MEMO 750

MEMO 750 Guidance BWC – cantilever beam	Date: Latest rev.: Doc. no.:	10.01.2020 21.02.2022 2001034A	Sign.: Sign.: Contr.:	OEH SB O.O

Guidance BWC - cantilever beam

CONTENTS

Instructions for using the BWC cantilever retrofitting for:

Concrete balconies

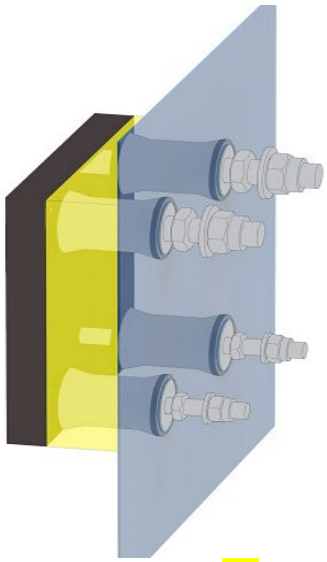
Steel balconies

Wooden balconies

PART 1 BWC–system (Balcony Wall Connection)

1.1 BWC U-H «with effective thermal insulation».

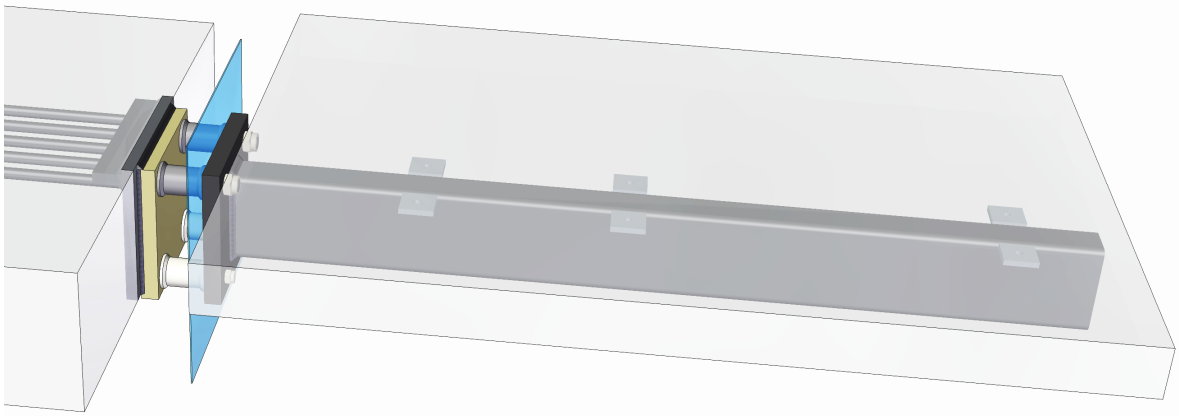
This is a system where the black plate is welded to different options such as:
Plate against building floor, RHS, HSQ (Beam for hollow core slabs) and more. In the next chapter these variations will be described in more detail.



Figur 1 The picture shows BWC 40 U-H with yellow thermal protection - NB! In the following figures, the back plate is shown in yellow.

1.2 Attachment against edge of story floor

1.2.1 When using a plate for welding with five reinforcing bars in the story floor (BWC Plate 40 U-H).



Figur 2 The picture shows BWC 40 U-H with cast-in BWC Plate with reinforcing bars in the story floor and RHS cantilever welded to vertical back plate.

