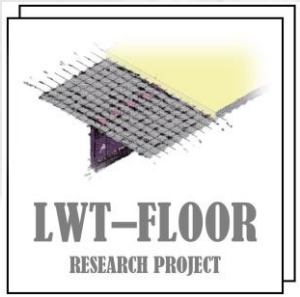
Project title: **Innovative lightweight cold-formed steel-concrete composite floor system**
Acronym: **LWT-FLOOR** Project ID: **UIP-2020-02-2964**
5th LWT-FLOOR Project Workshop, Zagreb, 18th-19th December 2025

Parametric Sensitivity Analysis on Bending Resistance of Built-Up Cold-Formed Steel-Concrete Composite System

Andrea Rajić, Ivan Lukačević, Ivan Ćurković, Vlaho Žuvelek



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Agenda

Agenda

1 Introduction

2 LWT-FLOOR Composite System

3 Numerical model

4 Sensitivity analysis

5 Results and discussion

6 Conclusions

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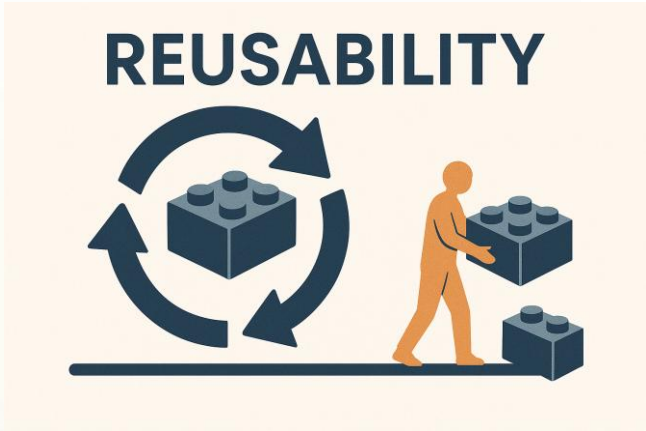
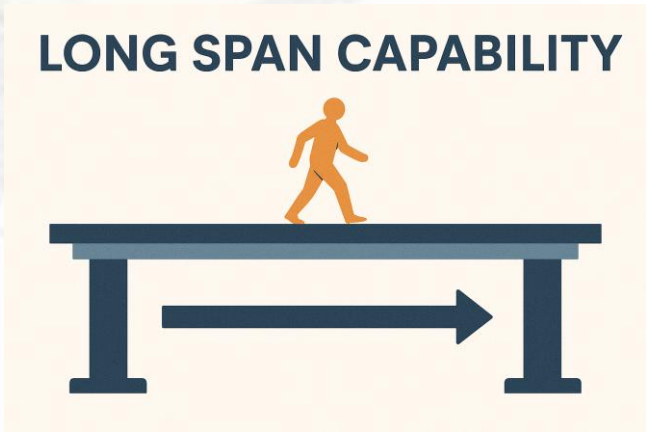
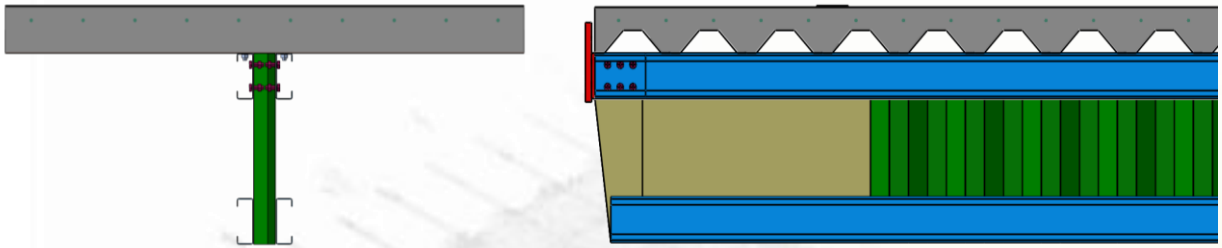
1 Introduction

