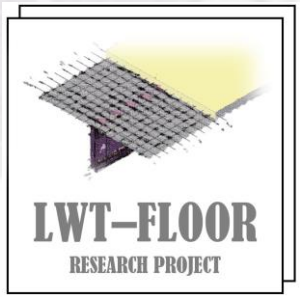
Project title: **Innovative lightweight cold-formed steel-concrete composite floor system**
Acronym: **LWT-FLOOR** Project ID: **UIP-2020-02-2964**
2nd LWT-FLOOR Project Workshop

Parametric finite element analyses of lightweight cold-formed steel-concrete composite floor beams

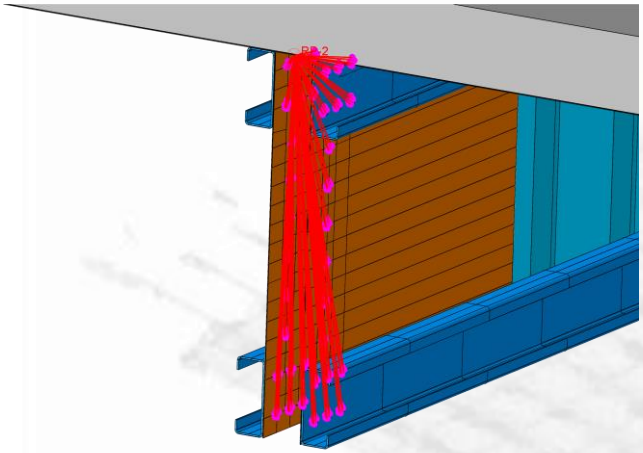
Ivan Lukačević, Ivan Ćurković, **Andrea Rajić**, Vlaho Žuvelek

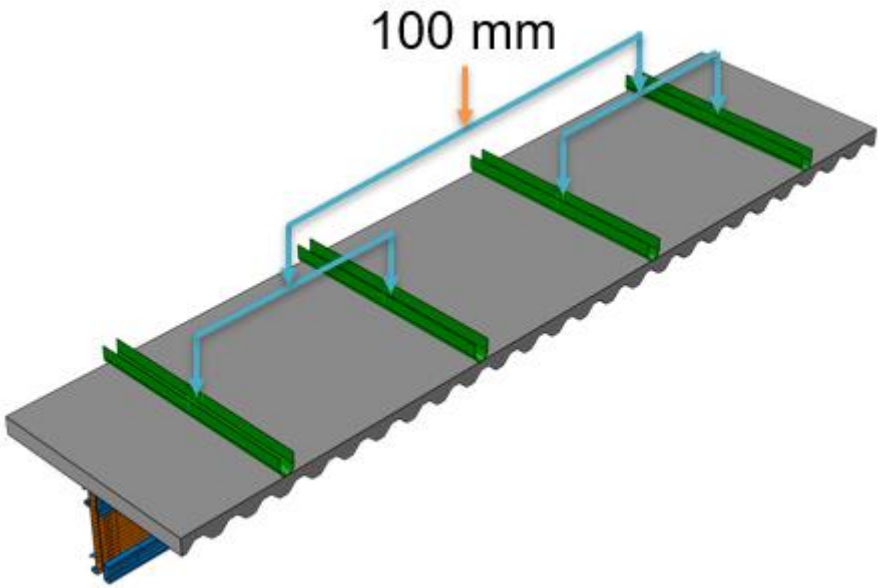


University of Zagreb/Faculty of Civil Engineering
http://www.grad.unizg.hr/lwtfloor

2. Numerical model

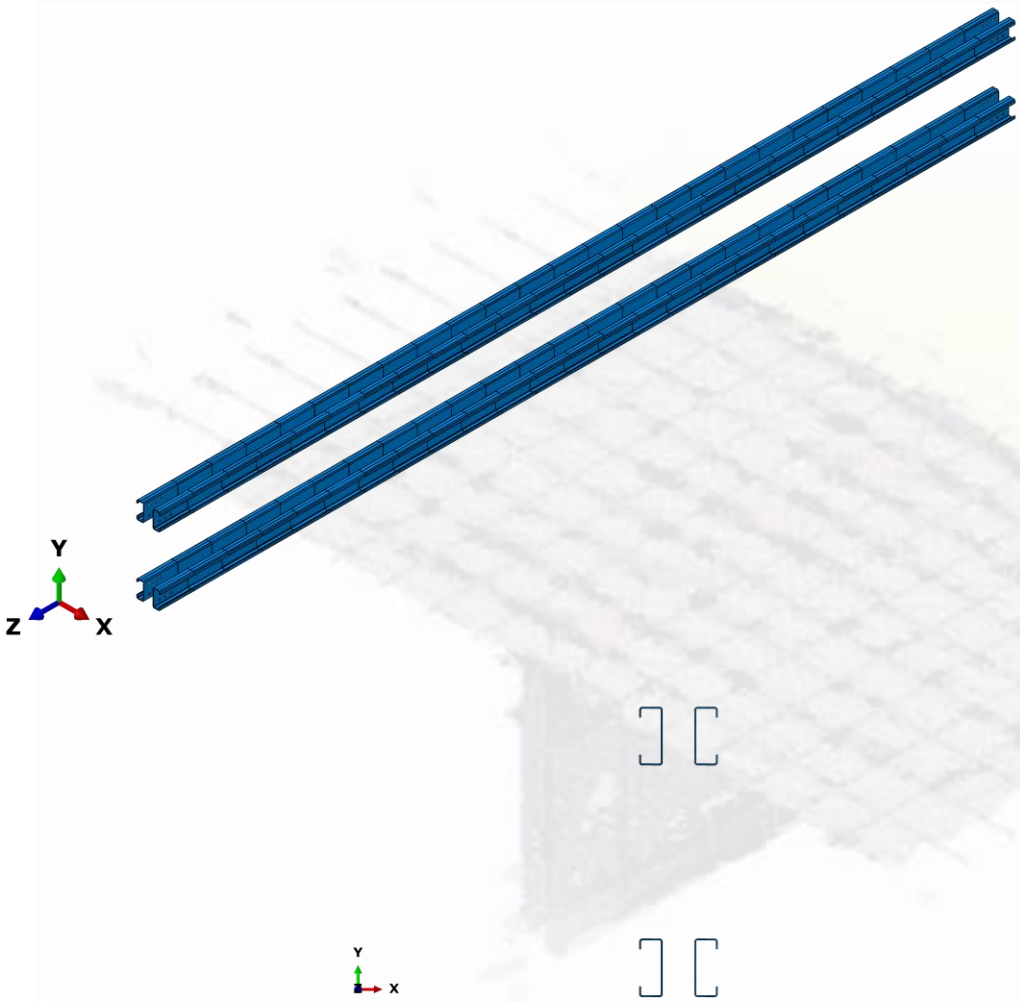
- Support conditions





ELEMENT	MESH SIZE	ELEMENT TYPE	ELEMENT	MESH SIZE	ELEMENT TYPE
C profile	10 mm	S4R	Metal sheet	20 mm	S4R
Shear plate	15 mm	S4R	Shear connector	15 mm	B31
Corrugated web	15 mm	S4R	Concrete slab	30 mm	C3D8R

