SCADA Pro™ 18
Structural Analysis & Design

User's Manual
C. COLD FORMED STEEL

ACE HELLAS
INTEGRATED SOLUTIONS

CONTENTS

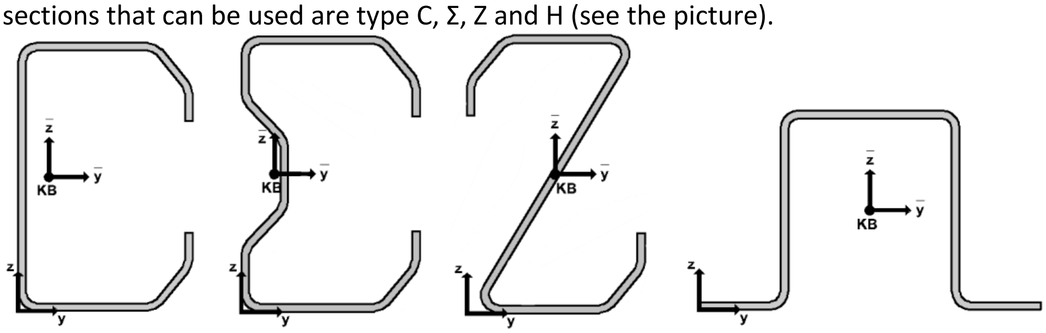
1. Cold Formed Steel Sections

The main feature of the cold formed steel sections is the production process and the small thickness. These characteristics dictate some variations from our previously known process of analysis and designing of warm formed steel sections. A number of cross-sections can be found on the market, however, the use of cold formed elements is generally limited due to the sense that they are ancillary elements. The reality is different, however, as apart from purlins/girders they can also be used as main load-bearing members. Due to the lack of plastification, they are designed for practically elastic behavior along with respective seismic behavior coefficients.
In the current SCADA Pro version cold formed steel sections:

- They consist of a different module than the other steel sections
- Can be used for all structural elements (not only purlins/griders)
- Are checked based on EC3-1-3

2. Available sections

The sections that can be used are type C, Σ, Z and H (see the picture).



Section C Section Σ Section Z Section H

The cross sections may be either not reinforced or have single or double end reinforcements (see figure below). The bending angle of the reinforcements and the trunk of the Z sections are also parametrically defined.

Note that this parametric feature is not a user-specific feature but concers the code in the program. The user can only place **ready-made profiles** specified by the manufacturer (and us) and **cannot modify them**.
The library includes cross sections of Greek and foreign companies.
More specifically:

Greek Companies	Foreign Companies
ELASTRON	*METSEC*

KAMARIDIS *ARKHON*	*SADEF* *BOUWEN MET STAAL* *RUUKKI*

3. Geometrical proportions

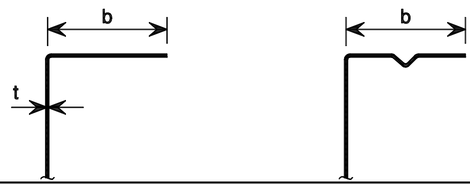
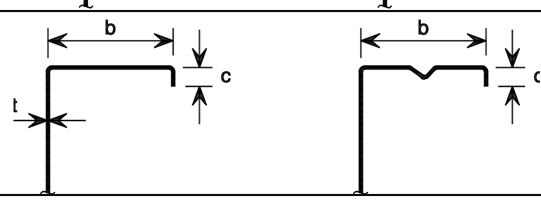
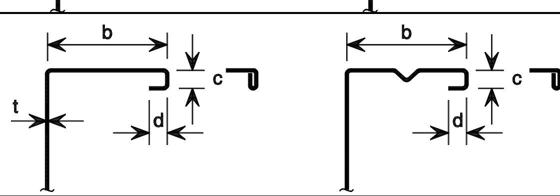
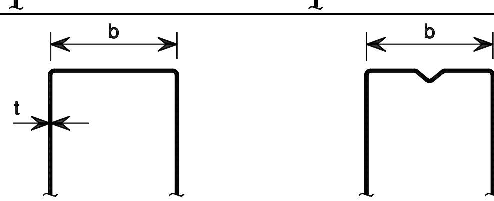
The design provisions based on EC3-1-3 calculations are valid only for width-thickness cross-sections ratios b/t, h/t, c/t και d/t within the limits of the following Table.
The limits for the reasons given are considered to represent the field for which there are sufficient experience and verification through experimental results. Cross sections with a larger width to thickness ratios may also be used, provided their ultimate limit state strength and their ultimate serviceability state behavior are verified, based on experiments and/or calculations, confirmed by an appropriate number of experiments.

