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Urban & Environmental Engineering

Bolted connections between thin-walled and thick elements made of cold-formed section

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Bolted connections between thick and thin CFS elements

Competitivity of the market of self-supporting rack storage

Optimisation of bigger and higher structures

Increasing of loads to be sustain by the structure

Thick columns and thin beams

Pinned connections between thick and thin elements

Bolted connections between thick and thin CFS elements

- Available design rules in the current European norms
  - EN1993-1-8
  - EN1993-1-3
  - EN15512
- Study case
  - Analytical investigations
  - Design method
  - Alternative connection
- Conclusions and perspectives

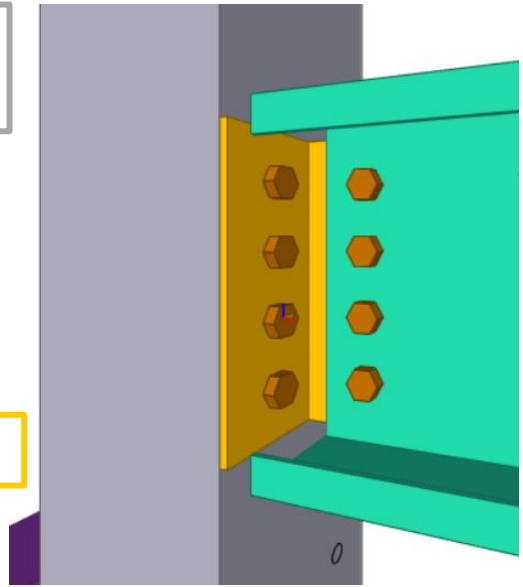
Available design rules in the current codes

- **EN1993-1-8/prEN1993-1-8**:
  - Provisions of prEN1993-1-8 applied for elements with a thickness ≥ 3 mm;
  - Recommendations to apply the component method but for semi-rigid joints made of H or I sections;
  - Propositions to characterise pinned joint will be provided in prEN1993-1-8;
  - Bearing resistance equations are differing from both versions of the code.
- **EN1993-1-3/prEN1993-1-3**:
  - EN1993-1-3 for thickness ≤ 3 mm but prEN1993-1-3 for thickness ≤ 4 mm;
  - Few details about the resistance of joints.
- **EN15512:2020:**
  - Not applicable as it concerns adjustable racking systems.

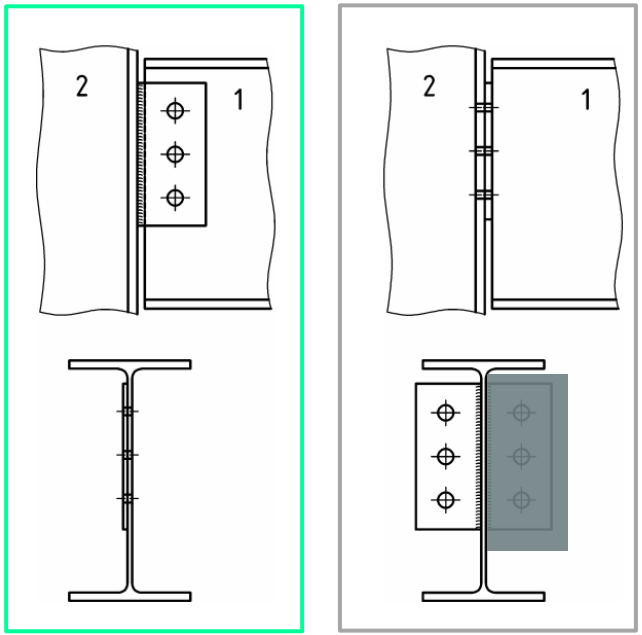
Case study

SHS column

L-profile



C-profile beam



prEN1993-1-8: Annex C

Preliminary verifications and ductility

- Preliminary requirements:
  - Spacing between bolts and edges check → prEN1993-1-3 / prEN1993-1-8.

- Rotational requirement:
  - Geometrical provisions given in Annex C of prEN1993-1-8.

- Ductility conditions:
  - 5.11 in prEN1993-1-8: $F_{V,Rd} > 0.8 \cdot F_{b,Rd}$ for any fasteners;
  - Table 10.5 in prEN1993-1-3: $F_{V,Rd} > 1.2 \cdot F_{b,Rd}$ for any fasteners.

Preliminary verifications and ductility

- Ductility conditions:
  - Criterion varies according to:
    - The considered side;
    - The thickness of the plate.

