Project title: **Innovative lightweight cold-formed steel-concrete composite floor system**
Acronym: **LWT-FLOOR** Project ID: **UIP-2020-02-2964**
1st LWT-FLOOR Workshop

Behaviour of lightweight built-up cold-formed steel-concrete composite beam in bending

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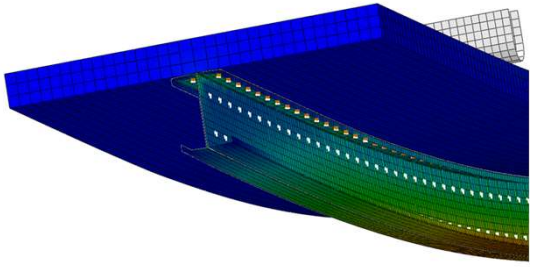

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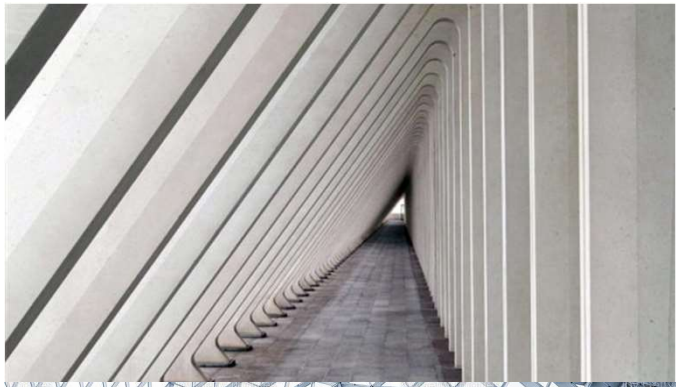
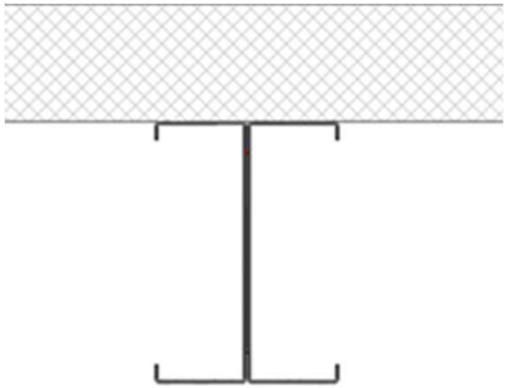
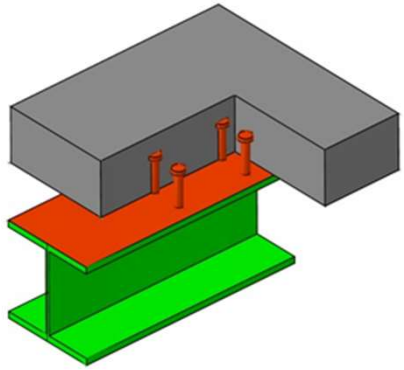
„ONE MATERIAL” SYSTEM vs COMPOSITE SYSTEM

