GRISPE PLUS

VALORISATION OF KNOWLEDGE FOR SPECIFIC PROFILED STEEL SHEETS

Interlocking planks

Building a calculation method based on tests realised according to EN 1993-1-3

The project has received financial support from the European Community (RFCS programme) under grant agreement No 754092

Content

- Introduction
- GRISPE tests and results
- Design method
- Amendment proposal

Introduction

Introduction

Architects concerns

- No appearing fixing device
- The flattest surface possible
- Cheep industrial image

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Introduction

Manufacturers' answer

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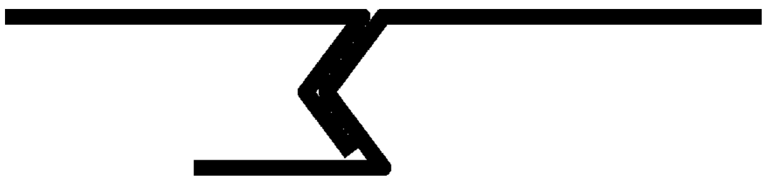
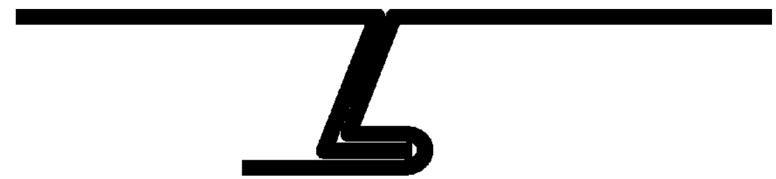
Introduction

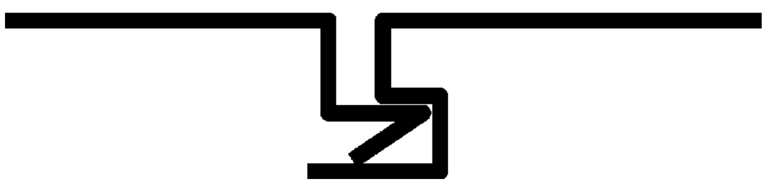
Manufacturers’ answer



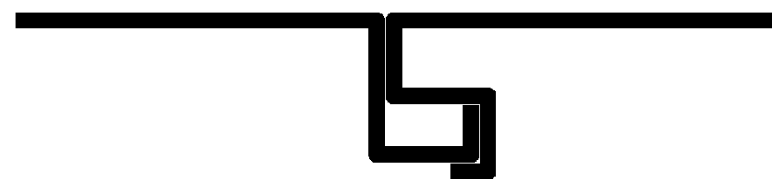
Chevron joint



Clip joint



Lock joint



Gutter joint

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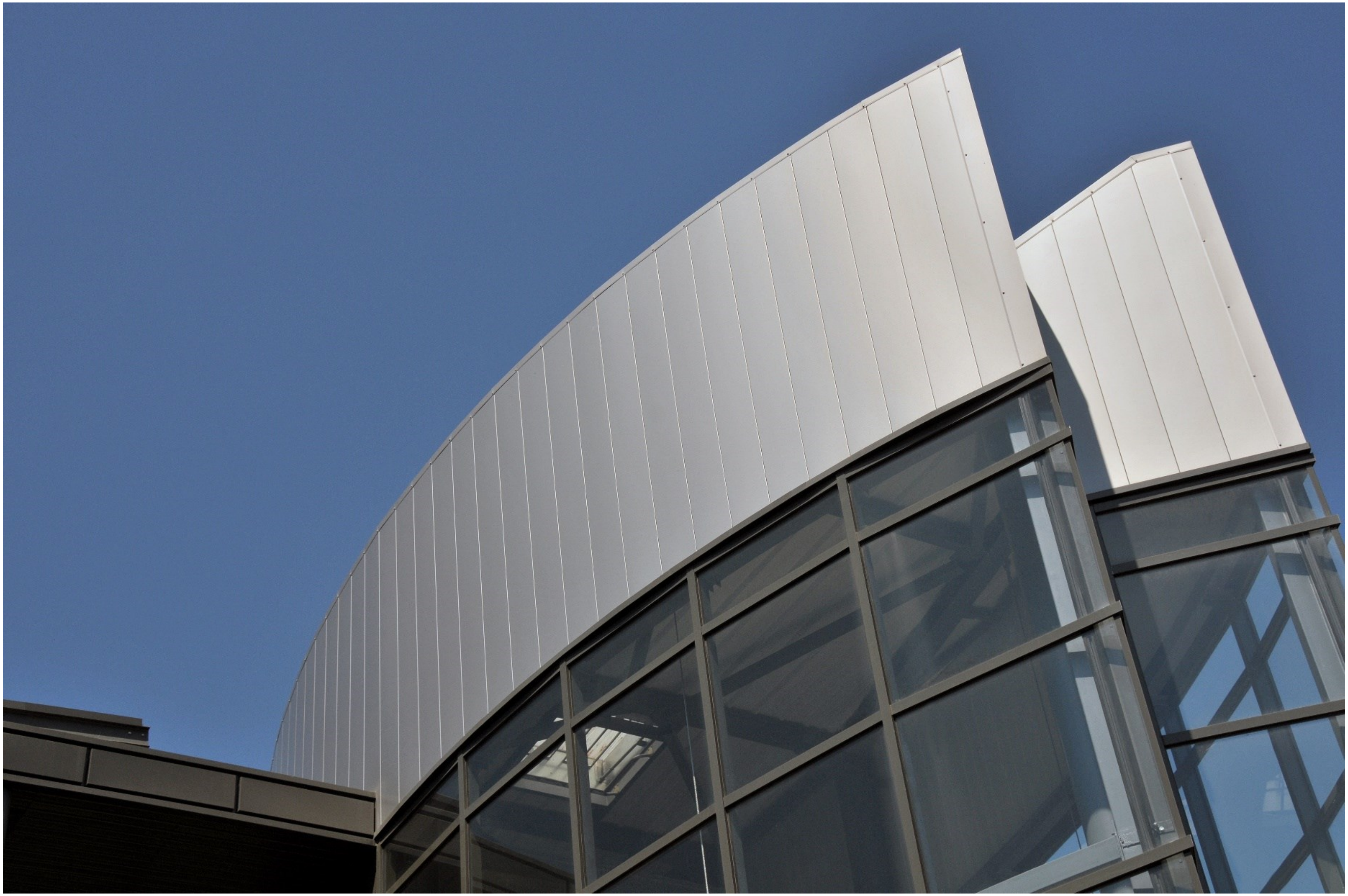

Introduction

Design methods

- Design by calculation
- Design by testing
- No harmonized solution
- Not in the scope of EN 1993–1–3

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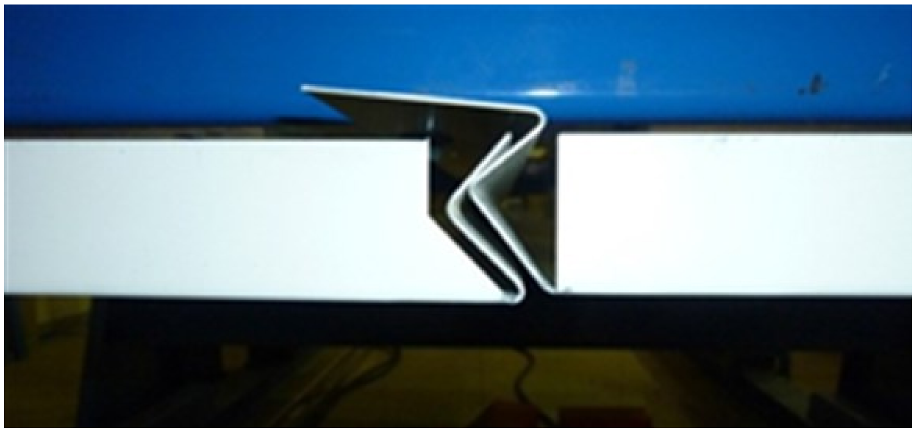
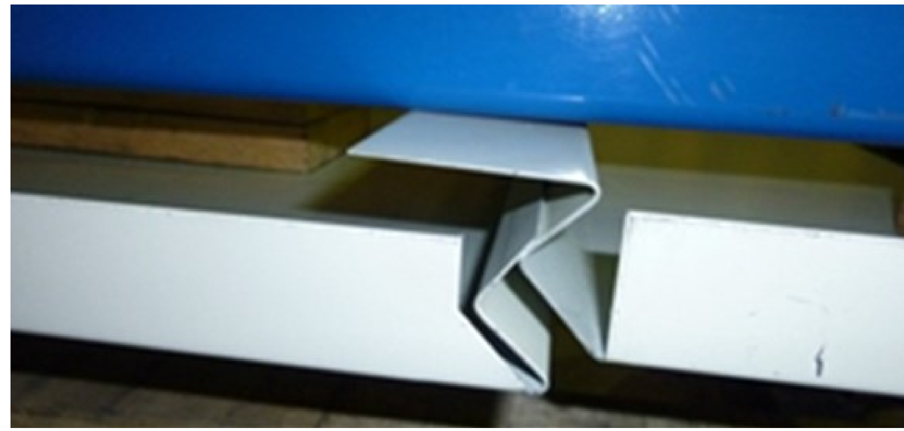
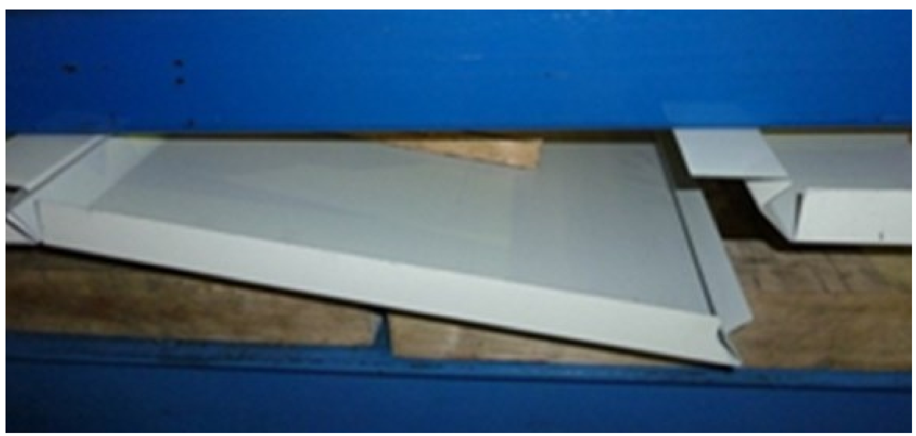
Introduction