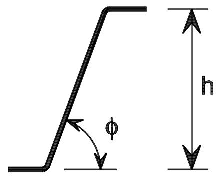
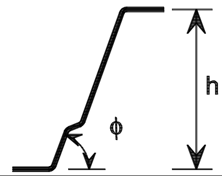
The dimensions of the reinforcements must be within the following limits, so as to provide sufficient stiffness and to prevent buckling of the reinforcement itself

$$0,2 \leq c / b \leq 0,6$$
$$0,1 \leq d / b \leq 0,3$$

If c / b < 0,2 ή d / b < 0,1 the lip is ignored and set equal to c = 0 or d = 0.

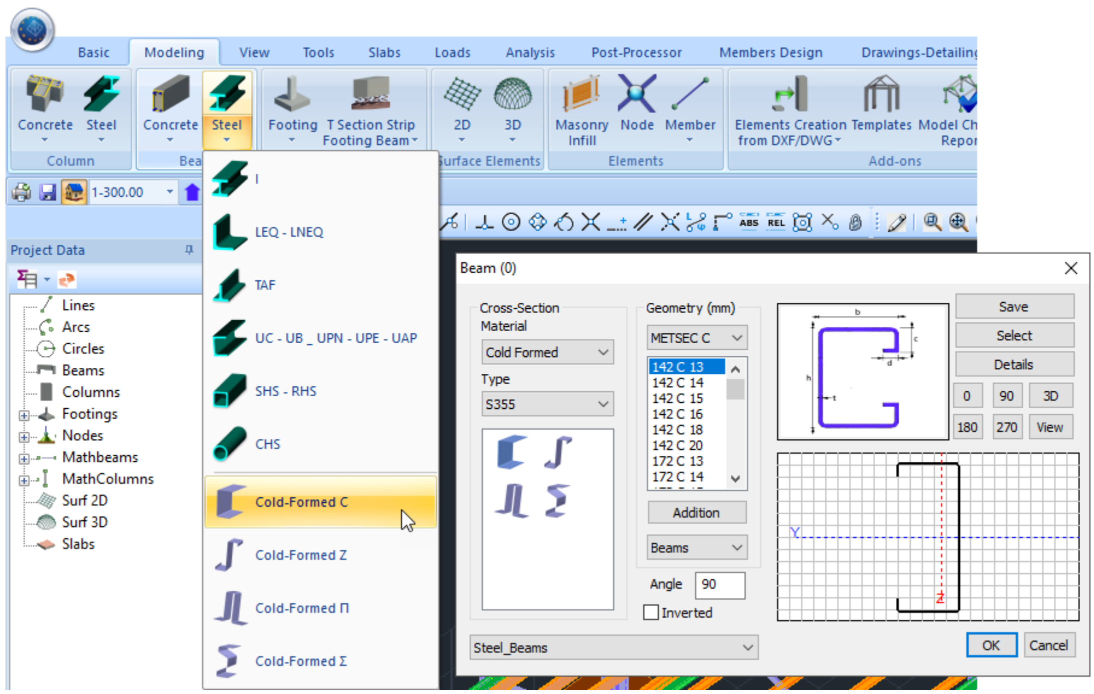
NOTE: Based on EC3-1-3 the lip length c is measured vertically on the flange in case that the lip is not perpendicular to the flange. However, in SCADA Pro, the angled length is taken into account, not the projection

Sections Data	Max Value
	$b / t \leq 50$
	$b / t \leq 60$ $c / t \leq 50$
	$b / t \leq 90$ $c / t \leq 60$ $d / t \leq 50$
	$b / t \leq 500$

 	$45^\circ \leq \phi \leq 90^\circ$ $h / t \leq 500 \sin\phi$

4. Modeling

The data is imported in a manner similar to that of the warm formed elements. For both beams and columns, cross sections have been placed in a new category called "Cold Formed".