1.2.2 Examples showing various solutions with hollow core slab (HCS) and arrangement on a story floor edge.

1.2.2.1 RHS

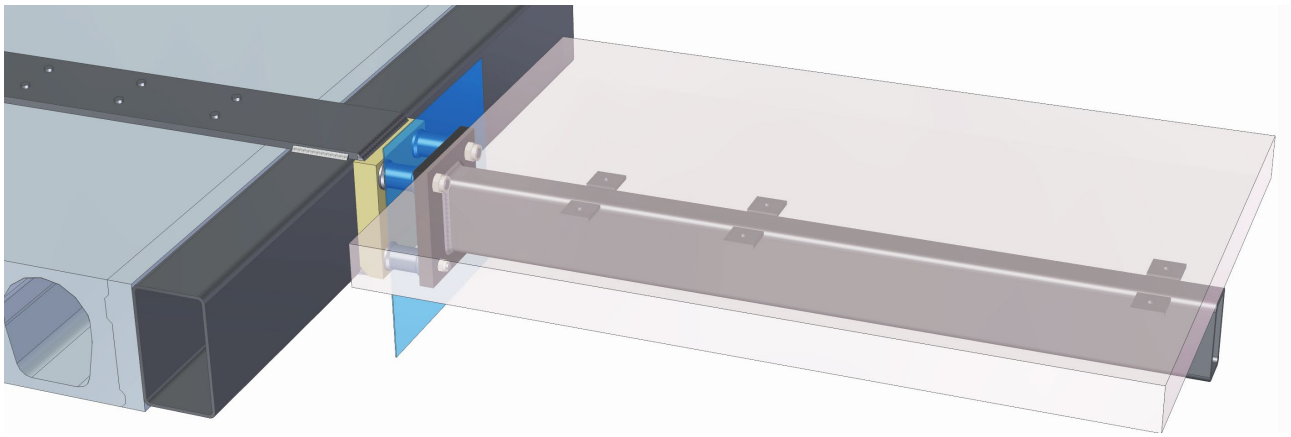


Figure 3 Illustration showing BWC 40 U-H against the side of RHS

1.2.2.2 RHS with sub plate

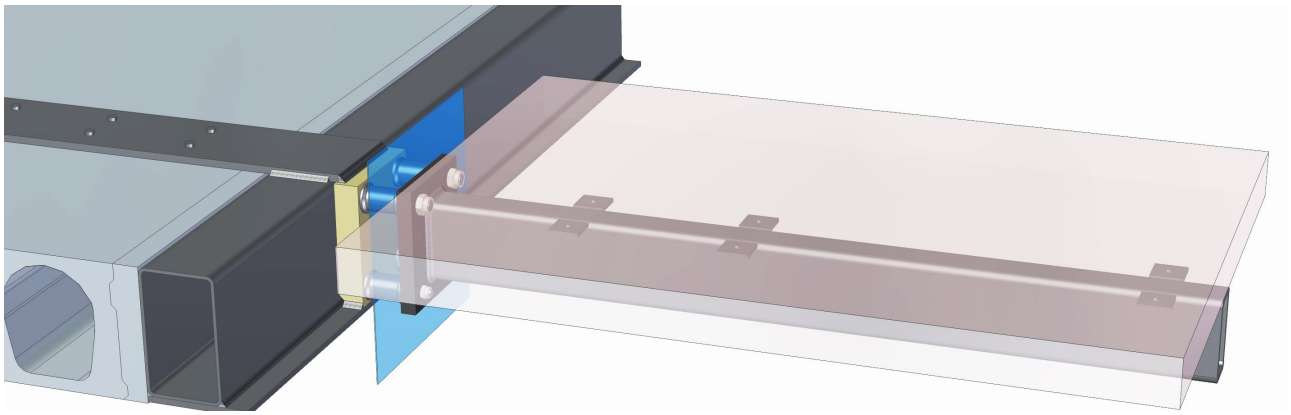


Figure 4 Illustration showing BWC 40 U-H against the side of RHS with sub plate

1.2.2.3 HSQ (Beam for hollow core slabs)

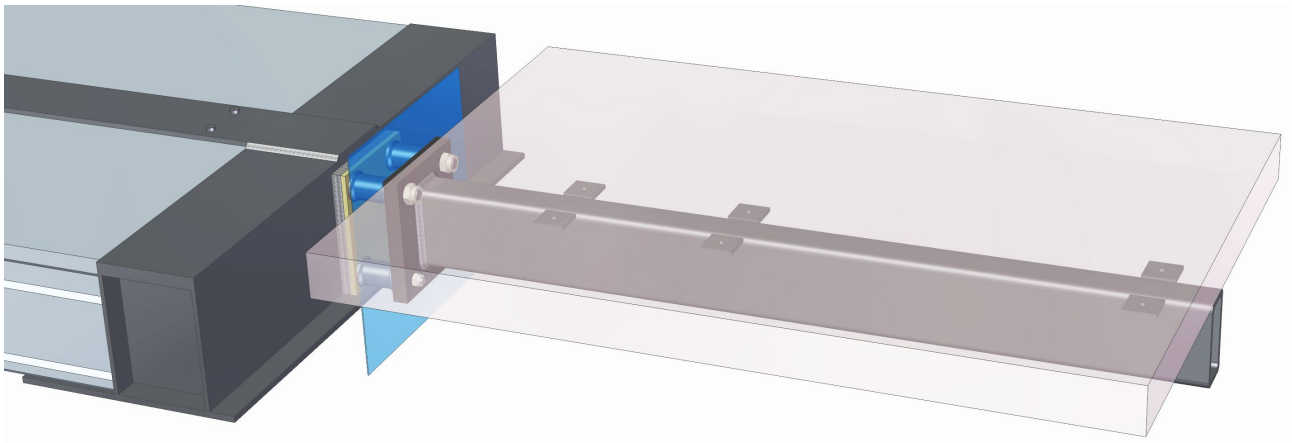


Figure 5 Illustration showing example using HSQ-beam

1.2.2.4 IPE-beam under the edge of a hollow core slab

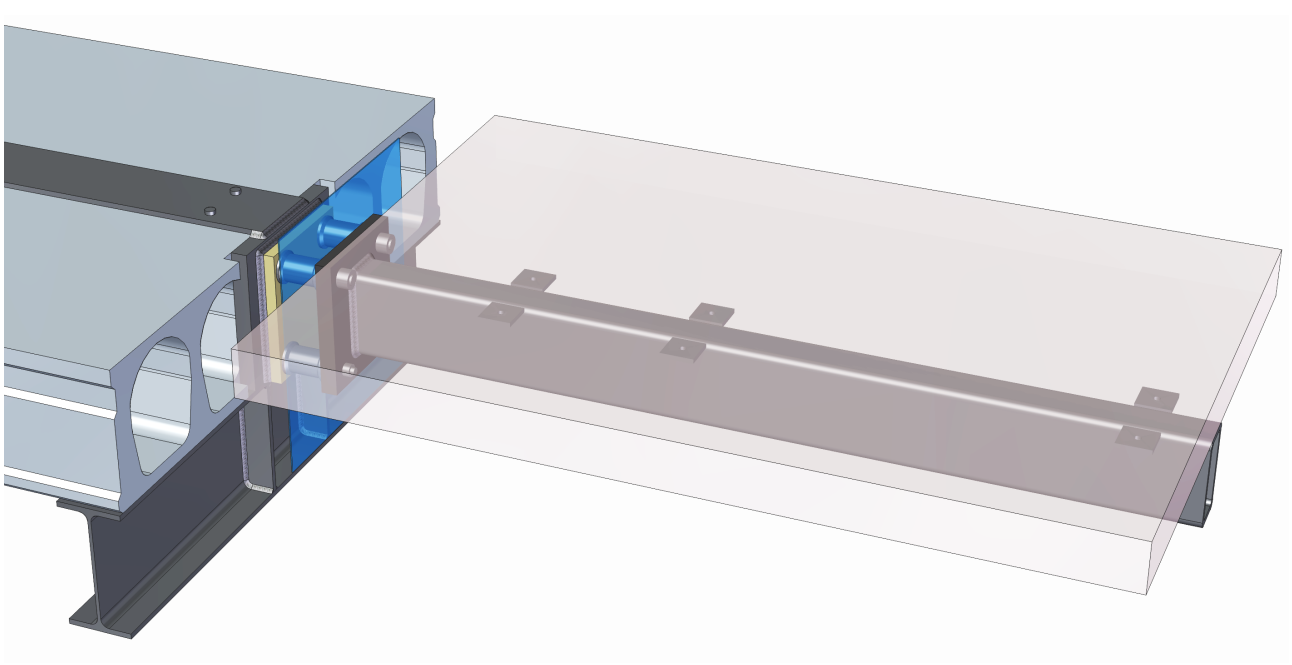


Figure 6 Illustration showing solution where a hollow core slab resting on an IPE-beam

1.3 Corner balconies

We recommend BWC 40 U-H in corner solutions.

1.3.1 On-site casted story floor with plate moulded into floor edge.

Instead of using steel connections combined with HCS, it is preferably to replace the HCS with an in-place casted story floor with reinforcement in the upper layer.

