

MEMO 756D	Date: 17.12.2019	Sign.: OEH
DEFLECTION AND LOAD CAPACITY.	Latest rev.: 01.03.2022	Sign.: JB
BWC 40 U-H CANTILEVER BALCONY -	Doc. nr.: 191216A	Contr.: O.O
FIXATION AGAINST IN-PLACE CASTED		
STORY FLOOR.		

Deflection data table BWC 40 U-H welded to BWC plate 40 U-H

TABLE OF CONTENTS

- Deflection table data BWC 40 U-H welded to BWC plate 40 U-H 1
- Basic numbers 2
- Model drawing used in the analyzes..... 3
- Report «Tynne balkongdekker» av Dr. techn. Olav Olsen AS 4
- Profile: RHS 5
- Deflection Ultimate Limit State (ULS) (fracture) 5
- Deflection Serviceability limit state (SLS) 6
- Deflection « Frequent occurrence» (Live Loads)..... 7
- Deflection “Balcony edge load” 8
- Profile: IPE 9
- Deflection Ultimate Limit State (ULS) (fracture) 9
- Deflection characteristic load (Serviceability limit state SLS) 10
- Deflection «Frequent occurrence» (Live Loads)..... 11
- Deflection “Balcony edge load” 12
- Summary of torque and shear forces..... 13
- Fracture (ultimate) limit and applied loads..... 14
- REVISION..... 15

Basic numbers

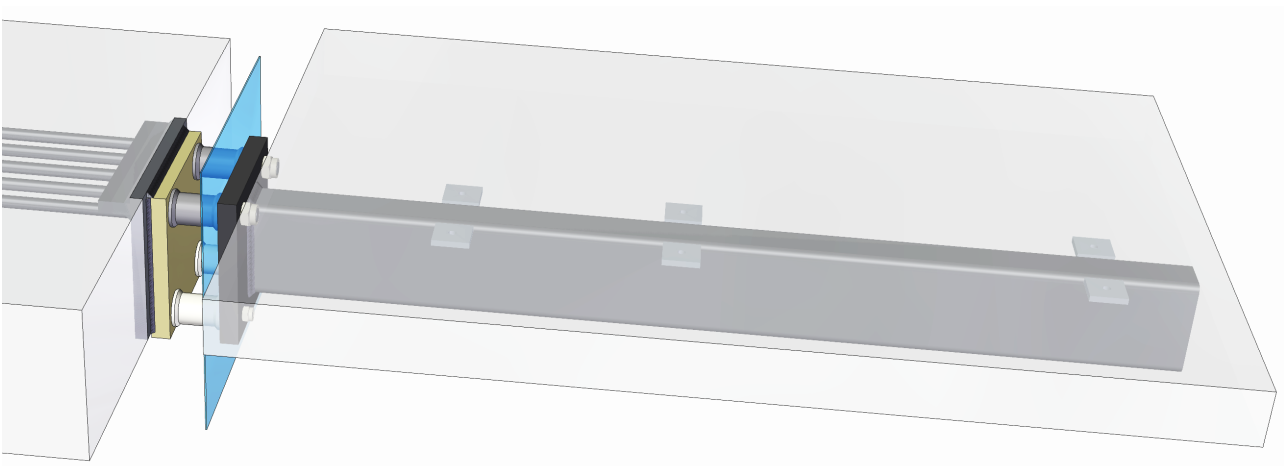
The following figures are used in the analyzes:

Units	kg/m²	kN/m²	Factors
Weight of reinforced concrete slab:	226,3	2,22	
Weight of balcony railings:	19,1	0,19	
Weight of balcony covering:	30,6	0,30	
Total dead weight G:	276,0	2,71	<i>1,2</i>
General payload Q:	407,7	4,00	<i>1,5</i>