Advantages of composite steel-concrete systems:





2 LWT-FLOOR Composite System

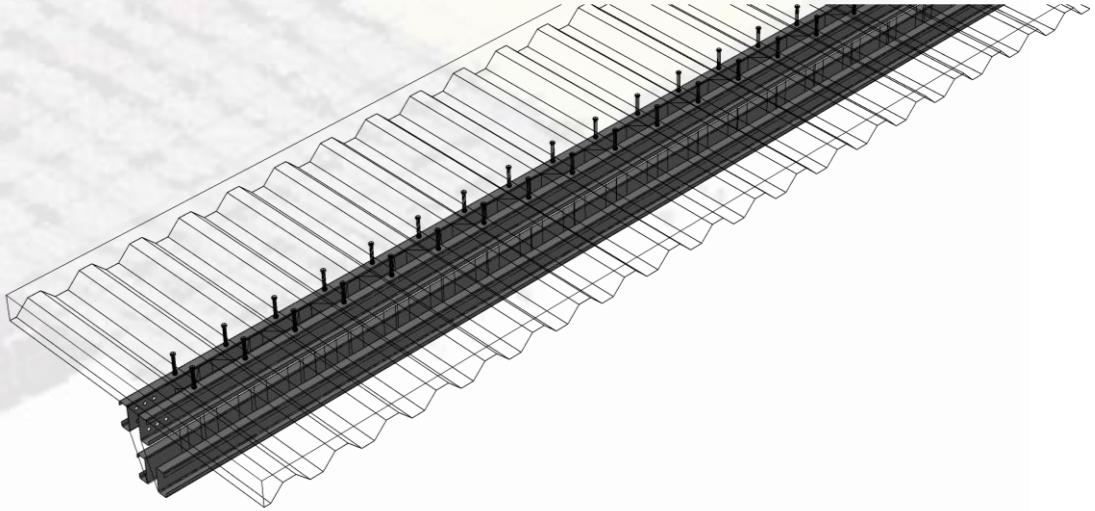


CHANNEL PROFILES

SHEAR PLATE

CORRUGATED WEB

CONCRETE SLAB



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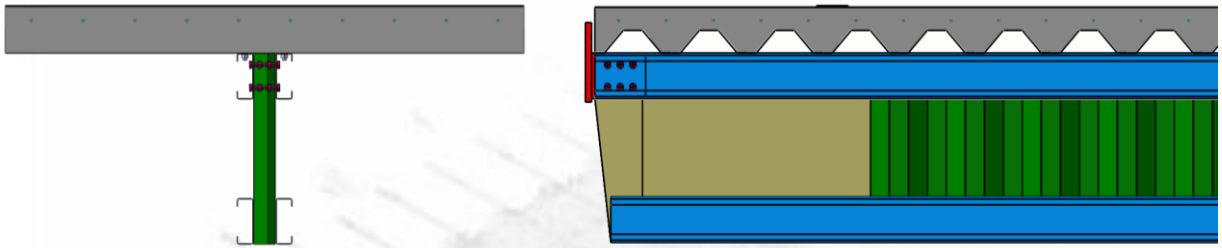

