

Stainless Steel Corrugated Web I-Girders for Composite Road Bridges



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Fatima Hlal

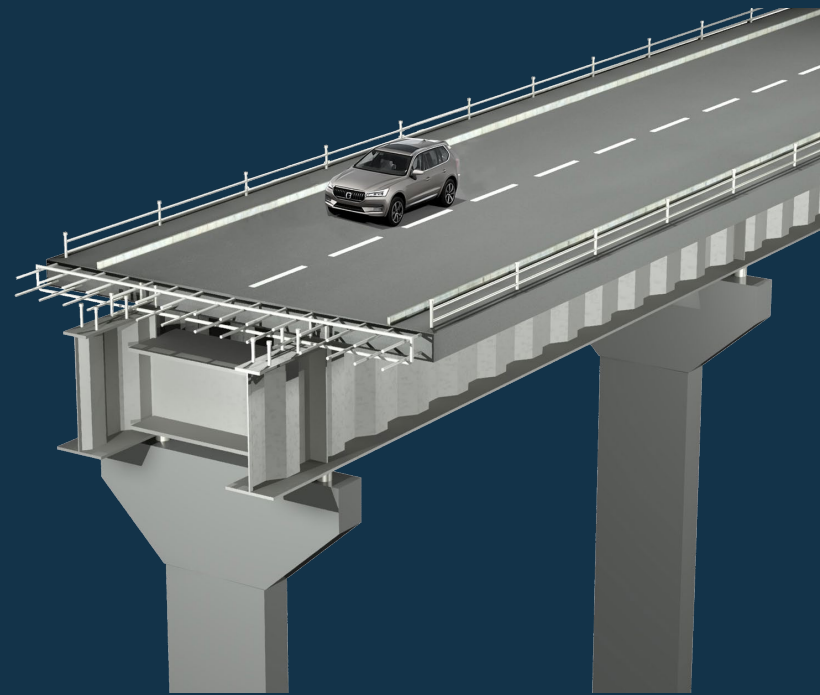
Stålbyggnadsdagen 2025

Funding:

Sustainable Bridges, Trafikverket

LOGLIFE, VINNOVA

Chalmers University of Technology
Department of Architecture and Civil Engineering
Lightweight Structures Research Group



Main points



01 Background

02 Developed design optimization tool

03 Concept evaluation

04 Design aspects

05 Conclusions

01

Background

01 Background

Carbon steel



Susceptible to corrosion, need frequent maintenance → **high paint maintenance cost, user disruption**

	F_y [MPa]	F_u [MPa]
S355	355	490
S460	460	550

Material cost: X → **lower initial cost**

Stainless steel

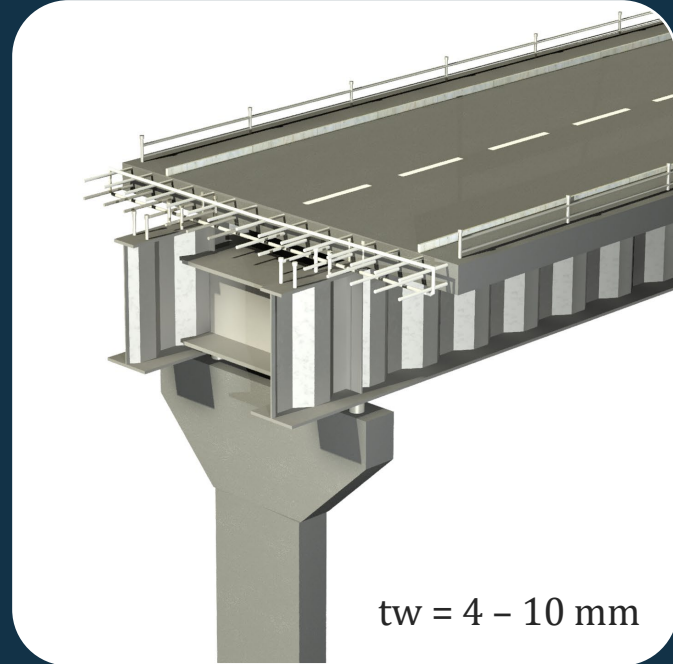
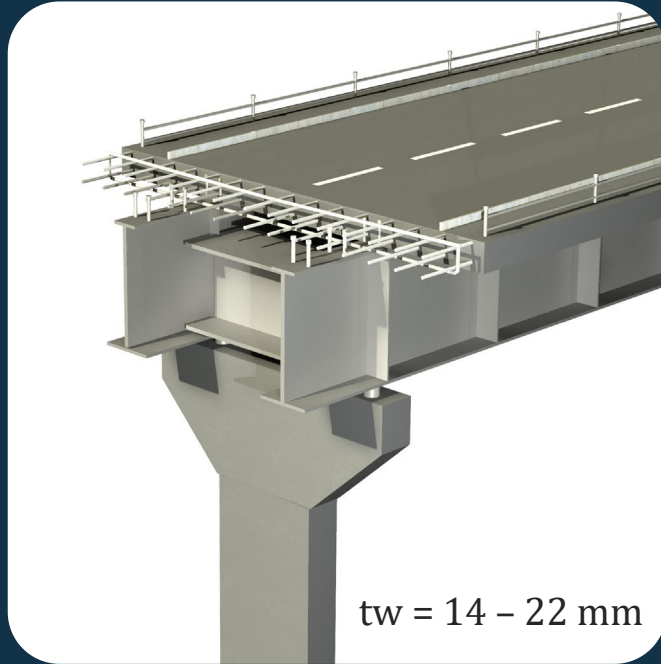