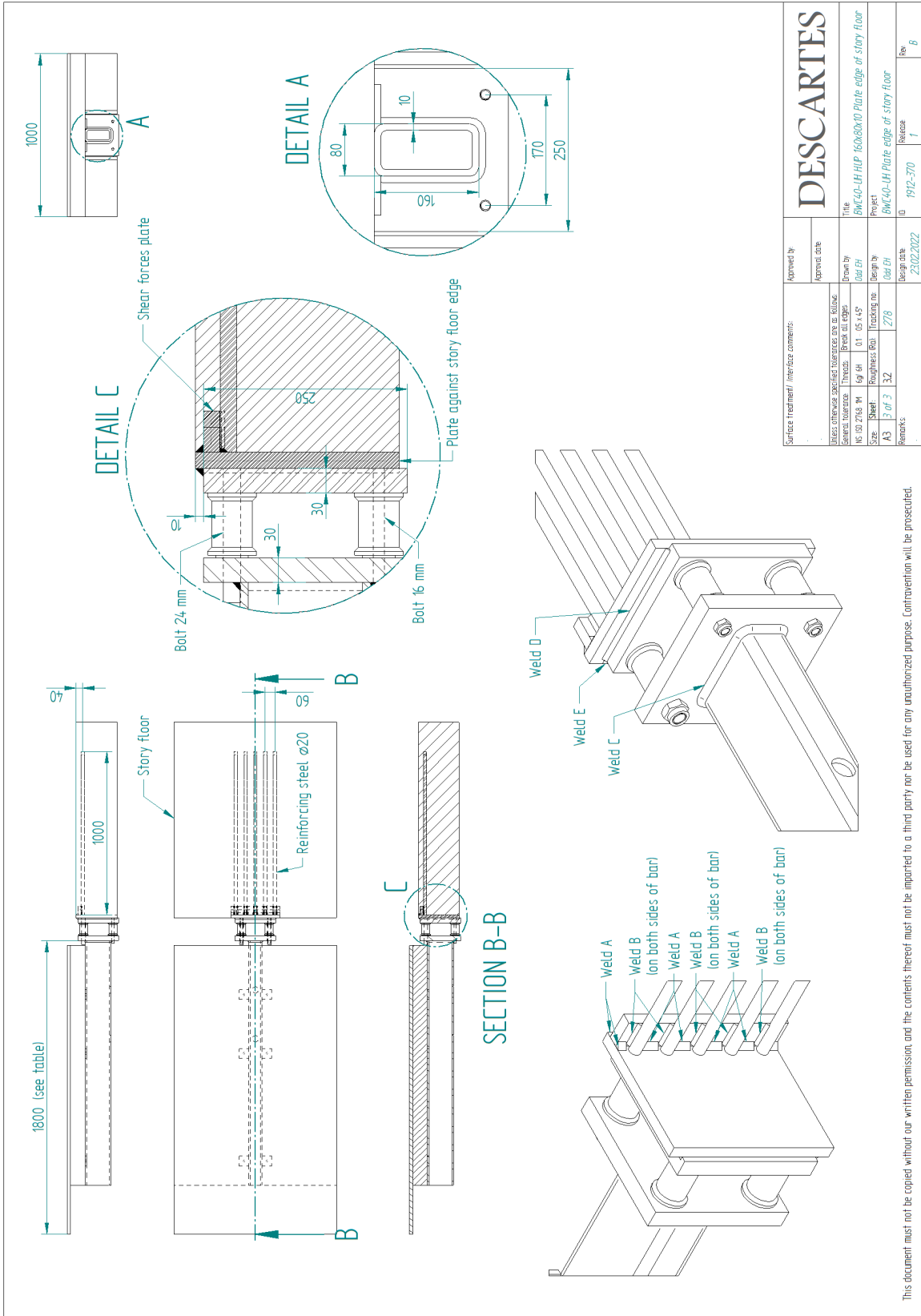
Thickness of balcony slab [mm]: 89

Max. torque [kNm] /Shear force [kN]:

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



Model drawing used in the analyzes.



Surface treatment / interface comments:	Approved by:	Approval date:
THESE INTERFACES SPECIFIED DISTANCES ARE IN MILLIMETERS. GENERAL TOLERANCE: ±0.25 mm (1st and 2nd class) / ±0.5 mm (3rd class) Size: Sheet: 7 of 3 / 32 / 278 Project: BMC40-LH/HP Plate edge of story floor Design date: 23/02/2022	DESCARTES	
Remarks:	Drawn by:	Drawn date:
	Design by:	Design date:
	Released by:	Released date:
	Rev:	Rev:
	1	6

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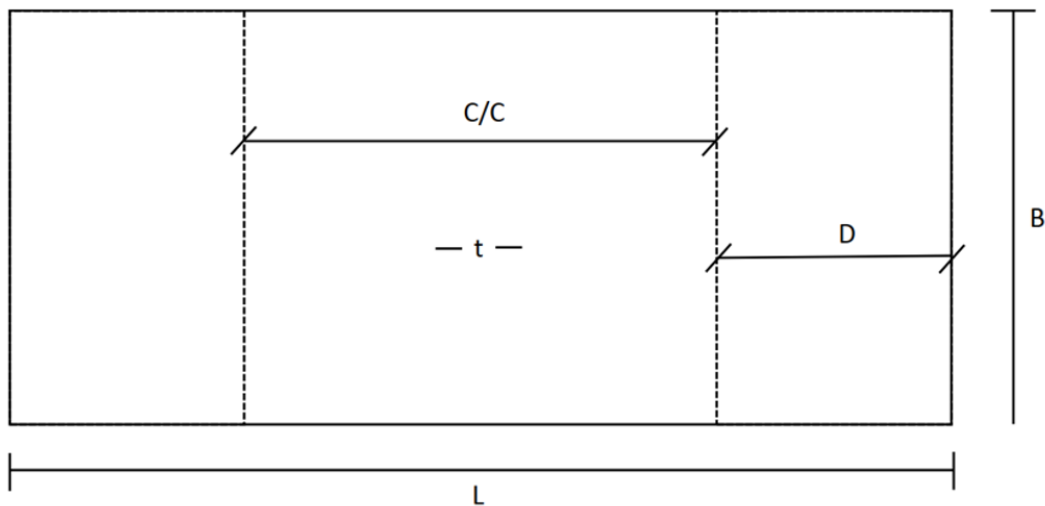
Report «Thin balcony slabs» by Dr. techn. Olav Olsen AS