	Beam side	**Column side**
Thickness $<$ 4 mm	$F_{V,Rd} \geq 1.2 \cdot F_{b,Rd}$	$F_{V,Rd} \geq 1.5 \cdot F_{b,Rd}$
Thickness $\geq$ 4 mm	$F_{V,Rd} > 0.8 \cdot F_{b,Rd}$	$F_{V,Rd} > 1.0 \cdot F_{b,Rd}$

$F_{b,Rd}$: Bearing resistance of a bolt
$F_{V,Rd}$: Shear resistance of a bolt

Characterisation of the column side

Components	Reference in prEN1993-1-8	Reference in prEN1993-1-3
L-profile in shear - gross section	C3.3.1(a)	Not available
L-profile in shear - net section	C4.1.1(6)	Not available
L-profile in shear – shear block	5.14	Not available
L-profile in bending	Not available	Not available
Resistance of the column face in bearing	Table 5.6	Table 10.5
Resistance of the L-profile leg in bearing	Table 5.6	Table 10.5

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- Equations available in *European recommendations for the design of simple joints in steel structure*, Jaspart et al., 2009

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- Header plate joint : 2 columns of bolts / 2 sides from the beam web;
- Studied joint: 1 column of bolts / 1 side from the beam web.

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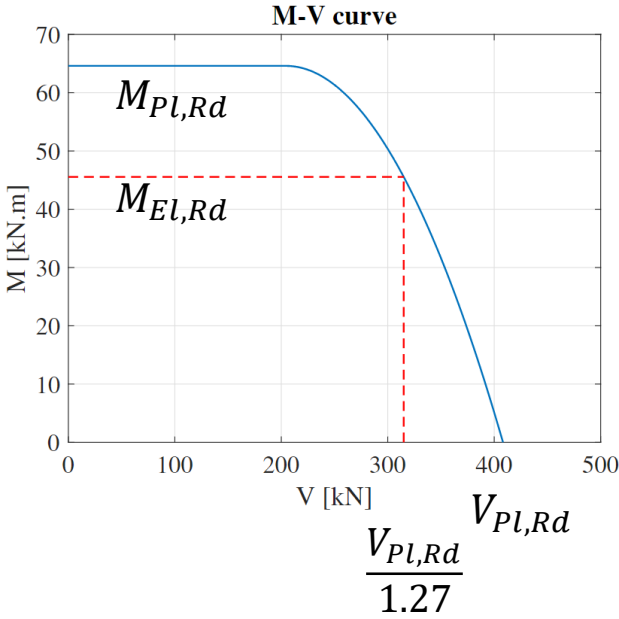

$$V_{Rd,L-profile\ in\ shear\ -gross\ section} = \frac{1}{1.27} \cdot \frac{A_v \cdot f_y}{\sqrt{3} \cdot \gamma_{M0}}$$

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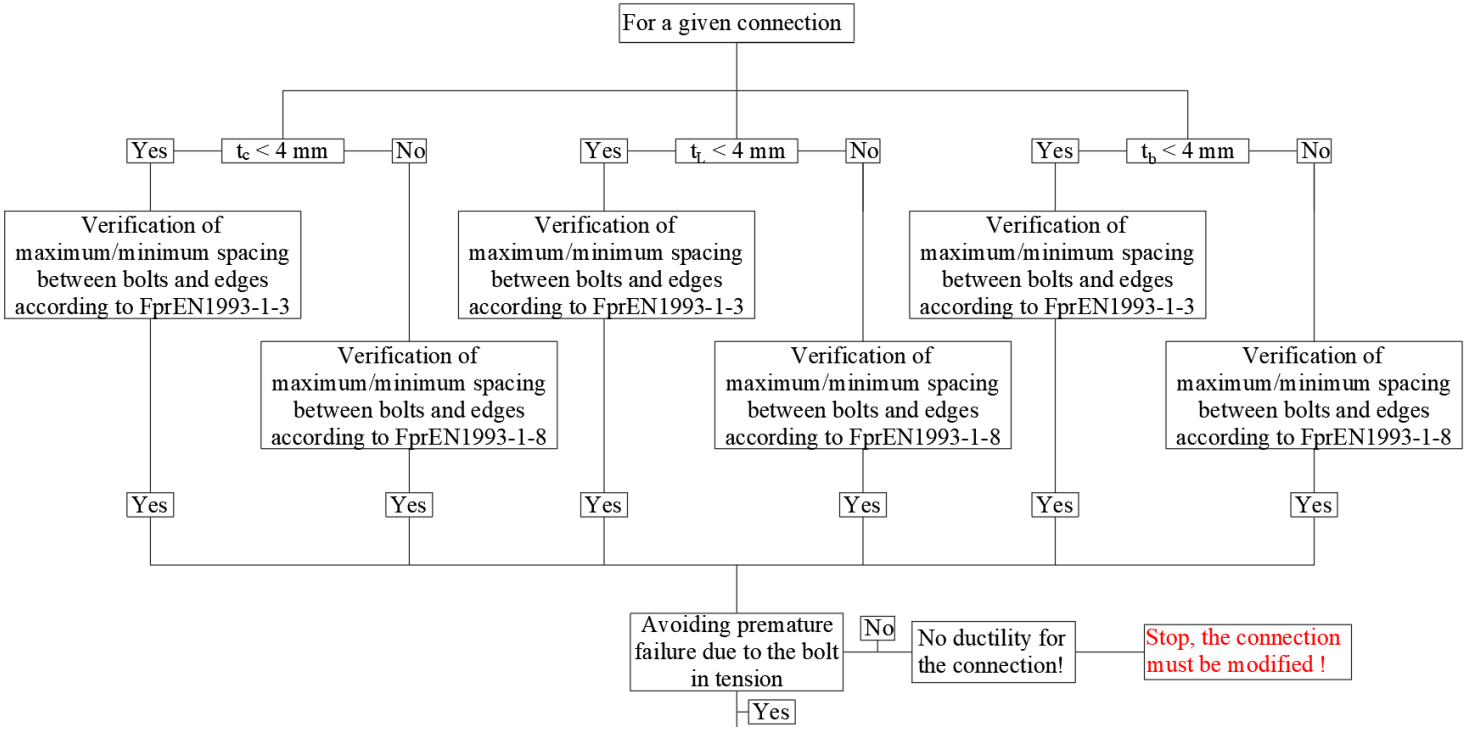
- prEN1993-1-8 : Distinction between end and inner bolt;
- prEN1993-1-3 : No distinction.