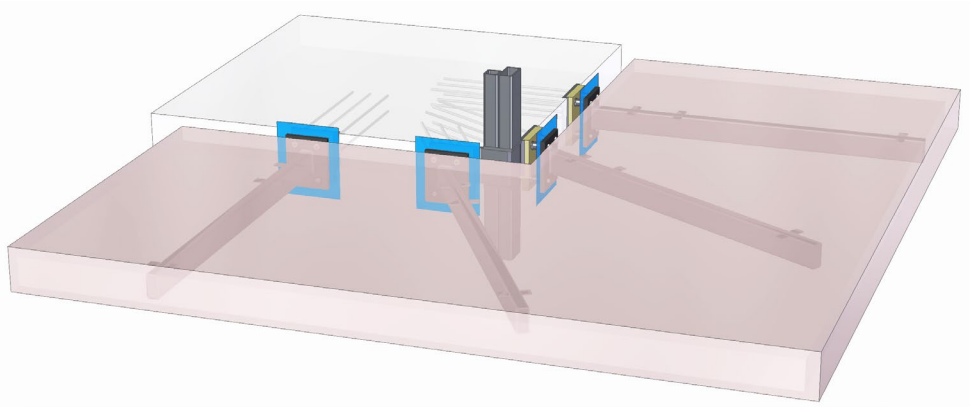


Figure 7 Illustration showing BWC 40 U-H equipped with weldment plate against floor edge and a corner steel column

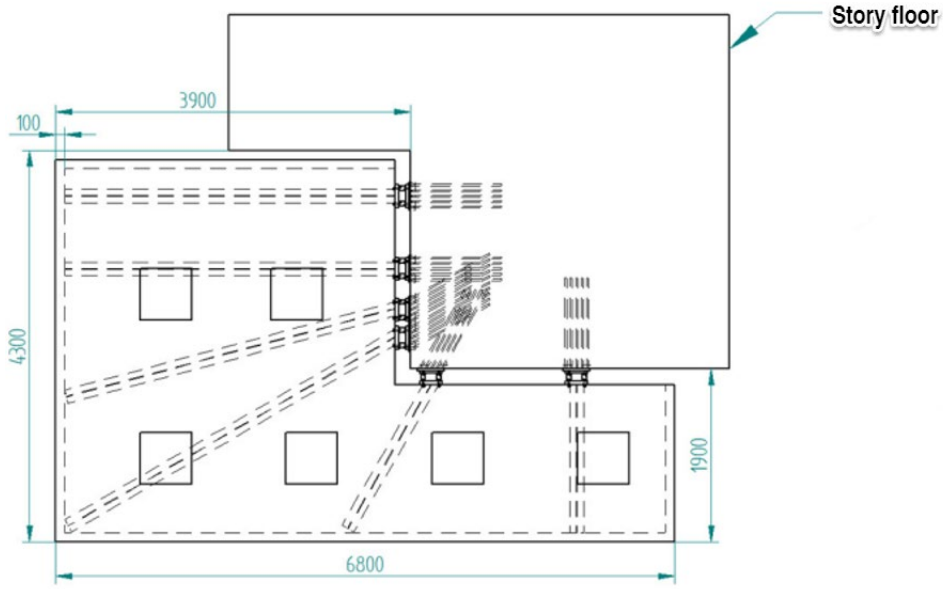


Figure 8 Drawing showing corner balcony with BWC 40 U-H, used in a modal-analysis (see Memo 755A).

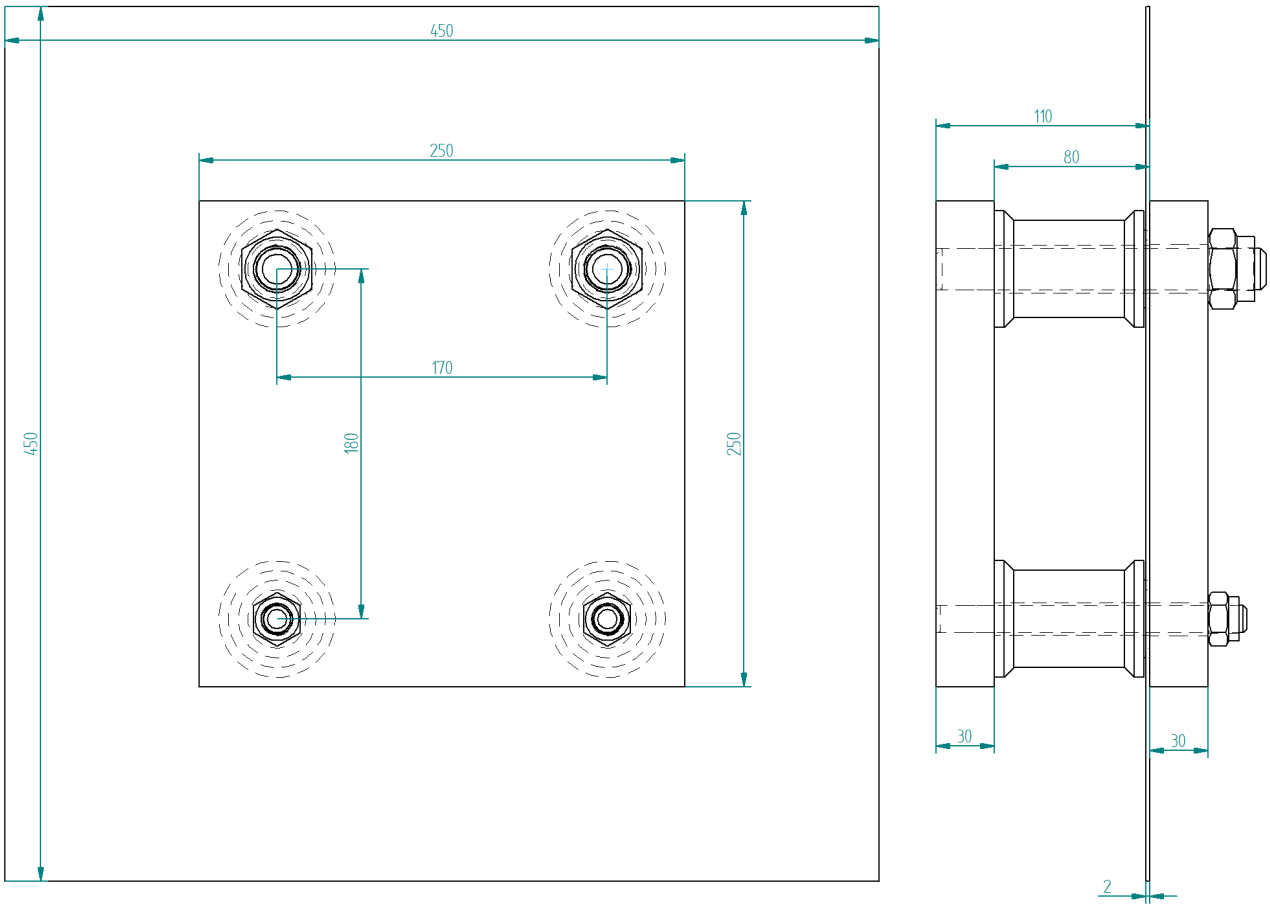
All corner balcony variants shall be calculated and checked individually! The tables will NOT give sufficient answers with regards to deflection. The relevant torques and shear forces shall also be controlled in each individual case.