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



Profile: RHS

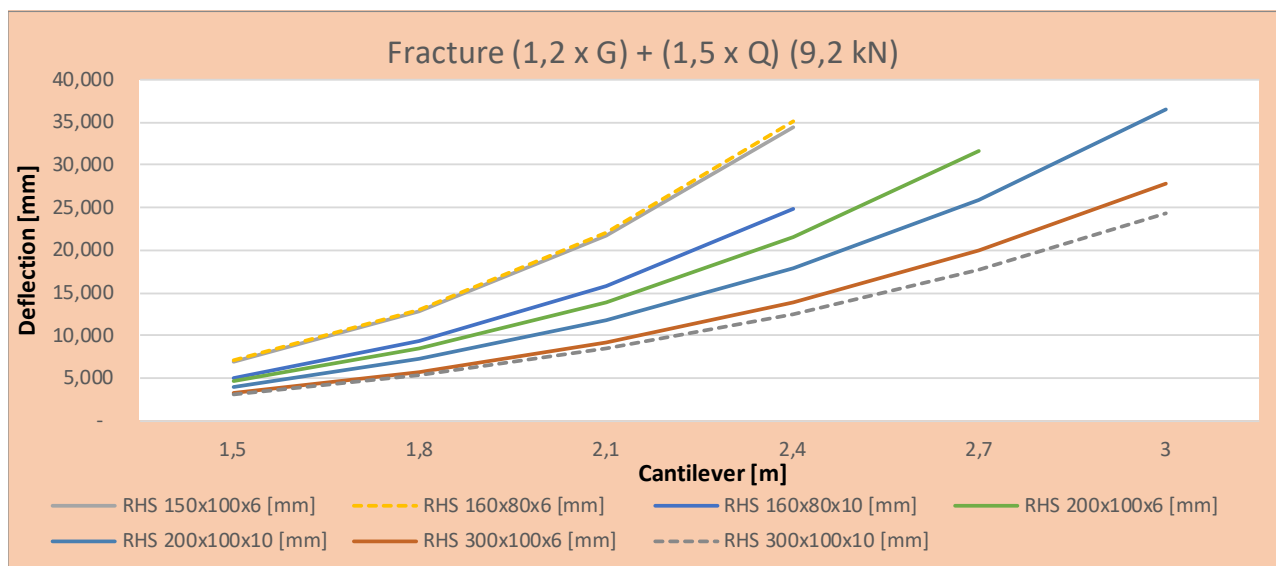
Deflection Ultimate Limit State (ULS) (fracture)

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

DEFLECTION (1 m balcony length per 1 pcs BWC)

Fracture (1,2 x G) + (1,5 x Q) (9,2 kN)								
Cantilver [m]	Recomm. deflec. 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	6,869	7,047	5,085	4,626	4,061	3,269	3,074
1,8	12,0	12,833	13,098	9,417	8,456	7,274	5,782	5,360
2,1	14,0	21,695	22,092	15,838	13,948	11,786	9,276	8,464
2,4	16,0	34,350	35,101	24,894	21,536	17,885	13,947	12,541
2,7	18,0	-	-	-	31,720	25,946	20,027	17,738
3,0	20,0	-	-	-	-	36,445	27,859	24,389

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



Deflection example:

Say we have a balcony with a length of 4 m. The cantilever is 1.8 m. RHS 200x100x6. We assume 3 BWC's.

- 1. First find the deflection number in the table, in this case: 8.456 mm.*
- 2. Multiply the deflection number by the balcony length of 4 m and then divide by the number of BWC's which is 3.*
- 3. Current deflection will be: $11.609 \times 4/3 = 11.275$ mm*

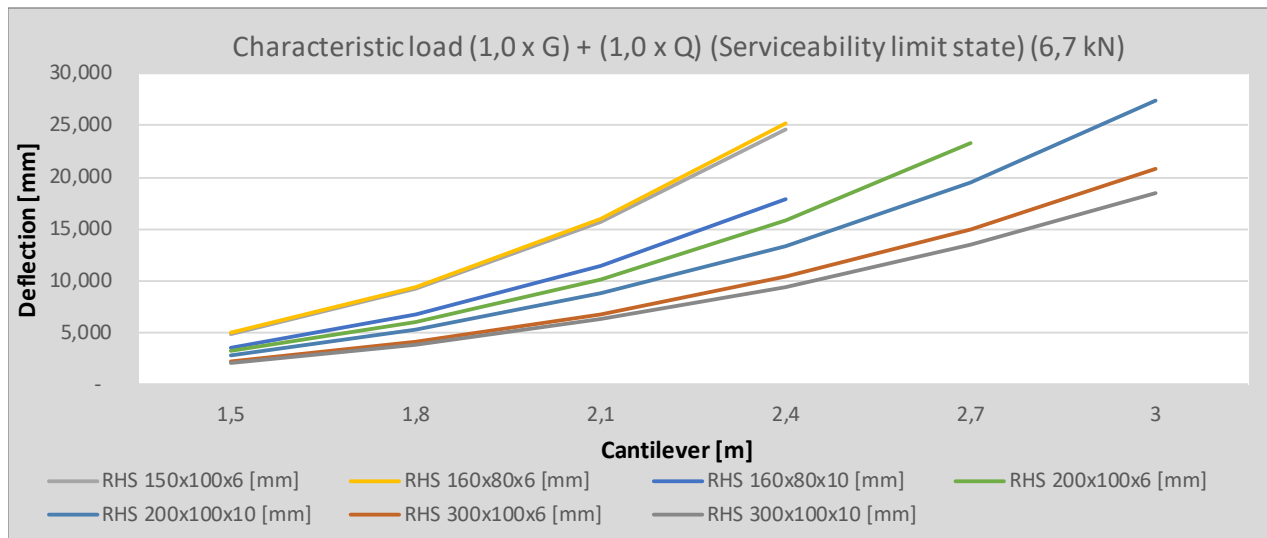
Deflection Serviceability limit state (SLS)

The table below shows deflection at different cantilever lengths of RHS profiles when they are exposed to SLS loads (Characteristic loads).

DEFLECTION (1 m balcony length per 1 pcs BWC)

Characteristic load (1,0 x G) + (1,0 x Q) (Serviceability limit state) (6,7 kN)								
Cantilever [m]	Recomm. deflec. 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	4,848	4,986	3,630	3,242	2,872	2,271	2,160
1,8	12,0	9,216	9,412	6,768	6,101	5,325	4,171	3,919
2,1	14,0	15,636	15,915	11,391	10,193	8,763	6,830	6,319
2,4	16,0	24,658	25,170	17,873	15,840	13,428	10,390	9,470
2,7	18,0	-	-	-	23,311	19,543	15,002	13,474
3,0	20,0	-	-	-	-	27,324	20,789	18,432

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



Deflection example:

Say we have a balcony with a length of 4 m. The cantilever is 1.8 m. RHS 200x100x6. We assume 3 BWCs.