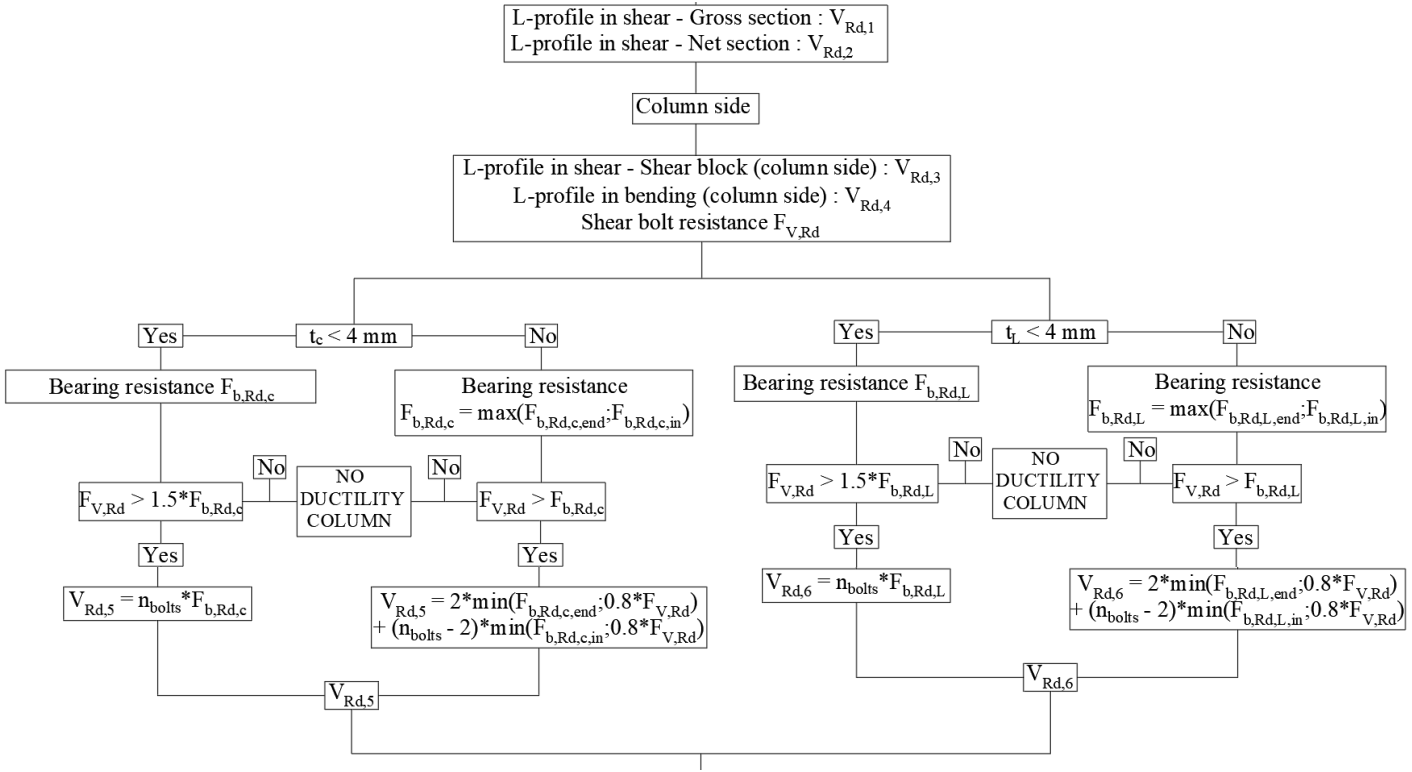
Characterisation of the beam side

Components	Reference in prEN1993-1-8	Reference in prEN1993-1-3
L-profile in shear – Shear block (beam side)	5.14	Not available
Beam web in shear – Gross section	C4.1.1(7)	Not available
Beam web in shear – Net section	C4.1.1(7)	Not available
Beam web in shear – Shear block	5.14	Not available
L-profile in bending (beam side)	C.4.1.3(5)	Not available