Corrosion resistant → **no paint required, no user disruption**

	F_y [MPa]	F_u [MPa]
EN 1.4462	460	640
EN 1.4162	450	650

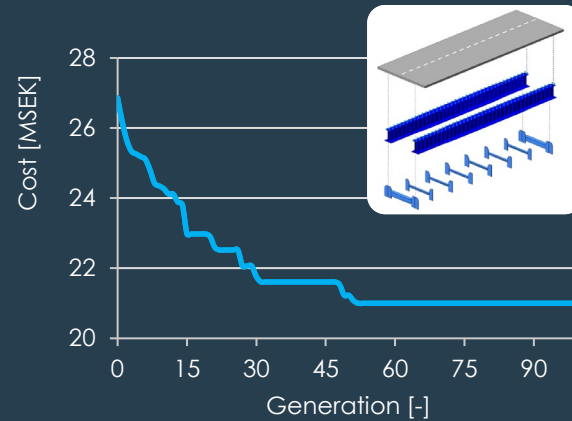
≈ 3X-5X times → **higher initial cost**

01 Background



02

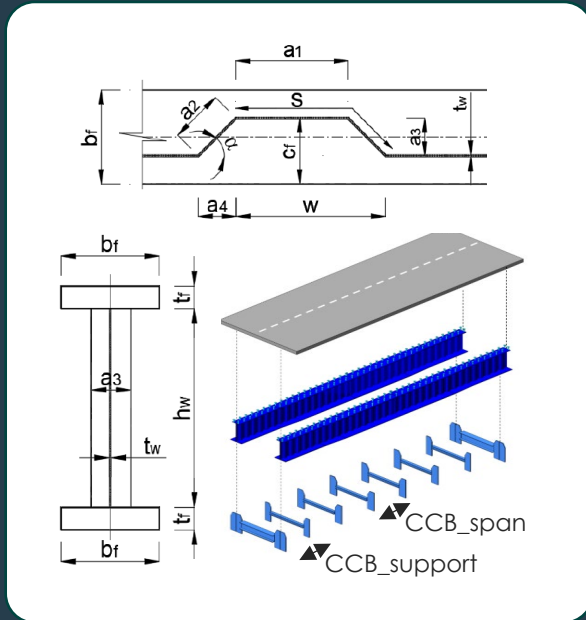
Developed design optimization tool



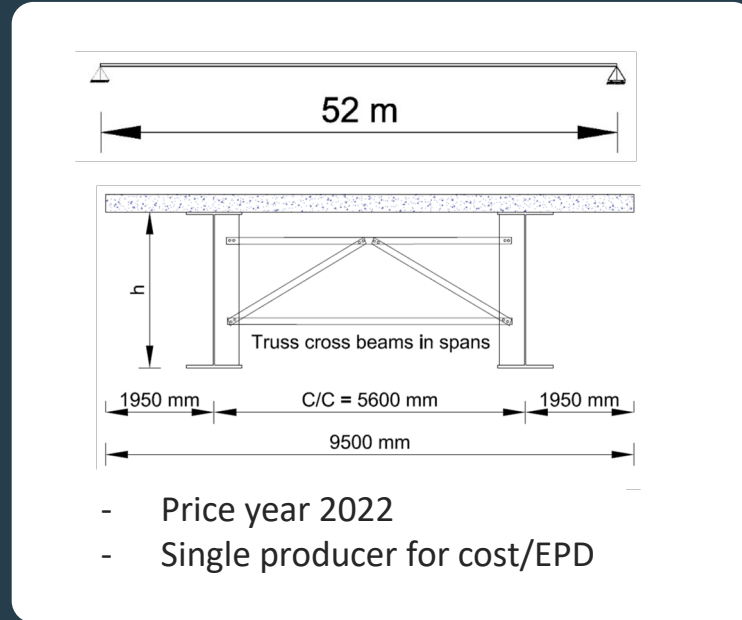
02 Design optimization

Developed tool & Input data

GA design optimization tool



Reference bridge

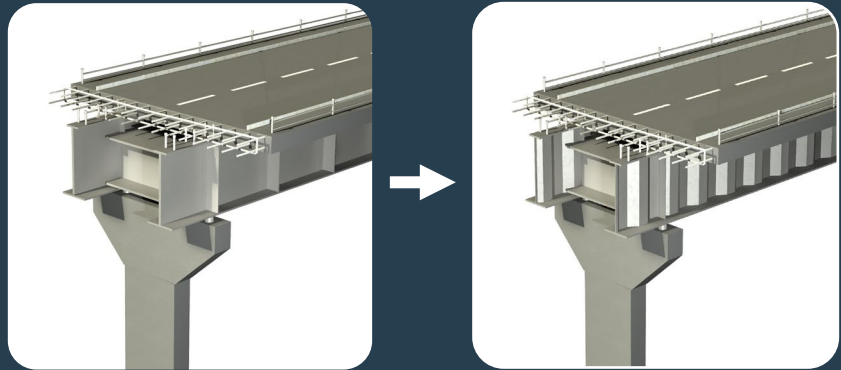


Parametric study EN1.4162 vs S355

- Paint maintenance schedule
- $ADT \& N_{Obs}$
- Height limitations
- Span length

