REPORT

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Date 2015-01-22 Reference 4P05819 Page 1 (6)

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Calculation of purlins

(2 appendices)

1 Introduction

SP Technical Research Institute of Sweden has been commissioned by Olly Terasprofiilid AS to perform structural calculations to define bearing capacity of steel purlins with thin walled cross sections. The profiles are cold-formed from steel plates and the company perform the fabrication according to EN1090. They have engaged Bureau Veritas for certification and will CE-mark the products according to EN1090. The structural calculations have been performed according to Eurocode.

2 References

The assessment has been carried out with references to the following parts of Eurocode:

[1] EN 1993-1-1:2005 Eurocode 3: Design of steel structures – Part 1-**1**: General rules and rules for buildings.
[2] EN 1993-1-3:2006 Eurocode 3: Design of steel structures – Part 1-3: General rules – Supplementary rules for cold-formed members and sheeting.
[3] EN 1993-1-5:2006 Eurocode 3: Design of steel structures – Part 1-5: Plated structural elements.

3 Test object

Two different types of purlins, C-profile and Z-profile, have been evaluated. Figure 1 is showing the type of profiles. The dimensions of the purlins are given in appendix 1.

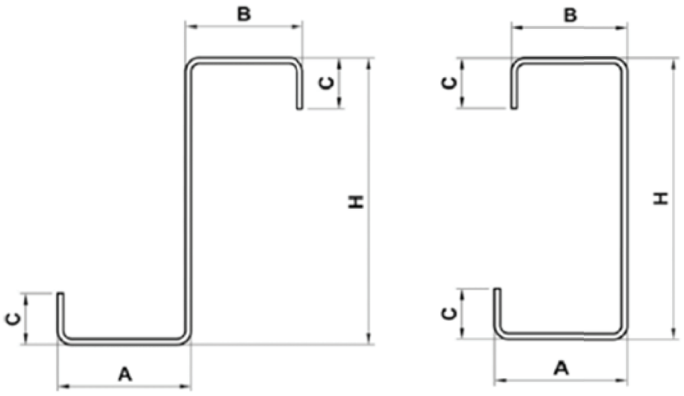

Figure 1 Type of purlins, Z-profile and C-Profile.

4 Calculation

The calculations have been performed according to [1]-[3]. Assumption of sharp edge corners have been made, which are acceptable when the radius for the profiles fulfils the criteria $r \leq 5\ t$ and $r \leq 0.10\ b_p$ (see EN1993-1-3 section 5.1).

The steel quality are S350GD+Z275 which gives the following dimensioning yield strength.

$f_{yk} = 350\ \text{MPa}$

$\gamma_m = 1.1$

$$f_{yd} = \frac{f_{yk}}{\gamma_m} = \frac{350\ \text{MP}a}{1.1} = 318\ \text{MPa}$$

Analytical calculations have been performed by using the commercial mathematical program Mathcad. Calculations for each individual profile are to be find in appendix 2. In accordance with [1]-[3], calculation of the effective area for the profiles has been performed for the following load situations, hole section compressed and upper or bottom flange compressed. Iterative calculations have been used to establish these values. Reduction in load capacity due to local buckling are taken into account by using these calculated effective areas. The dimensions of the flanges are the same for the C- and Z-profiles. Therefore, the result from the stiffest direction calculated for the C-profiles are also used for the Z-profiles.

5 Results

A summary of cross section characteristics are given in table 1 and 2 for the C-profile. For the Z-profile the summary is given in table 3 and 4. More detailed results can be found in appendix 2 for each evaluated profile. Effects of overall buckling are not included in these analyses. The results of the capacity from these calculations can only be directly used for constructions where the compressed flange are fixed sidewise. Otherwise design calculations for the specific situation have to be performed, including effect of flexural, torsional or lateral-torsional buckling.

Clarifications to some characteristics given in the tables.

A_{eff} effective cross-section area for load situations with the whole section in compression, i.e. vertical loading.