Typical failure mode: failure by dislocation of the joint





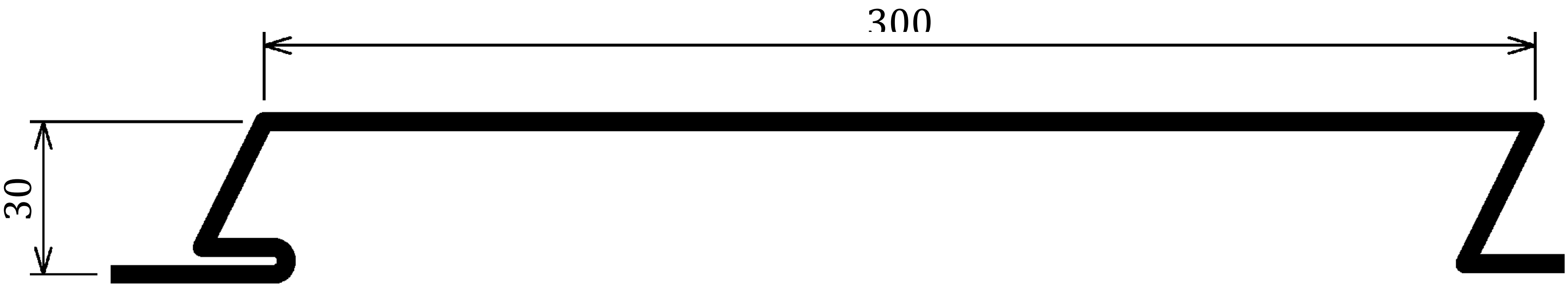


GRISPE tests and results

GRISPE tests and results

Plank profiles tested

- CLADEO 300 by BACACIER



Thicknesses : $0.75\ mm$ and $1.00\ mm$

GRISPE tests and results

Plank profiles tested

- ZEPHYR 300 b JORISIDE THE STEEL FUTURE

Thicknesses : $0.75\ mm$ and $1.00\ mm$

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GRISPE tests and results

Flexion tests

GRISPE tests and results

Flexion tests

- Test program

Load direction	Number of supports	Span length mm	Number of tests
Pressure / Suction	2	1500	6
	3	1000	6
		2000	6
		3000	6

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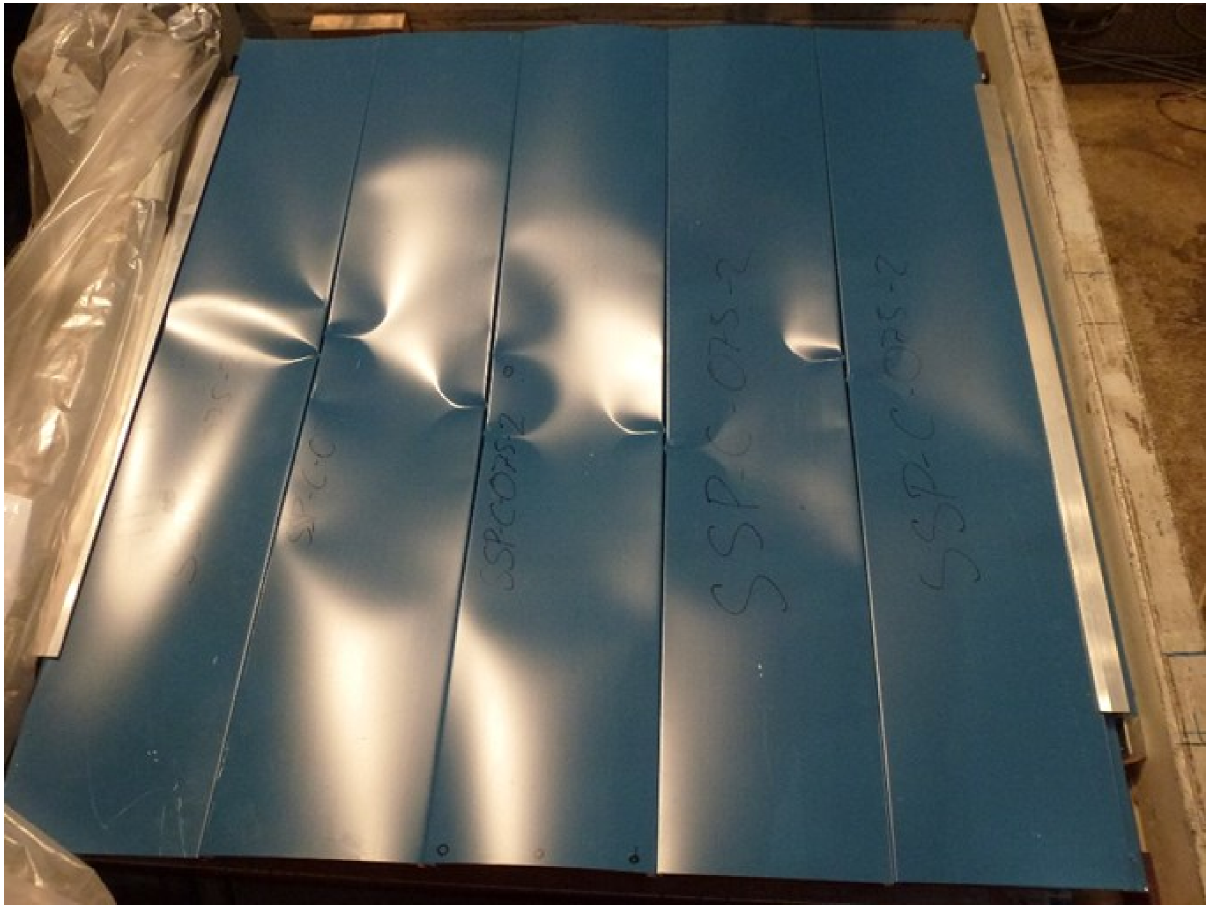
GRISPE tests and results