PART 2 Capacities

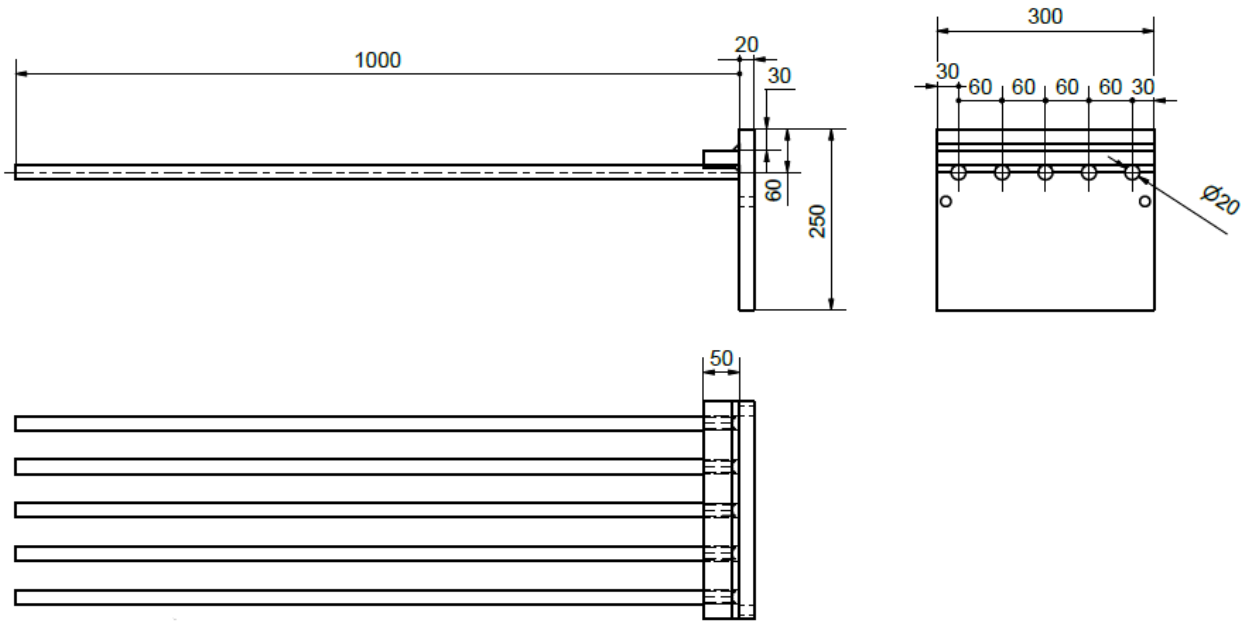
2.1 BWC 40 U-H

Capacities (Based on element analysis «*BWC 40 U-H Plate dekkekant 2020*» done with the FEM-tool Ansys. Project no «*AA*»)

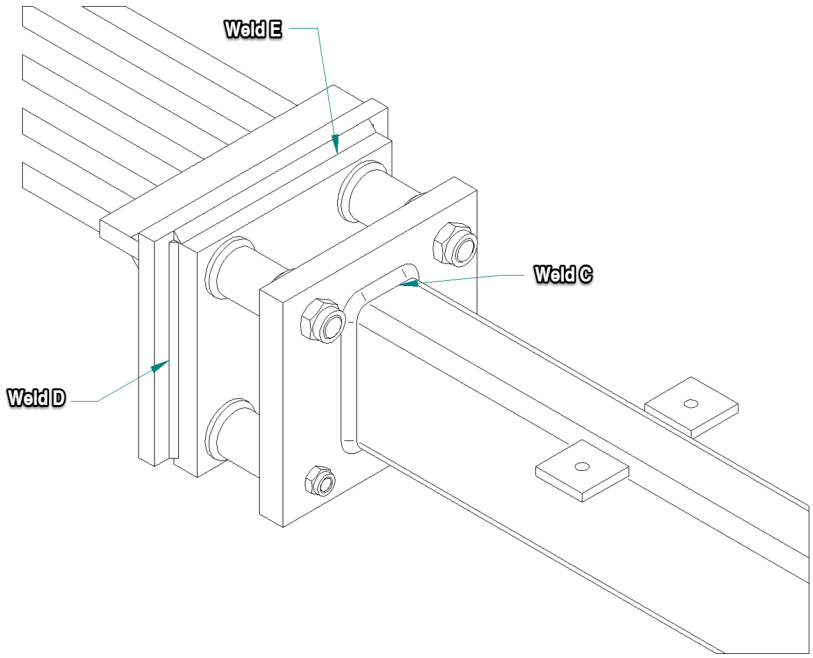
Unit	Max torque [kNm]	Max shear force [kN]	Max horizontal force [kN]
BWC 40 U-H	60	70	+/- 20