$M_{b,Rd}$ max moment capacity calculated as $M_{b,Rd} = f_{yd} W_{zeff}$

Table 1 Cross-sections characteristics for C-profiles part 1 of 2

Geometries					Weigth	Cross section area, gross	Cross-section area, effective	Centre of gravity	Centre of gravity	Moment of inertia, gross	Section modulus, gross
H	t_{nom}	A	B	C	g	A_{gross}	A_{eff}	Y_p	Z_p	I_z	W_z
mm	mm	mm	mm	mm	kg/m	mm^2	mm^2	mm	mm	cm^4	cm^3
100	1.0	45	39	18	1,70	216	141	15,0	48,6	34	6,63
	1.2	45.4	39.4	18	2,03	259	193	15,1	48,6	40,8	7,93
	1.5	46	40	18	2,54	324	267	15,4	48,6	50,8	9,88
	2.0	47	41	18	3,39	432	386	15,8	48,6	67,3	13,1
120	1.0	45	39	18	1,85	236	142	13,7	58,5	52,1	8,48
	1.2	45.4	39.4	18	2,22	283	195	13,9	58,5	62,4	10,2
	1.5	46	40	18	2,78	354	269	14,2	58,5	77,8	12,7
	2.0	47	41	18	3,71	472	393	14,6	58,5	103	16,8
150	1.0	45	39	18	2,09	266	143	12,2	73,3	88,2	11,5
	1.2	45.4	39.4	18	2,50	319	196	12,4	73,3	106	13,8
	1.5	46	40	18	3,13	399	272	12,6	73,3	132	17,2
	2.0	47	41	18	4,18	532	400	13,0	73,3	175	22,9
200	1.5	70	62	26	4,45	567	319	20,4	97,9	345	33,8
	2.0	71	63	26	5,93	756	521	20,8	97,9	459	45
	2.5	72	64	26	7,42	945	705	21,2	97,9	573	56,1
	3.0	73	65	26	8,90	1134	905	21,6	97,9	685	67,1
250	1.5	70	62	26	5,04	642	321	18,1	122,7	585	45,9
	2.0	71	63	26	6,72	856	525	18,5	122,7	778	61,1
	2.5	72	64	26	8,40	1070	718	18,9	122,7	971	76,3
	3.0	73	65	26	10,08	1284	918	19,3	122,7	1163	91,4
300	1.5	89	81	26	6,08	774	331	22,5	147,7	1032	67,7
	2.0	90	82	26	8,10	1032	553	22,8	147,7	1373	90,2
	2.5	91	83	26	10,13	1290	793	23,2	147,7	1714	112,5
	3.0	92	84	26	12,15	1548	1041	23,6	147,7	2053	134,8

Table 2 Cross-sections characteristics for C-profiles part 2 of 2

Geometries		Moment of inertia, effective/ Top flange compressed	Section modulus, effective/ Top flange compressed	Moment of inertia, effective/ Bottom flange compressed	Section modulus, effective/ Bottom flange compressed	Radius of gyration	Max. bending moment, in span/ Top flange compressed	Max. bending moment, in span/ Bottom flange compressed
H	t_{nom}	I_{zeff}	W_{zeff}	I_{zeff}	W_{zeff}	i_z	$M_{b,Rd}$	$M_{b,Rd}$
mm	mm	cm^4	cm^3	cm^4	cm^3	cm	kNm	kNm
100	1.0	32,8	6,51	31,5	6,09	3,97	2,07	1,94
	1.2	40,4	7,87	39,3	7,84	3,97	2,50	2,49
	1.5	50,8	9,88	50,8	9,88	3,96	3,14	3,14
	2.0	67,3	13,1	67,3	13,1	3,95	4,17	4,17
120	1.0	48,3	7,62	47,7	7,5	4,7	2,42	2,39
	1.2	61,8	10,1	60,3	10	4,7	3,21	3,18
	1.5	77,8	12,7	77,8	12,7	4,69	4,04	4,04
	2.0	103	16,8	103	16,8	4,68	5,34	5,34
150	1.0	78,1	9,05	79,1	9,64	5,76	2,88	3,07
	1.2	100	12,1	101	13	5,76	3,85	4,13
	1.5	132	17,2	132	17,2	5,75	5,47	5,47
	2.0	175	22,9	175	22,9	5,74	7,28	7,28
200	1.5	309	27,7	310	28,6	7,81	8,81	9,09
	2.0	459	44,9	450	44,6	7,79	14,28	14,18
	2.5	573	56,1	573	56,1	7,78	17,84	17,84
	3.0	685	67,1	685	67,1	7,77	21,34	21,34
250	1.5	503	33,1	513	36,7	9,55	10,53	11,67
	2.0	745	53,2	751	58,6	9,54	16,92	18,63
	2.5	971	76,3	971	76,3	9,53	24,26	24,26
	3.0	1163	91,4	1163	91,4		29,07	29,07
300	1.5	817	40,8	831	46,6	11,5	12,97	14,82
	2.0	1232	66	1240	75,8	11,5	20,99	24,10
	2.5	1638	98,2	1649	107	11,5	31,23	34,03
	3.0	2053	134,8	2053	134,8	11,5	42,87	42,87