Flexion tests

- Pressure loads



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GRISPE tests and results

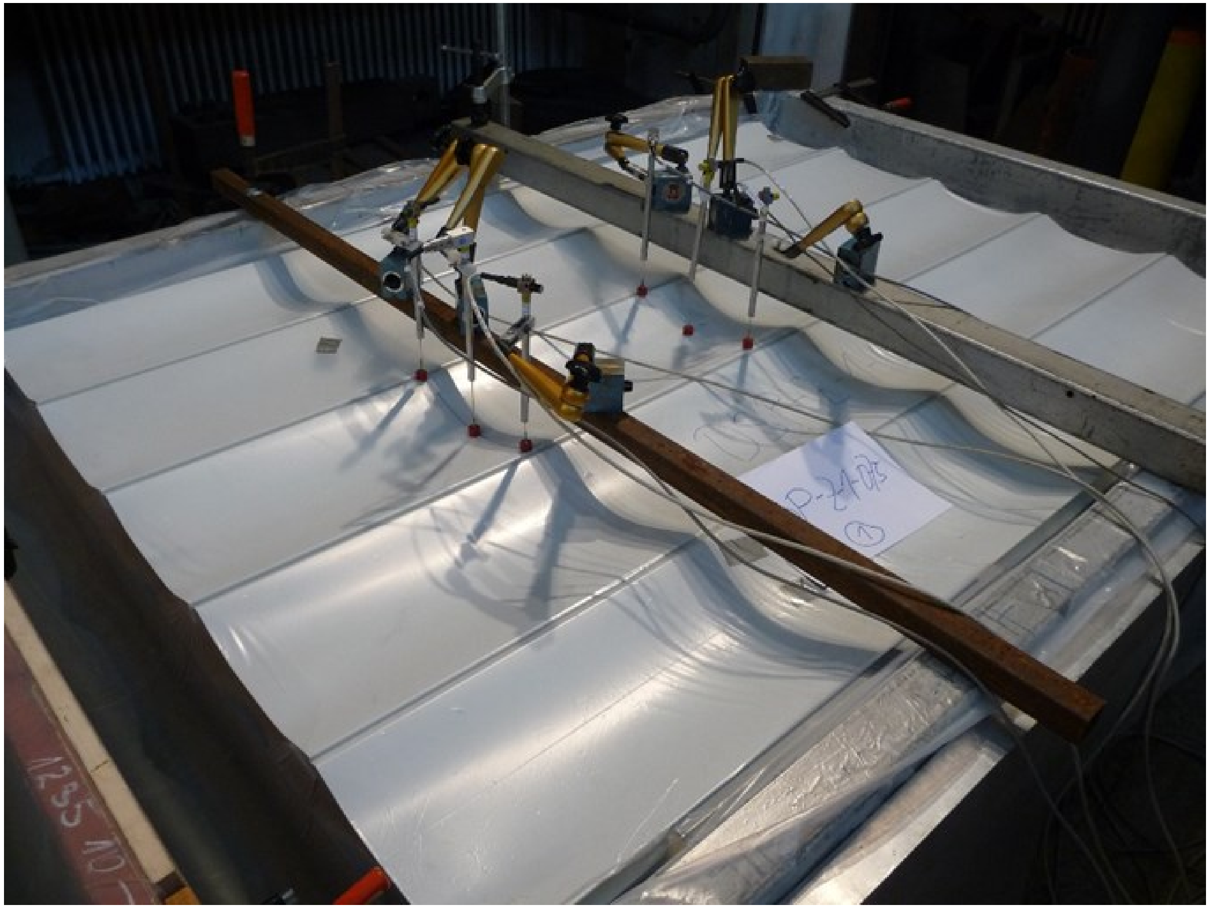
Flexion tests

- Pressure loads

GRISPE tests and results

Flexion tests

- Pressure loads



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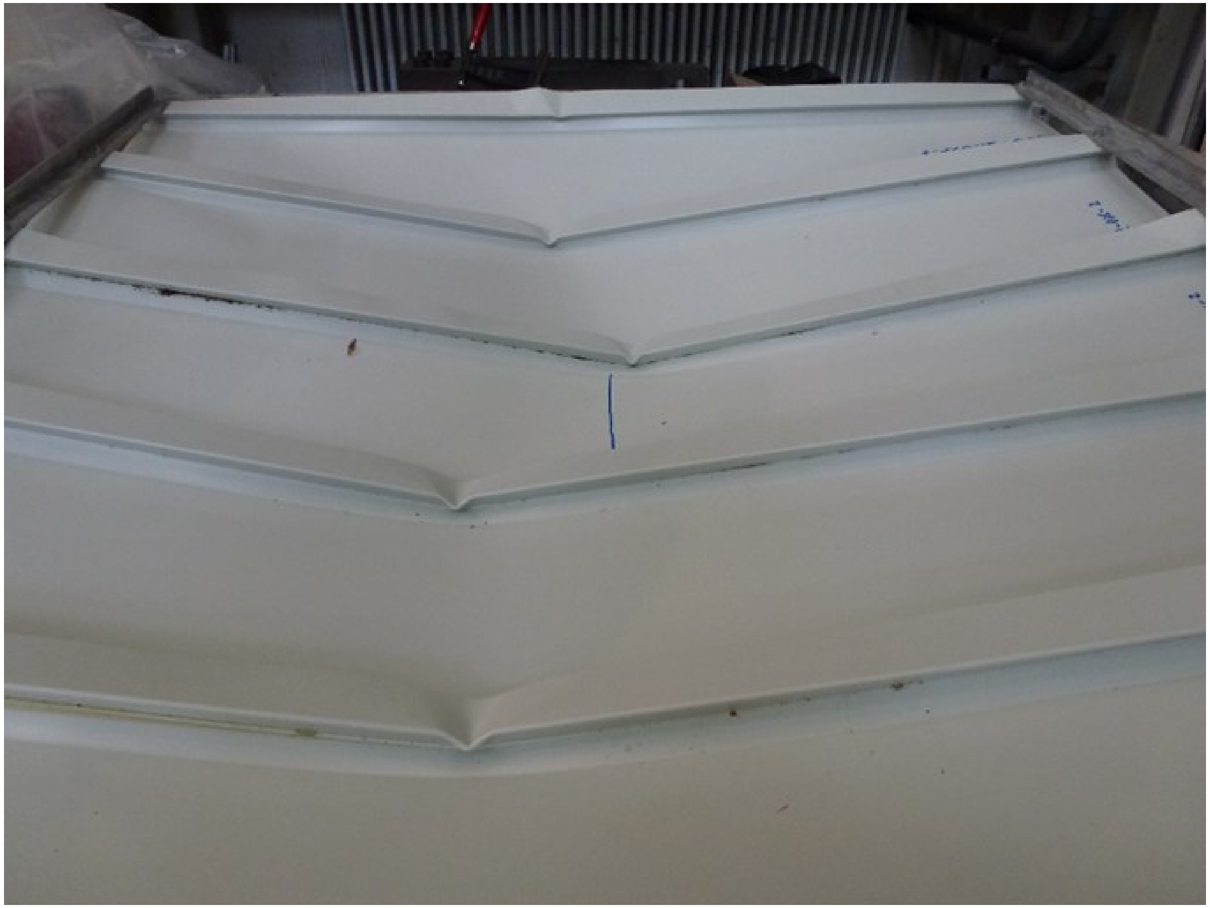
GRISPE tests and results