In the window which is displayed we select:

- **Cross-Section Type**
- **Company**
- **Cross-Section**
- **Material**
- **Quality**

5. Analysis

Based on the EC3-1-3 for the analysis, the properties of the cross sections must be modified, taking into account the influence of the rounded corners.

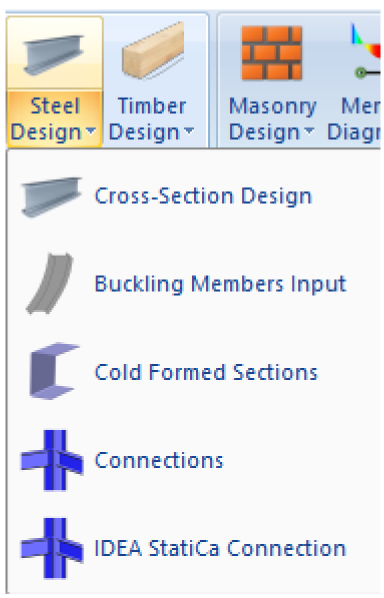
The properties of the original cross section are used in the SCADA Pro without modifying the inertial characteristics. Cross-section's transformation into a virtual one with sharp corners as well as the influence of the rounded corners is considered only in designing.

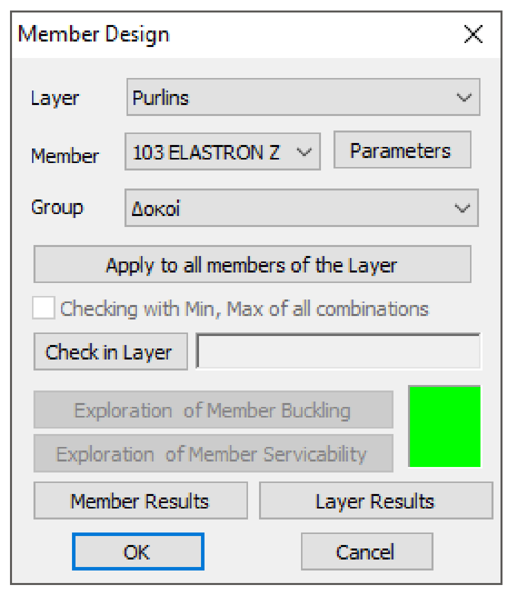
6. Members design

The design of cold formed sections concerns the:

- **Resistance check in cross sections**
- **Resistance check in members**
- **Serviceability check**

The main difference between the warm formed and the cold forms sections elements are that cross-sections' and members' checks are now done with **a common command** (see figure) rather than separately. An important feature is that all members and their cross sections are checked **for all combinations**.