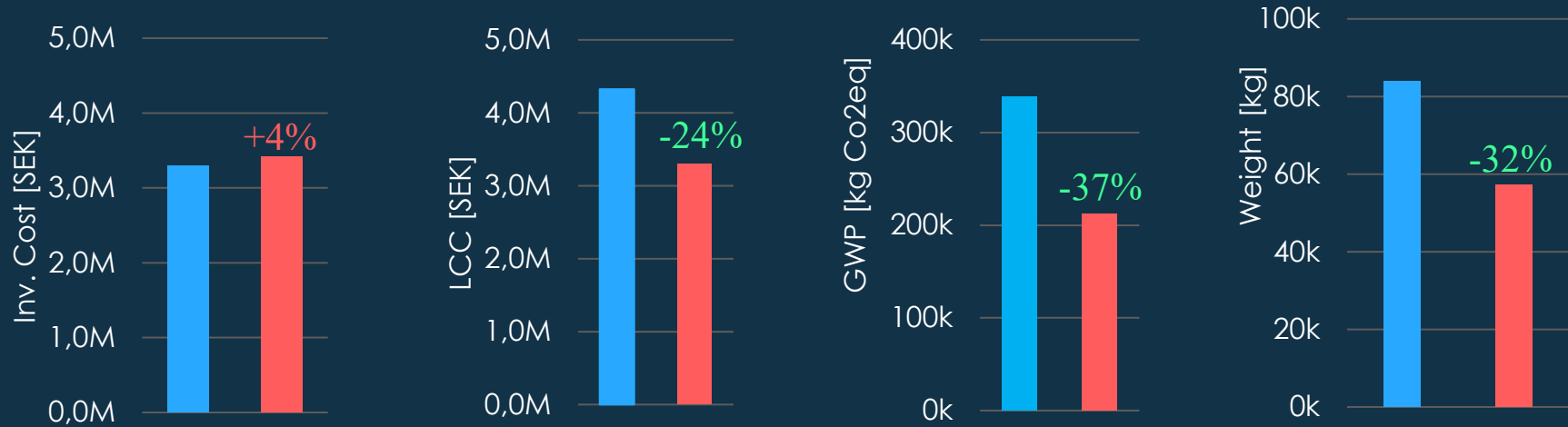
03

Concept evaluation



03 Concept evaluation

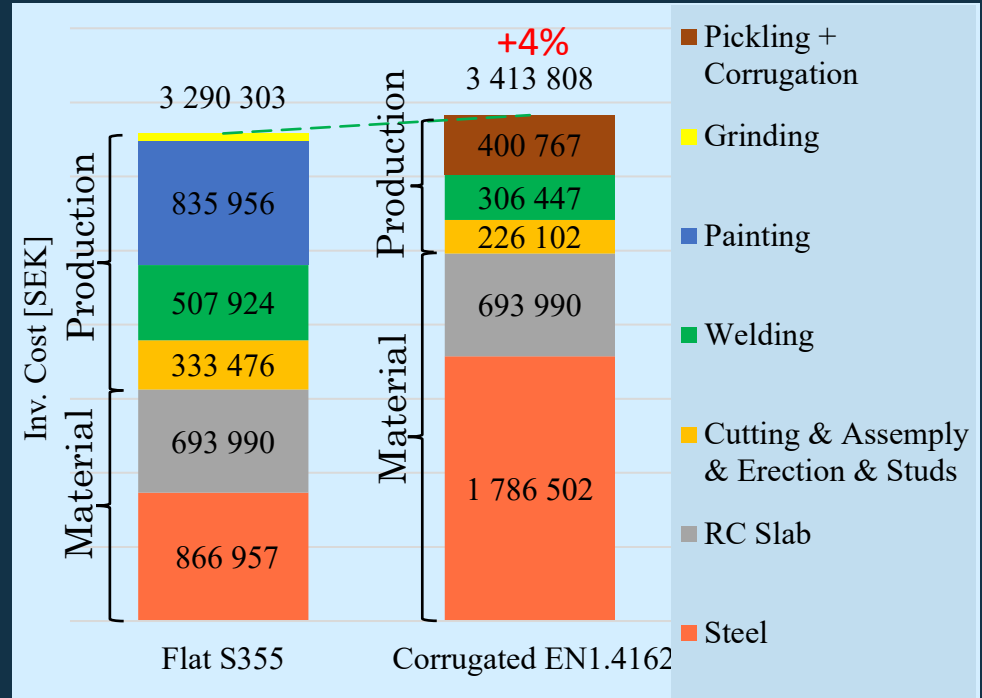
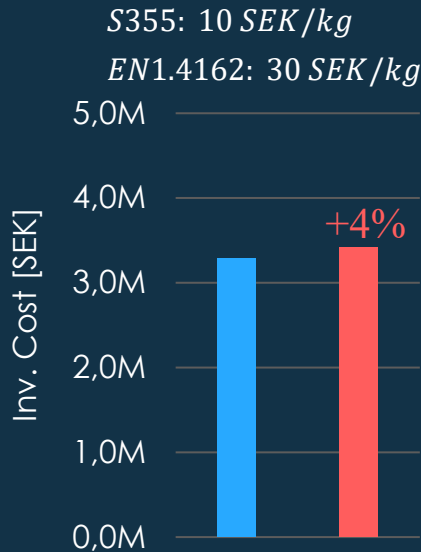
Flat S355 vs Corrugated Duplex