1. First find the deflection number in the table, in this case: 6.101 mm.
2. Multiply the deflection number by the balcony length of 4 m and then divide by the number of BWCs which is 3.
3. Current deflection will be: $6.101 \times 4 / 3 = 8.13 \text{ mm}$

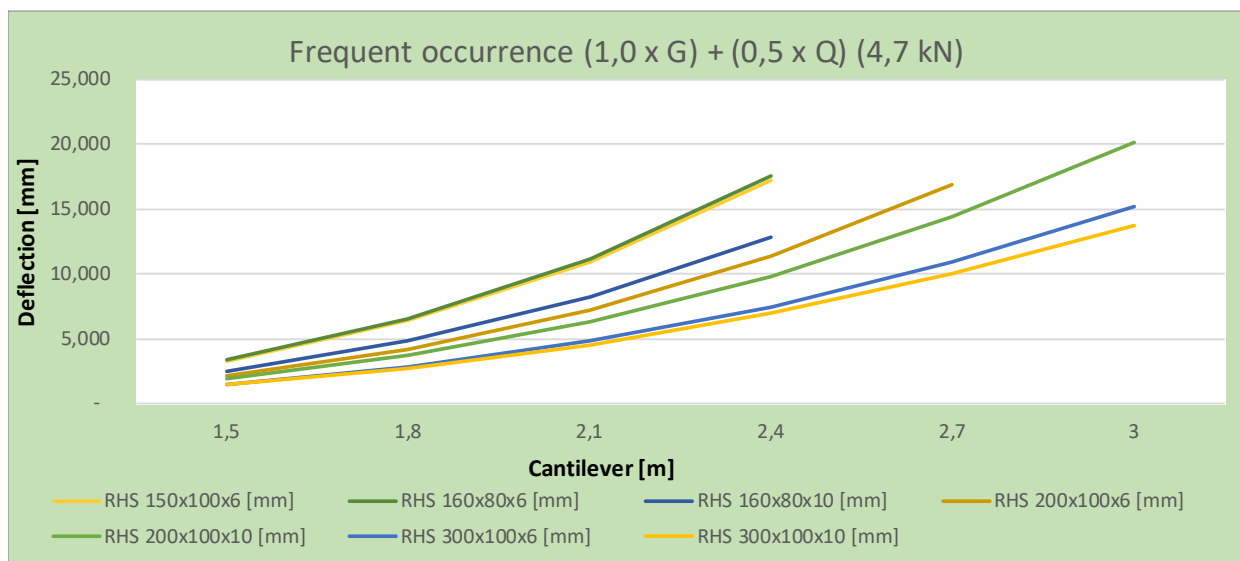
Deflection « Frequent occurrence» (Live Loads)

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

DEFLECTION (1 m balcony length per 1 pcs BWC)

Frequent occurrence (1,0 x G) + (0,5 x Q) (4,7 kN)								
Cantilever [m]	Recomm. deflec. 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 multiplied with length of balcony and then divided with the number of BWS's.



Deflection example:

Say we have a balcony with a length of 4 m. The cantilever is 1.8 m. RHS 200x100x6. We assume 2 BWCs.

1. First find the deflection number in the table, in this case: 4.222 mm.
2. Multiply the deflection number by the balcony length of 4 m and then divide by the number of BWCs which is 2.
3. Current deflection will be: $4.222 \times 4 / 2 = 8.44$ mm

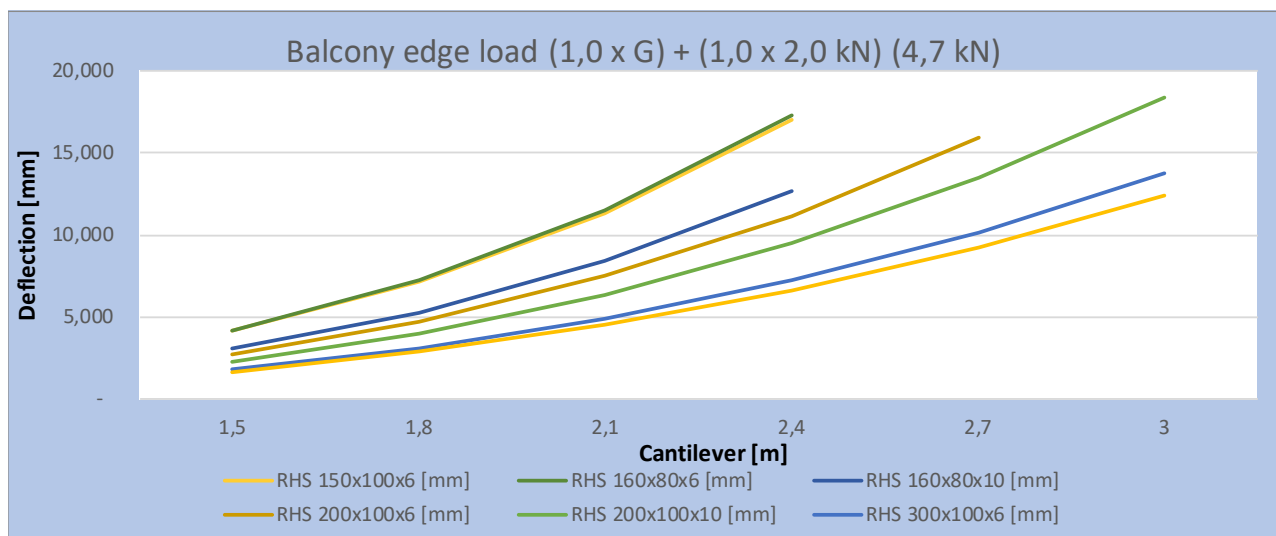
Deflection “Balcony edge load”