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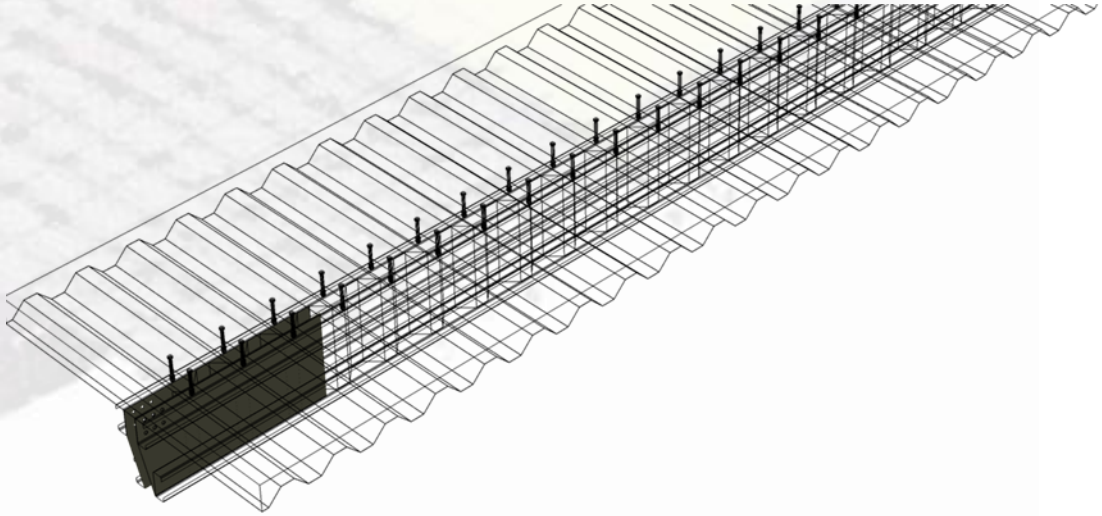

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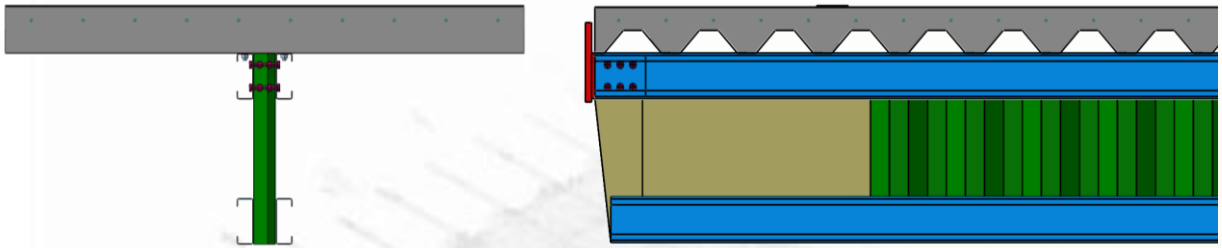

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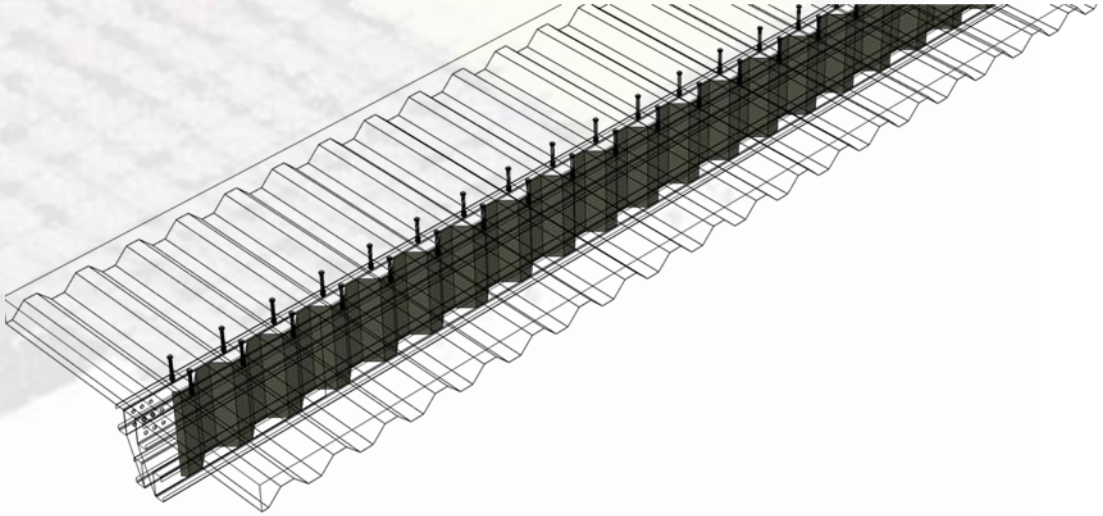