- Flat S355
- Corrugated duplex

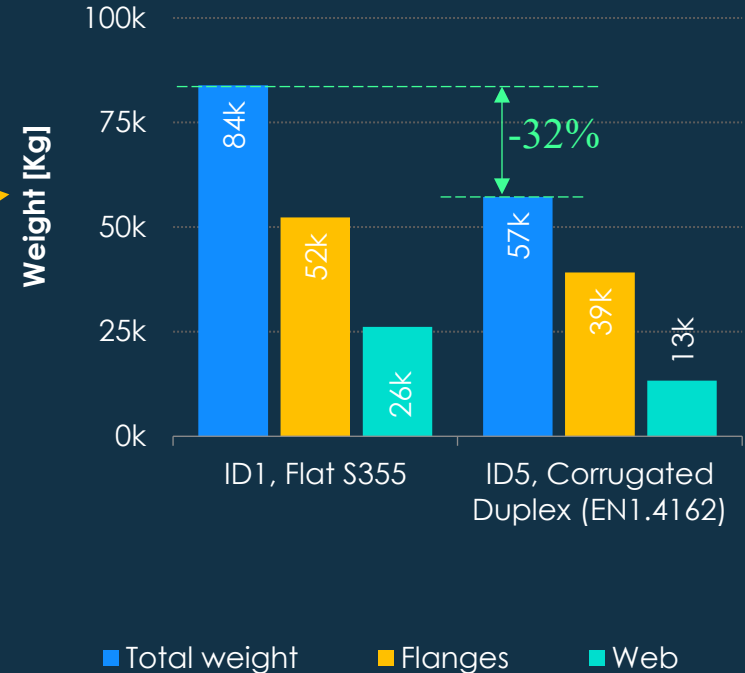
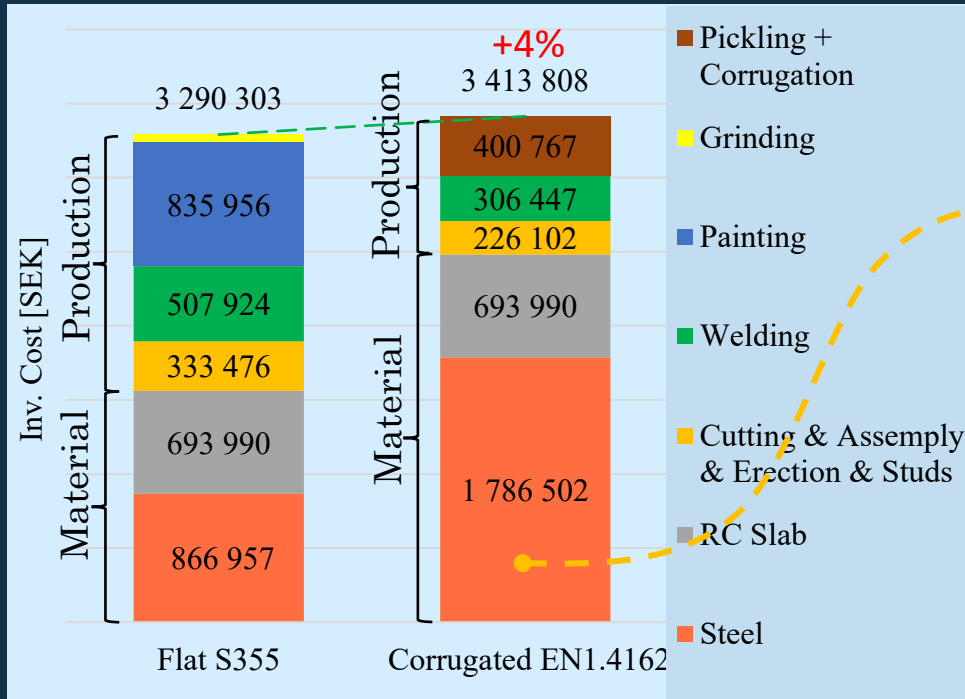
03 Concept evaluation

Flat S355 vs Corrugated Duplex



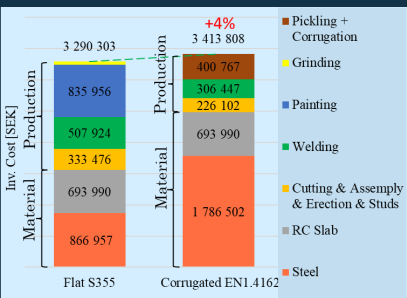
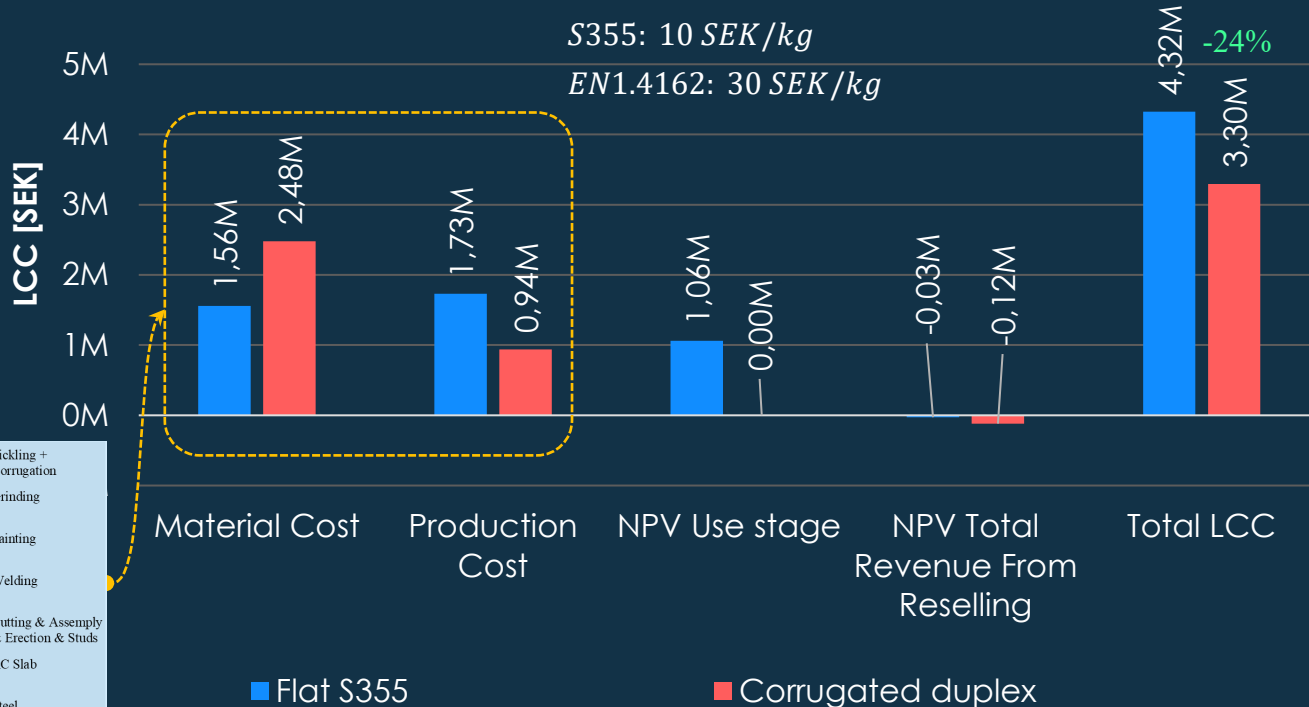
03 Concept evaluation