2.2 BWC Plate 40 U-H



2.3 Weld throat BWC Plate 40 U-H



Weld table	
Weld	Weld throat in mm
A	7
B	6
C	7
D	4,2
E	7

2.4 Extension of BWC 40 U-H against HSQ (or similar)

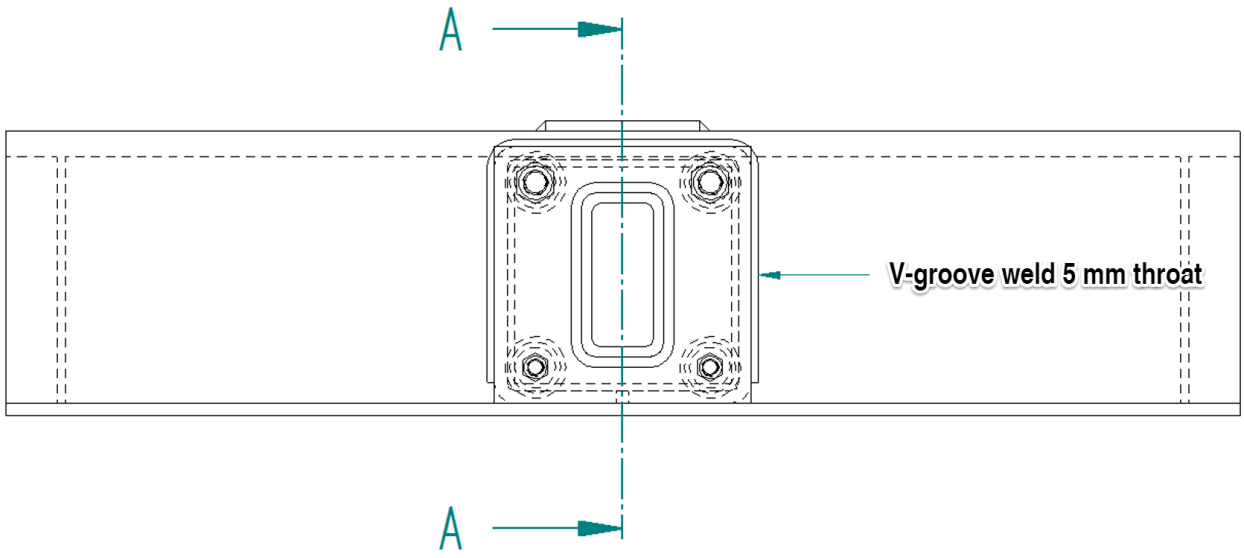
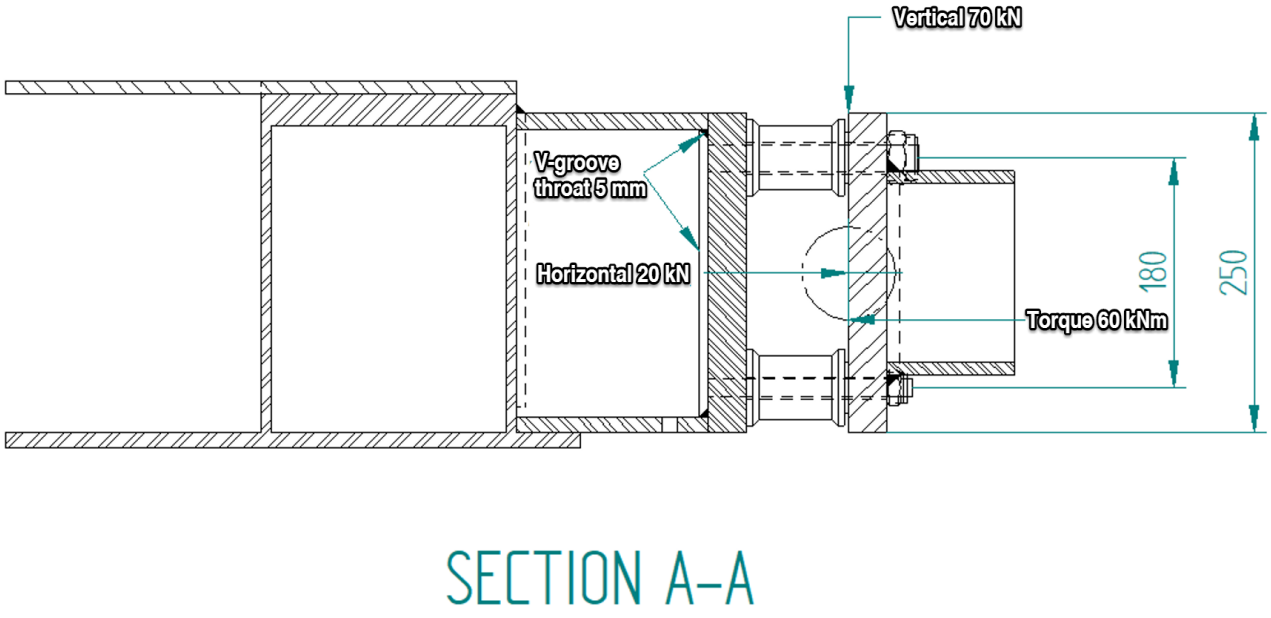