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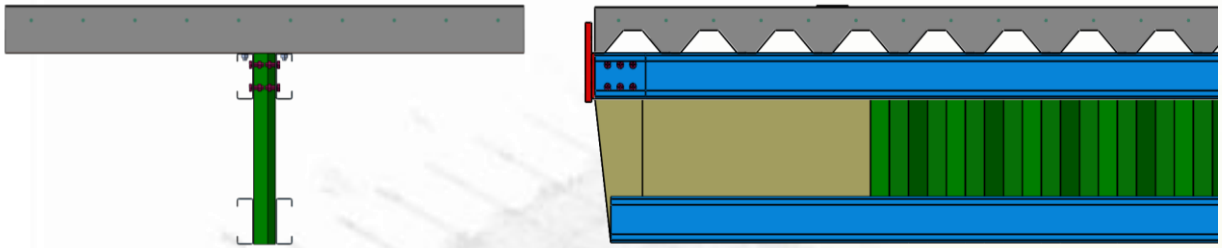

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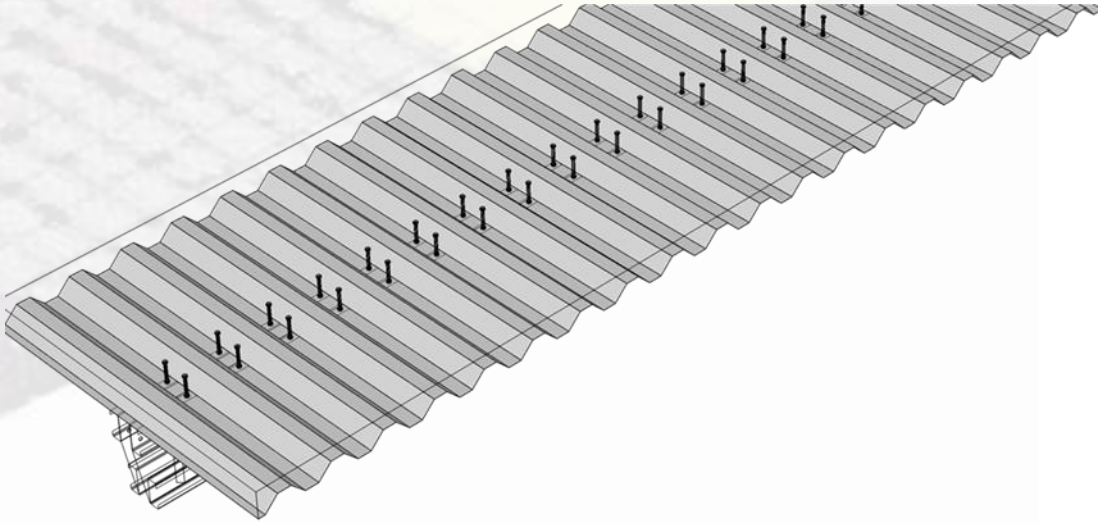

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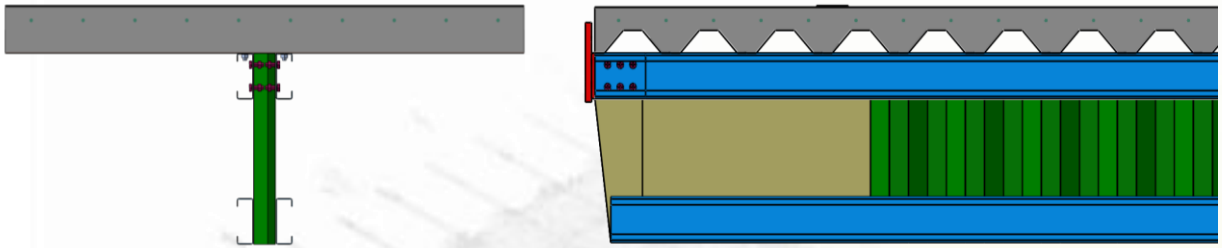