Flat S355 vs Corrugated Duplex



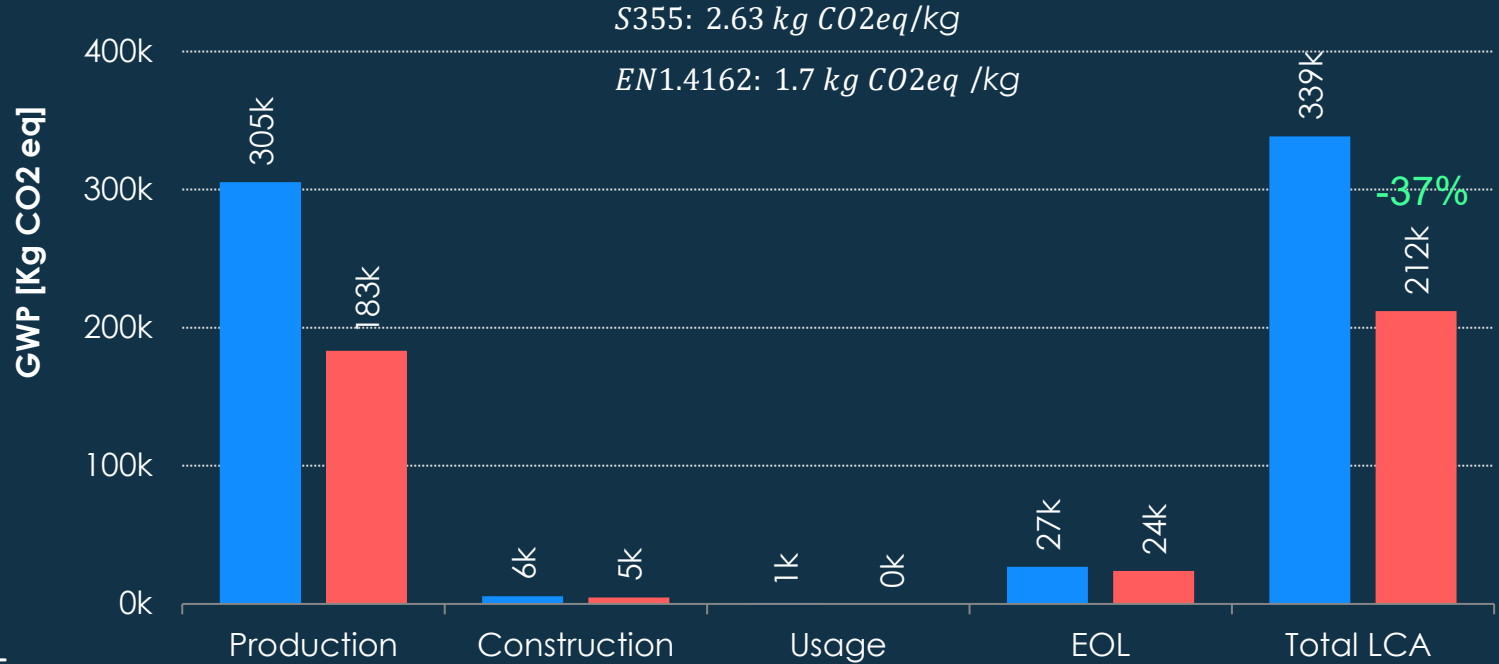
03 Concept evaluation

Flat S355 vs Corrugated Duplex



03 Concept evaluation

Flat S355 vs Corrugated Duplex



S355: 2.63 kg CO2eq/kg

EN1.4162: 1.7 kg CO2eq /kg

- Flat S355
- Corrugated duplex

03 Concept evaluation

Flat S355 vs Corrugated Duplex



- More beneficial for deep girders:
 - 1–11% higher investment cost
 - 20–49% LCC savings
 - 32–42% lower GWP
- More significant saving for more extensive paint maintenance schedule
- More significant saving for higher ADT