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

DEFLECTION (1 m balcony length per 1 pcs BWC)

Balcony edge load (1,0 x G) + (1,0 x 2,0 kN) (4,7 kN)								
Cantilever [m]	Recomm. deflec.. 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	4,132	4,182	3,057	2,706	2,298	1,829	1,660
1,8	12,0	7,129	7,245	5,285	4,707	4,025	3,129	2,875
2,1	14,0	11,349	11,499	8,417	7,478	6,378	4,904	4,506
2,4	16,0	16,995	17,258	12,634	11,164	9,474	7,224	6,598
2,7	18,0	-	-	-	15,921	13,439	10,157	9,199
3,0	20,0	-	-	-	-	18,374	13,774	12,370

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



Deflection example:

Say we have a balcony with a length of 4 m. The cantilever is 1.8 m. RHS 200x100x6. We assume 2 BWCs.

1. First find the deflection number in the table, in this case: 4.707 mm.
2. Multiply the deflection number by the balcony length of 4 m and then divide by the number of BWCs which is 2.
3. Current deflection will be: $4.707 \times 4 / 2 = 9.41 \text{ mm}$

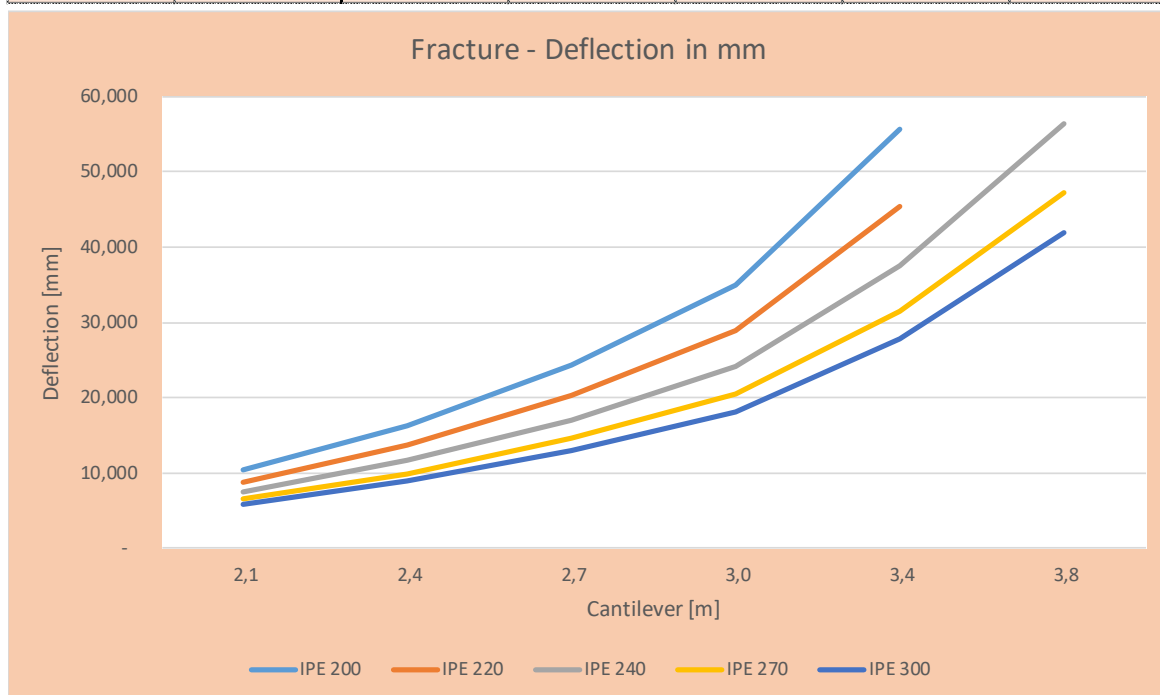
Profile: IPE

Deflection Ultimate Limit State (ULS) (fracture)

The table below shows deflection at different cantilever lengths of IPE profiles when they are exposed to ultimate loads. **NB! The thickness of the wall plate has been increased from 30 to 40 mm compared to the RHS-profiles.**

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

Fracture (1,2 x G) + (1,5 x Q) (9,2 kN)						
Cantilever [m]	Recomm. deflec. 1:150	IPE 200	IPE 220	IPE 240	IPE 270	IPE 300
2,1	14,0	10,356	8,818	7,526	6,502	5,881
2,4	16,0	16,276	13,699	11,609	9,959	8,961
2,7	18,0	24,349	20,325	17,083	14,550	13,016
3,0	20,0	35,038	28,940	24,135	20,411	18,155
3,4	22,7	55,641	45,403	37,606	31,472	27,817
3,8	25,3			56,471	47,279	41,891



Deflection example:

Say we have a balcony with a length of 4 m. The cantilever is 2.4 m. IPE 240. We assume 3 BWC's.