CHANNEL PROFILES

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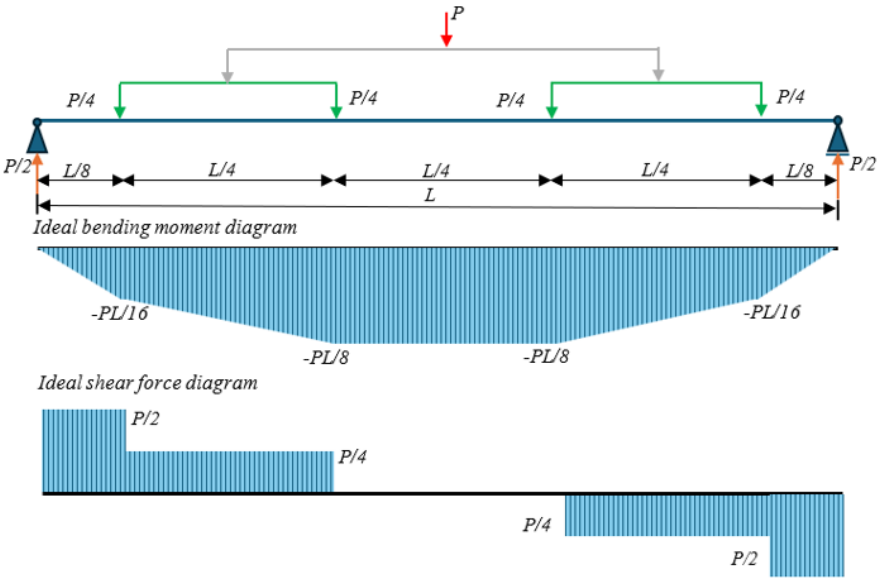
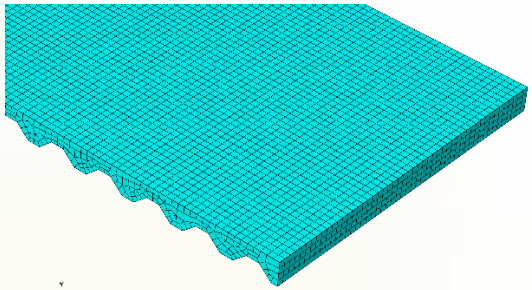
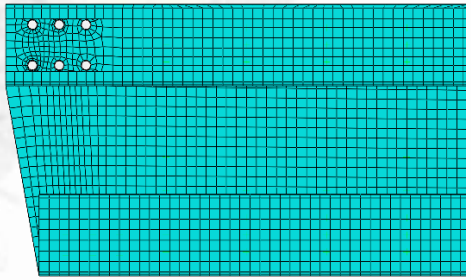
3 Numerical model