2. Numerical model



CFS C120 profiles: S350 GD
- thickness: 2.5 mm

Shear plates: S350 GD
- thickness: 1.0 mm
- height: 400/500/600 mm

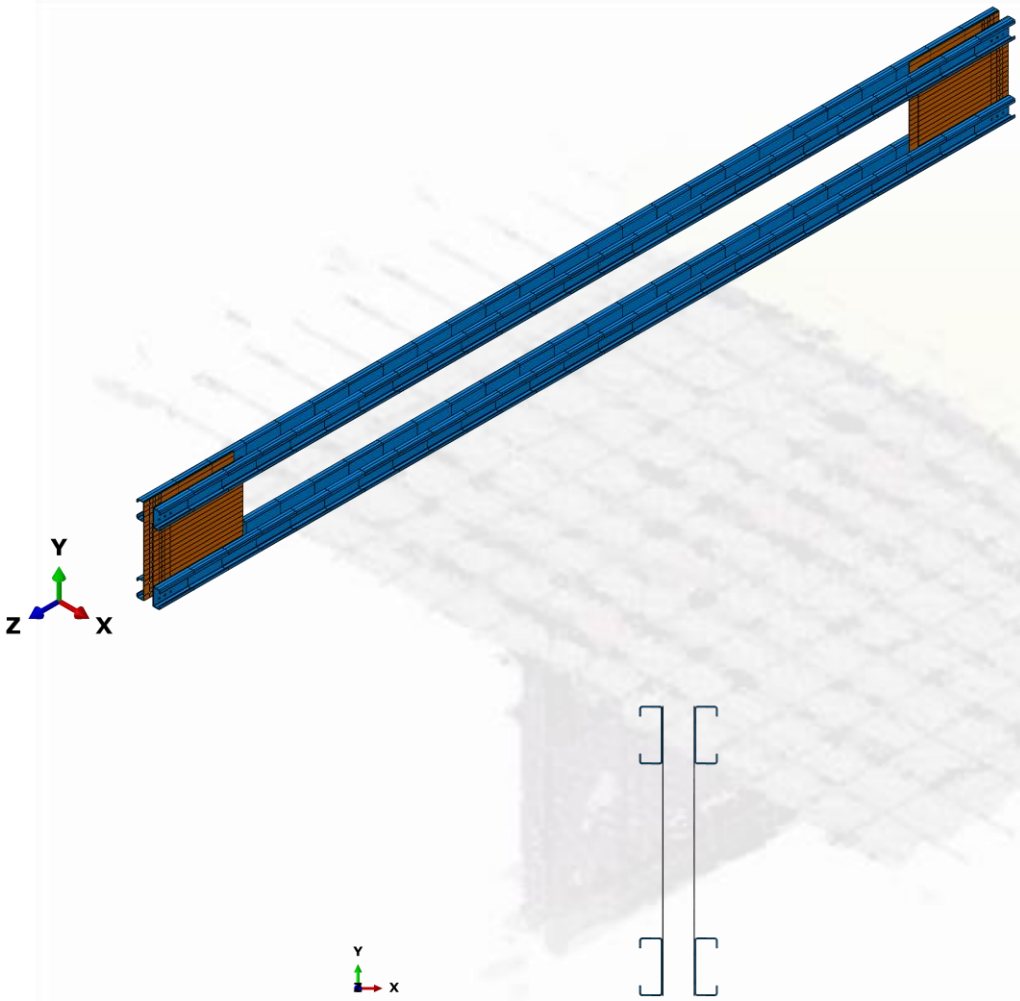
Corrugated web: S350 GD
- thickness: 0.8/1.0/1.5 mm
- height: 400/500/600 mm

Metal sheet: S350 GD
- thickness: 1.0 mm
- eff. width: 1500 mm

Shear connectors:
- in pairs
- M12
- height: 84 mm
- quality: 8.8

Concrete slab:
- C25/30
- eff. width: 1500 mm
- height: 120 mm

2. Numerical model



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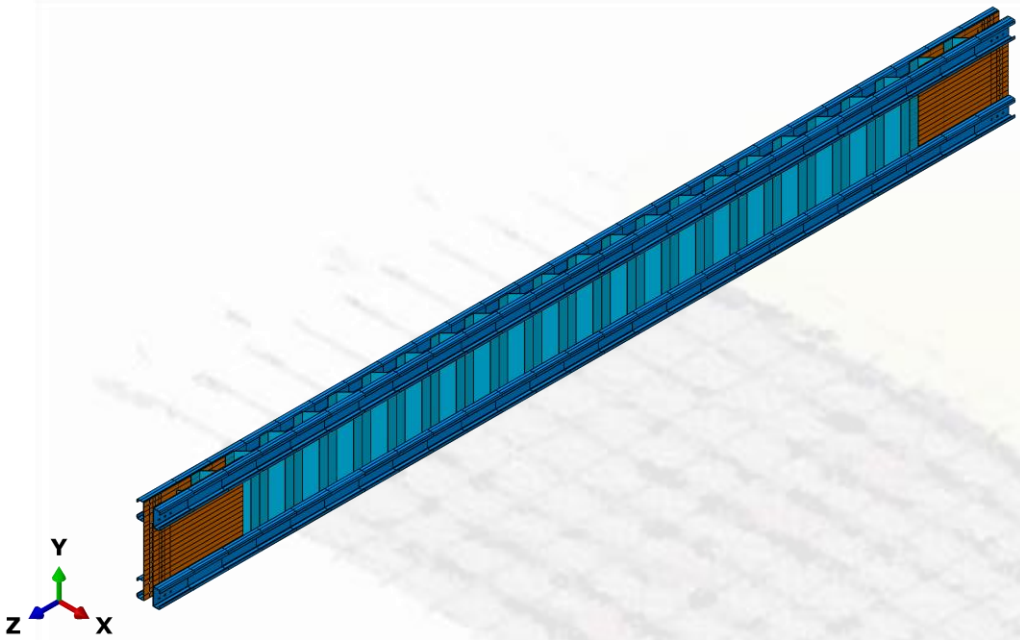