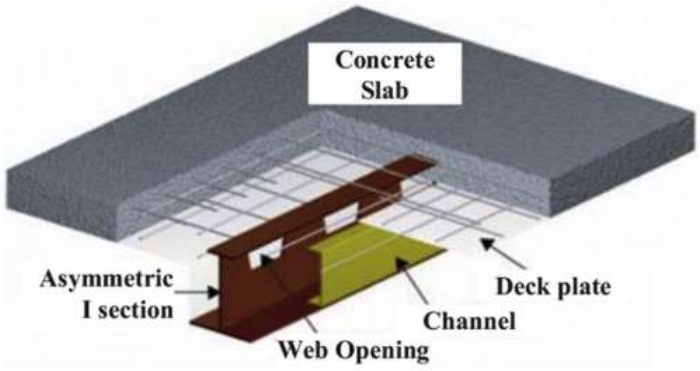


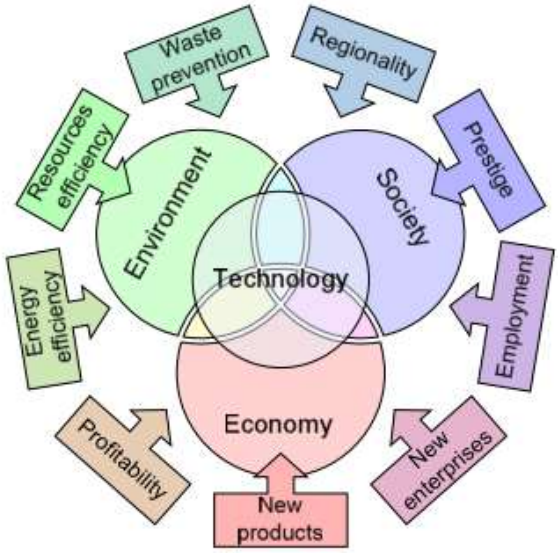


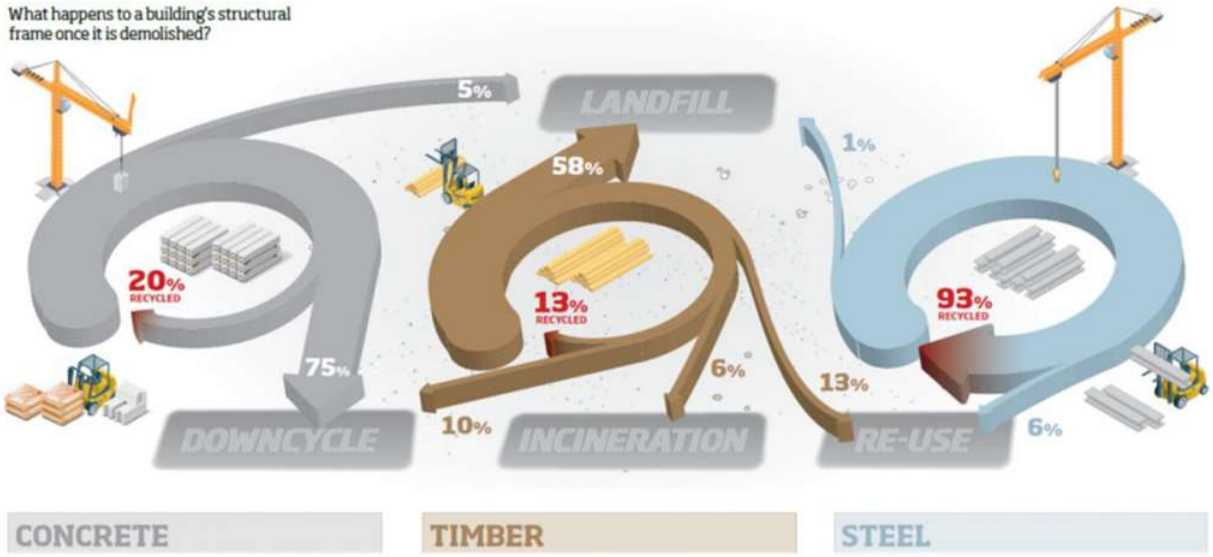


- lower total construction weight
- easier foundation
- faster construction
- lower construction cost

ADVANTAGES


Concrete Slab
Asymmetric I section
Deck plate
Channel
Web Opening


Waste prevention
Regionality
Resources efficiency
Prestige
Environment
Society
Technology
Energy efficiency
Employment
Economy
Profitability
New enterprises
New products


What happens to a building's structural frame once it is demolished?
5%
LANDFILL
58%
1%
20%
RECYCLED
13%
RECYCLED
93%
RECYCLED
75%
6%
13%
10%
DOWNCYCLE
INCINERATION
RE-USE
6%
CONCRETE
TIMBER
STEEL

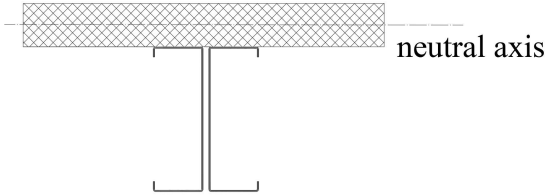
HYPOTHESES

- H1: Bending resistance of a composite beam consisting of steel profiles of class 3 or class 4 can be calculated by the plastic resistance of the steel section
- H2: The method of connecting cold-formed C profiles and the degree of shear connection between the steel and concrete part of the cross-section affect the bending resistance of the composite beam

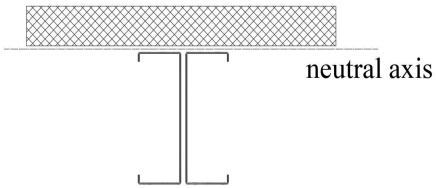
COLD-FORMED STEEL PROFILES

- Classification: class 3 or 4 = NO PLASTIC RESISTANCE

EXCEPTION!