- Nonlinearities of the models
- Explicit solver



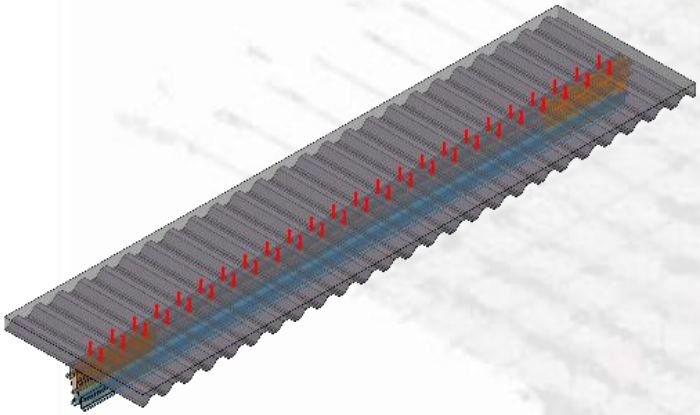


- C3D8R finite elements
- Mesh size: 30 mm



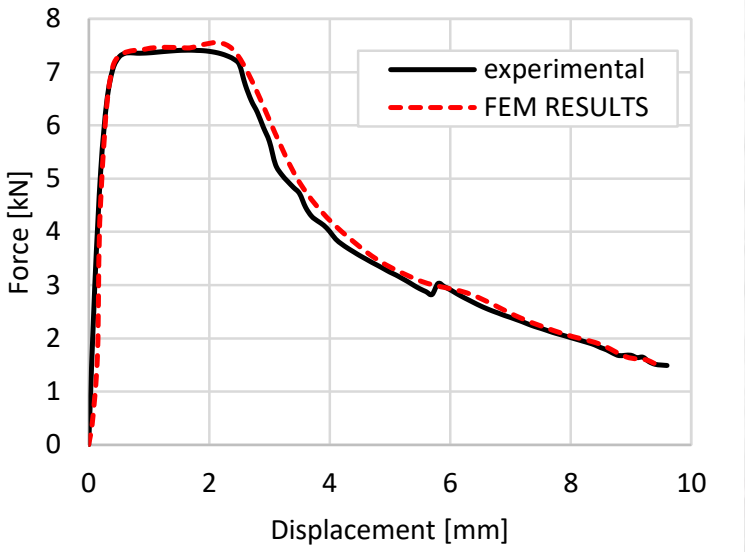
- S4R finite elements
- Mesh size: 15 mm

3 Numerical model



- Shear connectors:
  - Solid elements
  - Partially embedded in the concrete slab
  - Longitudinal arrangement: defined by the axial distance of the concrete slab ribs
  - Transversal arrangement: defined by axial distances between channel profiles

3 Numerical model



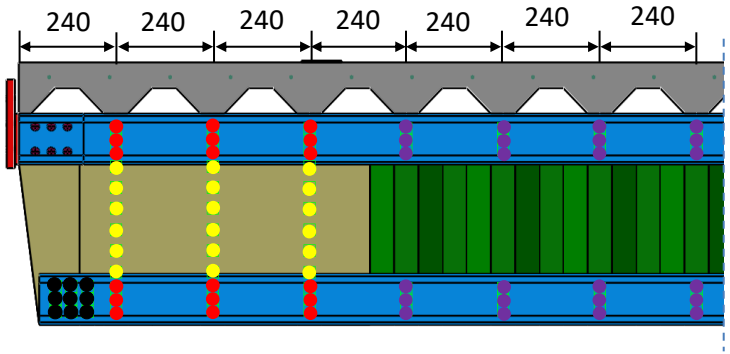
- Connection between steel sheets – spot welds:
  - Independently studided through both experimental and numerical research
  - The welding parameters were defined based on the thickness of the steel sheets
  - The total number of spot welds varies depending on the height of the steel beam

3 Numerical model

- Connection between steel sheets – spot welds:
  - Region 1 corresponds to the joint of the channel profiles to the shear plates and corrugated web.
  - Region 2 is where the corrugated web joins the shear plate.

    Region 3 is located at the ends of the lower channel profiles, where they are connected to the shear plates.

    Region 4 is where the channel profiles and the corrugated web are joined.



