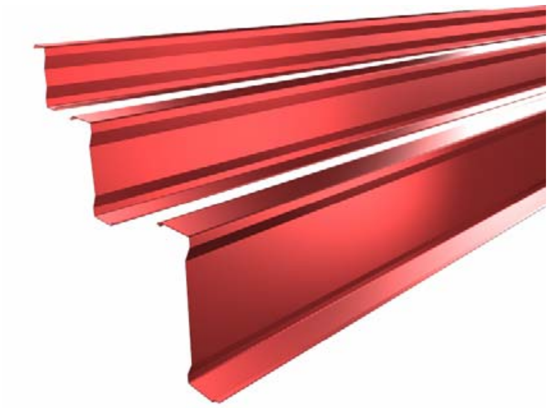
Z-PURLINS



TECHNICAL DOCUMENTATION

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APPENDIX **A**: Factory engineering standard sheet

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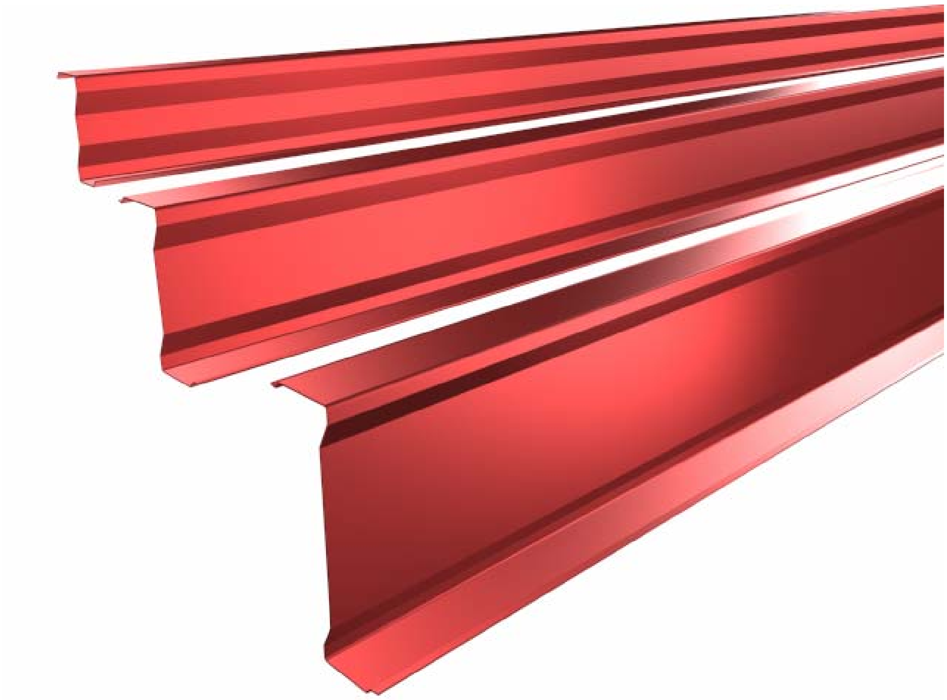
Status: June 1998, revised May 2000.

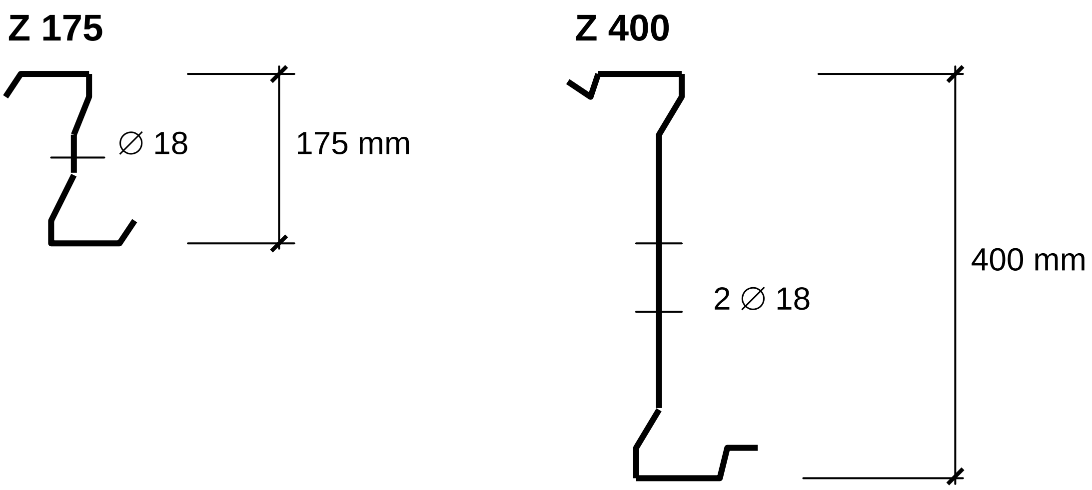
1. Description, application area:

ZEMAN – Z – PURLINS are thin-gauge lightweight construction elements produced by roll forming which are mainly used as roof purlins, but also as secondary girders.



Profile forms particularly aiming at the optimization of the carrying capacity values render the exceptionally favorable weight / capacity ratio of these construction elements.

Z – purlins can be produced in an infinite variation, ranging from the smallest to the largest possible profile type, and in different overall heights.



Available sheet thickness: 1.5 mm, 2.0 mm and 2.5 mm.

Please see factory engineering standard sheets 012, 013, 014 in appendix A for dimensions and degrees of sheet thickness for the standard delivery program.

2. Basics of calculation, standard references :

Basic static calculations of purlin profiles and the preparation of load tables were carried out by the expert- and engineer partnership "DAS KOLLEGIUM LEICHTBAU" (Collegium Light Weight Construction) based on ENV 1993-1-3 (status 01.93).

The characteristic constructed section properties for standard section depths are summarized in **table 1.**

Stabilization of the purlin top flange by the roof sheeting is a precondition for the use of lightweight purlins. Hence calculations stipulated that the purlin top flanges on the roof level should be supported sufficiently by trapezoidal sheet panels or sandwich elements. The bearing capacity values have to be reduced accordingly for other, less rigid, roofing (e.g. trapezoidal sheets with thermal insulation or fiber-cement slabs sandwiched between purlin and trapezoidal sheet).

Usually lightweight purlins are only verified for bending – with or without additional normal force – vertical to roof resp. wall level ("bound bending"). The compensation of loads parallel to the roof level (roof shear force) has to be ensured resp. verified separately by means of constructive measures.

The **roof shear force** can be calculated with the following formulas.
For surcharge:

$$q_{II} = (k_{II}.\cos\beta - \sin\beta \pm 0.03)q_A$$

and for suction load (simplified):

$$qII = (kII \pm 0.03)qS$$

with:

q_{II}	roof shear force; positive, if directed towards ridge
β	roof pitch
q_A	surcharge, vertical to horizontal
q_S	suction load, vertical to roof level ($q_S \leq 0$)
k_{II}	auxiliary variable

The minimum and maximum values for k_{II} for standard trapezoidal metal plate covering were evaluated in **table 2**. Thereby *min* k_{II} are valid for positive position (= broad flange up) and *max* k_{II} for negative position (= broad flange down) of the trapezoidal sections.

The following constructive measures can be considered for the absorption of roof shear force:

- Normal force transmit through roofing and ridge coupling along the entire length of the building, or
- Formation of the roof sheeting as shear zone, whereby the absorption of support reactions of the roof plate has to be verified separately.

TABLE 1: Characteristic section properties

According to static calculations [1], [2], and [3].