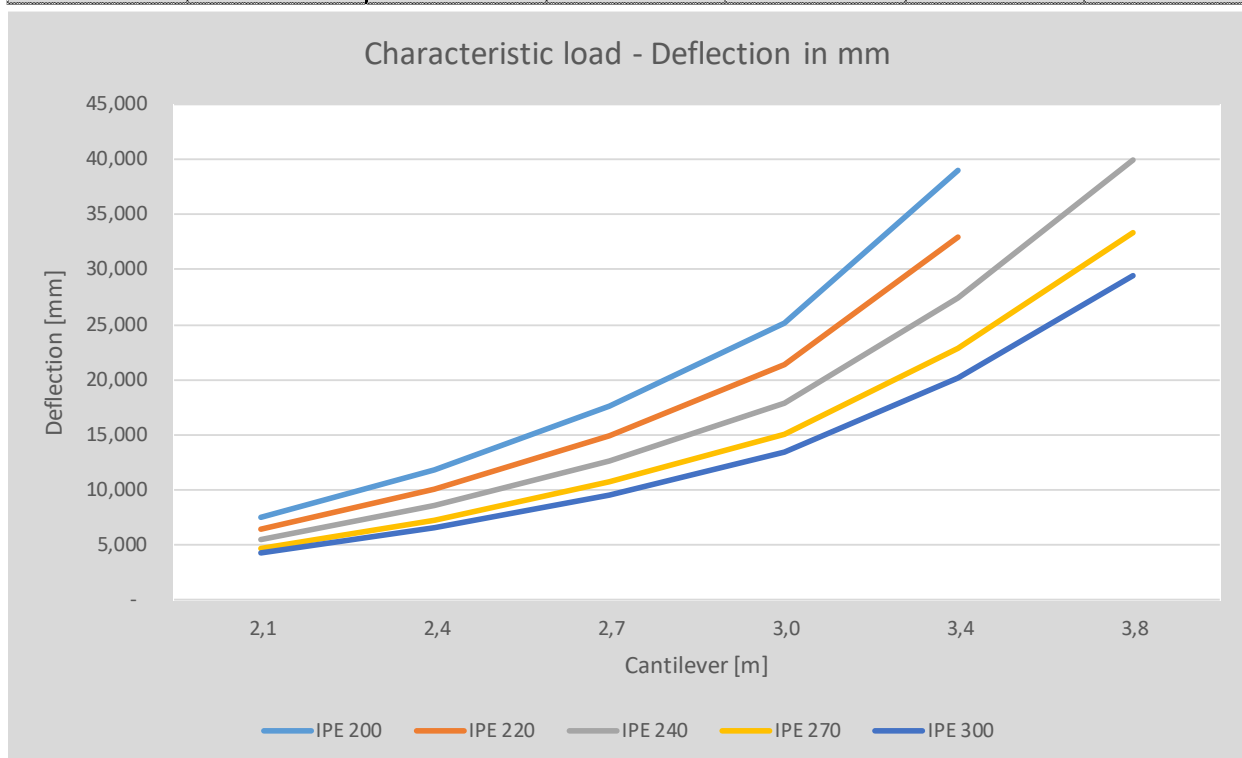
1. First find the deflection number in the table, in this case: 11.609 mm.
2. Multiply the deflection number by the balcony length of 4 m and then divide by the number of BWC's which is 3.
3. Current deflection will be: $11.609 \times 4 / 3 = 15.479 \text{ mm}$

Deflection characteristic load (Serviceability limit state SLS)

The table below shows deflection at different cantilever lengths of IPE profiles when they are exposed to SLS loads (Characteristic loads). **NB! The thickness of the wall plate has been increased from 30 to 40 mm compared to the RHS-profiles.**

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

Characteristic load (1,0 x G) + (1,0 x Q) (Serviceability limit state) (6,7 kN)						
Cantilever [m]	Recomm. deflec. 1:150	IPE 200	IPE 220	IPE 240	IPE 270	IPE 300
2,1	14,0	7,500	6,445	5,481	4,722	4,262
2,4	16,0	11,816	10,076	8,537	7,312	6,580
2,7	18,0	17,622	14,979	12,6	10,728	9,595
3,0	20,0	25,184	21,359	17,834	15,092	13,437
3,4	22,7	38,926	32,966	27,393	22,890	20,220
3,8	25,3			39,935	33,327	29,383



Deflection example:

Say we have a balcony with a length of 3 m. The cantilever is 3.0 m. IPE 300. We assume 2 BWC's.

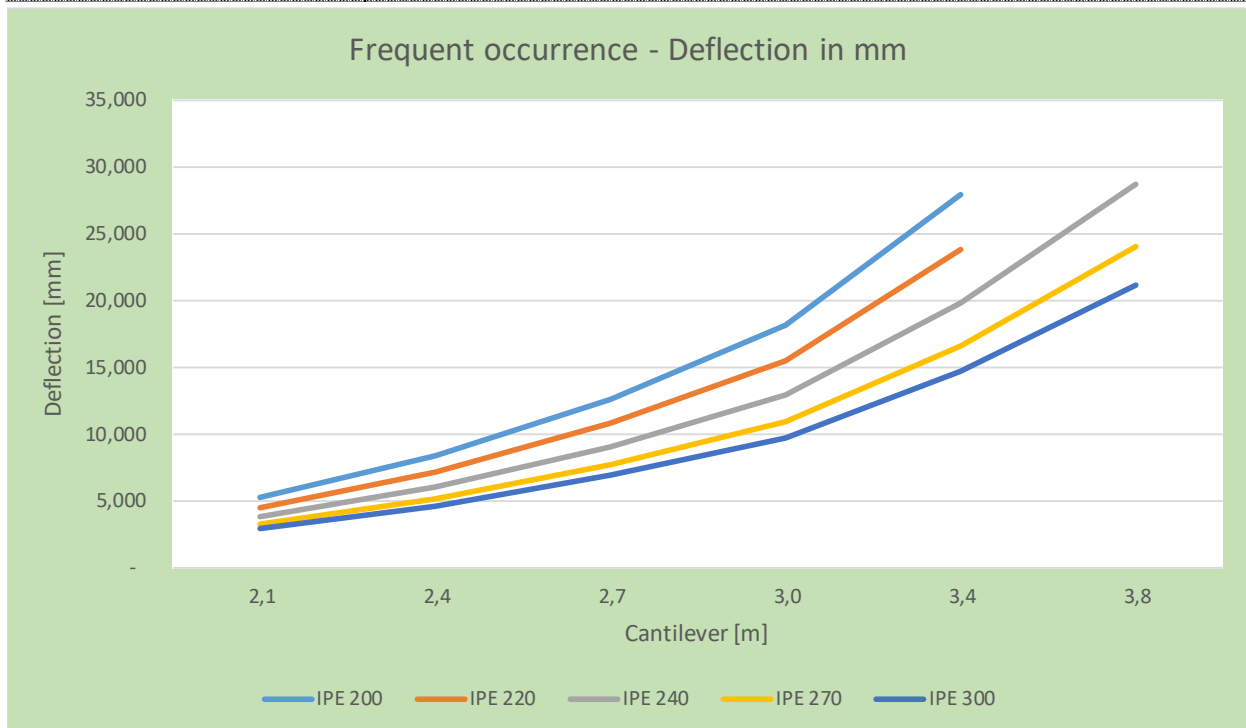
1. First find the deflection number in the table, in this case: 13.437 mm.
2. Multiply the deflection number by the balcony length of 3 m and then divide by the number of BWC's which is 2.
3. Current deflection will be: $13.437 \times 3 / 2 = 20.156 \text{ mm}$