Flexion tests

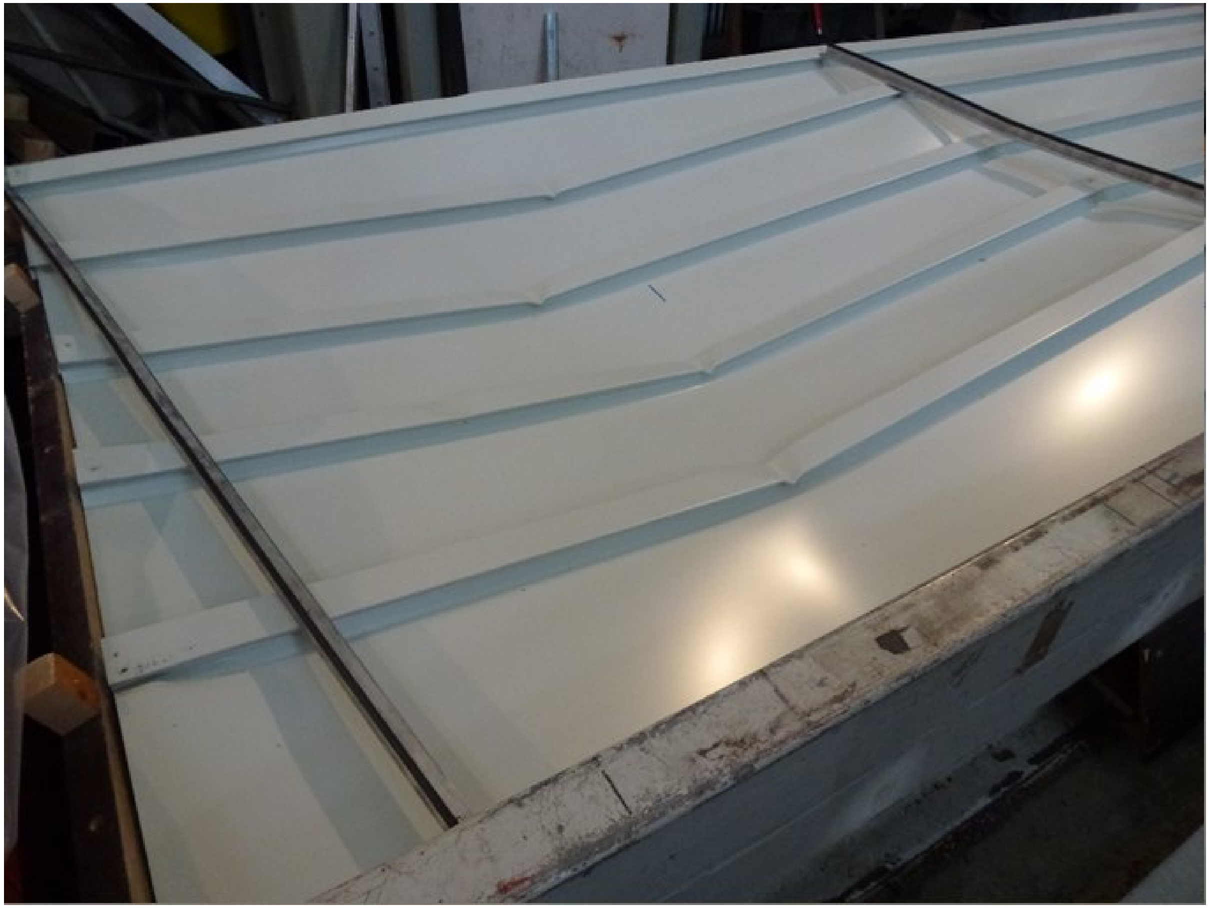
- Suction loads



GRISPE tests and results

Flexion tests

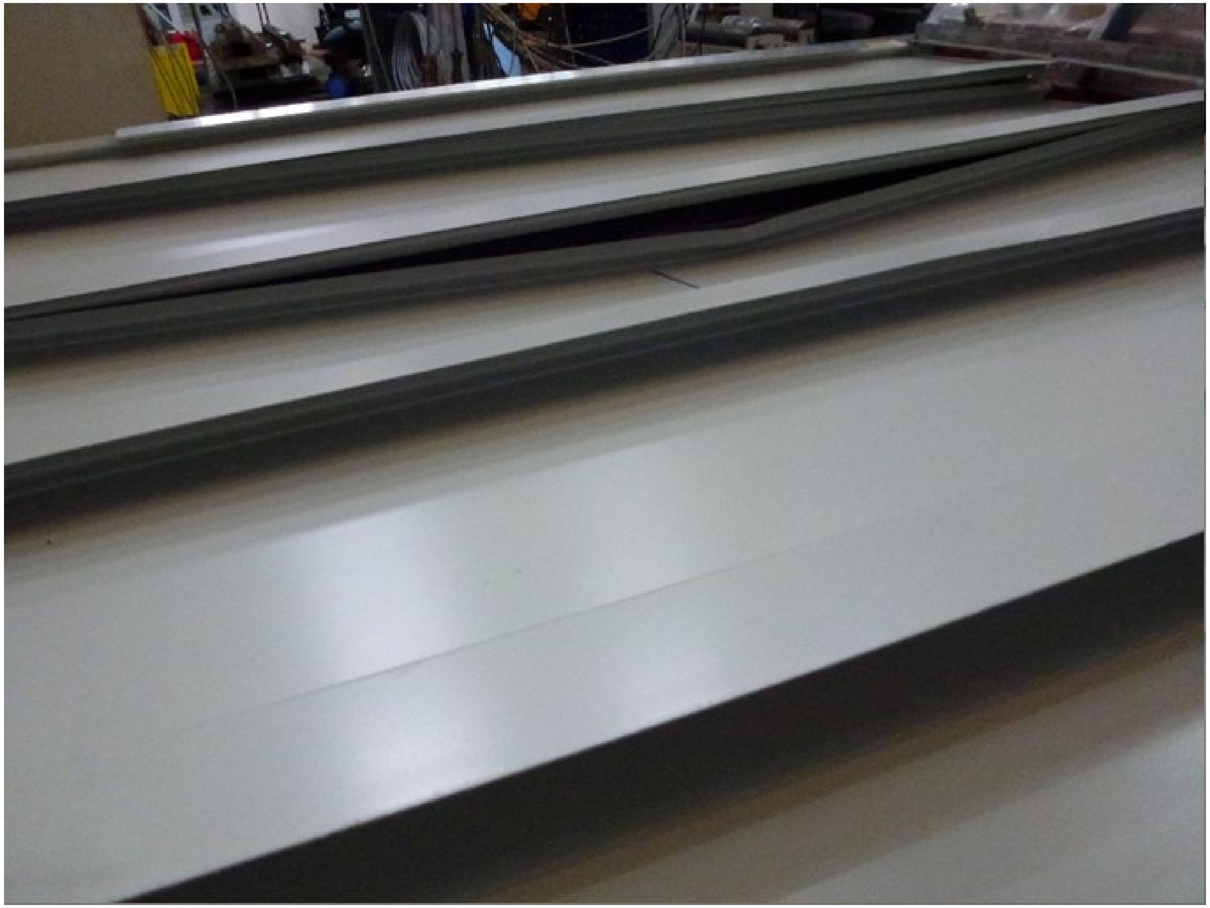
- Suction loads



GRISPE tests and results

Flexion tests

- Suction loads



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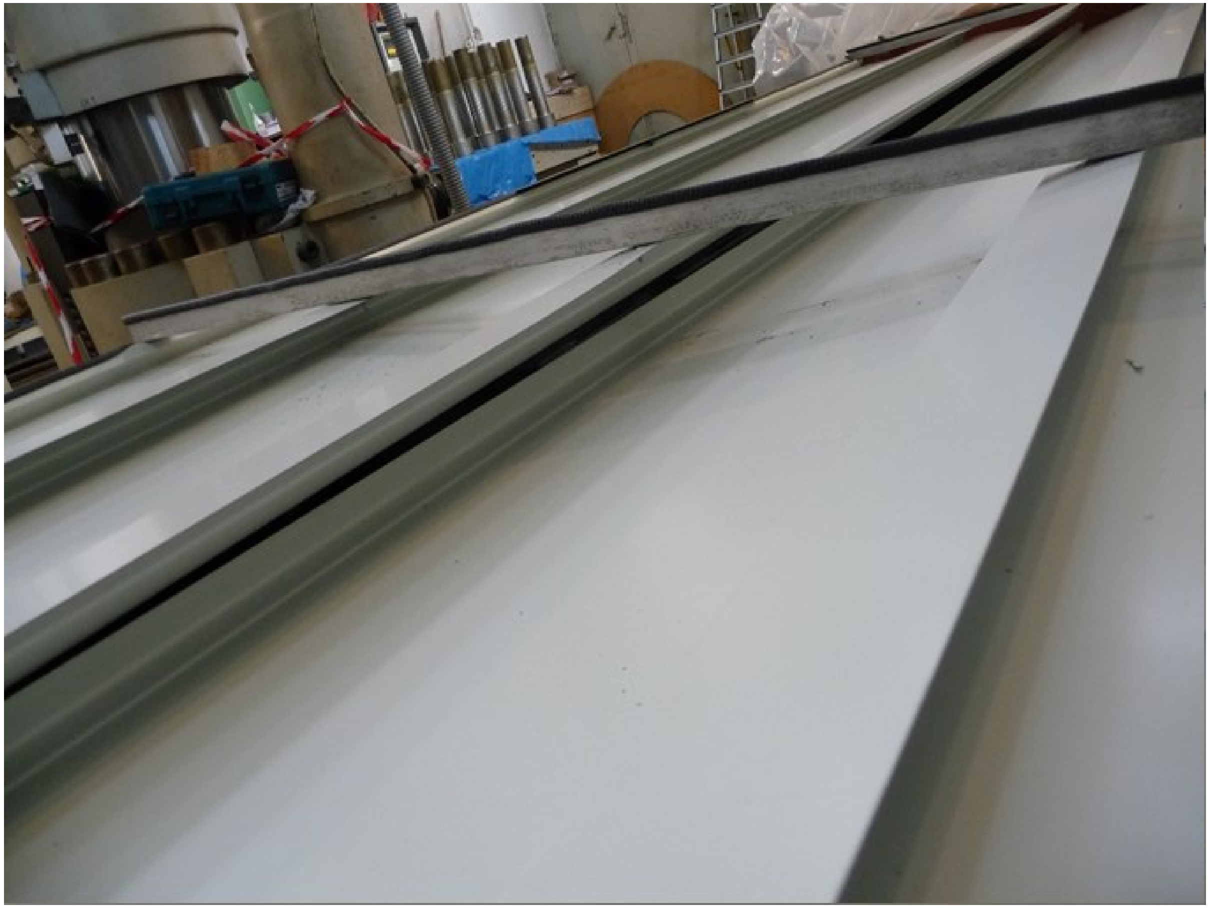
GRISPE tests and results

Flexion tests

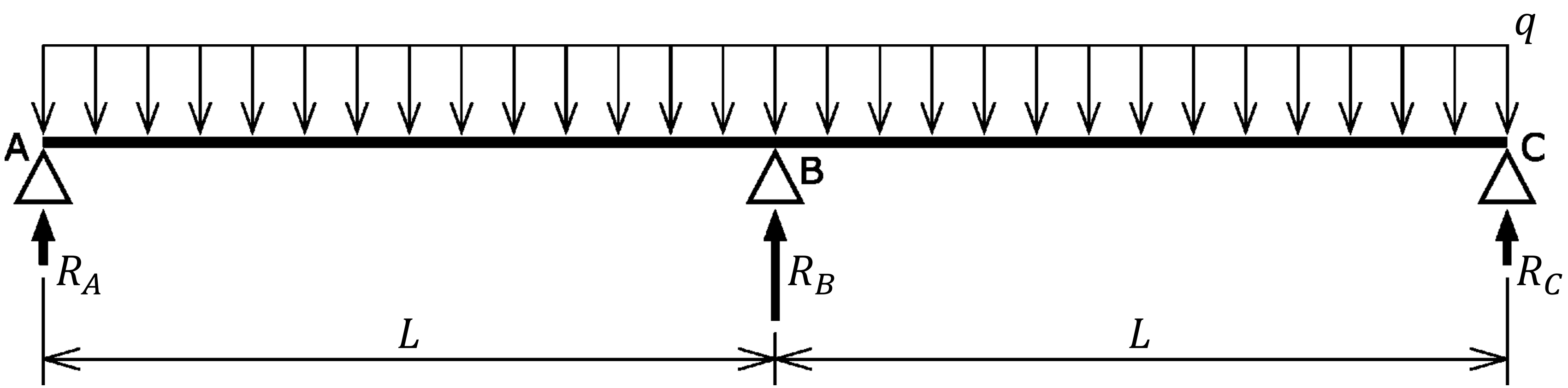
- Suction loads



GRISPE tests and results

Flexion tests

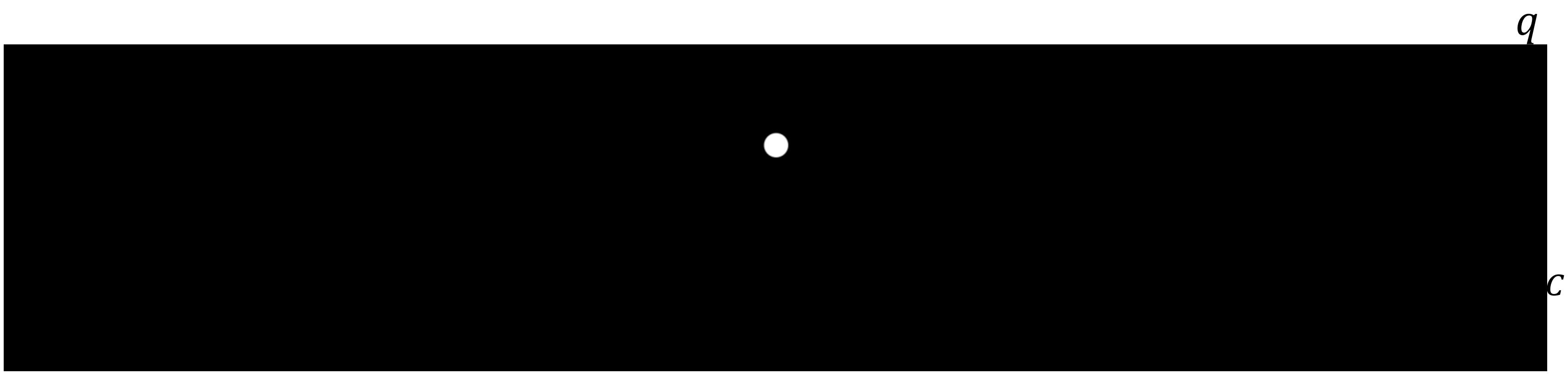
- Expected behaviour for double span tests



$$\left.\begin{array}{c} R_A = R_C = 0.375 \cdot q \cdot L \\ R_B = 1.25 \cdot q \cdot L \end{array}\right| \rightarrow R_B = 3.33 \cdot R_A$$

Flexion tests

- Observed behaviour for double span tests



$$R_A = R_C = 0.50 \cdot q \cdot L$$
$$R_B = 1.00 \cdot q \cdot L \quad \rightarrow R_B = 2.00 \cdot R_A$$

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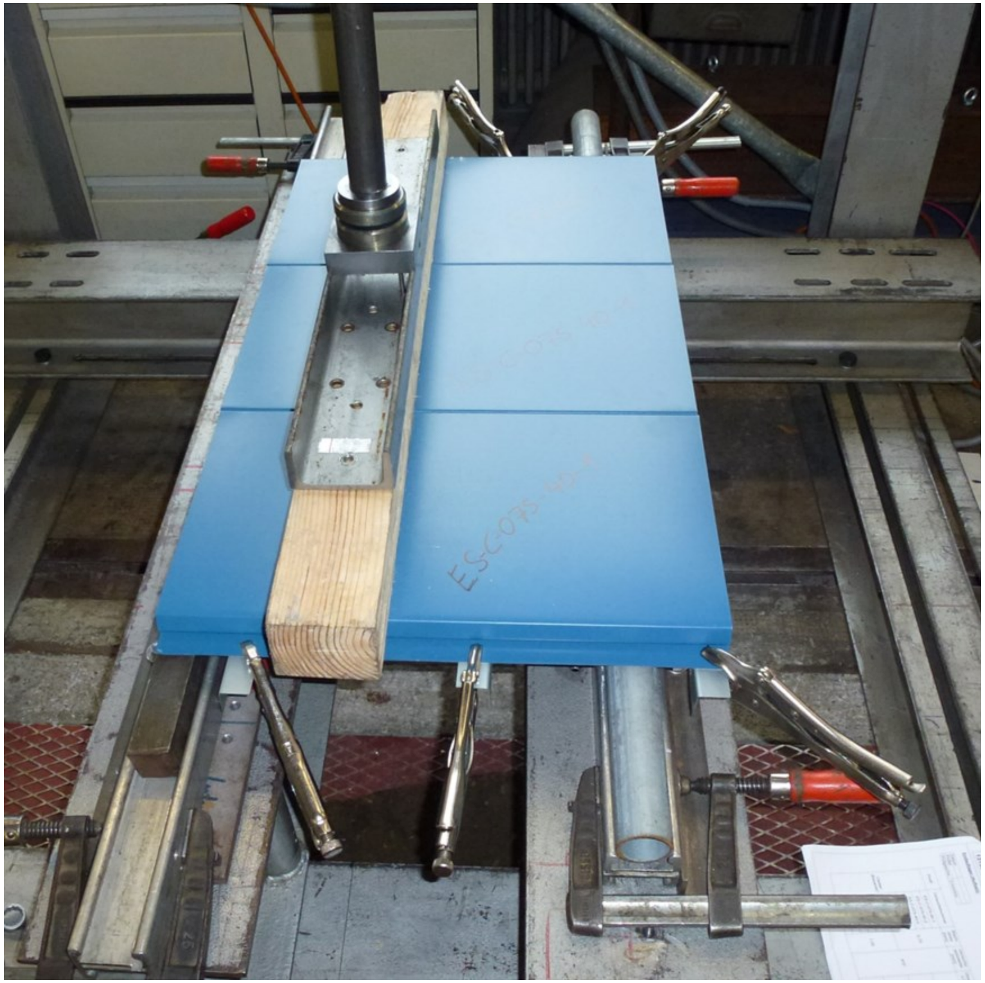
GRISPE tests and results