03 Concept evaluation

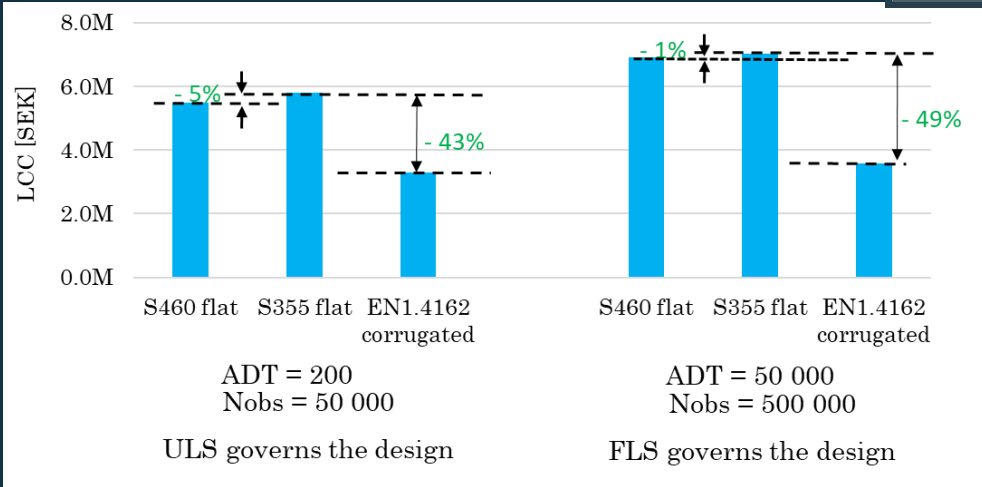
Comparison with Flat S460



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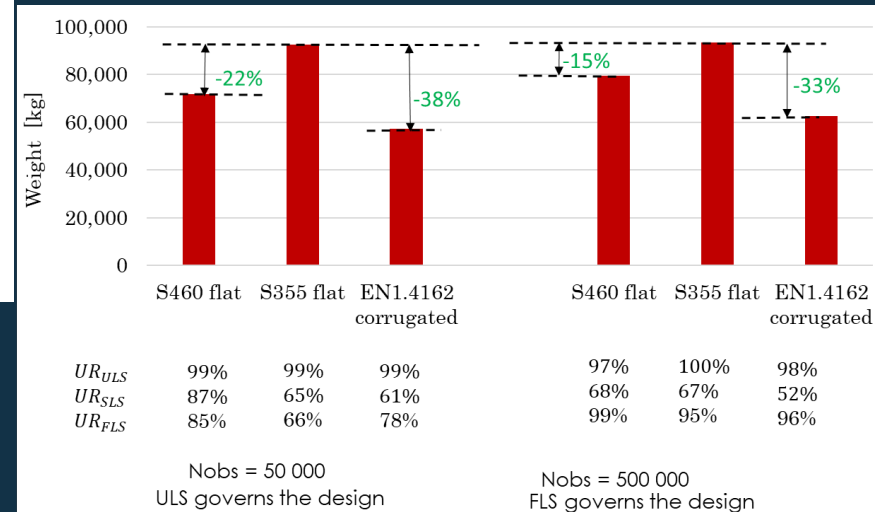
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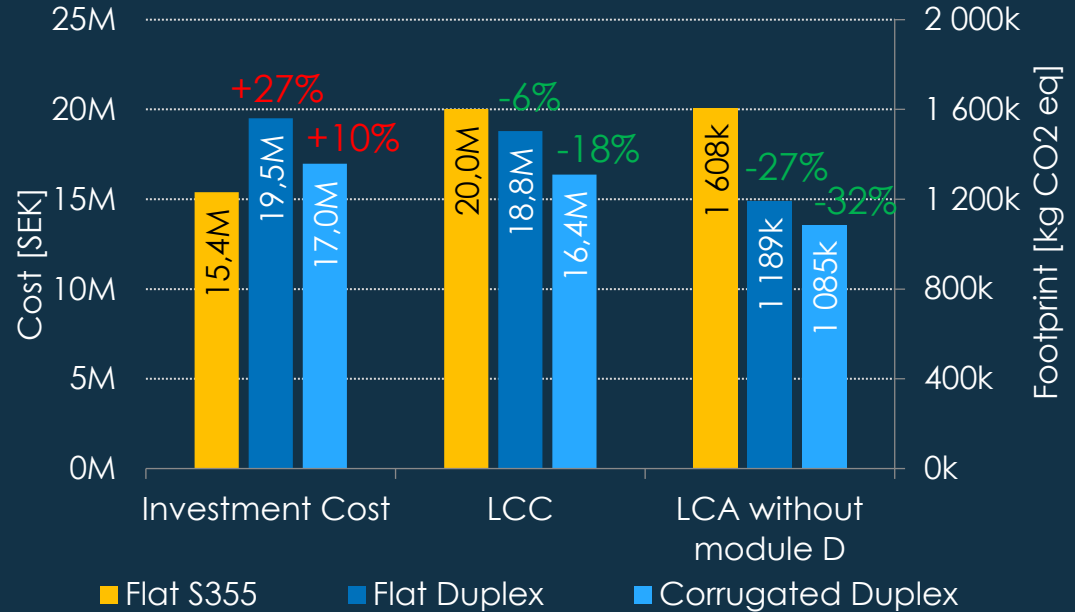
1 kg S460 = 1.13 * 1kg S355