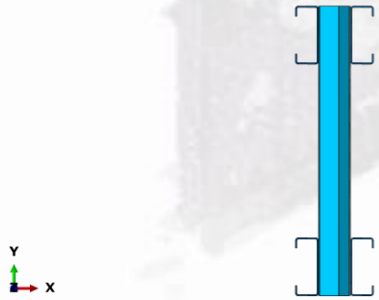

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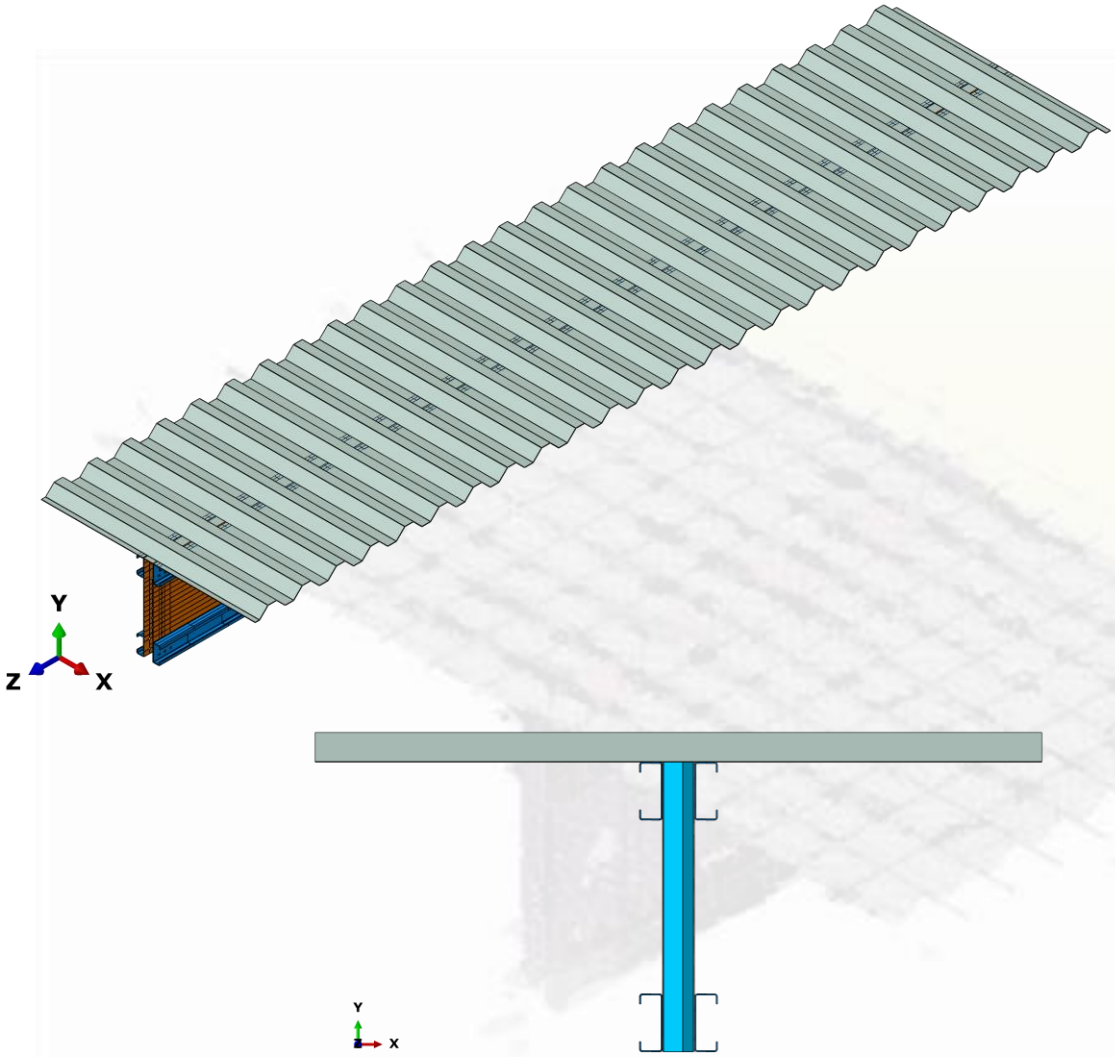

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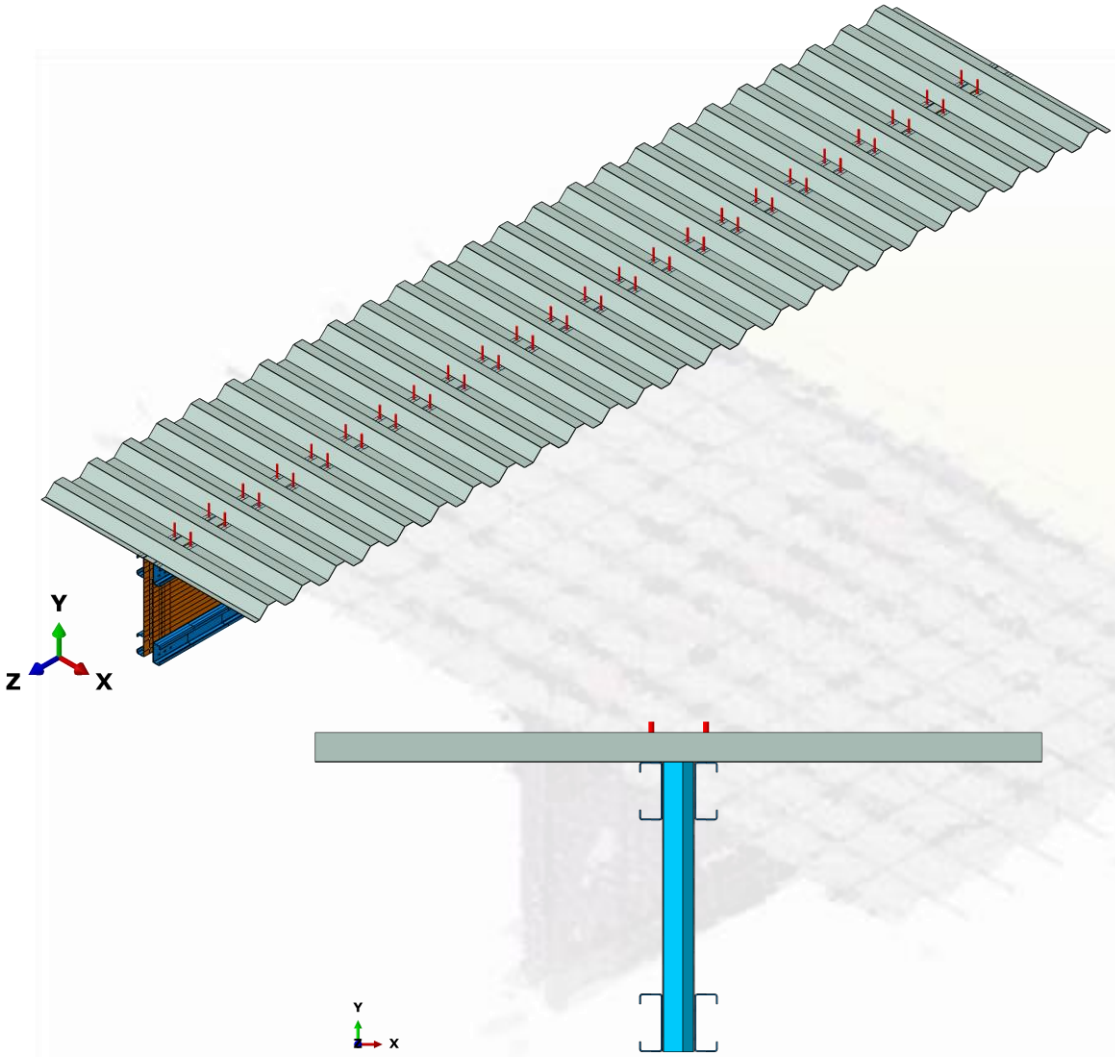