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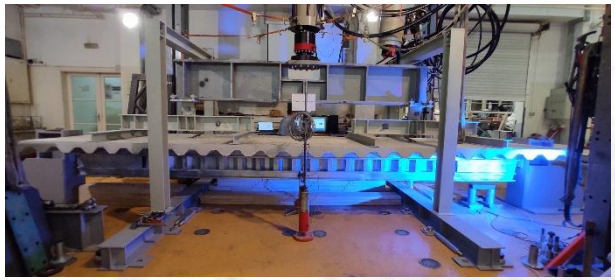
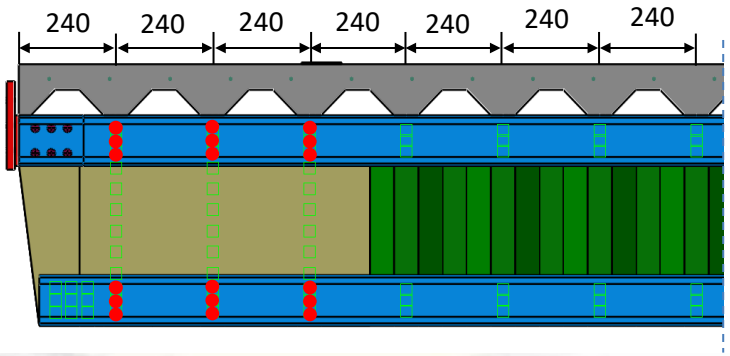
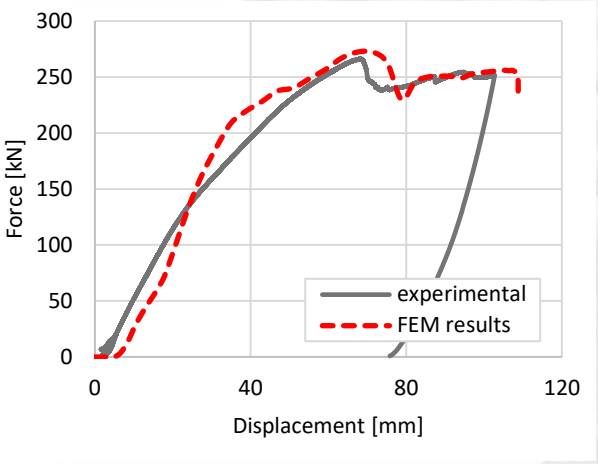
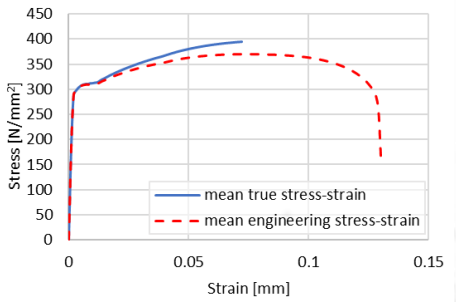




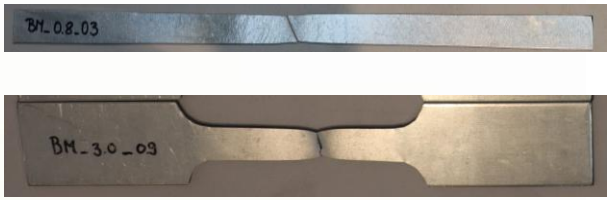


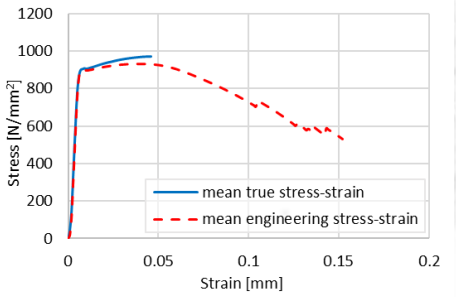
- spot weld characteristics: as in Region 1

