile force in one pair of wire rope loops

Wire rope loop	Design value for tensile force in one pair of wire rope loops F_{Rd} [kN]		
	C25/30	C30/37	C40/50
RVL-60 RVL-80 RVL-100 RVL-120	13,4	14,9	16,3
RVL-140	17,7	18,7	18,7

Design values for tensile force apply for one pair of RVL wire rope loops (one on each side of the joint). Distance between wire rope loop pairs must be according to section 5.1.1.

4.5 Resistances 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

5. Application

5.1 Limitations for application

Resistances presented in tables 2…9 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. Resistances of the RVL wire rope loops are calculated for the joint width presented in figure 2 and it is assumed that the steel boxes and the seam are fully filled with concrete.

5.1.1 Minimum edge and center distances

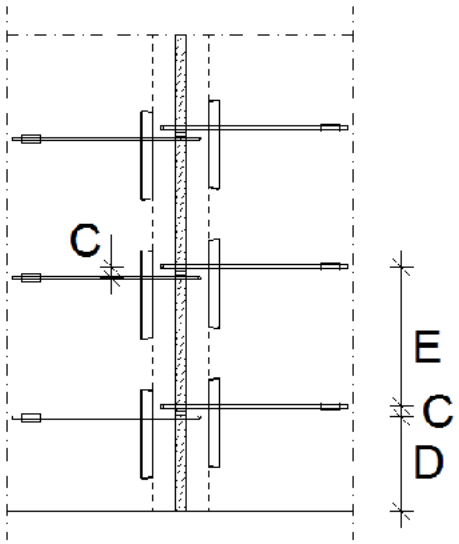

Figure 9. Distances of the RVL wire rope loops

Table 15. Minimum distances of RVL wire rope loops

Wire rope loop	center to center E_{min} [mm]	edge distance D_{min} [mm]	center to center C_{max} [mm]	minimum width B_{min} [mm]
RVL-60 RVL-80 RVL-100 RVL-120	250	150	20	80
RVL-140	350	200	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} = minimum distance between wire rope loops at opposite sides of the joint.

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

The size of the wire rope loops must be chosen according to the thickness 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 2), the width of the steel box of the wire rope loop (table 1) and the required concrete cover.

5.1.2 Recommended and maximum seam thickness

Recommended and maximum seam thickness are according to table 8 and figure 7.

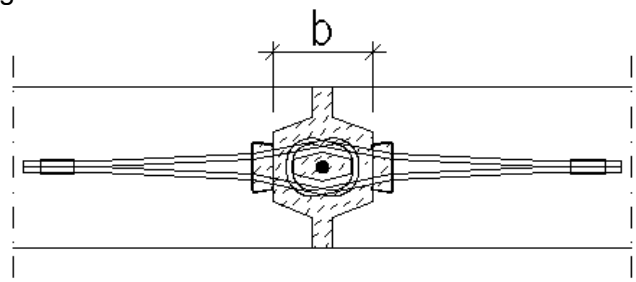

Figure 10. Seam thickness b

Table 16. Recommended and maximum thicknesses of the seam b

Wire rope loop	Recommended seam thickness b [mm]	Maximum seam thickness b [mm]
RVL-60	70…90	90
RVL-80	90…110	110
RVL-100	110…140	140
RVL-120	140…180	180
RVL-140	160…220	220

Maximum values for seam thickness b must not be exceeded when using RVL wire rope loops.

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 8. This ribbed steel bar is installed through the wire rope loops according to figure 8.

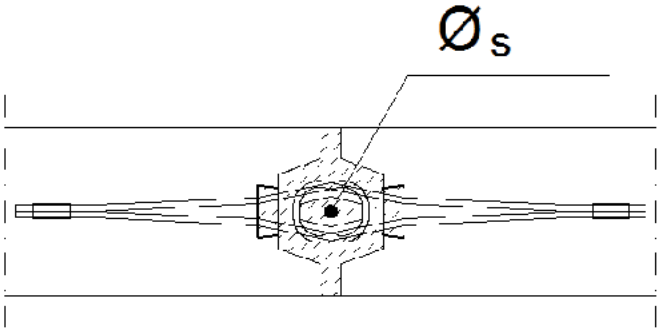

Figure 11. Ribbed steel bar in the joint

Table 17. Size of the ribbed steel bar in the joint, steel B500B (K500C-T)

Wire rope loop	Diameter of the ribbed steel bar $Ø_s$ [mm]
RVL-60 RVL-80 RVL-100 RVL-120	12
RVL-140	16

5.2.2 Reinforcement of the concrete element

The wall elements must be reinforced according to the wall element design.

1) When RVL wire rope loops are used to transfer forces

When RVL wire rope loops are used to transfer forces in the joint, anchorage of the wire rope loop 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} = 24 kN and for wire rope loop RVL-140 it is 44 kN. The anchorage of the wire rope loops must be designed for these forces when using design values for resistances presented in tables 2…9.