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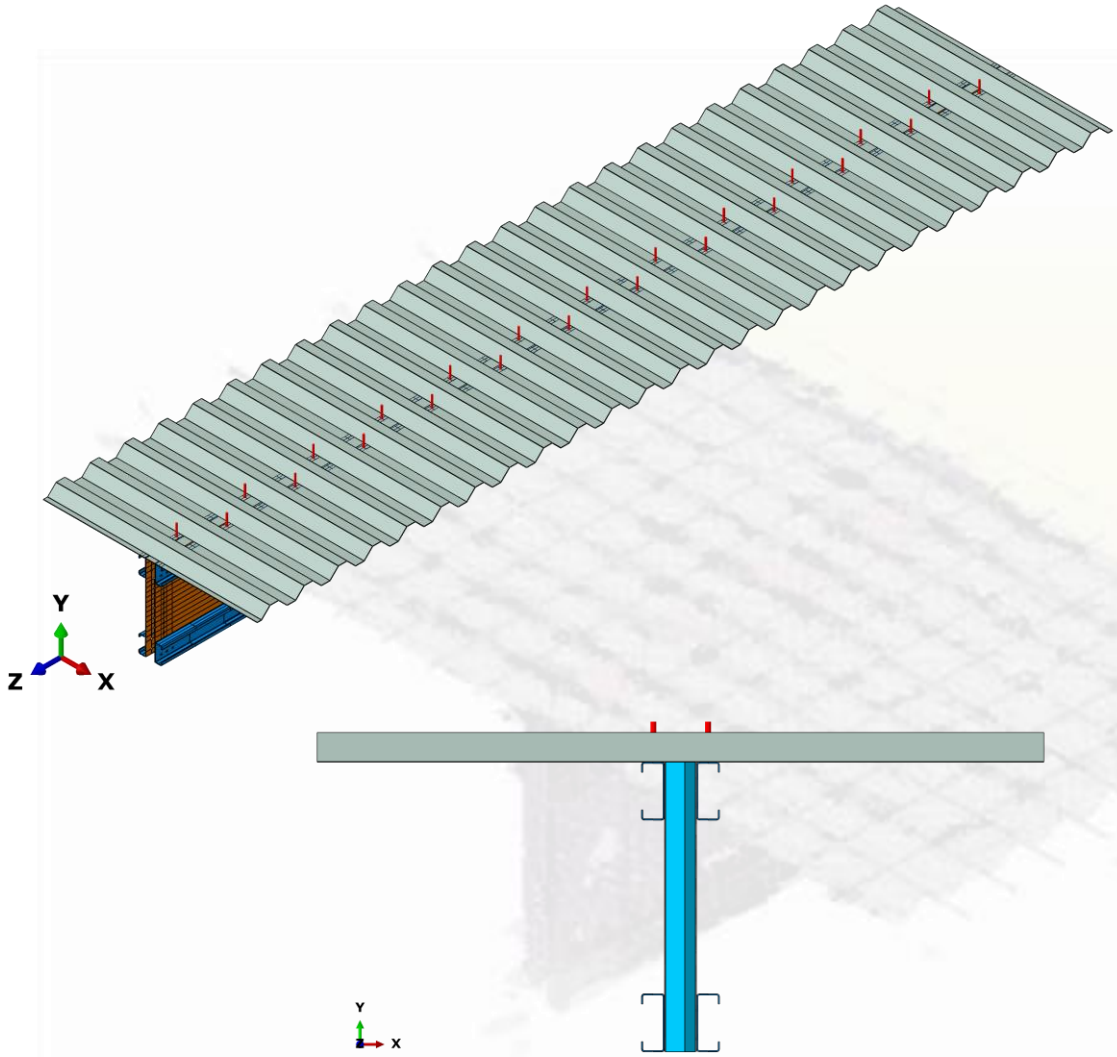

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Metal sheet: S350 GD
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- eff. width: 1500 mm

Shear connectors:
- staggered position
- M12
- height: 84 mm
- quality: 8.8

Concrete slab:
- C25/30
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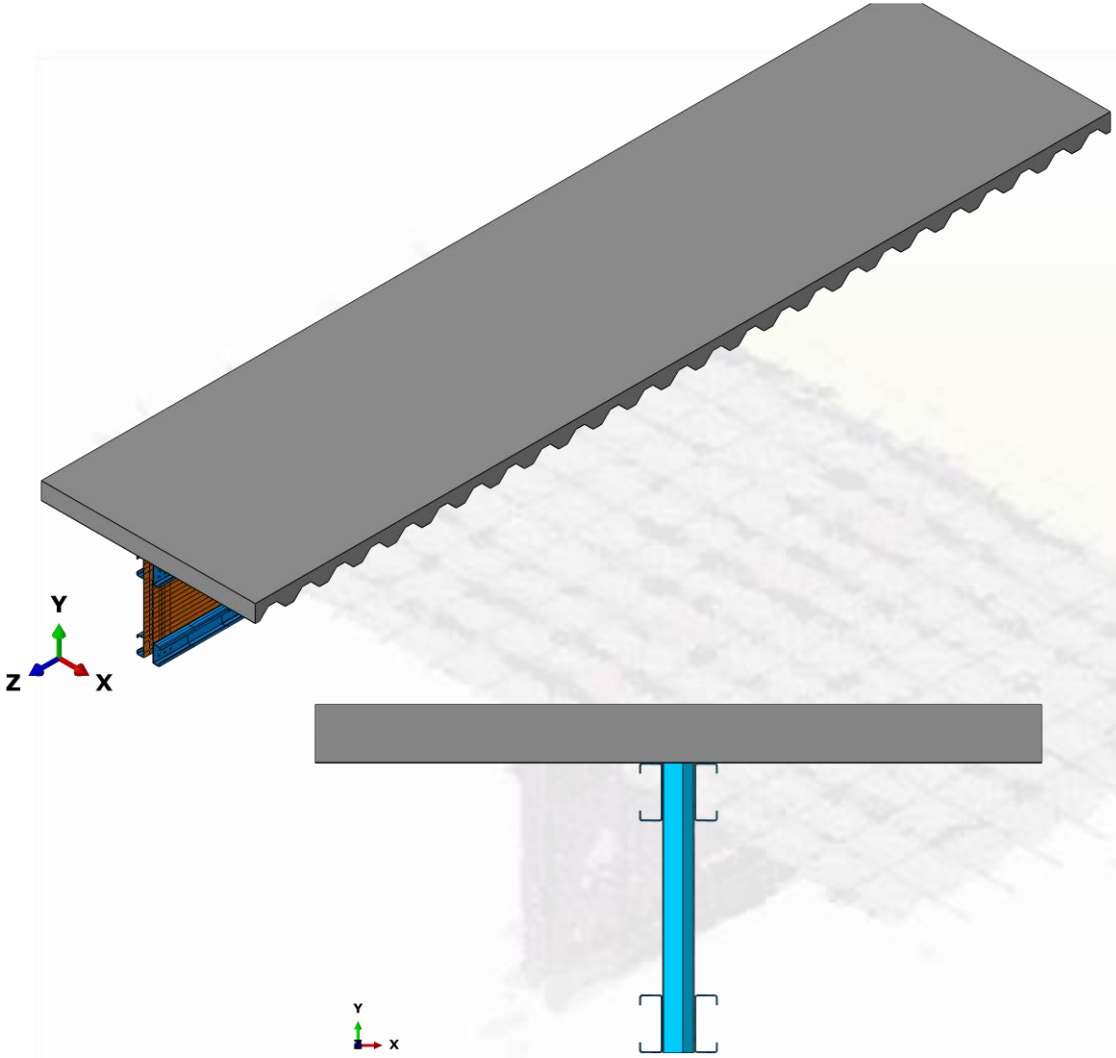