End support tests



GRISPE tests and results

End support tests

- Test program

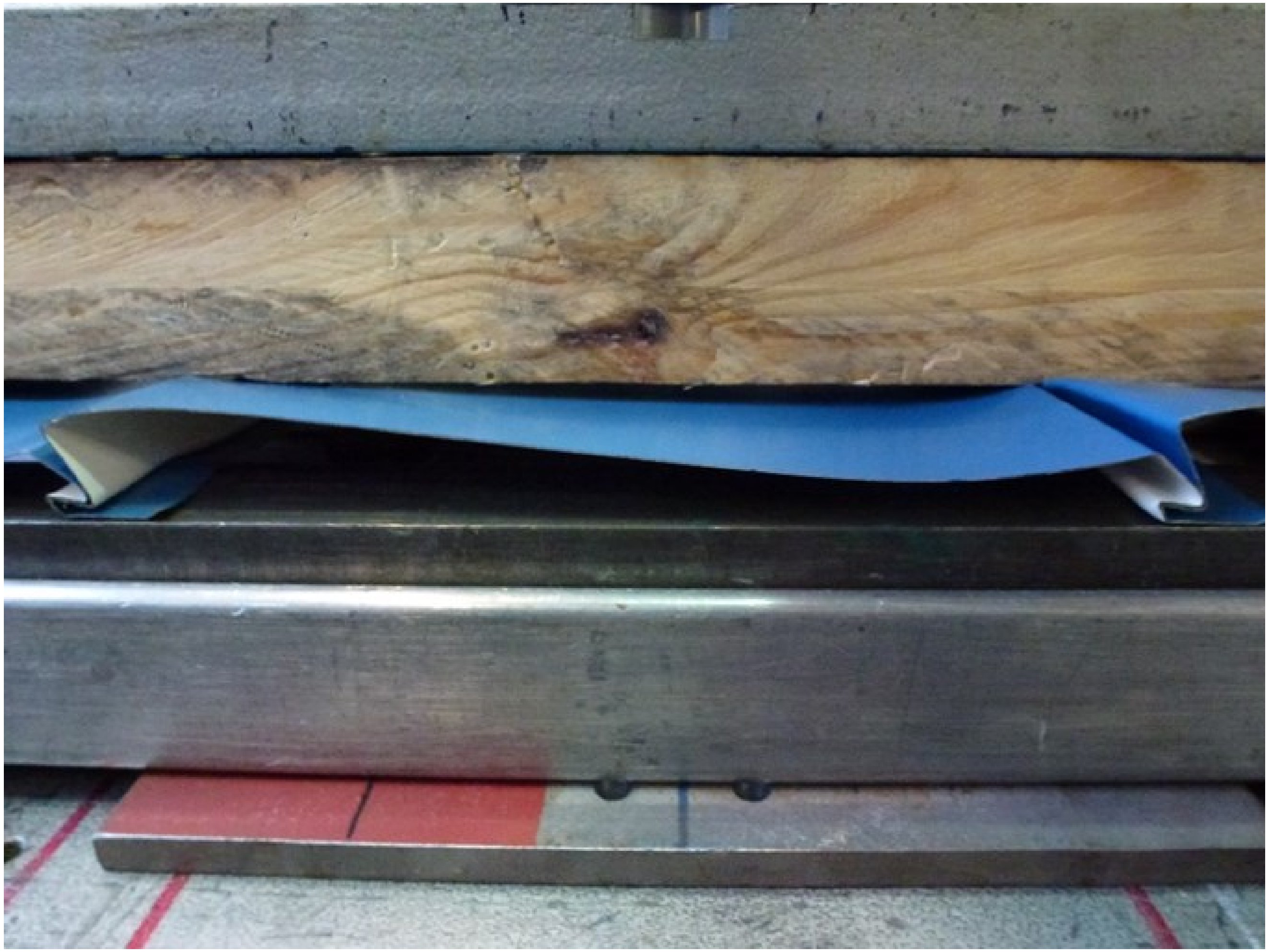
Span length mm	Cantilever length mm	Number of tests
540	40	3
	80	3