Figure 9 Front view



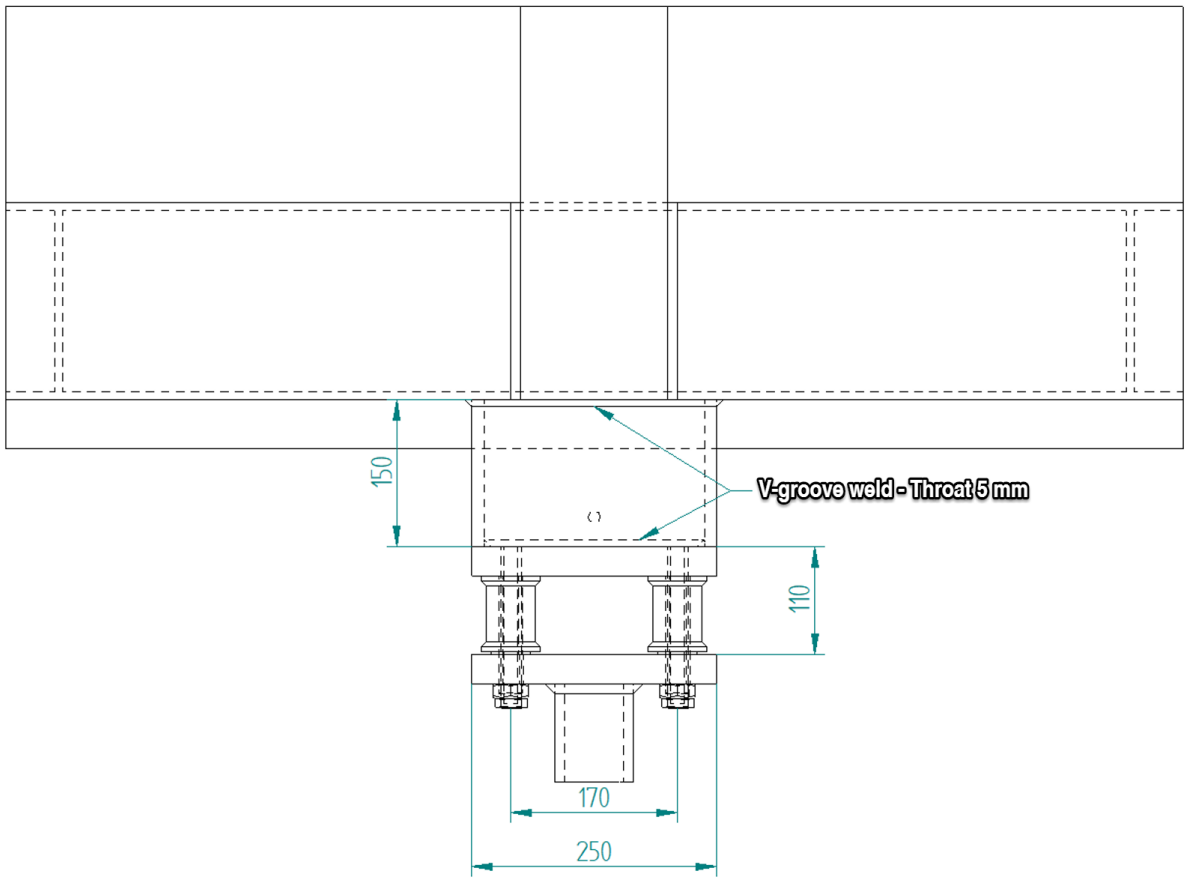


Figure 20 Top view

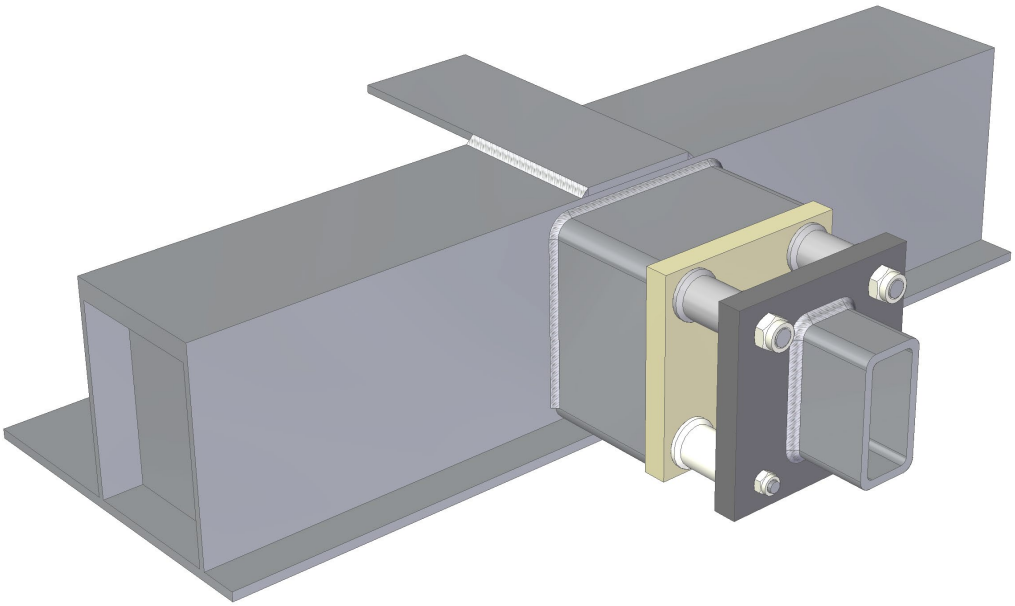


Figure 3 Perspective

2.5 Load tables – examples, von-Mises stress

Stress [MPa]	RHS 150x100x6 [mm]	RHS 160x80x6 [mm]	RHS 160x80x10 [mm]	RHS 200x100x6 [mm]	RHS 200x100x10 [mm]	RHS 300x100x6 [mm]	RHS 300x100x10 [mm]
$W_{elastic-x}*10^3$ [mm³]	111	105	161	170	244	449*	714*
Area [mm²]	2760	2640	4290	3360	5260	4440*	7273*

1 pcs BWC, 1 m balcony length

Balcony cantilever [m]	Ultimate load [N]	Von-Mises stress: $\sigma j = \sqrt{\sigma b^2 + 3 * \tau^2}$ [MPa]						
1,5	9677	66	69	45	43	30	17	10
1,8	11652	95	100	65	62	43	24	15
2,1	13627	129	137	89	84	59	32	20
2,4	15601	169	179	116	110	77	42	26
2,7	17576	214	226	148	140	97	53	33
3,0	19551	264	280	182	173	120	66	41

2 pcs BWC, 2 m balcony length

Balcony cantilever [m]	Ultimate load [N]	Von-Mises stress: $\sigma j = \sqrt{\sigma b^2 + 3 * \tau^2}$ [MPa]						
1,5	9677	66	69	45	43	30	17	10
1,8	11652	95	100	65	62	43	24	15
2,1	13627	129	137	89	84	59	32	20
2,4	15601	169	179	116	110	77	42	26
2,7	17576	214	226	148	140	97	53	33
3,0	19551	264	280	182	173	120	66	41

2 pcs BWC, 3 m balcony length

Balcony cantilever [m]	Ultimate load [N]	Von-Mises stress: $\sigma j = \sqrt{\sigma b^2 + 3 * \tau^2}$ [MPa]						
1,5	9677	99	104	68	64	45	25	16
1,8	11652	142	150	98	93	65	36	22
2,1	13627	194	205	134	127	88	48	30
2,4	15601	253	268	175	166	115	63	40
2,7	17576	321	339	221	210	146	80	50
3,0	19551	397	419	273	259	181	99	62

2 pcs BWC, 4 m balcony length

Balcony cantilever [m]	Ultimate load [N]	Von-Mises stress: $\sigma j = \sqrt{\sigma b^2 + 3 * \tau^2}$ [MPa]						
1,5	9677	131	139	90	86	60	33	21
1,8	11652	190	200	131	124	86	48	30
2,1	13627	258	273	178	169	118	65	41
2,4	15601	338	357	233	221	154	84	53
2,7	17576	428	453	295	280	195	107	67
3,0	19551	529	559	365	346	241	132	83

Numbers in red are showing stress values which are too high. (Compared to steel quality S355). Ultimate load equals the load used in deflection analyses, not the capacity of the RHS.

**Values extracted from 3D-model. Current supplier documentation does not cover these profiles.*

PART 3 Calculation examples/ Introduction

Experience indicates that it is the deflection that becomes dimensioning in most applications. But torque and shear forces must always be controlled.