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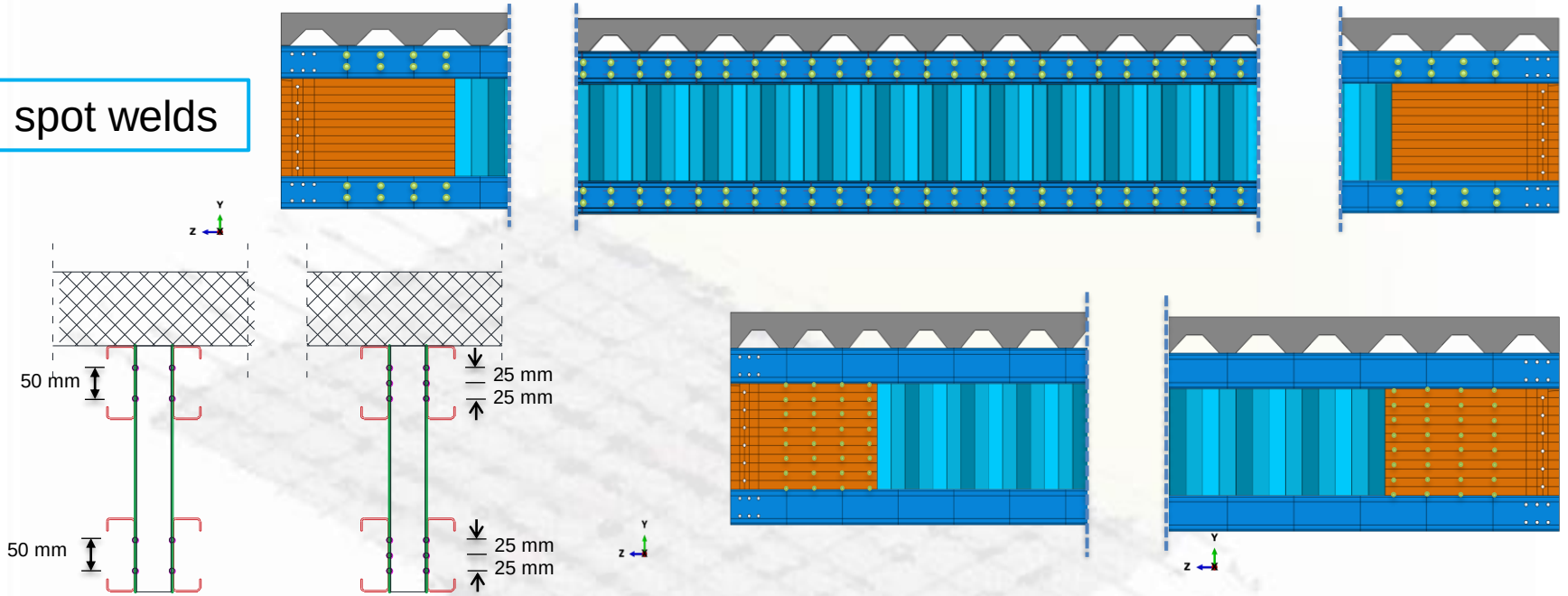
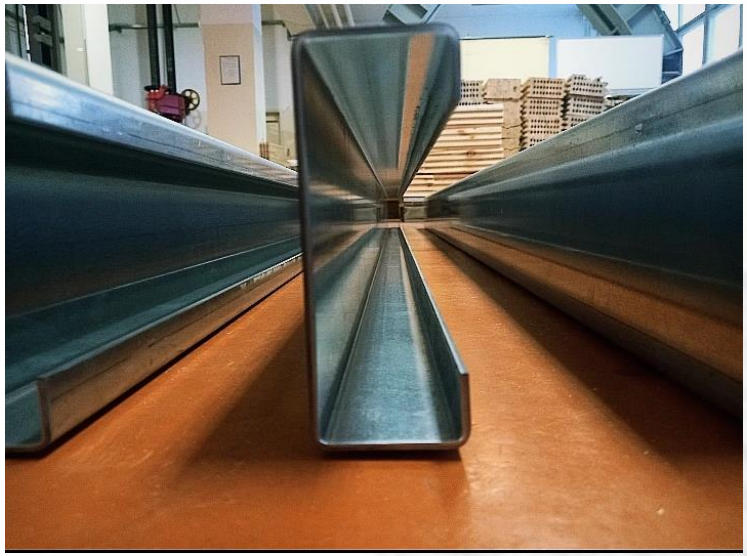
2. Numerical model

2 spot welds



3 spot welds

3. Analytical model



CFS sections

↓

Class 3 and 4

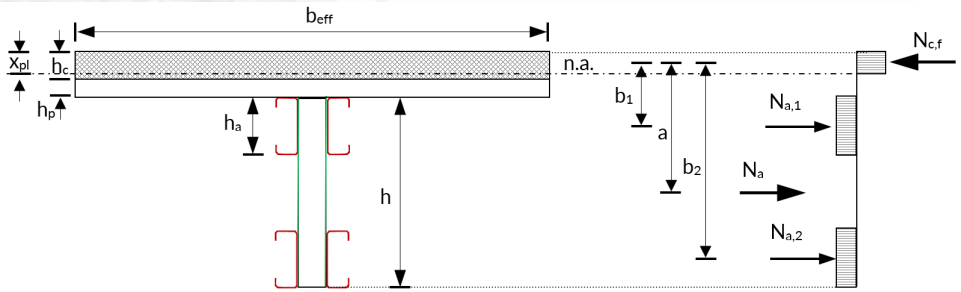
↓

No possibilty of plastic bending resistance

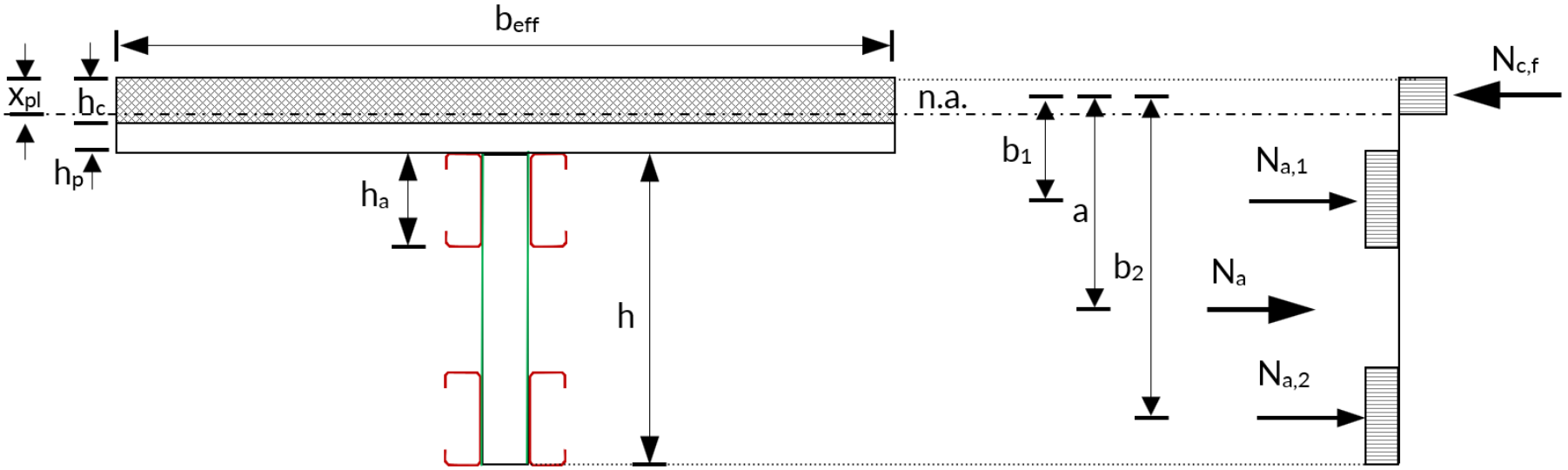
Composite CFS-concrete sections

↓

plastic bending resistance



3. Analytical model



$$x_{pl} = \frac{4 \cdot A_a \cdot f_{yd}}{b_{eff} \cdot 0.85 \cdot f_{cd}}$$

EN 1994-1-1 $$M_{Rd} = M_{pl,a,Rd} + \left(M_{pl,Rd} - M_{pl,a,Rd}\right) \cdot \eta$$