Full shear connection +



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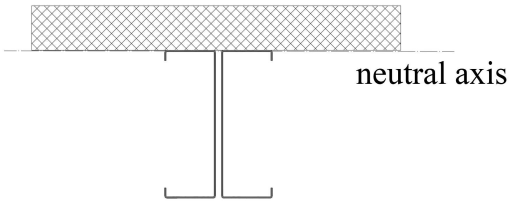
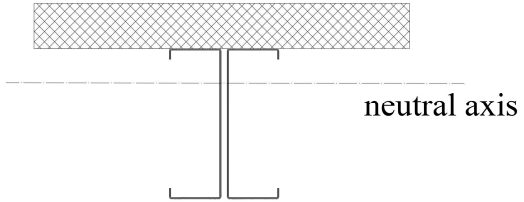
Class 1 or 2





BEAM RESISTANCE TO BENDING

- position of the neutral axis (from the upper edge of the concrete flange):

$$x_{pl} = \frac{2 \cdot A \cdot f_{yd}}{b_{eff} \cdot 0.85 \cdot f_{cd}}$$

- neutral axis in concrete flenge – full shear connection:

$$M_{pl,Rd} = 2 \cdot A \cdot f_{yd} \cdot \left(\frac{h}{2} + \frac{h_c}{2} \right)$$

- neutral axis in concrete flenge – partially shear connection:

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

MODELING OPTIONS

STEEL

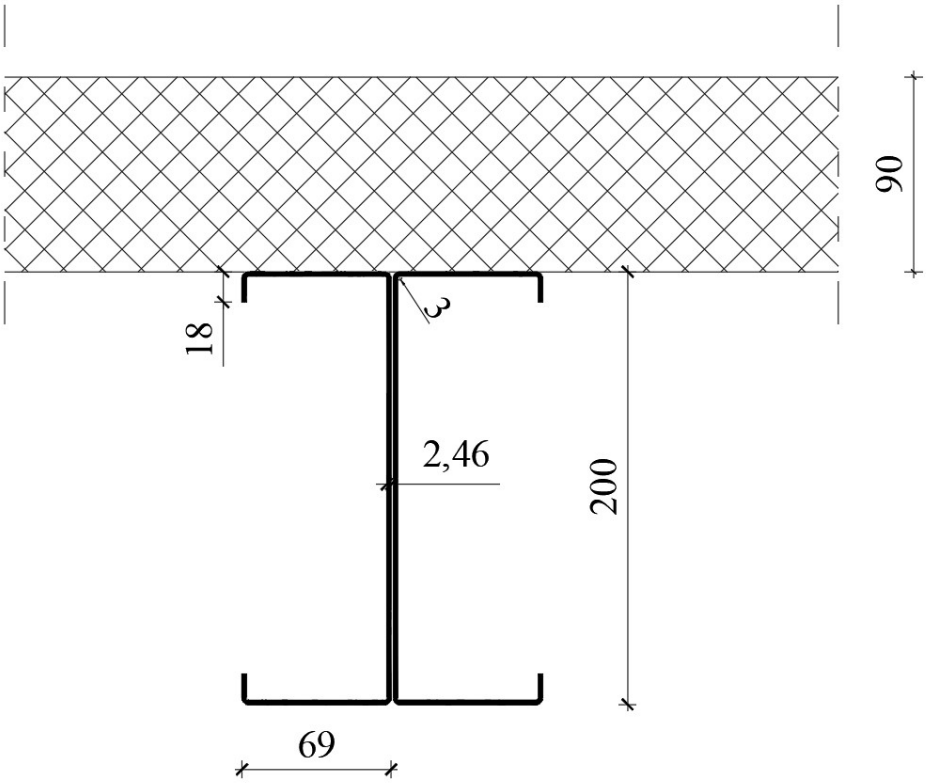
C150
C175
C200
C220
C250
C275
C300

Thickness: 1-4 mm

CONCRETE

C20/25
C25/30
C30/37

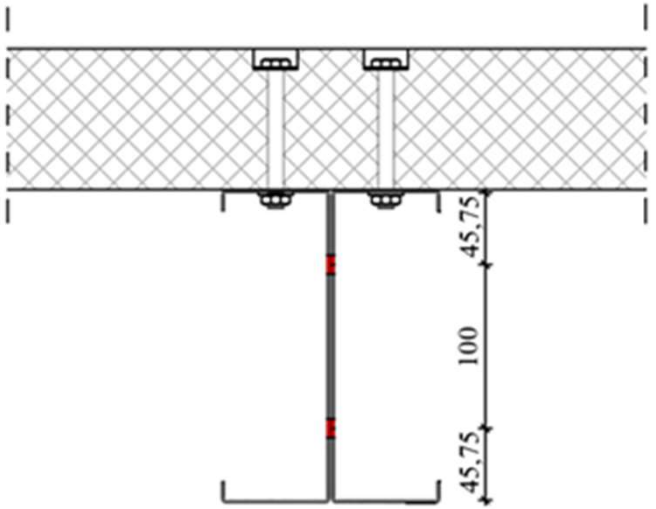
ANALYSED COMPOSITE BEAM



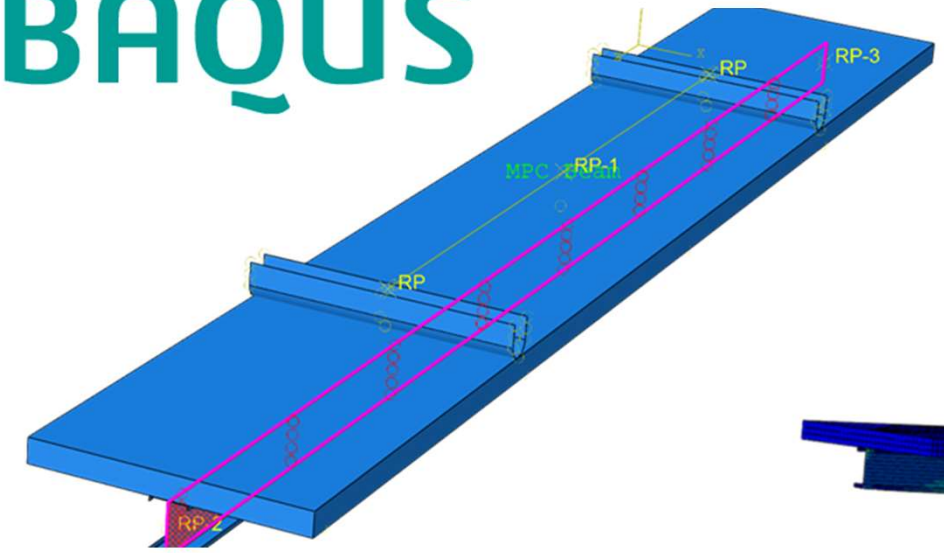
- steel profile: C200
- beam flenge: C25/30