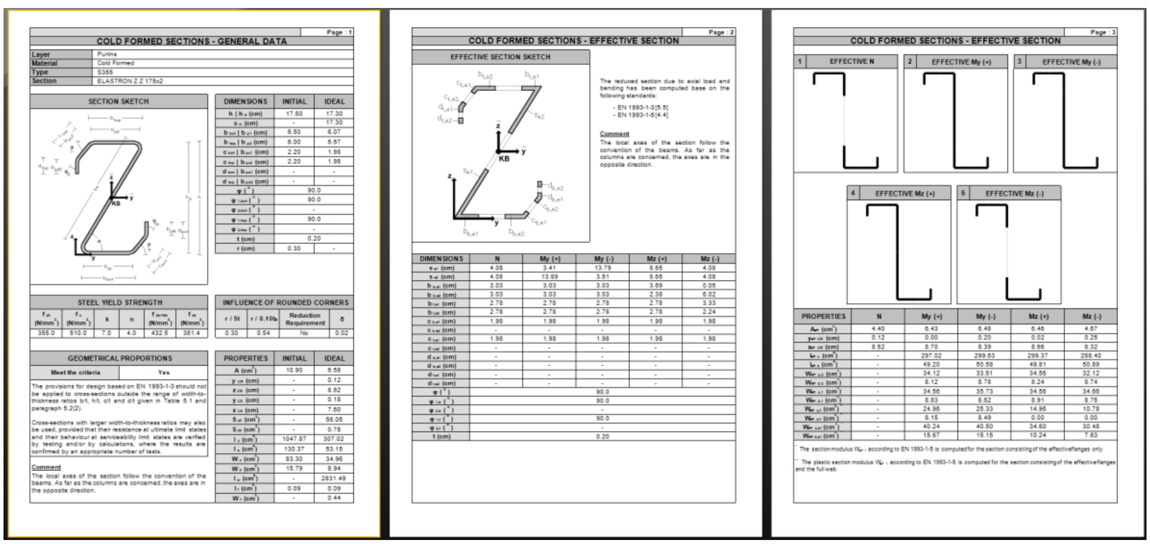
For the rest, the steps to design are the same as those for warm formed elements (per layer, members' merge, buckling parameters, etc.).

7. Design printouts

The design results are displayed either per member or per layer. In the second and more general case, the printout's form is the following:

1. **Page 1: General cross-section 1 data**
   Information about dimensions and properties of the initial and virtual cross-section
2. **Page 2: Active cross-section 1 (A part)**
   Information about N, My, and Mz ratios of active cross section dimensions
3. **Page 3: Active cross-section 1 (B part)**
   Information about N, My and Mz ratios of active cross-section properties
4. **Page 4: Cross-Section check for the 1st member with cross-section 1**
   Resistance checks based on §6.1
5. **Page 5: Member check for the 1st member with cross-section1**
   Resistance checks based on §6.2 & 6.3 and serviceability check based on §7
6. **Repeat steps 4 & 5 :**
   If multiple members have the same cross section within the layer.
7. **Repeat steps 1 to 6:**
   In case of multiple cross sections within the layer.

The printout per layer can also be extracted while creating the **Design Printout**.
(See "Cold Formed sections" in the User's manual)



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COLD FORMED ELEMENTS DESIGN
SECTION CHECK (EN 1993-1-3)

Memb.	103	Node i	51	Node j	56
		Initial Length L		300.00	cm

ELEMENT MERGE DATA			
Merge L_{y-y}			cm
Merge L_{zz}			cm

Edge	Rigid Offsets dX (cm)	dY (cm)	dZ (cm)	Member Releases N	V_y	V_z	M_x	M_y	M_z
i	0.00	0.00	0.00						
j	0.00	0.00	0.00						

AXIAL LOAD CHECK

TENSION (§ 6.1.2)		COMPRESSION (§ 6.1.3)	
Comb.	-1	Comb.	53
N_{Ed} (kN)	0.00	N_{Ed} (kN)	-0.17
A_g (cm²)	0.00	A_{eff} (cm²)	4.40
$F_{n,Rd}$ (kN)	-	$\lambda_{e,max}/\lambda_{e0}$	2.78
$N_{t,Rd}$ (kN)	0.00	$N_{c,Rd}$ (kN)	156.21
$N_{Ed}/N_{t,Rd}$	0.00	$N_{Ed}/N_{c,Rd}$	0.00
SUFFICIENCY		SUFFICIENCY	Yes

BENDING CHECK (§ 6.1.4)

	y-y	z-z
Comb.	1	65
M_{Ed} (kN)	-0.11	-0.11
W_{el} (cm³)	33.61	8.74
M_{Rd} (kNm)	11.93	3.10
Flange	Compressed	Compressed
M_{Ed}/M_{Rd}	0.01	0.04
SUFFICIENCY	Yes	Yes