$$M_{pl,Rd} = b_{eff} \cdot x_{pl} \cdot 0.85 \cdot f_{cd} \cdot \left(\frac{h}{2} + h_c + h_p - \frac{x_{pl}}{2}\right)$$

$$M_{Rd} = M_{el,a,Rd} + \left(M_{pl,Rd} - M_{el,a,Rd}\right) \cdot \eta$$

$$M_{pl,Rd} = 2A_a \cdot f_{yd} \cdot \left(\frac{h_a}{2} + h_c + h_p - \frac{x_{pl}}{2}\right) + 2A_a \cdot f_{yd} \cdot \left(h - \frac{h_a}{2} + h_c + h_p - \frac{x_{pl}}{2}\right)$$

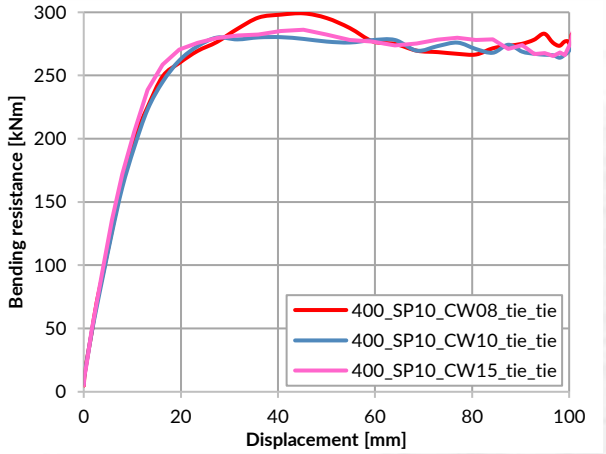
$$k_t = \frac{0.7}{\sqrt{n_r}} \cdot \frac{b_0}{h_p} \cdot \left(\frac{h_{sc}}{h_p} - 1\right)$$

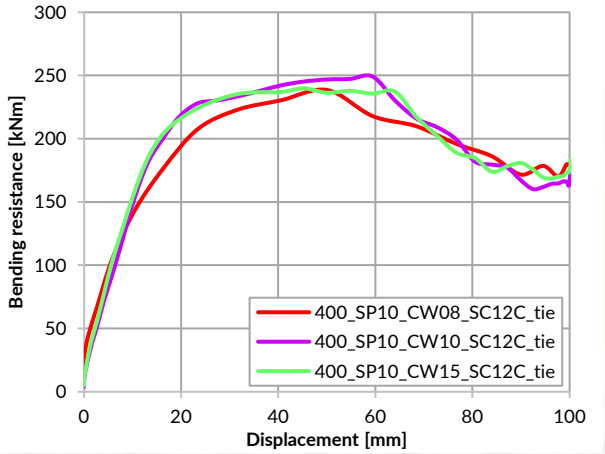
4. Parametric numerical study

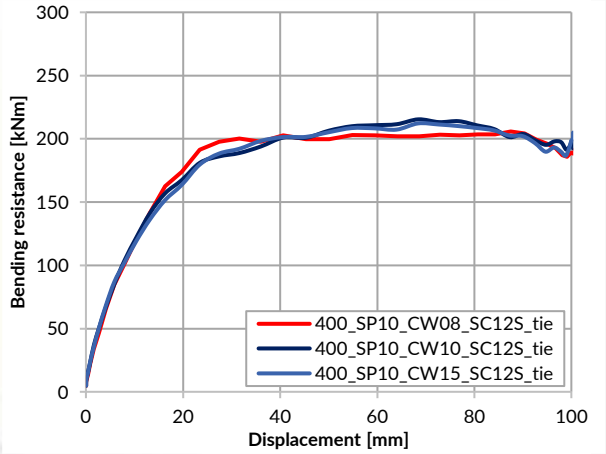
- Influence of corrugated web thickness
  - → 0.8 mm → 1.0 mm → 1.5 mm
- Influence of the connection between steel elements
  - → tied → 2 SW → 3 SW
- Influence of the degree of shear connection
  - → tied → in pairs → in staggered arrangement
- Influence of the steel beam height
  - → 400 mm → 500 mm → 600 mm