1 kg EN1.4162 = 3 * 1kg S355



03 Concept evaluation

Comparison with Flat Duplex



04

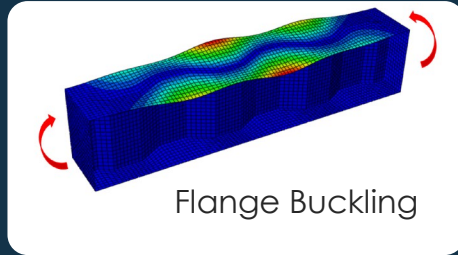
Design aspects

04 Design aspects

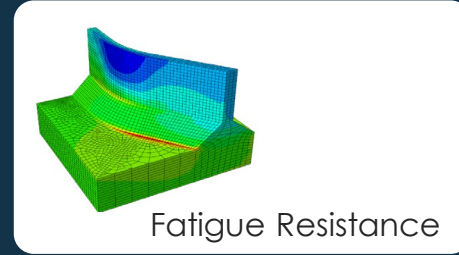
Current Standard



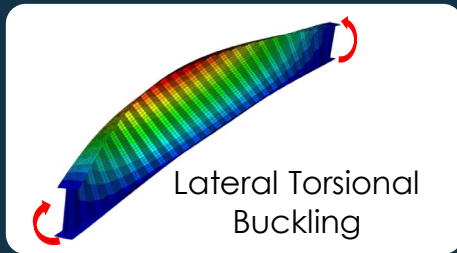
Not conservative for CS!



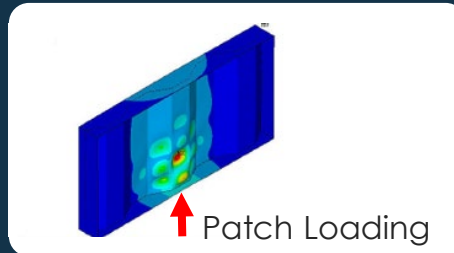
Not included in EN1993-1-9



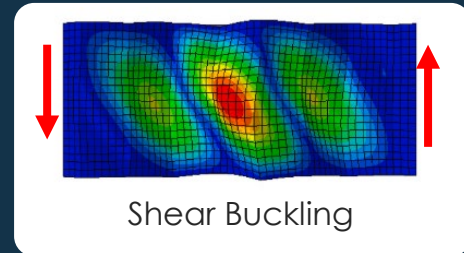
Higher resistance



Conservative

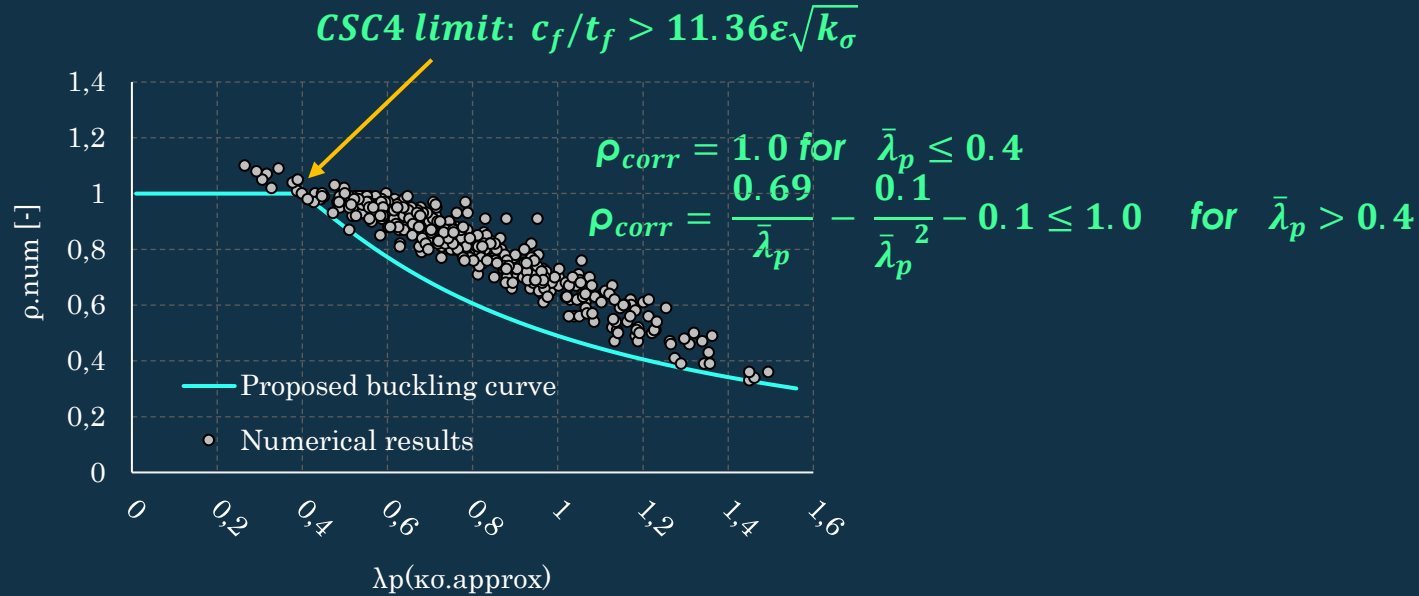
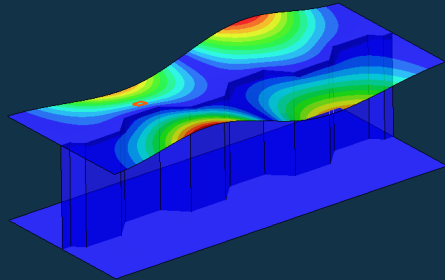