Table 3 Cross-sections characteristics for Z-profiles part 1 of 2

Geometries					Weigth	Cross section area, gross	Cross-section area, effective	Centre of gravity	Centre of gravity	Moment of inertia, gross	Section modulus, gross
H	t_{nom}	A	B	C	g	A_{gross}	A_{eff}	Y_p	Z_p	I_z	W_z
mm	mm	mm	mm	mm	kg/m	mm^2	mm^2	mm	mm	cm^4	cm^3
100	1.0	45	39	18	1,70	216	141	1.,4	48,6	34	6,63
	1.2	45.4	39.4	18	2,03	259	193	1,4	48,6	40,8	7,93
	1.5	46	40	18	2,54	324	267	1,3	48,6	50,8	9,88
	2.0	47	41	18	3,39	432	386	1.2	48,6	67,3	13,1
120	1.0	45	39	18	1,85	236	142	1,2	58,5	52,1	8,48
	1.2	45.4	39.4	18	2,22	283	195	1,2	58,5	62,4	10,2
	1.5	46	40	18	2,78	354	269	1,1	58,5	77,8	12,7
	2.0	47	41	18	3,71	472	393	1,0	58,5	103	16,8
150	1.0	45	39	18	2,09	266	143	1.0	73,3	88,2	11,5
	1.2	45.4	39.4	18	2,50	319	196	1.0	73,3	106	13,8
	1.5	46	40	18	3,13	399	272	0.9	73,3	132	17,2
	2.0	47	41	18	4,18	532	400	0.8	73,3	175	22,9
200	1.5	70	62	26	4,45	567	319	1,5	97,9	345	33,8
	2.0	71	63	26	5,93	756	521	1,4	97,9	459	45
	2.5	72	64	26	7,42	945	705	1,3	97,9	573	56,1
	3.0	73	65	26	8,90	1134	905	1,2	97,9	685	67,1
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	2.0	71	63	26	6,72	856	525	1,1	122,7	778	61,1
	2.5	72	64	26	8,40	1070	718	1,0	122,7	971	76,3
	3.0	73	65	26	10,08	1284	918	0,8	122,7	1163	91,4
300	1.5	89	81	26	6,08	774	331	1,3	147,7	1032	67,7
	2.0	90	82	26	8,10	1032	553	1,1	147,7	1373	90,2
	2.5	91	83	26	10,13	1290	793	1,0	147,7	1714	112,5
	3.0	92	84	26	12,15	1548	1041	0,8	147,7	2053	134,8

Table 4 Cross-sections characteristics for Z-profiles part 2 of 2

Geometries		Moment of inertia, effective/ Top flange compressed	Section modulus, effective/ Top flange compressed	Moment of inertia, effective/ Bottom flange compressed	Section modulus, effective/ Bottom flange compressed	Radius of gyration	Max. bending moment, in span/ Top flange compressed	Max. bending moment, in span/ Bottom flange compressed
H	t_{nom}	I_{zeff}	W_{zeff}	I_{zeff}	W_{zeff}	i_z	$M_{b,Rd}$	$M_{b,Rd}$
mm	mm	cm^4	cm^3	cm^4	cm^3	cm	kNm	kNm
100	1.0	32,8	6,51	31,5	6,09	3,97	2,07	1,94
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	1.5	50,8	9,88	50,8	9,88	3,96	3,14	3,14
	2.0	67,3	13,1	67,3	13,1	3,95	4,17	4,17
120	1.0	48,3	7,62	47,7	7,5	4,7	2,42	2,39
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	1.5	77,8	12,7	77,8	12,7	4,69	4,04	4,04
	2.0	103	16,8	103	16,8	4,68	5,34	5,34
150	1.0	78,1	9,05	79,1	9,64	5,76	2,88	3,07
	1.2	100	12,1	101	13	5,76	3,85	4,13
	1.5	132	17,2	132	17,2	5,75	5,47	5,47
	2.0	175	22,9	175	22,9	5,74	7,28	7,28
200	1.5	309	27,7	310	28,6	7,81	8,81	9,09
	2.0	459	44,9	450	44,6	7,79	14,28	14,18
	2.5	573	56,1	573	56,1	7,78	17,84	17,84
	3.0	685	67,1	685	67,1	7,77	21,34	21,34
250	1.5	503	33,1	513	36,7	9,55	10,53	11,67
	2.0	745	53,2	751	58,6	9,54	16,92	18,63
	2.5	971	76,3	971	76,3	9,53	24,26	24,26
	3.0	1163	91,4	1163	91,4		29,07	29,07
300	1.5	817	40,8	831	46,6	11,5	12,97	14,82
	2.0	1232	66	1240	75,8	11,5	20,99	24,10
	2.5	1638	98,2	1649	107	11,5	31,23	34,03
	3.0	2053	134,8	2053	134,8	11,5	42,87	42,87

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Appendices

1. Dimensions of purlins (1 page)
2. Calculations of capacity for purlins. (302 pages)