Dimensioning balconies using this system is the same for both BWC U (special solution on request) and BWC U-H. In MEMO 756A-B-C-D tables are showing deflection at given cantilevers.

3.1 Example 1 – BWC 40 U-H

A balcony with a cantilever 1,8 m has a length of 4 m. Preferred profile is a RHS 200x100x6 together with BWC 40 U-H, welded to BWC Plate 40 U-H.

MEMO 756D

Deflection « Frequent occurrence»

The table below shows deflection at different cantilever lengths of RHS-profiles when they are exposed to frequent occurrence loads.

Deflection (1 m length of balcony on 1 pcs BWC)

Frequent occurence (1,0 x G) + (0,5 x Q) (4,7 kN)								
Cantilever [m]	Recom. deflect. 1:150 [mm]	RHS 150x100x6 [mm]	RHS 160x80x6 [mm]	RHS 160x80x10 [mm]	RHS 200x100x6 [mm]	RHS 200x100x10 [mm]	RHS 300x100x6 [mm]	RHS 300x100x10 [mm]
1,5	10,0	3,280	3,378	2,525	2,162	1,922	1,471	1,417
1,8	12,0	6,375	6,517	4,807	4,222	3,731	2,849	2,727
2,1	14,0	10,914	11,101	8,172	7,226	6,298	4,822	4,544
2,4	16,0	17,228	17,542	12,887	11,374	9,788	7,477	6,943
2,7	18,0				16,882	14,378	10,913	9,991
3,0	20,0					20,197	15,247	13,777

NB! Deflection in the table must be multiplicated with length of balcony and then divided with the number of BWC's.

To find the correct deflection, select a line from the table, for instance RHS 200x100x6, and the cantilever 1,8 m in this case. This number (4,222 mm) must be multiplied by the balcony length and divided with the number of BWC's chosen.

In this case the balcony has a length of 4 meters, and we want to use only 2 BWC's. The calculation will then be as follows:

Actual deflection: 4,222 mm x 4 meter / 2 BCW's = 8,44 mm.

In the second column from the left we find the recommended deflection at 1: 150 is 12,0 mm. This means that 8,44 mm is within the recommendation.

3.2 Example 2 – BWC 40 U-H

A balcony with a cantilever 2,1 m has a length of 4 m. The choice of unit is BWC 40 U-H welded to BWC Plate 40 U-H, with a RHS 200x100x10.

MEMO 756D

Deflection « Frequent occurrence»

The table below shows deflection at different cantilever lengths of RHS-profiles when they are exposed to frequent occurrence loads.

Deflection (1 m length of balcony on 1 pcs BWC)

Frequent occurence (1,0 x G) + (0,5 x Q) (4,7 kN)								
Cantilever [m]	Recom. deflect. 1:150 [mm]	RHS 150x100x6 [mm]	RHS 160x80x6 [mm]	RHS 160x80x10 [mm]	RHS 200x100x6 [mm]	RHS 200x100x10 [mm]	RHS 300x100x6 [mm]	RHS 300x100x10 [mm]
1,5	10,0	3,280	3,378	2,525	2,162	1,922	1,471	1,417
1,8	12,0	6,375	6,517	4,807	4,222	3,731	2,849	2,727
2,1	14,0	10,914	11,101	8,172	7,226	6,298	4,822	4,544
2,4	16,0	17,228	17,542	12,887	11,374	9,788	7,477	6,943
2,7	18,0				16,882	14,378	10,913	9,991
3,0	20,0					20,197	15,247	13,777

NB! Deflection in the table must be multiplicated with length of balcony and then divided with the number of BWC's.

To find the correct deflection, select a line from the table, in this example RHS 200x100x10 and cantilever of 2,1 m. This number (6,298 mm) shall be multiplied by the balcony length and divided by the number of BWC's chosen.

In this case the balcony has a length of 4 meters, and we want to use only 2 BWC's. The calculation will then be as follows:

Actual deflection: 6,298 mm x 4 meter / 2 BCW's = 12,6 mm.

In the second column from the left we find the recommended deflection at 1: 150 is 14,0 mm. This means that 12,6 mm is within the recommendation.

3.2.1 *Calculation of shear forces and torque in the story floor with BWC 40 U-H welded to BWC Plate 40 U-H*

Unit	Max torque [kNm]	Max shear force [kN]	Max horizontal force [kN]
BWC 40 U-H	60	70	+/- 20

To calculate the reinforcement in the story floor, use the red-brown table on page 13 in the documents Memo 756D. Here you will find the current shear force that is transferred to the story floor.

Load combinatios (up to 3,8 m)

Ultimate (1,2 x G) + (1,5 x Q) (9,2 kN)			
Recom. deflec. 1:150 [mm]	Cantilever [m]	Shear force/ m [kN]	Torque control [kNm]
10,0	1,5	13,9	10,4
12,0	1,8	16,6	15,0
14,0	2,1	19,4	20,4
16,0	2,4	22,2	26,6
18,0	2,7	25,0	33,7
20,0	3,0	27,7	41,6
25,3	3,8	35,1	66,8

Figure 12 Table from Memo 756D page 13

3.2.1.1 Controlling torque using 2 pcs BWC 40 U-H, welded to BWC Plate 40 U-H.

Max permitted torque 60 kNm: Effective torque per BWC 40 U-H: 20,4 kN x 4 m balcony length / 2 BWC's = 40,8 kNm.

3.2.1.2 Controlling shear force using 2 pcs BWC 40 U-H, welded to BWC Plate 40 U-H

Max permitted shear force 70 kN: Shear force per BWC 40 U-H: 19,4 kN x 4 m balcony length / 2 BWC's = 38,8 kN.

3.3 Dimension control

3.3.1 Report «Tynne balkongdekker» av Dr. techn. Olav Olsen AS

Below is an excerpt from the report by Dr. techn. Olav Olsen AS. This is the result of analyses that show the connection between the location of BWC units, and the length of cantilever.