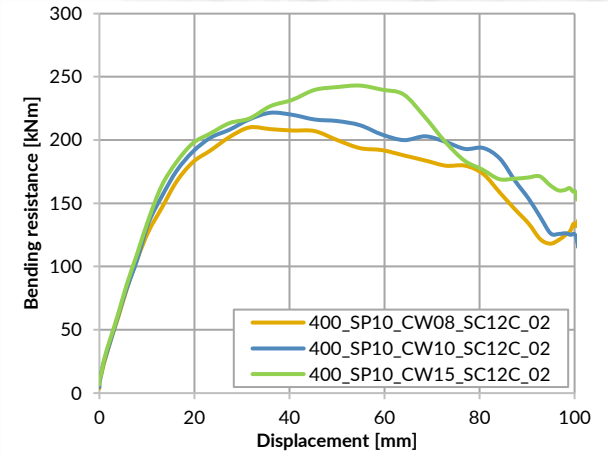
4. Parametric numerical study

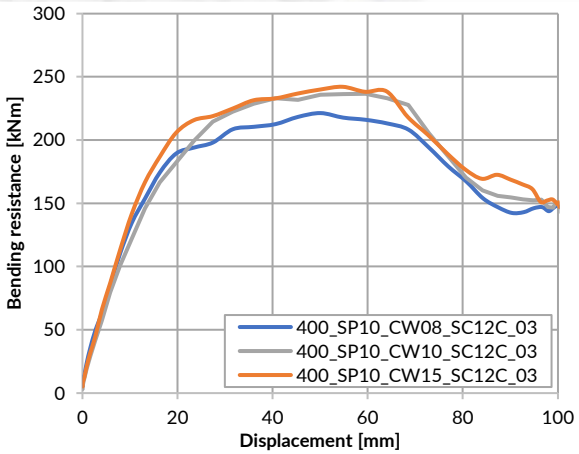
- Influence of corrugated web thickness





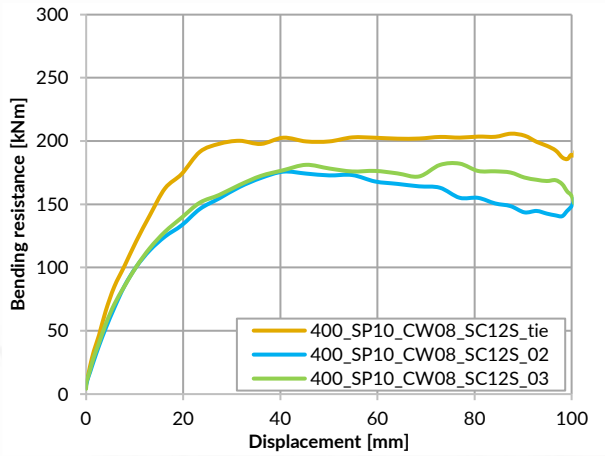


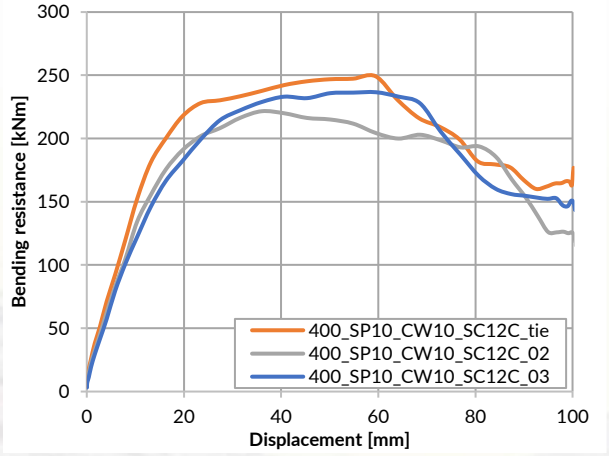


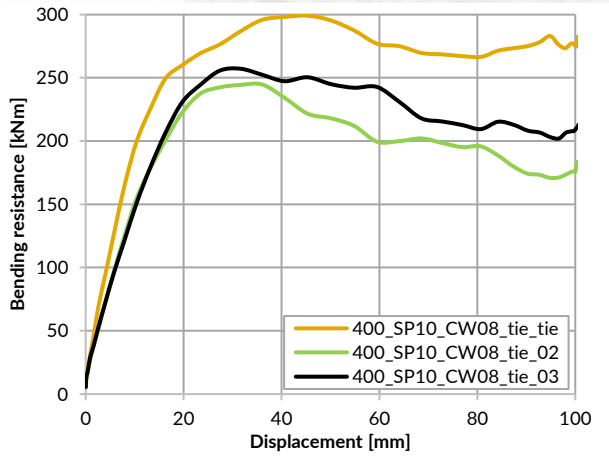


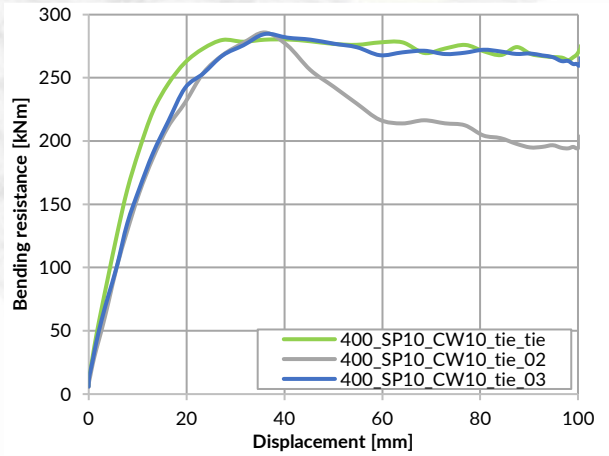
4. Parametric numerical study

- Influence of the connection between steel elements



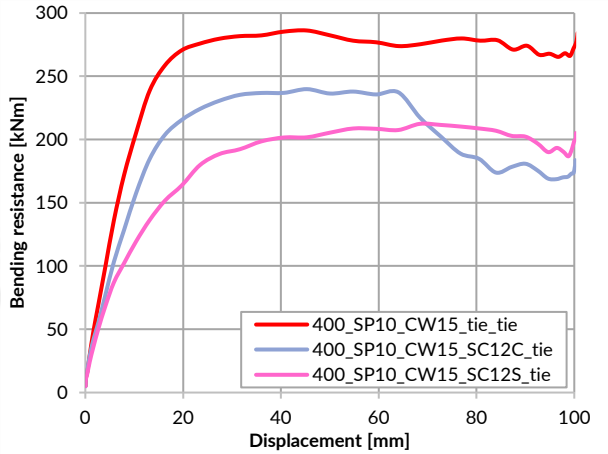


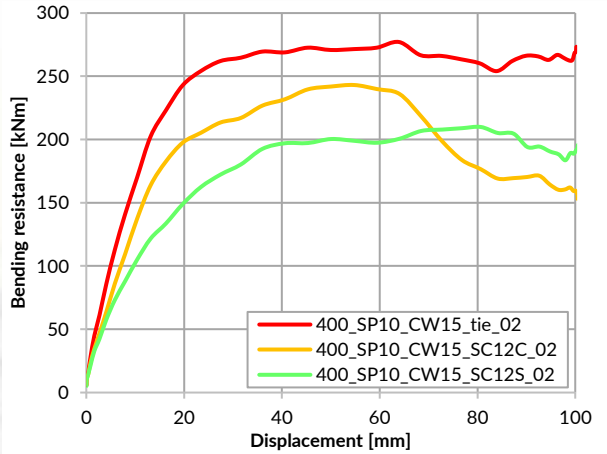


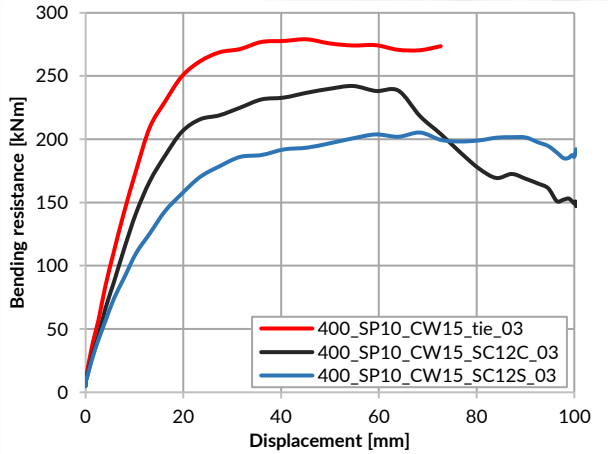


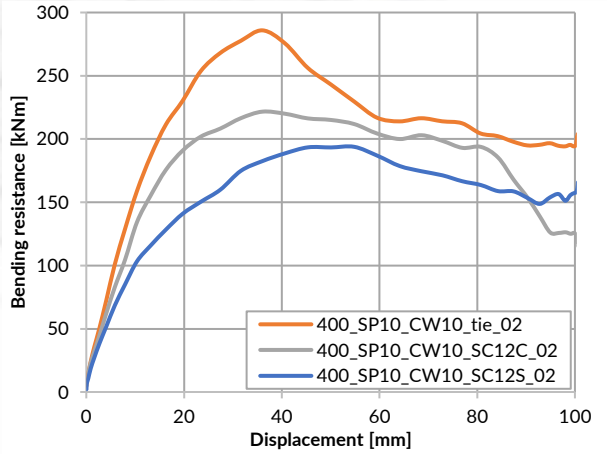
4. Parametric numerical study

- Influence of the degree of shear connection



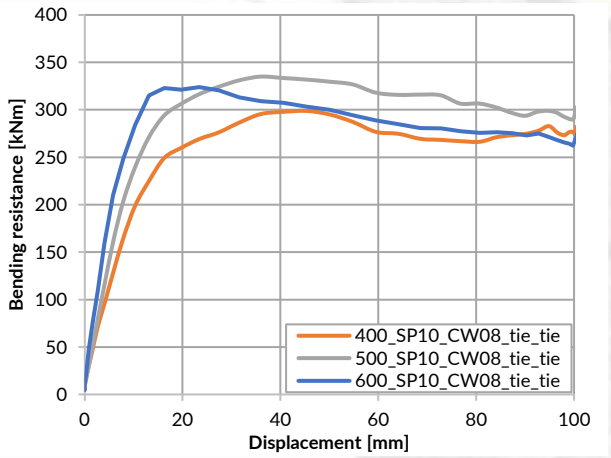


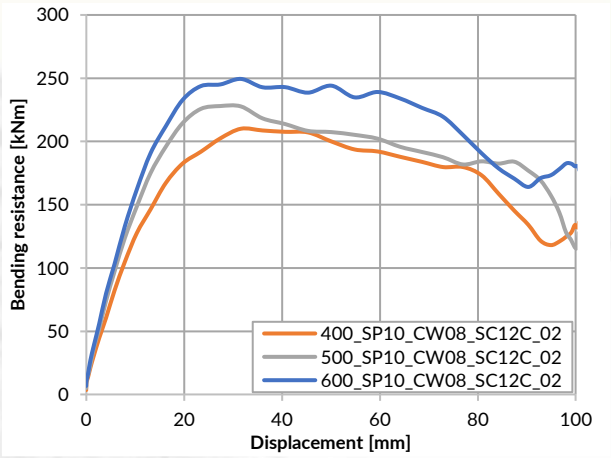




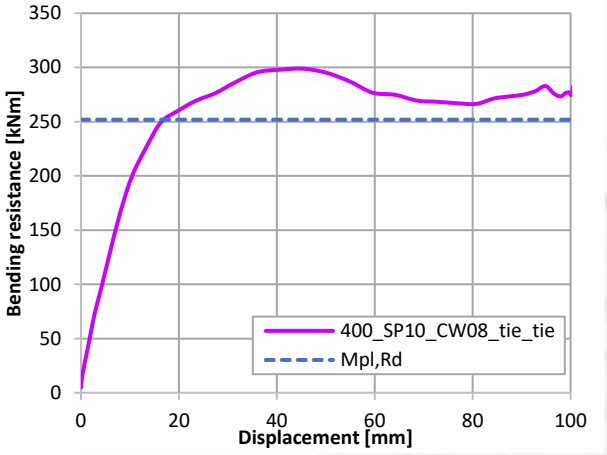
4. Parametric numerical study

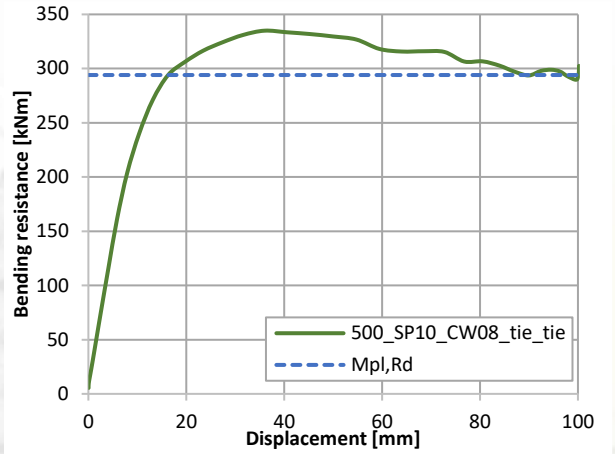
- Influence of the steel beam height

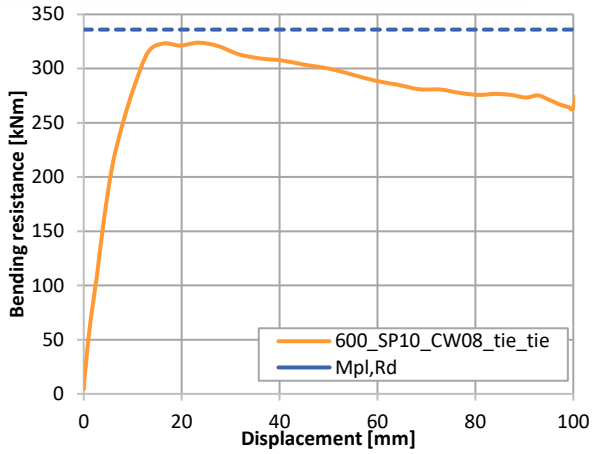


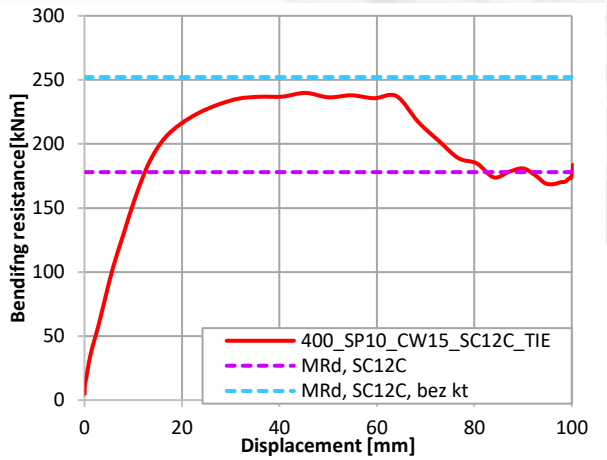


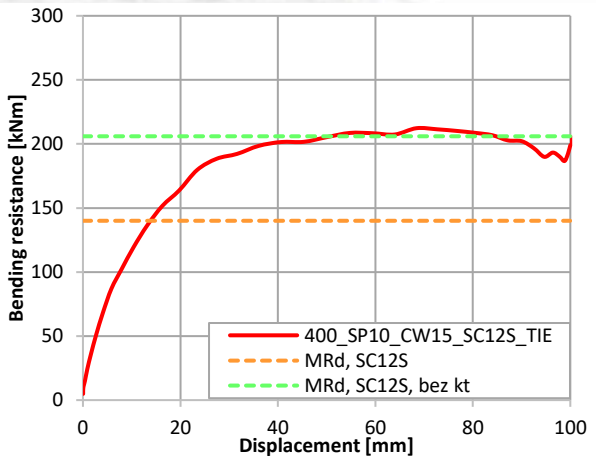
5. Analytical vs numerical results











6. Conclusions

- The influence of connections between steel beam elements and the degree of shear connection had the most significant impact on system behaviour.