TORSION CHECK (§ 6.1.6)

	Direct	Shear	Von Mises
Comb.	65	60	65
Design(MPa)	11.74	0.80	13.87
Capacity(MPa)	381.39	220.19	419.52
Design / Capacity	0.03	0.00	0.03
SUFFICIENCY	Yes	Yes	Yes

It should apply:
$\sigma_{tot,Ed} = \sigma_{N,Ed} + \sigma_{My,Ed} + \sigma_{Mz,Ed} + \sigma_{w,Ed} \leq f_{ya}/\gamma_{M0}$
$\tau_{tot,Ed} = \tau_{Vy,Ed} + \tau_{Vz,Ed} + \tau_{t,Ed} + \tau_{w,Ed} \leq (f_{ya}/\sqrt{3})/\gamma_{M0}$
$\sqrt{\sigma_{tot,Ed}^2 + 3\tau_{tot,Ed}^2} \leq 1.1 f_{ya}/\gamma_{M0}$

SHEAR CHECK (§ 6.1.5)

	y-y	z-z
Comb.	65	1
V_{Ed} (kN)	-0.10	0.20
Stiffening	NO	NO
Number of Webs	2.00	1.00
$V_{b,Rd}$ (kN)	47.90	47.91
$V_{Ed}/V_{b,Rd}$	0.00	0.00
SUFFICIENCY	Yes	Yes

CHECK OF COMBINED TENSION & BENDING (§ 6.1.8)

AXIAL N (kN)		MOMENT My (kNm)		MOMENT Mz (kNm)		Combination
N_{Ed}	0.00	$M_{y,Ed}$	0.00	$M_{z,Ed}$	0.00	-1
$N_{t,Rd}$	0.00	$M_{y,Rd}$	0.00	$M_{z,Rd}$	0.00	SUFFICIENCY
Combination Criterion Equation				Result	0.00	

CHECK OF COMBINED COMPRESSION & BENDING (§ 6.1.9)

AXIAL N (kN)		MOMENT My (kNm)		MOMENT Mz (kNm)		Combination
N_{Ed}	-0.05	$M_{y,Ed}$	0.00	$M_{z,Ed}$	-0.11	65
		$\Delta M_{y,Ed}$	0.00	$\Delta M_{z,Ed}$	0.00	
$N_{c,Rd}$	156.21	$M_{y,Rd}$	12.11	$M_{z,Rd}$	3.10	SUFFICIENCY
Combination Criterion Equation			...(6.25)	Result	0.04	Yes

CHECK OF COMBINED SHEAR, AXIAL LOAD & BENDING (§ 6.1.10)

SHEAR Vz (kN)		AXIAL N (kN)		MOMENT My (kNm)				Combination
$V_{z,Ed}$	0.15	N_{Ed}	-0.10	$M_{y,Ed}$	-0.08	$W_{f,Rd}$	25.33	101
$V_{w,Rd}$	47.91	N_{Rd}	156.21	$M_{y,Rd}$	11.93	$W_{pl,Rd}$	40.50	SUFFICIENCY
Combination Criterion Equation						Result	0.00	Yes
SHEAR Vy (kN)		**AXIAL N (kN)**		**MOMENT Mz (kNm)**				**Combination**
$V_{y,Ed}$	0.03	N_{Ed}	-0.10	$M_{z,Ed}$	-0.01	$W_{f,Rd}$	0.00	101
$V_{w,Rd}$	47.90	N_{Rd}	156.21	$M_{z,Rd}$	3.10	$W_{pl,Rd}$	7.63	SUFFICIENCY
Combination Criterion Equation						Result	0.00	Yes

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COLD FORMED ELEMENTS DESIGN
ELEMENT CHECK (EN 1993-1-3)

FLEXURAL (F), TORSIONAL (T) & TORSIONAL-FLEXURAL (TF) BUCKLING UNDER AXIAL LOAD (§6.2.2 & §6.2.3)