Project no.:	12492
Document no.:	12492-OO-R-001
Date:	04.07.2018
Revision:	3
Number of pages:	38
Prepared by:	Odd. H. Holt Kristensen
Controlled by:	Ottar Bjørklid/ Lars Nerland
Approved by:	Øystein Løset

Table 1: Maximum balcony length for different cantilevers

Balcony cantilever B [m]	Max length balcony L [m]	Plate thickness t [mm]	Distance between cantilevers C/C [m]	Edge distance D [m]
1,5	6,20	89	3,63	1,28
1,8	5,80	89	3,40	1,20
2,1	4,25	89	2,49	0,88
2,4	3,25	89	1,90	0,67
2,7	2,55	89	1,49	0,53
3,0	2,10	89	1,23	0,43

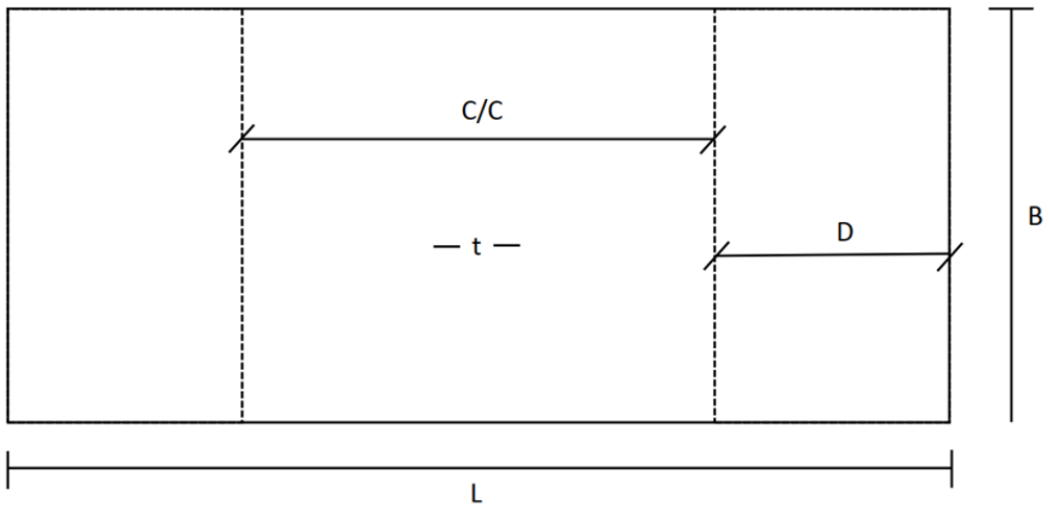


Figure 14 Balcony dimensions

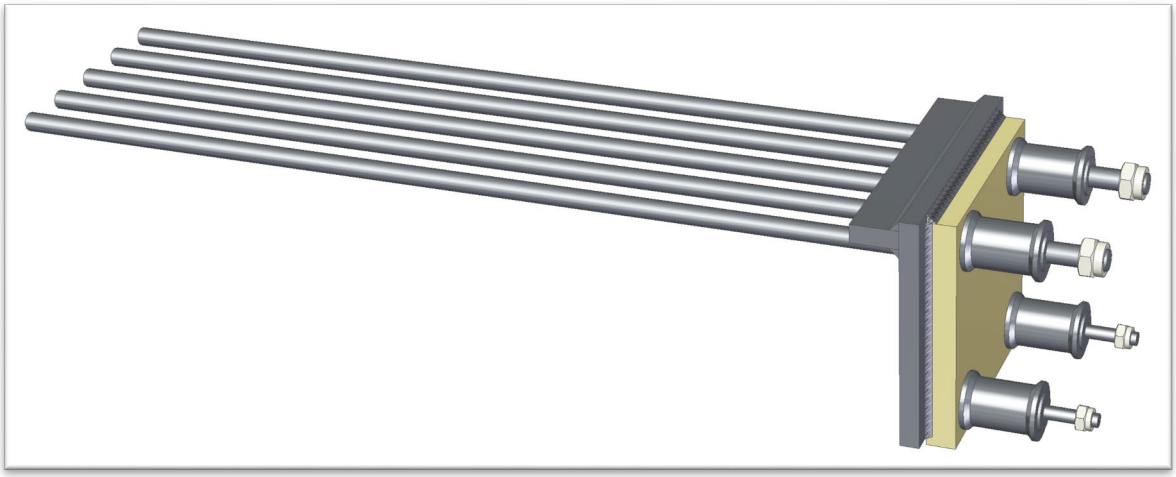


Figure 13 BWC 40 U-H welded to BWC Plate 40 U-H

PART 4 Tightening torque

4.1 Minimum tightening torque to achieve the preferred preload

Bolt	Strength class	Minimum tightening torque	Ultimate bolt load	Lubrication of thread, washer, and bolt head	Required tightening torque (50% of ultimate torque)
M16	8.8 (A4-80)	62 kN	125 kN	Würth cold galvanizing	245 Nm (25 kpm)
M24	8.8 (A4-80)	150 kN	293 kN	Würth cold galvanizing	785 Nm (80 kpm)

NB! Tests are performed by lubricating the nut, threads, and washer with "Würth cold galvanizing." It is important to follow the same procedure when mounting in the field.

REVISION

Date	Description	Sign.
10.01.2020	First edition	OEH
19.02.2020	Added Part 3, Tightening Torques	OEH
13.03.2020	Correction review after input from Jan Erik and O. Olsen.	OEH
19.03.2020	Introduction of a new section «Part 2 Capacities». Various changes to content. "THIN BALCONY FLOOR CAPACITY REPORT" has been added.	OEH
24.03.2020	Proofreading, minor corrections.	OEH
23.04.2020	Corrected error in table. All numbers are now halved.	OEH
04.05.2020	Corrected table p. 13. The table now shows values for elastic modulus instead of plastic modulus.	OEH
26.05.2020	Updated drawings on page 12 to the latest version	OEH
03.06.2020	Added IPE variant to HCS (1.3.3.4 page 7)	OEH
04.08.2020	Illustrations on page 9 to page 12 now show the membrane and additional dimensions.	OEH
05.08.2020	Added variant with BWC 40 U-H extended towards HSQ	OEH
25.08.2020	Corrected drawings on page 5 (1.3.1 and 1.3.2). The plate is incorporated into floor.	OEH
28.09.2020	Added illustrations showing weld throat on BWC Plate 30 and 40 U-H p. 14	OEH
03.02.2022	Removed BWC 30/40 U and BWC 30 U-H.	SB
15.02.2022	Translation into English.	OEH
15.02.2022	Added new page 16.	OEH
21.02.2022	Switched page 15 and 16	JB

Appendix

«THIN BALCONY FLOOR CAPACITY REPORT».

The report is used as a basis for determining balcony thicknesses, cantilevers, and lengths etc. on balconies. Excerpts from this report can also be found in the document Memo 756A-D. The entire report is on our website.