- The steel beam height, the corrugated web thickness and spot weld density had less influence on the analysed composite system behaviour.
- The corrugated web thickness has a low influence on bending capacity in the case of tied steel beam elements.
- In the case of discrete connections between steel beam elements, a certain influence of corrugated web thickness on bending capacity is observed.

6. Conclusions

- It is possible to achieve similar bending resistance by varying cross-sectional parameters such as the density of spot welds instead of steel beam height.
- The analytical and numerical results are in agreement for the full shear connection between the steel beam and concrete slab while steel beam elements are fully tied.
- In the case of partial shear connection, when comparing analytical results with numerical parametric results, it is concluded that the proposed modification of the Eurocode 4 model using the reduction factor, k_t, can provide resistance corresponding to the numerically obtained values.

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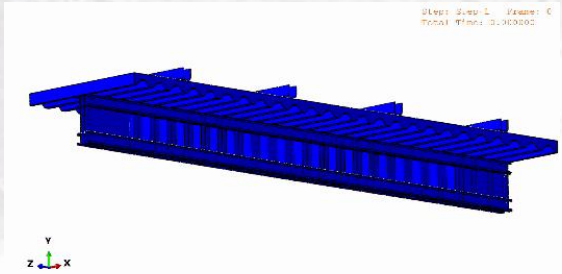

Thank you!