Deflection «Frequent occurrence» (Live Loads)

The table below shows deflection at different cantilever lengths of IPE profiles when they are exposed to frequent occurrence loads. **NB! The thickness of the wall plate has been increased from 30 to 40 mm compared to the RHS-profiles.**

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

Frequent occurrence (1,0 x G) + (0,5 x Q) (4,7 kN)						
Cantilever [m]	Recomm. deflec. 1:150	IPE 200	IPE 220	IPE 240	IPE 270	IPE 300
2,1	14,0	5,334	4,586	3,867	3,308	2,969
2,4	16,0	8,460	7,235	6,125	5,224	4,697
2,7	18,0	12,661	10,819	9,104	7,745	6,940
3,0	20,0	18,171	15,472	12,935	10,957	9,768
3,4	22,7	27,903	23,831	19,873	16,624	14,719
3,8	25,3			28,736	24,019	21,221



Deflection example:

Say we have a balcony with a length of 3 m. The cantilever is 2.1 m. IPE 200. We assume 2 BWC's.

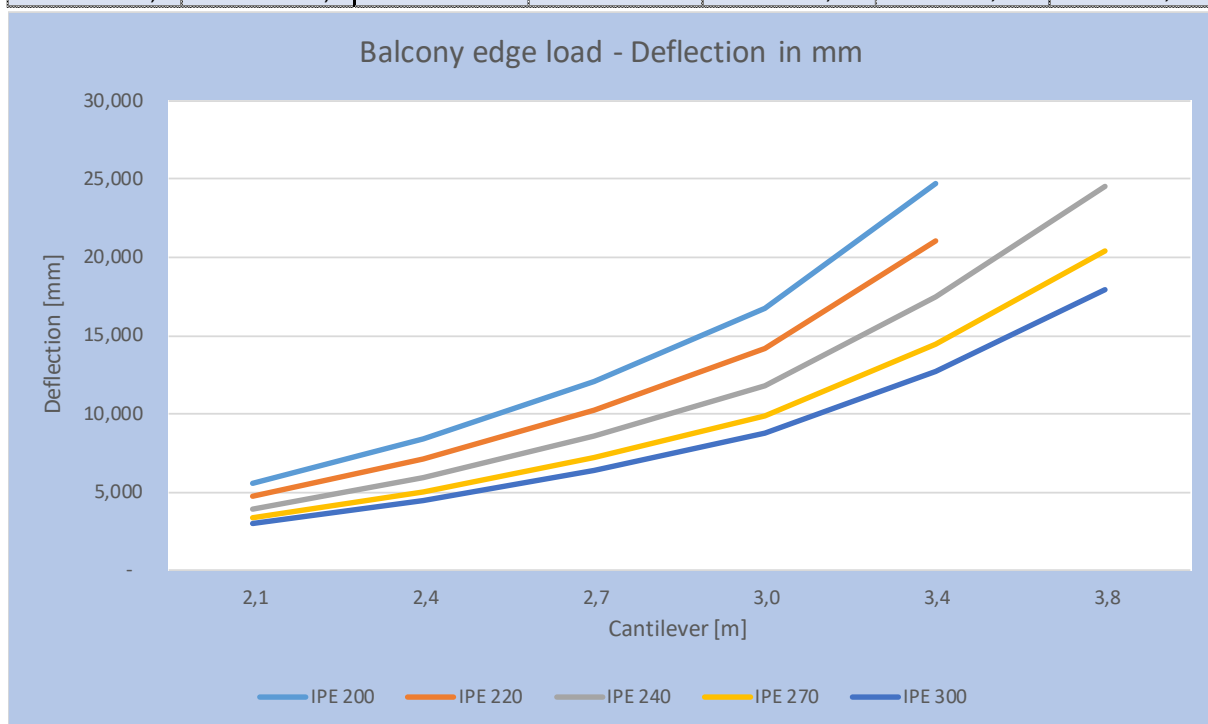
- 1. First find the deflection number in the table, in this case: 5.334 mm.*
- 2. Multiply the deflection number by the balcony length of 3 m and then divide by the number of BWC's which is 2.*
- 3. Current deflection will be: $5.334 \times 3 / 2 = 8.0 \text{ mm}$*

Deflection “Balcony edge load”