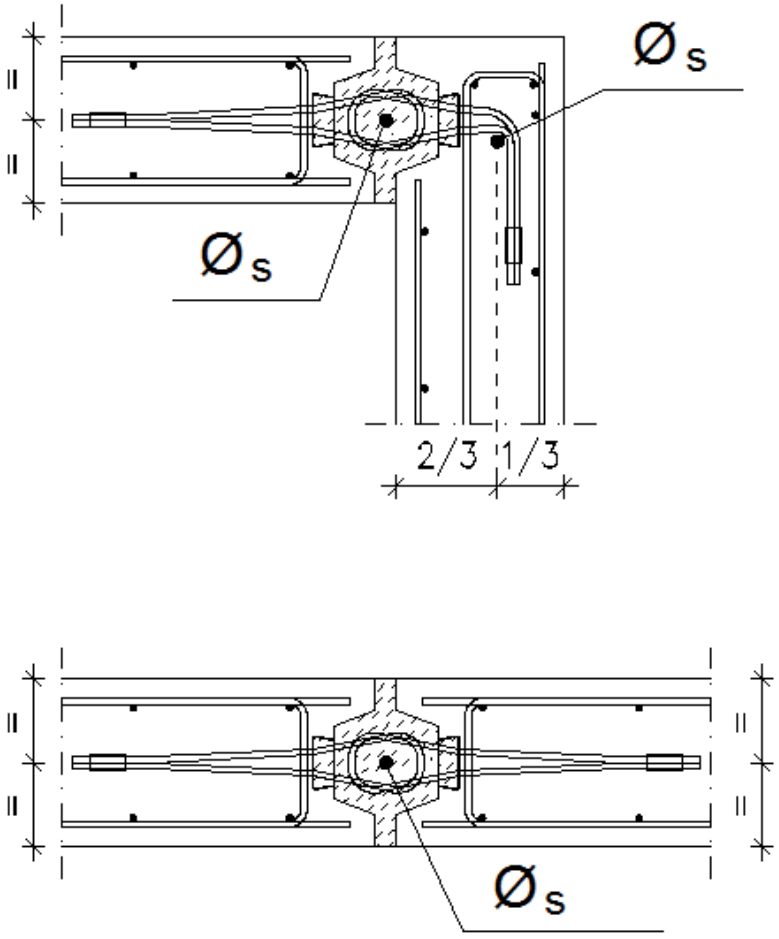

Figure 12. Example of element edge reinforcement when transferring forces

2) When RVL wire rope loops are not used to transfer forces

When RVL wire rope loops are used to limit cracking of the seam or to tie elements together without defining the required force edge reinforcement of the element may be done according to principles presented in figure 10. Edge reinforcement 2-Ø10 and additional reinforcement according to figure 10 is recommended.

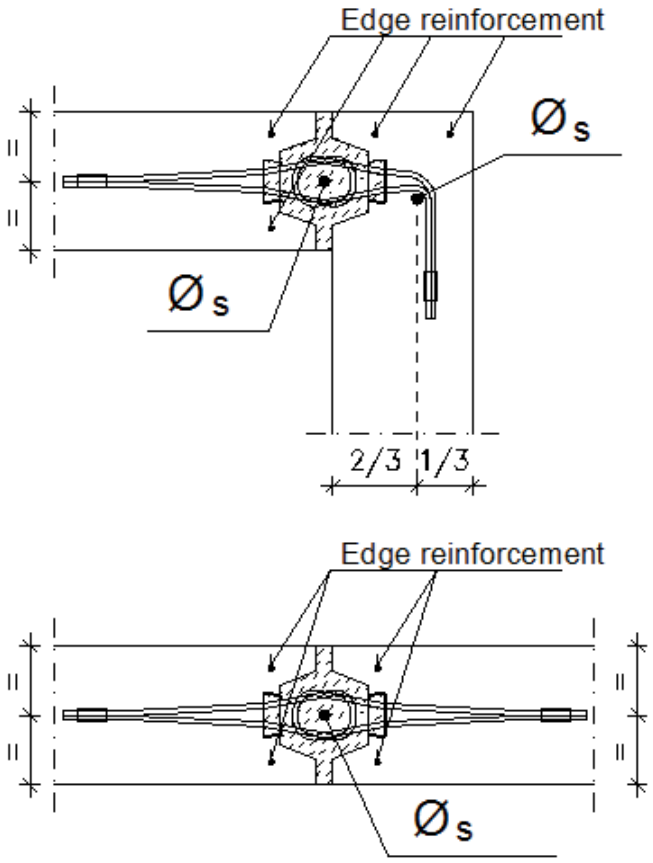

Figure 13. Example of element edge reinforcement when not transferring forces

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 9 and 10. RVL wire rope loops are tied to element reinforcement.

7. SUPERVISION OF INSTALLATION

7.1 Installing the RVL wire rope loops

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.

Notes

About
R-Group

R-Group is a leading provider of steel connections for precast and cast-in- situ construction around the globe.

With over three decades of our participation in huge projects, we don't compromise on quality or customer satisfaction and we create connections for a lifetime.

Our customer-oriented service, excellent and reliable network of suppliers plus our extensive product portfolio ensure that we are able to offer professional and flexible solutions for any kind of projects.

In our operations we comply with the ISO 9001 and 14001 standards

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