  b_{eff}=1 m

  h_c=90 mm



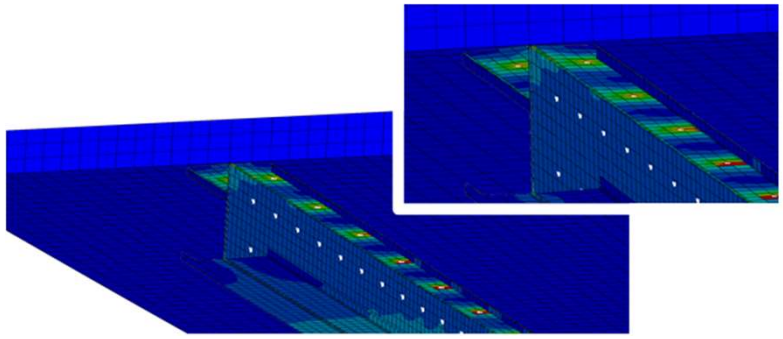
NUMERICAL MODELS



- FE mesh density:
  - steel section: 20 mm
  - concrete slab: 30 mm

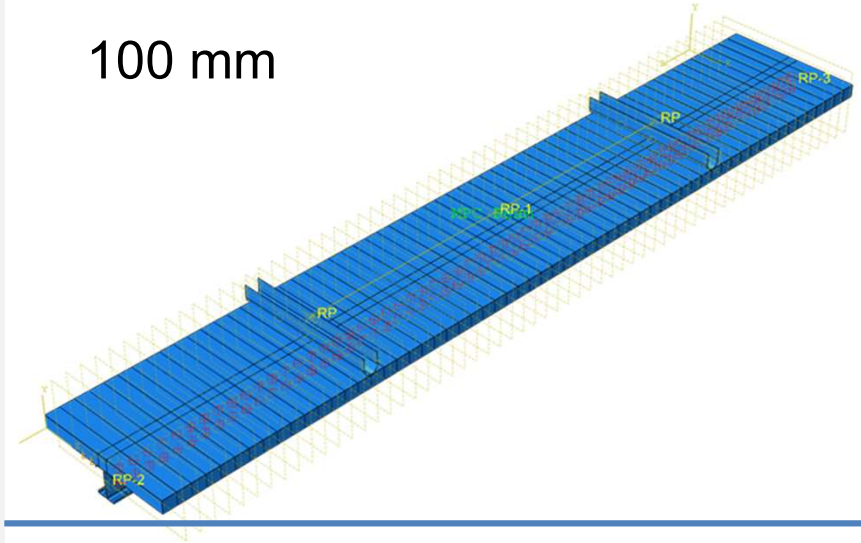
- shell elements – S4R
- solid elements – C3D8R

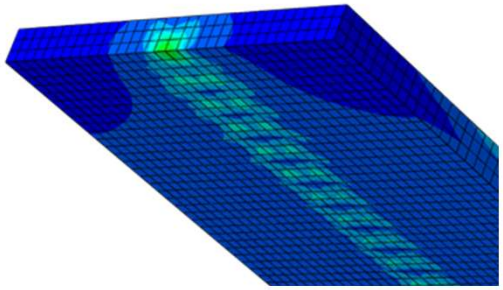
- geometric and material nonlinearities
- analyses were performed for different degrees of shear connection between steel profiles and concrete and various type of contact of back to back C-profiles