GRISPE tests and results

End support tests

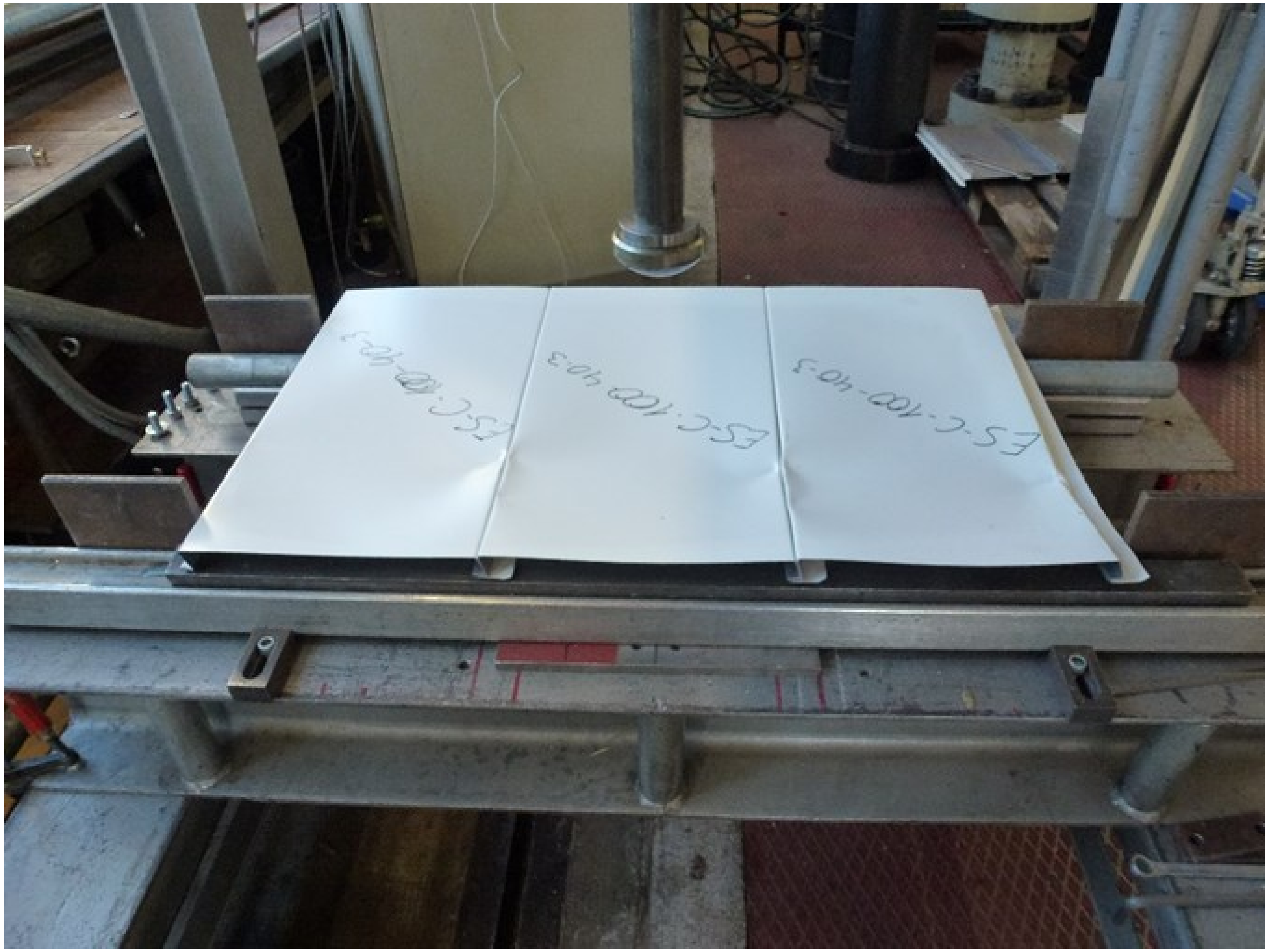
GRISPE tests and results

End support tests



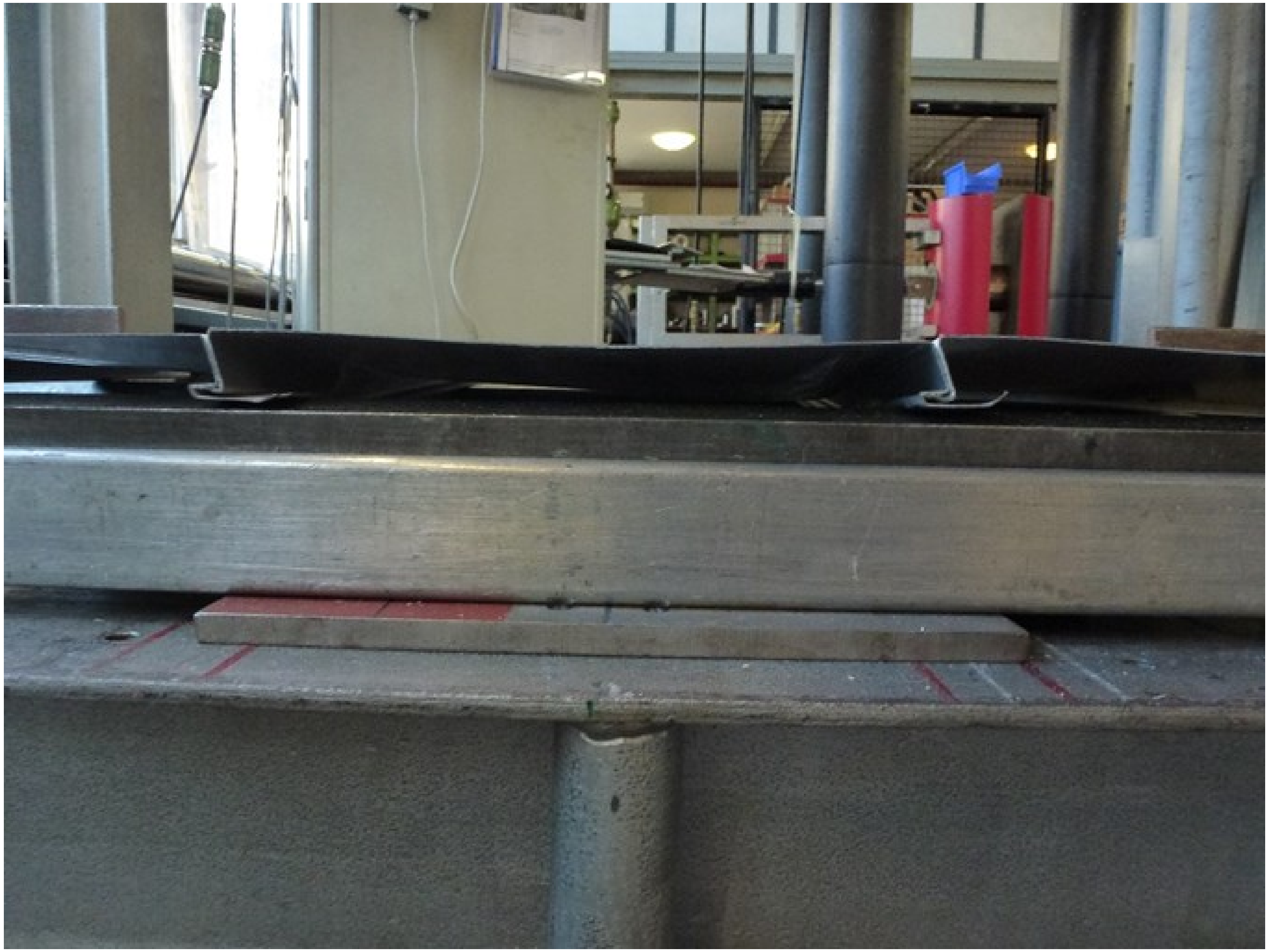
GRISPE tests and results

End support tests



GRISPE tests and results

End support tests



Design method

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Design method

Usual design criterions

- Calculation method for liner trays of EN 1993–1–3

Additional criterion : maximum bearable load regarding dislocation of the joint

- Evaluation of the displacement of the joint
- Limitation of this displacement

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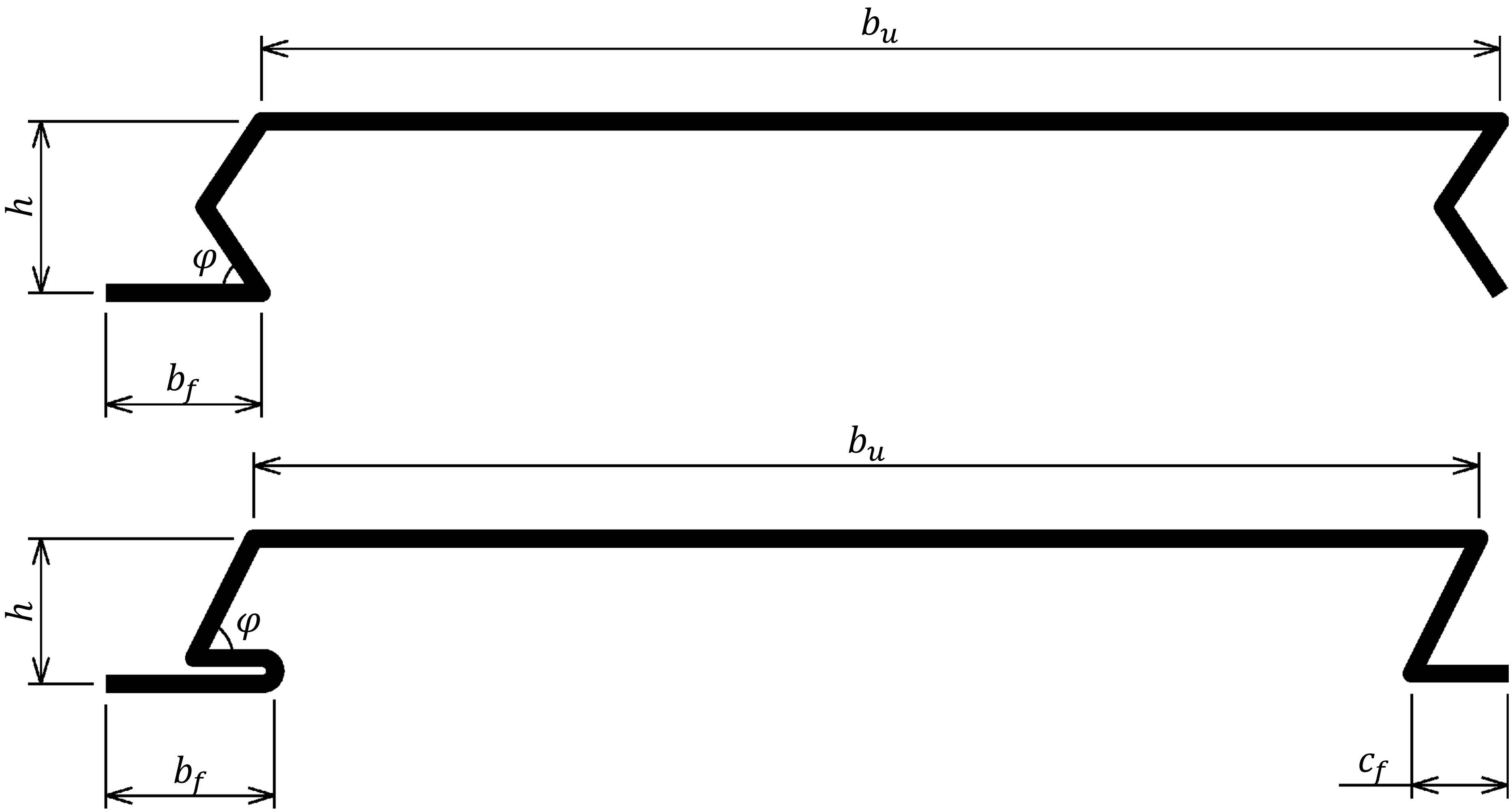
Design method

Notations



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Design method

Moment resistance under pressure $M_{c,Rd}$

- Effective width of the flat flange (EN 1993–1–5)

$$\bar{\lambda}_p \Rightarrow \rho \Rightarrow b_{u,eff} = \rho \cdot b_u$$

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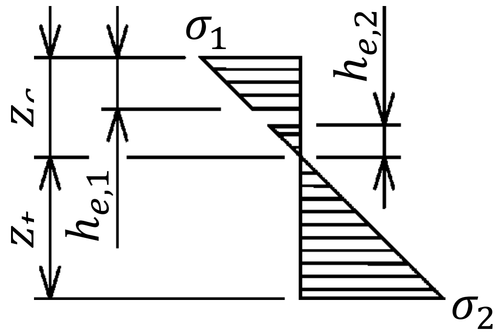
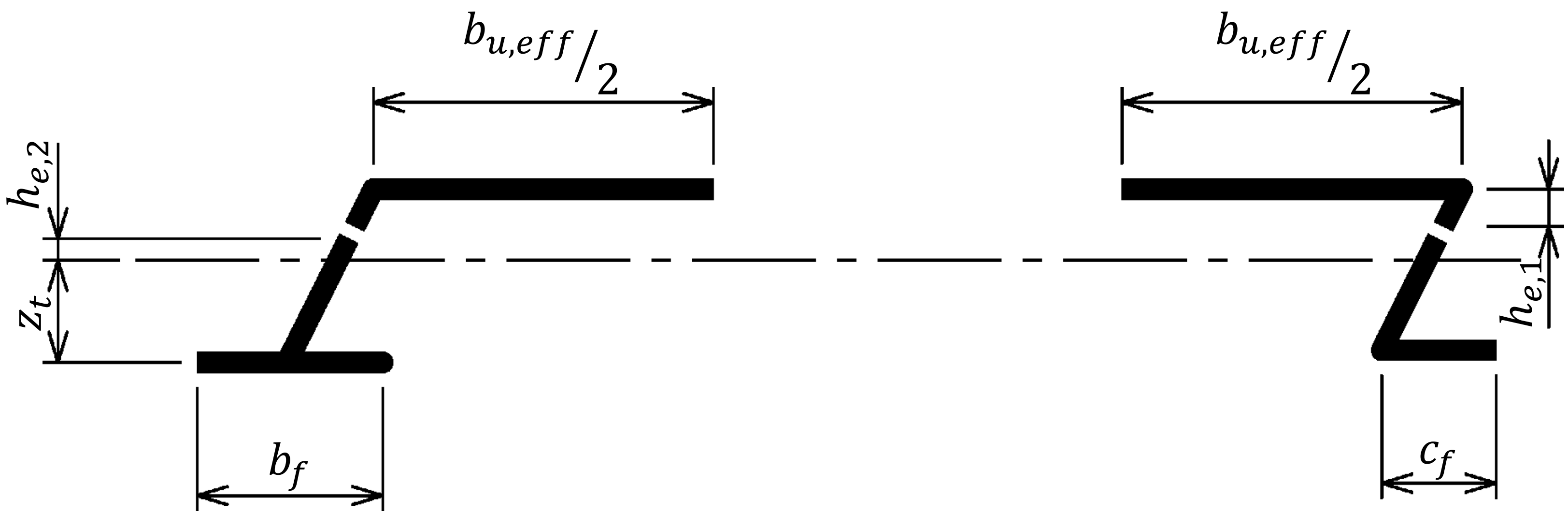
Design method

Moment resistance under pressure $M_{c,Rd}$

- Effective part of the web (EN 1993–1–5)



$$\bar{\lambda}_p \Rightarrow \rho \Rightarrow \left| \begin{array}{l} h_{e,1} = 0.4 \cdot \rho \cdot z_c \\ h_{e,2} = 0.6 \cdot \rho \cdot z_c \end{array} \right.$$