In the following tables these values describe

$J_{y,Br}$ moment of inertia of the gross cross-section in relation to the axis parallel to the flange
min $J_{y,\,ef}$ effective moment of inertia for the calculation of deflections
min W_y moment of resistance for the boundary state of the load-bearing capacity
A_{ef} effective cross section area under centric pressure
N_{Rk} characteristic value of resistance at bending
min $M_{y,Rk}$ characteristic value of resistance at bending
V_{Rk} characteristic value of resistance caused by shear force

Profile type	**PROFILE Z 175**			**PROFILE Z 200**		
t_N [mm]	**1.50**	**2.00**	**-**	**1.50**	**2.00**	**2.50**
$J_{y,Br}$ [cm^4]	229.8	304.4	-	381.5	505.7	626.5
min $J_{y,ef}$ [cm^4]	197.1	273.3	-	323.2	457.1	581.1
min W_y [cm^3]	20.57	30.32	-	28.89	43.25	57.41
A_{ef} [cm²]	3.94	5.73	-	4.50	6.83	9.15
N_{Rk} [kN]	126.1	183.2	-	144.1	218.4	292.8
min $M_{y,Rk}$ [kNm]	6.58	9.70	-	9.28	13.84	18.37
V_{Rk} [kN]	34.68	59.77	-	34.55	59.60	89.76

Profile type	**PROFILE Z 250**			**PROFILE Z 300**		
t_N [mm]	**1.50**	**2.50**	**3.00**	**1.50**	**2.50**	**3.00**
$J_{y,Br}$ [cm^4]	957.2	1118.0	1414.0	1553.0	1930.0	2300.0
min $J_{y,ef}$ [cm^4]	814.2	1056.0	1283.0	1281.0	1674.0	2041.0
min W_y [cm^3]	58.69	79.25	99.75	75.28	101.8	129.2
A_{ef} [cm²]	6.82	9.50	12.20	6.77	9.51	12.44
N_{Rk} [kN]	218.4	303.9	390.3	216.8	304.2	398.1
min $M_{y,Rk}$ [kNm]	18.78	25.36	31.92	24.09	32.58	41.34
V_{Rk} [kN]	59.21	90.45	127.9	53.81	89.92	127.2

Profile type	**PROFILE Z 175**			**PROFILE Z 400**		
t_N [mm]	**1.50**	**2.50**	**3.00**	**1.50**	**2.50**	**3.00**
$J_{y,Br}$ [cm^4]	2228.0	2771.0	3305.0	3055.0	3802.0	4536.0
min $J_{y,ef}$ [cm^4]	1838.0	2406.0	2931.0	2495.0	3297.0	4025.0
min W_y [cm^3]	90.68	125.1	159.1	105.9	146.7	189.9
A_{ef} [cm²]	6.76	9.51	12.48	6.73	9.49	12.49
N_{Rk} [kN]	216.3	304.3	399.5	215.5	303.7	399.5
min $M_{y,Rk}$ [kNm]	29.02	40.05	50.90	33.89	46.94	60.78
V_{Rk} [kN]	45.49	84.98	126.6	39.3	73.51	122.7

TABLE 2: **Auxiliary values for the calculation of roof shear force and forces on connecting devices**
According to static calculations [1], [2], and [3].

PROFILE	t_N [mm]	$2k_{h,a}$ [-]	min k_{II} *) [-]	max k_{II} *) [-]	K_{VS} [-]
Z 175	**1.5**	0.041	0.016	0.026	1.37
	2.0	0.038	0.014	0.024	1.38
Z 200	**1.5**	0.146	0.059	0.086	1.27
	2.0	0.141	0.057	0.084	1.26
	2.5	0.137	0.055	0.082	1.26
Z 250	**2.0**	0.168	0.071	0.097	1.18
	2.5	0.165	0.069	0.096	1.18
	3.0	0.161	0.068	0.094	1.19
Z 300	**2.0**	0.162	0.069	0.093	1.19
	2.5	0.160	0.070	0.090	1.18
	3.0	0.157	0.067	0.090	1.20
Z 350	**2.0**	0.133	0.057	0.076	1.21
	2.5	0.130	0.055	0.075	1.21
	3.0	0.128	0.054	0.073	1.21
Z 400	**2.0**	0.111	0.047	0.063	1.22
	2.5	0.109	0.046	0.062	1.22
	3.0	0.107	0.045	0.061	1.23

Remarks: *) applies to positive position (= broader flange up)
**) applies to negative position (= broader flange down)

In addition to the strain caused by external loads (e.g. snow, roof live load, wind, etc.) the connecting devices between purlin and roof sheeting are further loaded by forces resulting from the stabilization of the purlins.