Quantity	(K) y-y	(K) z-z	(Σ)	(ΣK)
L_{cr} (cm)	300.00	300.00	300.00	300.00
Curve	b			
Imp. factor α	0.34			
Comb.	53	53	53	53
N_{Ed} (kN)	-0.17	-0.17	-0.17	-0.17
N_{cr} (kN)	707.04	122.41	130.05	130.05
N_{Ed}/N_{cr}*	0.00	0.00	0.00	0.00
λ_1	76.40	76.40	76.40	76.40
λ_bar*	0.47	1.13	1.10	1.10
Φ	0.66	1.30	1.25	1.25
χ	0.90	0.52	0.54	0.54
$N_{b,Rd}$ (kN)	140.16	80.87	83.98	83.98
$N_{Ed}/N_{b,Rd}$	0.00	0.00	0.00	0.00
SUFFICIENCY	Yes	Yes	Yes	Yes

LATERAL-TORSIONAL BUCKLING UNDER BENDING (§6.2.4)

Quantity	
L_{cr} (cm)	300.00
Curve	b
Imp. factor α	0.34
Comb.	1
$M_{y,Ed}$ (kNm)	-0.11
M_{cr} (kNm)	380.37
$M_{y,Ed}/M_{cr}$**	0.00
$W_{eff,y}$ (cm³)	33.61
λ_{LT}_bar**	1.77
Φ_{LT}	2.34
χ_{LT}	0.26
$M_{b,Rd}$ (kNm)	309.28
$M_{y,Ed}/M_{b,Rd}$	0.00
SUFFICIENCY	Yes

Comment
*If $N_{Ed}/N_{cr} \leq 0.04$ or λ_bar ≤ 0.2 buckling effects may be ignored.

**If $M_{y,Ed}/M_{cr,y} \leq 0.04$ or λ_{LT}_bar ≤ 0.2 buckling effects may be ignored.

CHECK OF COMBINED BENDING & COMPRESSION (§ 6.2.5)

Comb.	N_{Ed} (kN)	M_{Ed} (kNm)	ΔM_{Ed} (kNm)	$N_{b,Rd}$ (kN)	$M_{b,Rd}$ (kNm)	$(N_{Ed}/N_{b,Rd})^{0.8}+(M_{Ed}+\Delta M_{Ed}/M_{b,Rd})^{0.8}$	SUFF/CY
-1	0.00	0.00	0.00	0.00	0.00	0.00	

Comment
In case buckling effects are ignored the moment and axial capacity from section check are used.

CHECK OF COMBINED BENDING & TENSION (§ 6.3)

Comb.	N_{Ed} (kN)	M_{Ed} (kNm)	$N_{t,Rd}$ (kN)	$M_{b,Rd}$ (kNm)	$(N_{Ed}/N_{t,Rd})^{0.8} + (M_{Ed}/M_{b,Rd})^{0.8}$	SUFF/CY
-1	0.00	0.00	0.00	0.00	0.00	

Comment
In case buckling effects are ignored the moment and axial capacity from section check are used.

MEMBERS DEFORMATIONS (LOCAL AXES)

Quantity	Value y-y	Value z-z	
Combination	101	101	
$\delta_{Ed,max}$	0.00	0.00	cm
L_{cr}	300.00	300.00	cm
Coefficient	200.00	200.00	
δ_{max}	1.50	1.50	cm
$\delta_{Ed,max}/\delta_{max}$	0.00	0.00	
SUFFICIENCY	Yes	Yes	

NODES DISPLACEMENTS (GLOBAL AXES)

Quantity	Value X-X	Value Z-Z	
Combination	-1	-1	
$\Delta u_{Ed,max}$	0.00	0.00	cm
L_{cr}	0.00	0.00	cm
Coefficient	0.00	0.00	
Δu_{max}	0.00	0.00	cm
$\Delta u_{Ed,max}/\Delta u_{max}$	0.00	0.00	
SUFFICIENCY			