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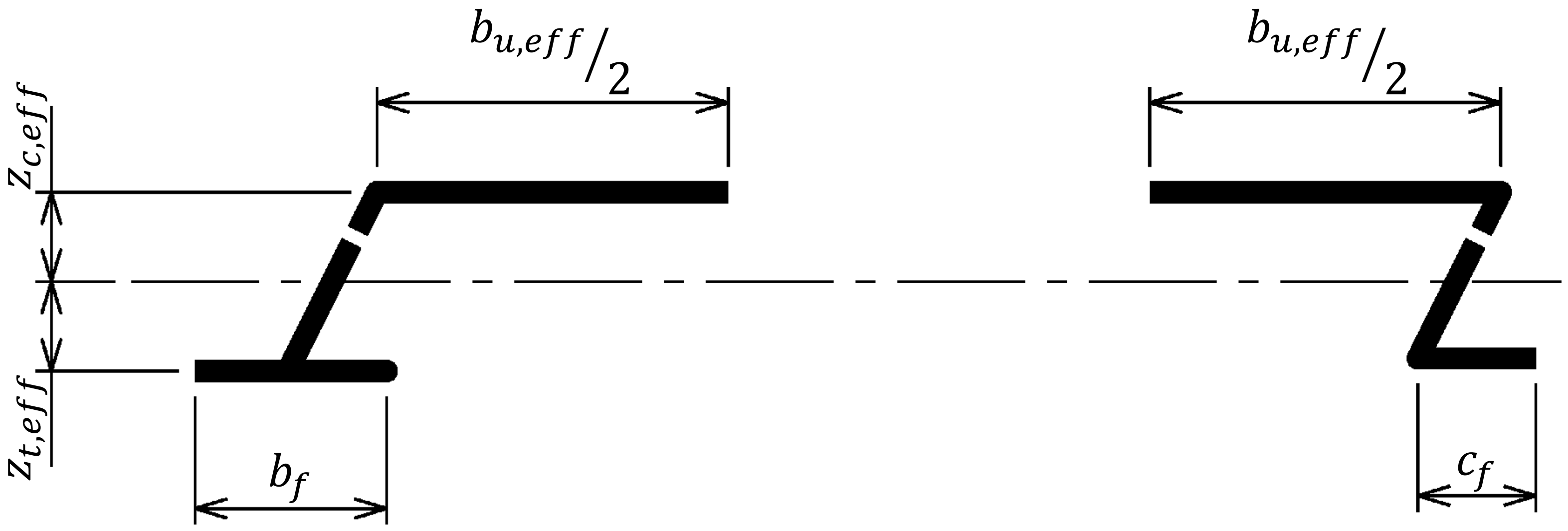
Design method

Moment resistance under pressure $M_{c,Rd}$

- Centroid of the effective section

$$W_{eff} = \frac{I_{y,eff}}{\max\left(z_{c,eff}; z_{t,eff}\right)} \quad \Rightarrow \quad M_{c,Rd} = W_{eff} \cdot \frac{0.8 \cdot f_{yb}}{\gamma_{M0}}$$



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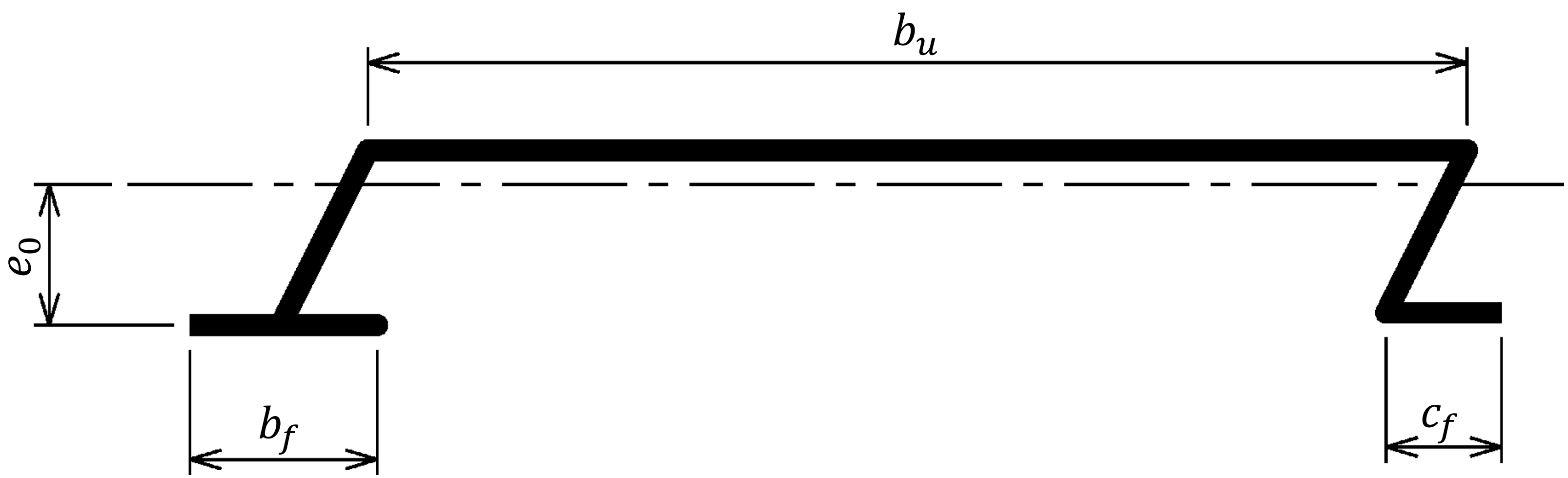
Design method

Moment resistance under suction $M_{b,Rd}$

- Effective width of the flat flange (EN 1993–1–3)

$$b_{u,eff} = \frac{53.3 \cdot 10^{10} \cdot {e_0}^2 \cdot t^3 \cdot t_{eq}}{h \cdot L \cdot {b_u}^3}$$



Design method

Moment resistance under suction $M_{b,Rd}$

- Effective width of the narrow flanges (EN 1993–1–5)

σ

$b_{f,e}$ [redacted]

$$\bar{\lambda}_{p,b} \Rightarrow \rho_b \Rightarrow b_{f,eff} = \rho \cdot b_f$$
$$\bar{\lambda}_{p,c} \Rightarrow \rho_c \Rightarrow c_{f,eff} = \rho \cdot c_f$$

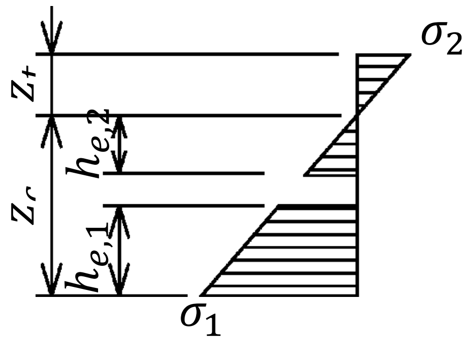
$b_{u,eff}/2$ $b_{u,eff}/2$

z_t z_c [redacted]

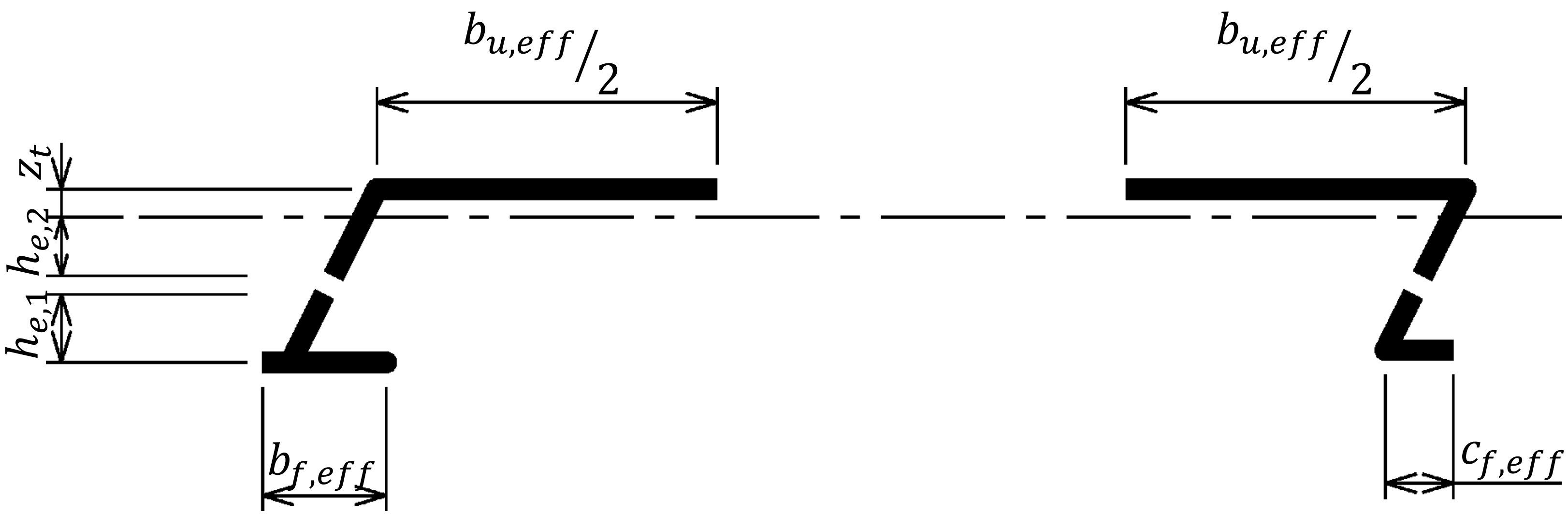
Design method

Moment resistance under suction $M_{b,Rd}$

- Effective part of the web (EN 1993–1–5)



$$\bar{\lambda}_p \Rightarrow \rho \Rightarrow \left| \begin{array}{l} h_{e,1} = 0.4 \cdot \rho \cdot z_c \\ h_{e,2} = 0.6 \cdot \rho \cdot z_c \end{array} \right.$$