Forces on connecting devices:
Results for surcharge:

$$q_{h,A} = (2 \,.\, k_{h,A} \,.\, \cos \quad \pm 0.03) q_A$$

$$q_{u,A} = 0$$

and for suction load:

$$q_{h,S} = (2 \,.\, k_{h,A} \pm 0.03) q_S$$

$$q_{u,S} = k_{V,S} \,.\, / q_S /$$

with:
- q_h Roof parallel load for verification of connecting devices
- q_u Load for calculation of tensile force in the connecting devices
- q_A surcharge, vertical to horizontal
- q_S suction load, vertical to roof area
- $k_{h,A}$ auxiliary value according to table 2
- $k_{V,S}$ auxiliary value according to table 2

Depending on the structural formation of the roof the parallel bolt forces have to be superimposed by strain caused by the compensation of the roof share force.

For optimal utilization of lightweight purlins the area above the supporting girders is usually strengthened with additional reinforcement or – as in case of ZEMAN Z- PURLINS – by overlapping profiles. Various ways of overlapping are described under Laying patterns, appendix C.

Collegium Light Weight Construction has also drawn up design tables for the laying patterns described in Appendix C, which allow direct reading of the allowable load in kN/m for spans from 2.75 to 10 m. Appendix B presents these load tables in a practicable range from 4.5 m to 8 m.

Preconditions for the use of the load tables in Appendix B are summarized in section 7.

Appendix D represents a summarized model calculation.

Standards:

[ ] ENV 1993-1-1, Eurocode 3: Design and construction of steel structures. Part 1.1: general design rules, design rules for building construction.

[ ] ENV 1993-1-3, Eurocode 3: Design and construction of steel structures. Part 1.3: general rules – supplementary rules for cold finished thin-walled construction elements and sheets.

Calculations [1] to [3] are based on Eurocode, status January 1993.

[ ] DASt-Ri. 103: National application document (NAD) of DIN V ENV 1993-1-1 Eurocode 3. Directive for application of DIN V ENV 1993-1-1 Eurocode 3: Design and construction of steel structures. Part 1.1: general design rules, design rules for building construction. Cologne 1993.

Report:

[1] Static calculation no. 92/212/1, Characteristic cross section and bearing capacity values for Zeman purlins Z 175/t, Z 250/t, Z 300/t and Z 400/t“, put forward by Collegium Light Weight Construction, 12.09.1994.

[2] Static calculation no. 92/212/2, Characteristic cross section and bearing capacity values for Zeman purlins Z 175/t, Z 250/t, Z 300/t and Z 400/t“, put forward by Collegium Light Weight Construction, 23.09.1994.

[3] Static calculation no. 92/212/3, Characteristic cross section and bearing capacity values for Zeman purlins Z 175/t, Z 250/t, Z 300/t and Z 400/t“, put forward by Collegium Light Weight Construction, 18.04.1995.

3. Standard delivery program:

The standard delivery program comprises the following purlin profiles:

Profile	Sheet thickness			Web punching ∅ mm	Cast purlin fasteners cf. chapter 6
	1.5 mm	**2.0 mm**	**2.5 mm**		
Z 175	**X**	**X**		1 x 18	--
Z 200	*X*	**X**	**X**		X
Z 250		**X**	**X**	2 x 18	X
Z 300		**X**	**X**		--
Z 350		**X**	**X**		--
Z 400		**X**	**X**		--

Please refer to factory engineering standard sheets in Appendix A for the exact dimensions of the purlins and the possible web punching patterns.

4. Material:

The purlins are made of steel Fe 320 G according to EN 10147.

Elastic limit: $f_y \geq 320$ N/mm²
Tensile strength: $f_u \geq 390$ N/mm²

5. Corrosion protection:

The purlins are conveyor galvanized, grade Z 275 in accordance with EN 10147.

6. Allowable variations:

The stipulations of ENV 1090-2, section 11.2 are applicable.