Buckling of L-profile (beam side)	C.4.1.2(6)	Not available
Resistance of the fasteners – L-profile plate	Table 5.6	Table 10.5
Resistance of the fasteners – Beam plate	Table 5.6	Table 10.5
Bolts in shear	Table 5.6	Table 10.5

Global design procedure



Global design procedure



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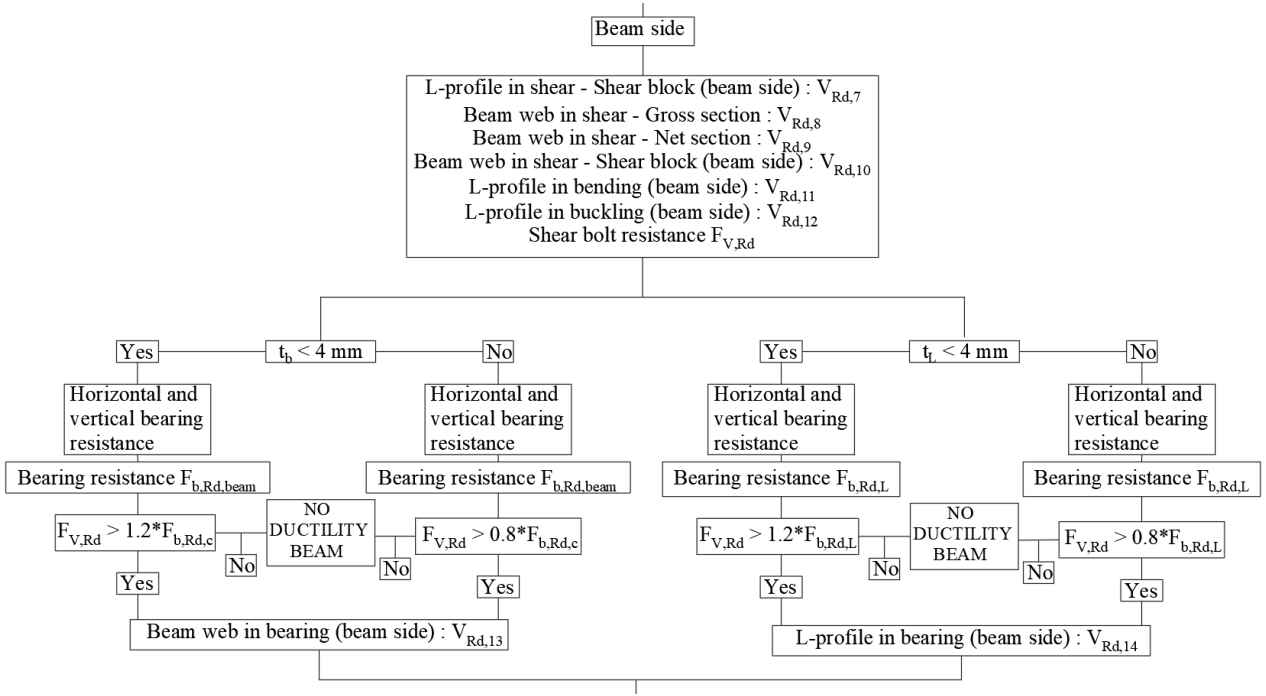