The table below shows deflection at different cantilever lengths of IPE profiles when they are exposed to balcony edge load. **NB! The thickness of the wall plate has been increased from 30 to 40 mm compared to the RHS-profiles.**

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

Balcony edge load (1,0 x G) + (1,0 x 2,0 kN) (4,7 kN)						
Cantilever [m]	Recomm. deflec. 1:150	IPE 200	IPE 220	IPE 240	IPE 270	IPE 300
2,1	14,0	5,575	4,731	3,962	3,345	2,982
2,4	16,0	8,430	7,104	5,968	5,029	4,492
2,7	18,0	12,097	10,263	8,555	7,197	6,406
3,0	20,0	16,744	14,207	11,796	9,898	8,777
3,4	22,7	24,708	21,022	17,447	14,469	12,760
3,8	25,3			24,555	20,403	17,961



Deflection example:

Say we have a balcony with a length of 5 m. The cantilever is 2.7 m. IPE 300. We assume 2 BWC's.

1. First find the deflection number in the table, in this case: 6.406 mm.
2. Multiply the deflection number by the balcony length of 5 m and then divide by the number of BWC's which is 2.
3. Current deflection will be: $6.406 \times 5 / 2 = 16.015 \text{ mm}$

Summary of torque and shear forces

It is emphasized that both the coupling and the IPE/ HUP profile exhibit linear elastic behavior, which is a prerequisite for summing and dividing loads, capacities, and deflections.

Combined loads (up to 3.8 m)

Ultimate (fracture) (1,2 x G) + (1,5 x Q) (9,2 kN)

Recom. deflec. 1:150 [mm]	Cantilever [m]	Shear force per 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
22,7	3,4	31,4	53,5
25,3	3,8	35,1	66,8

Characteristic (1,0 x G) + (1,0 x Q) (6,7 kN)

Recom. deflec. 1:150 [mm]	Cantilever [m]	Shear force per m [kN]	Torque control [kNm]
10,0	1,5	10,1	7,5
12,0	1,8	12,1	10,9
14,0	2,1	14,1	14,8
16,0	2,4	16,1	19,3
18,0	2,7	18,1	24,4
20,0	3,0	20,1	30,2
22,7	3,4	22,8	38,8
25,3	3,8	25,5	48,4

Frequent occurrence (1,0 x G) + (0,5 x Q) (4,7 kN)

Recom. deflec. 1:150 [mm]	Cantilever [m]	Shear force per m [kN]	Torque control [kNm]
10,0	1,5	7,1	5,3
12,0	1,8	8,5	7,6
14,0	2,1	9,9	10,4
16,0	2,4	11,3	13,6
18,0	2,7	12,7	17,2
20,0	3,0	14,1	21,2
22,7	3,4	16,0	27,2
25,3	3,8	17,9	34,0

Balcony edge load (1,0 x G) + (1,0 x 2,0 kN) (4,7 kN)

Recom. deflec. 1:150 [mm]	Cantilever [m]	Shear force per m [kN]	Torque control [kNm]
10,0	1,5	4,7	7,1
12,0	1,8	4,7	8,5
14,0	2,1	4,7	9,9
16,0	2,4	4,7	11,3
18,0	2,7	4,7	12,7
20,0	3,0	4,7	14,1
22,7	3,4	4,7	16,0
25,3	3,8	4,7	17,9

NB! For short cantilevers, the shear forces must be controlled.

Fracture (ultimate) limit and applied loads

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

The bolts are required to achieve the specified preload.

Figures used in the analyzes

Cantilever [m]	1,5	1,8	2,1	2,4	2,7	3,0	3,4	3,8
Balcony edge load [N]	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Half payload [N]	2 940	3 540	4 140	4 739	5 339	5 939	6 799	7 599
Characteristic load [N]	5 879	7 079	8 279	9 479	10 679	11 879	13 598	15 198
Fracture load [N]	9 677	11 652	13 627	15 601	17 576	19 485	22 381	25 013

Dead weight is got from the 3D model. The factor 0.2 of deadweight is included as a load in the fracture load.

*Characteristic load is as follows (uses 1.5 m as an example): From the table on page 2, payload [Q] (407.7 kg / m) is obtained. Actual load length on RHS is in reality 0.03 m shorter than the table values indicate (ie 1.47 m): $407.7 * 9.81 * 1.47 m = 5879 N$. Fracture load contains payload [Q] * 1.5 + dead weight supplement [Gt] * 0.2 + dead weight supplement RHS * 0.2. Thus: $(5879 * 1.5) + (276 * 1.47 * 0.2 * 9.81) + (31.8 kg * 0.2 * 9.81) = 9677 N$.*



REVISION		
Date	Description	Sign.
17.12.2019	First release.	OEH
19.02.2020	Correcting shear capacity	OEH
13.03.2020	Completed proofreading	OEH
19.03.2020	Minor corrections. Corrected torque, revision method etc. Added description of characteristic load.	OEH
24.03.2020	Proofreading	OEH
26.03.2020	Updated table p. 4 to current version.	OEH
25.08.2020	Updated drawings pp. 2 and 3	OEH
28.09.2020	Added torque capacity and vertical load capacity	OEH
17.12.2021	Added deflection tables for IPE profiles	OEH
18.01.2022	Added text at the top of page 4, changed text in table p 4. Added explanatory text on pages 5, 6 7, 8, 9, 10, 11 and 12. Added text at the top of page 13.	OEH
19.01.2022	Added text concerning 40 mm plate pp. 9-12.	OEH
24.02.2022	Document translated to English	OEH
01.03.2022	Included loads in kN/m ² in table on page 2. Corrected minor typing error in heading, table page 14.	SSS
01.03.2022	Corrected calculation pp. 5	JB