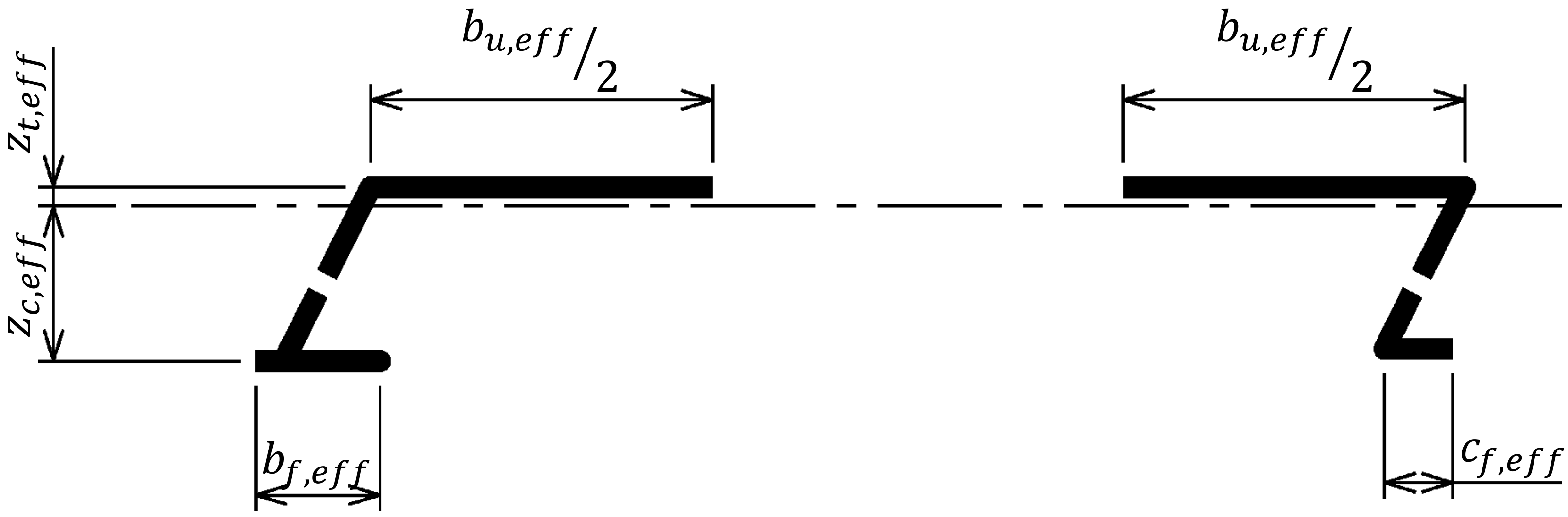


Design method

Moment resistance under suction $M_{b,Rd}$

- Centroid of the effective section

$$W_{eff} = \frac{I_{y,eff}}{\max(z_{c,eff}; z_{t,eff})} \quad \Rightarrow \quad M_{b,Rd} = W_{eff} \cdot \frac{0.8 \cdot f_{yb}}{\gamma_{M0}}$$



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Design method

Reaction at end support resistance $R_{w,Rd}$

$$R_{w,Rd} = \frac{\alpha \cdot t^2 \cdot \sqrt{f_{yb} \cdot E} \cdot \left(1 - 0.1 \cdot \sqrt{\frac{r}{t}}\right) \cdot \left(0.5 + \sqrt{0{,}02 \cdot \frac{l_a}{t}}\right) \cdot \left(2.4 + \left(\frac{\varphi}{90}\right)^2\right)}{\gamma_{M1}}$$

with

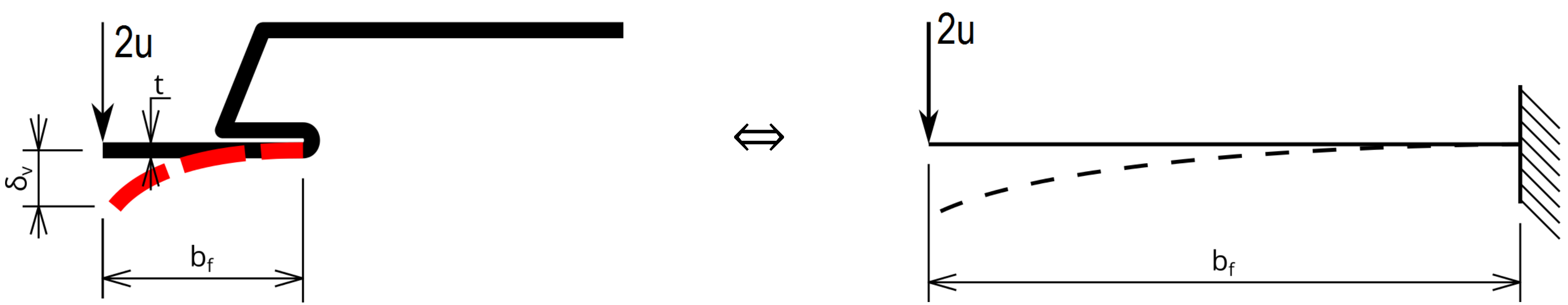
- $\alpha = 0.115$
- $l_a = 10\ mm$

No interaction moment/local load

Design method

Load resistance regarding dislocation of joints q_{Rd}

- Vertical displacement of one joint

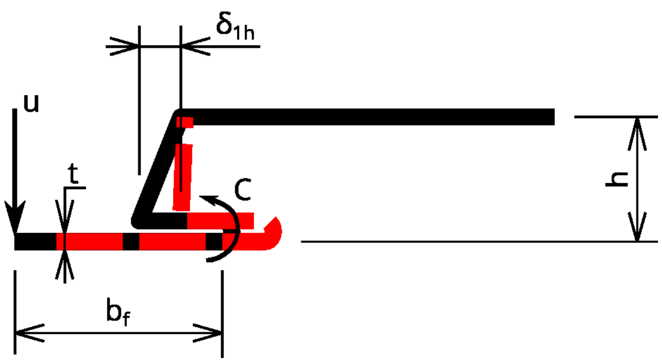


$$\delta_v = \frac{2 \cdot u \cdot {b_f}^3}{3 \cdot E \cdot I} \quad \text{with} \quad I = \frac{1000 \cdot t^3}{12 \cdot (1 - \nu^2)}$$

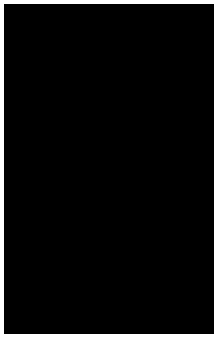
Design method

Load resistance regarding dislocation of joints q_{Rd}

- Horizontal displacement (local deformation of the joint)



$\Leftrightarrow$



$$\delta_{1h} = \frac{u \cdot b_f \cdot h^2}{2 \cdot E \cdot I} \quad \text{with} \quad I = \frac{1000 \cdot t^3}{12 \cdot (1 - \nu^2)}$$

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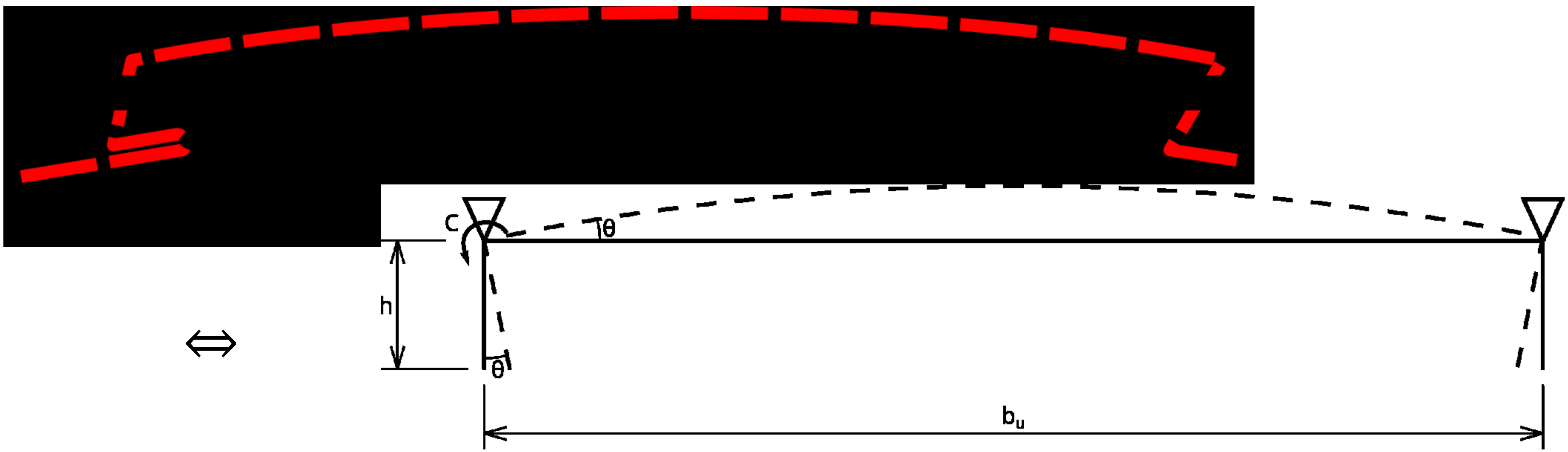
Design method

Load resistance regarding dislocation of joints q_{Rd}

- Horizontal displacement (bending of the wide flange)



$$\delta_{2h} = \frac{2 \cdot u \cdot b_u \cdot h}{3 \cdot E \cdot I} \quad \text{with} \quad I = \frac{1000 \cdot t^3}{12 \cdot (1 - \nu^2)}$$

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Design method

Load resistance regarding dislocation of joints q_{Rd}

- Total displacement

$$\delta = \sqrt{{\delta_v}^2 + {\delta_h}^2} \quad \text{with} \quad \delta_h = \delta_{1h} + \delta_{2h}$$

- Link between local force u and uniform load on plank q

$$u = \frac{1}{2} \cdot q \cdot b_u \Leftrightarrow q = \frac{2 \cdot u}{b_u}$$

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Design method

Load resistance regarding dislocation of joints q_{Rd}

$$q_{Rd} = \frac{2 \cdot E \cdot 1000 \cdot t^3 \cdot \delta_{\text{lim}}}{b_u \cdot \left(12 \cdot (1 - \nu^2) \cdot \sqrt{\left(\frac{2 \cdot {b_f}^3}{3}\right)^2 + \left[b_f \cdot \left(\frac{b_u \cdot h}{3} + \frac{h^2}{2}\right)\right]^2}\right)}$$

with

- Chevron joint:

$$\delta_{\text{lim}} = \frac{h}{2 \cdot \tan \varphi}$$

- Clip joint:

$$\delta_{\text{lim}} = c_f$$

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