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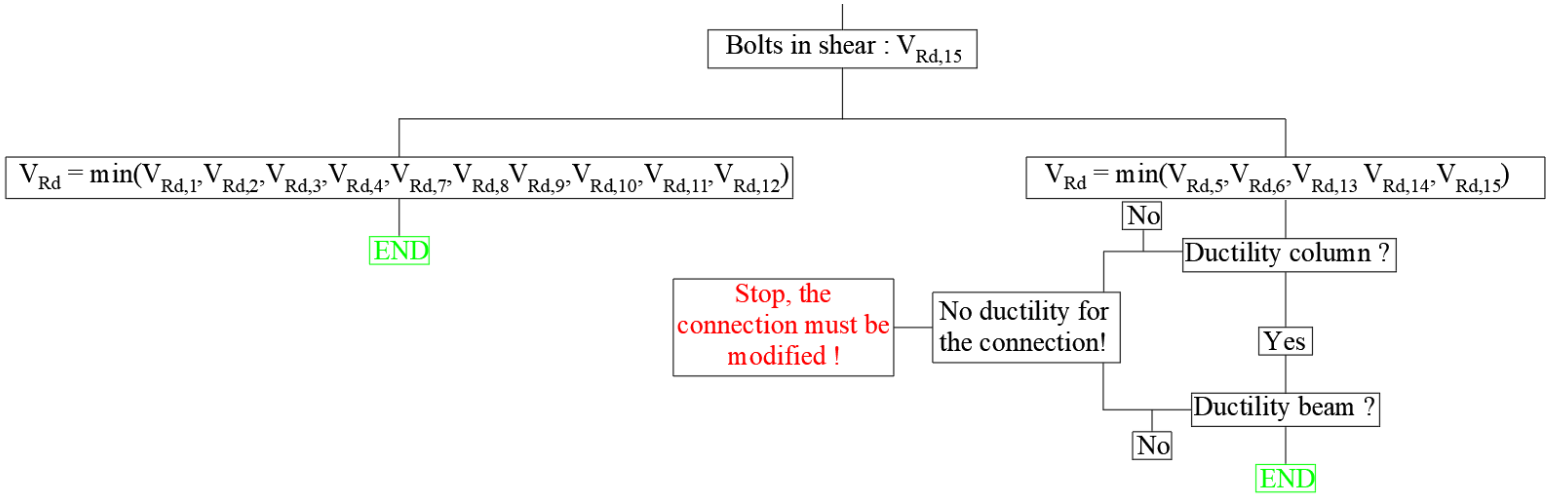
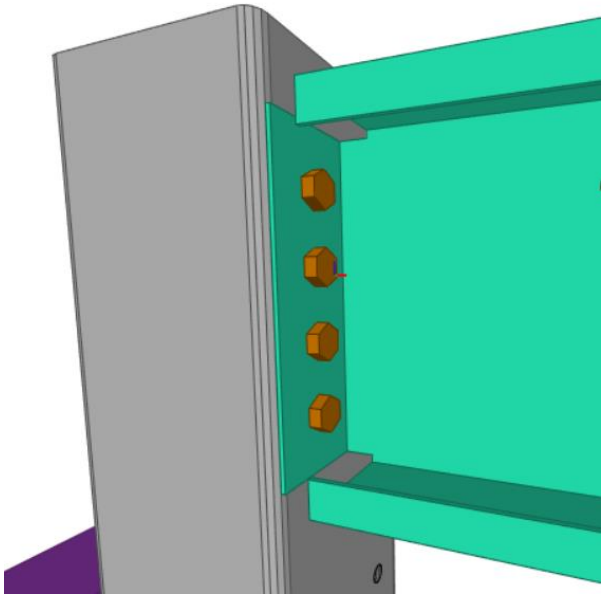


Alternative connection



One column of bolts, no L-profile used → global weight ↘.

Six components activated:

(i) Column face in bearing;
(ii) Header web in bearing;
(iii) Header web in shear - net section;
(iv) Header web in shear - gross section;
(v) Header web in shear - shear block;
(vi) Header web in bending.

Global design method available in the conference paper.

Conclusion

- New equations to characterise the bearing resistance are presented in prEN1993-1-8;
- prEN1993-1-8 gives recommendations to design pinned joint but made of H or I section elements, some modifications have been proposed for the studied joint;
- Ductility conditions vary according to the thickness and the joint configuration;
- Design methodology is proposed to characterise a pinned connection between a C-beam and a SHS-column;
- An optimised joint configuration is suggested;
- Based on this analytical study, numerical simulations are in progress and an experimental campaign on both configuration will be performed.

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