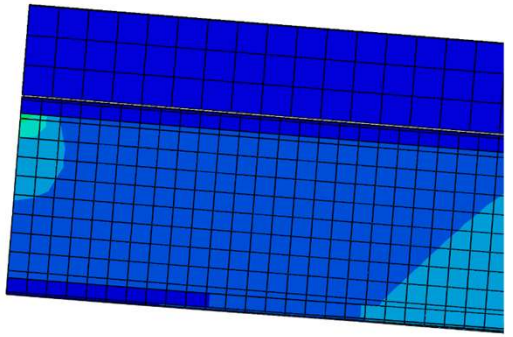


NUMERICAL MODELS

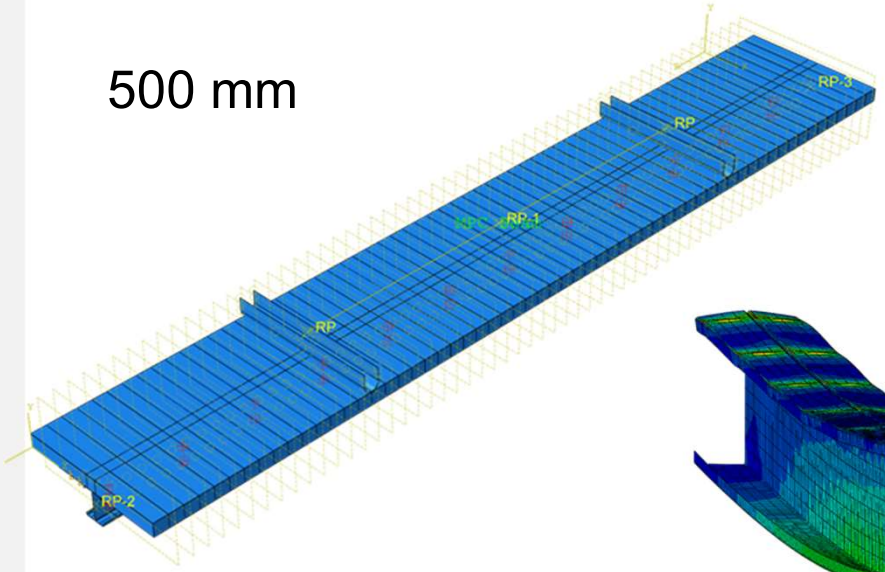
100 mm

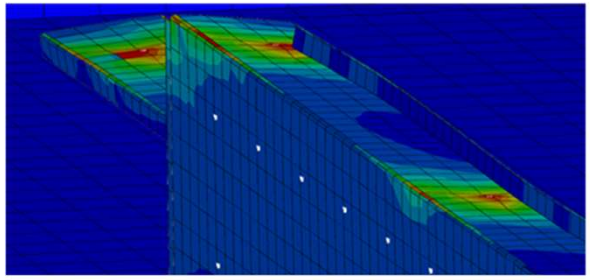


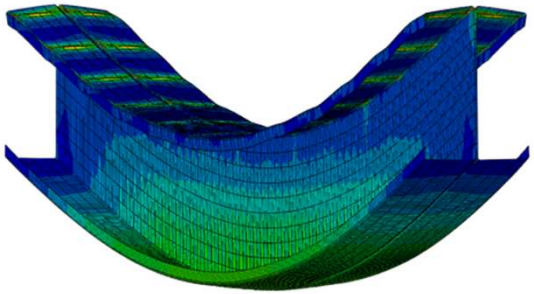


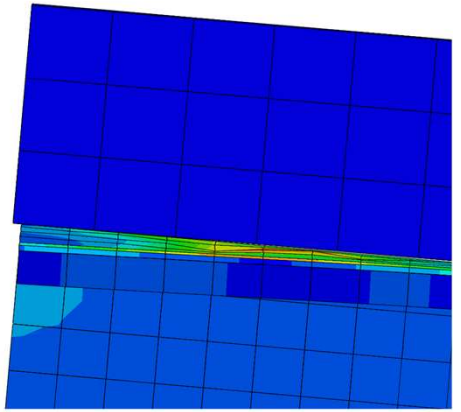


500 mm

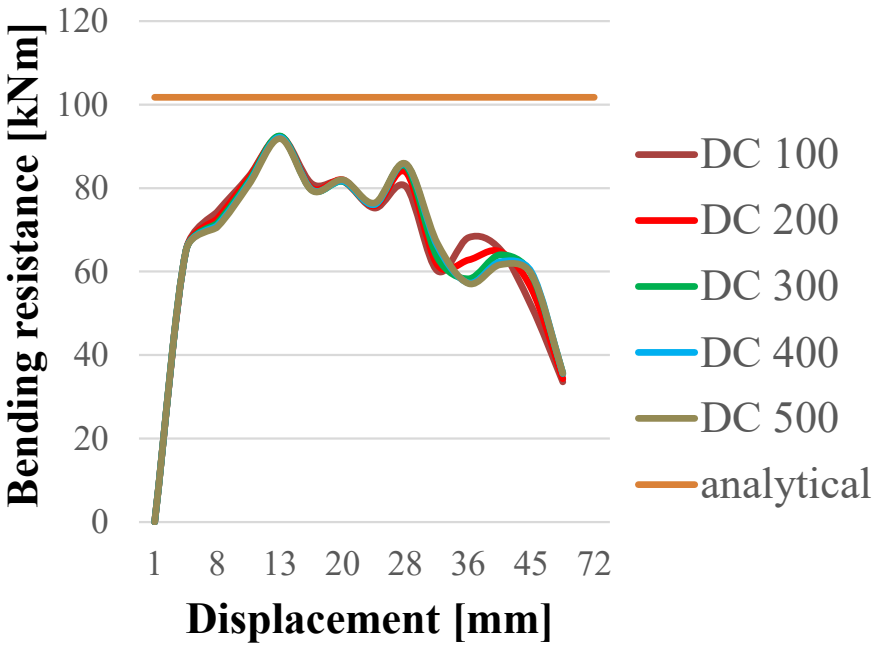


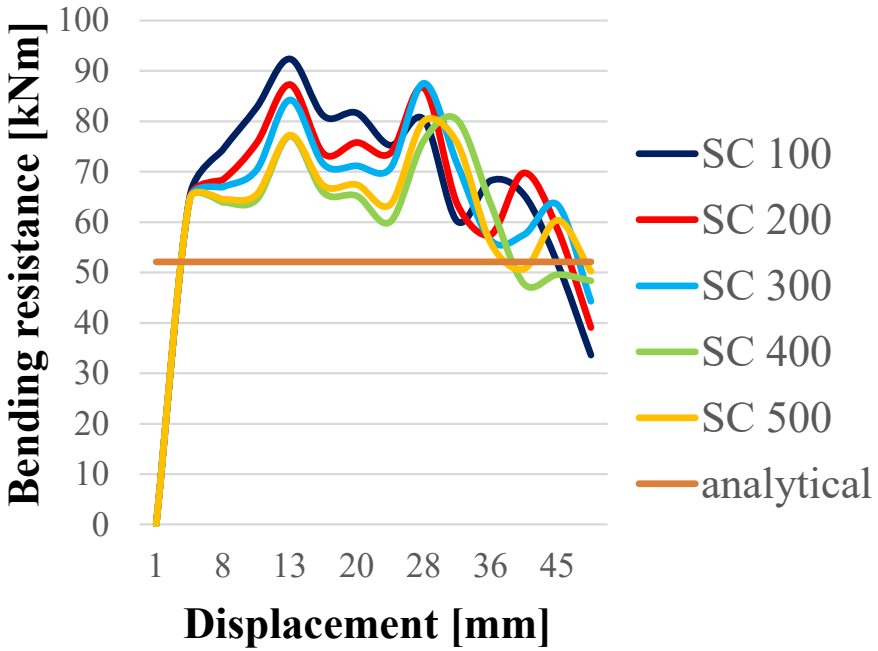






RESULTS


Bending resistance [kNm]
120
100
80
60
40
20
0
1
8
13
20
28
36
45
72
Displacement [mm]
DC 100
DC 200
DC 300
DC 400
DC 500
analytical


Bending resistance [kNm]
100
90
80
70
60
50
40
30
20
10
0
1
8
13
20
28
36
45
Displacement [mm]
SC 100
SC 200
SC 300
SC 400
SC 500
analytical

CONCLUSIONS

- The results of numerical analysis of two cold-formed steel C-profiles joined in the area of webs connected to a concrete slab show that the resistance of such shaped and joined elements depends on the method and type of joint that establishes the connection between the two elements.
- It was observed that different spacing at the joint of steel profiles has a small influence on the behaviour of the beam and its resistance to bending.

RECOMMENDATIONS FOR FURTHER RESEARCH

- In order to prove the accuracy of the performed analytical and numerical results, it is necessary to perform laboratory tests of the considered coupled carrier.
- The improvement of the numerical model can be carried out by defining the force at which the point joint or concrete fails, depending on which value is relevant.
- It is possible to use profiled sheet metal to make the beam slab, which can result in an efficient composite slab system while also serving as formwork until the concrete hardens, or as a working platform. In this case, the sheet metal is not removed but remains as part of the coupled system.

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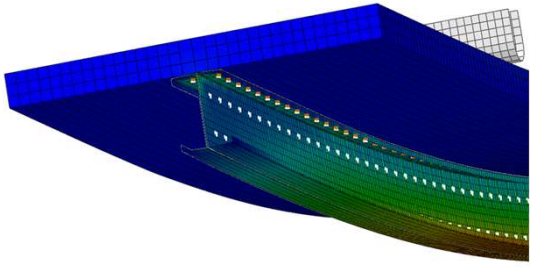

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