Conservative



04 Design aspects

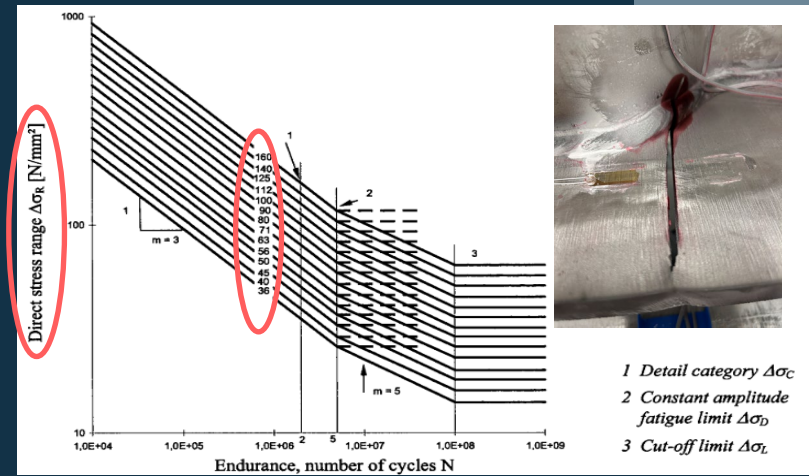
Flange buckling



$$k_{\sigma,corr} = 1.7 - \sqrt{\frac{a_3}{b_f}} + 0.76 \cdot \frac{t_w}{t_f} + 0.94 * \left(\frac{b_f}{t_f}\right)^{0.17} - 2.56 \left(\frac{w}{s}\right)^2$$

04 Design aspects

Fatigue



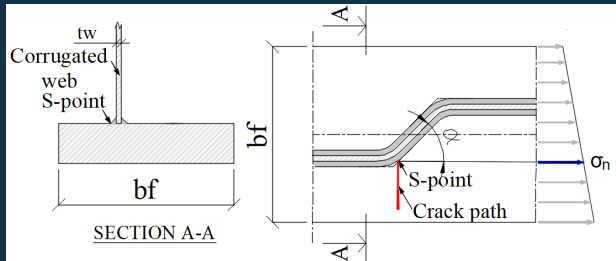
Corrugation angle (α)

$\alpha \leq 30^\circ$

$30^\circ < \alpha \leq 40^\circ$

$40^\circ < \alpha \leq 45^\circ$

$45^\circ < \alpha \leq 60^\circ$



DC125

DC112

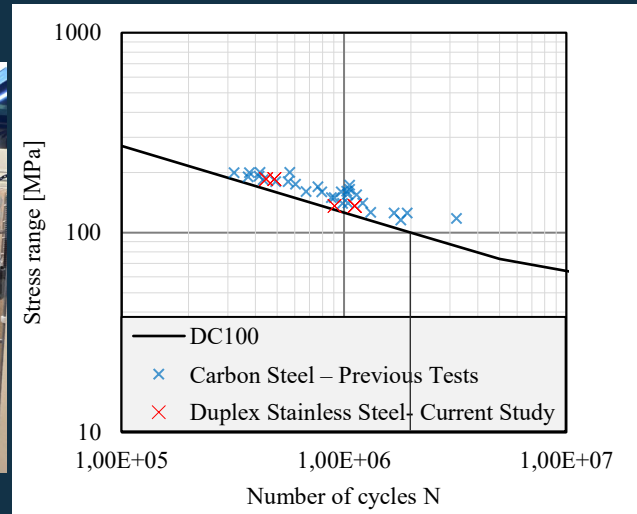
DC100

DC90

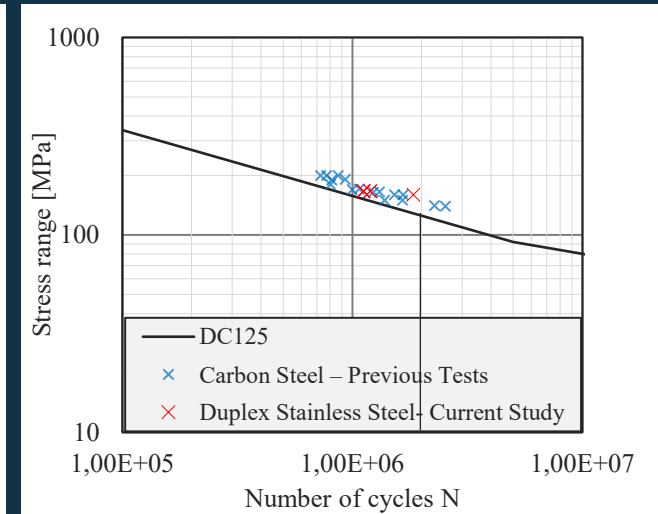
$$\sigma_n = \frac{M_y}{W_y} + \frac{M_z}{W_{flange}} * \frac{a_3}{b_f}$$

04 Design aspects

Fatigue



$\alpha = 45^\circ$ DC = 100 MPa



$\alpha = 30^\circ$ DC = 125 MPa

Equivalent fatigue strength to carbon steel

05

Conclusions

05 Conclusions



- The studied concept can reduce the investment cost gap between carbon and stainless steels. The combination of high corrosion resistance, eliminated need for painting, and significant weight savings means a moderate increase in investment cost, while providing lower life cycle costs and reduced climate impact.
- The benefits are more pronounced for deep girders, high ADTs, and more intensive paint maintenance activities.
- The duplex stainless steel with corrugated web exhibited comparable fatigue strength to carbon steel, making it well-suited for road bridges.



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WSP

Thank You!