However, the allowable variations of cross section shape were partly limited compared to ENV 1090-2 and are specified for production quality control in a separate factory engineering standard.

[ ] ENV 1090-2 (1998): Execution of steel load bearing structures – part 2: supplementary rules for cold finished thin-walled construction elements and sheets.

7. Quality control:

In addition to self-monitoring constant quality control as defined under RAL-RG 617 by the GERMAN INSTITUTE FOR QUALITY CONTROL AND is carried out. At preparation of this documentation the authority carrying out these surveillance tests is the “Landesmaterialprüfamt LMPA” (local material testing institute) Sachsen-Anhalt in Magdeburg, Germany.

8. Purlin fasteners:

TYPE 1 for purlins Z 200/t

TYPE 2 for purlins Z 250/t

Purlin fasteners made of cast steel (construction material GTS 35) for the most common purlin profiles
(Z 200/t and Z 250/t) with two pitches each at the base of the purlin fasteners, are available for the requirements of different girder profiles.

The exact dimension details can be found in the factory engineering standard sheets G 200/70, G 200/110, G 250/70 and G 250/110 in Appendix A.

Welded purlin fasteners have to be used for other purlin profiles. These may be delivered by the manufacturer or produced by the user. The latter is particularly useful if the purlin fasteners are built to the steel substructure.

Technical drawings for such welded purlin fasteners are available on request.

9. Dimensioning by means of load tables:

9.1. Preconditions for the use of load tables:

(1) The purlin top flanges are sufficiently supported at the roof level, e.g. by means of trapezoidal sections or sandwich elements.

(2) The connection of the purlins with the roofing resp. the wall covering features the following minimum values for non-dimensional connecting rigidity:

- Surcharge: $minc_{\delta A}$ = 2000 Nm/m/rad
- Suction load: $minc_{\delta A}$ = 1700 Nm/m/rad

(3) The purlin fasteners serve as suspending support for the purlins to avoid the support reaction being effective as concentrated load through the edge web/flange.

(4) The purlins are built in with the top flanges orientated towards the ridge.

(5) For static verification loads vertical to the laying area have to be compared to the allowable loads in the design tables. Loads effective parallel to the laying area (e.g. roof shear force) have to be verified separately. (see also previous remarks as well as model calculations in Appendix D).

(6) The space between the connecting points of the profiles and the purlin fasteners has to be assumed as spacing of the columns. The tables may in terms of approximation also be used
for multi-span girders with different spans, in case the spans do not vary by more than 20% and the tables are evaluated for the largest occurring spans.

(7) The tables for overlapping systems are valid for girders with a minimum of 3 spans only.

(8) The bolts at the lap ends of overlapping girders must at least reach the load bearing capacity of bolts M16 5.6. Starting with purlin type Z 250 a minimum of 2 bolts per overlap point must be used. The minimum load bearing length of the overlapping must be 535 mm.

(9) Allowable loads for surcharge already include the dead load of the purlins. In case of lateral loads and the use of sections as secondary girders, the allowable uniform loads may be increased by their own weight.

9.2. Further required verification:

On application of the load tables the following verifications have **not been taken into account** and must therefore be carried out individually:

(1) During construction safety against overturning is low before connecting the roofing with the purlins, so that the purlins might have to be stabilized by means of adequate provisions. It has to be examined individually whether verification for a progressive single load of 1.0 kN (manload) e.g. in accordance with DIN 1055 part 3, section 6.2.1, has to be considered.

(2) Calculations of the allowable load do not take into account roof shear force, which is compensated by a corresponding structural formation of the roof and has to be verified individually. Thereby sufficient dimensioning of the connecting devices has to be considered. Chapter 2 and the related model calculation in APPENDIX D contain remarks for calculating the extent of the roof shear force.

(3) The purlin fasteners and the connection of the purlins to the purlin fasteners have to be verified separately. When normal forces are transmitted through overlapping purlins it is presumed that the normal force is not passed on at the purlin fasteners. Hence the normal force has to be taken into account for verification of this connection.