3 Numerical model

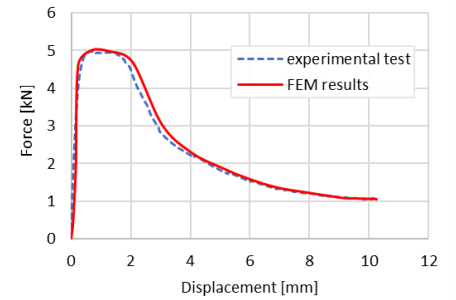


STEEL SHEETS

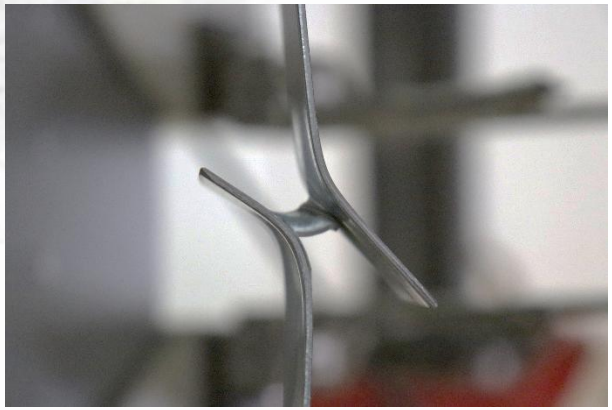




SHEAR CONNECTORS



SPOT WELDS



4 Sensitivity analysis

- The statistical data regarding base material test results and the spot welds' characteristics were used to develop the numerical model.
- Calibrated model - steel sheet material properties and thicknesses - mean values of measured properties
- Sensitivity analysis - minimum and maximum values of measured material properties and thicknesses

4 Sensitivity analysis

CB1

Parameter	Element/region		value
yield strength [MPa]	C profiles	min	287
		max	342
		average	328
	CW; SP	min	298
		max	319
		average	308
ultimate strength [MPa]	C profiles	min	355
		max	430
		average	413
	CW; SP	min	388
		max	407
		average	395
thickness [mm]	upper C profile	min	2.41
		max	2.61
		average	2.53
	bottom C profile	min	2.36
		max	2.51
		average	2.46
	CW	min	0.98
		max	1.09
		average	1.04
	SP	min	0.99
		max	1.08
		average	1.03
SW resistance [kN]	Region 1		21.69
	Region 2		6.90
	Region 3		8.15
	Region 4		8.15

CB2

Parameter	Element/region		value
yield strength [MPa]	C profiles	min	250
		max	298
		average	283
	CW; SP	min	298
		max	319
		average	308
ultimate strength [MPa]	C profiles	min	344
		max	391
		average	376
	CW; SP	min	388
		max	407
		average	395
thickness [mm]	upper C profile	min	1.84
		max	2.11
		average	1.96
	bottom C profile	min	1.92
		max	2.06
		average	1.98
	CW	min	0.96
		max	1.09
		average	1.04
	SP	min	0.9
		max	1.07
		average	1.01
SW resistance [kN]	Region 1		17.60
	Region 2		6.90
	Region 3		8.08
	Region 4		8.08

CB3

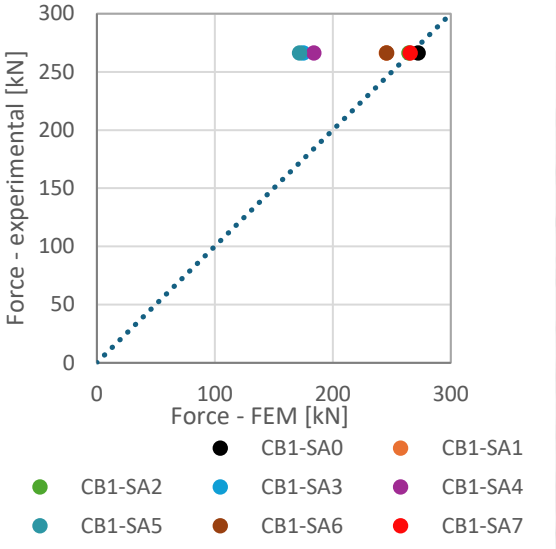
Parameter	Element/region		value
yield strength [MPa]	C profiles	min	316
		max	347
		average	332
	CW; SP	min	333
		max	342
		average	338
ultimate strength [MPa]	C profiles	min	392
		max	410
		average	403
	CW; SP	min	417
		max	426
		average	421
thickness [mm]	upper C profile	min	2.83
		max	3.03
		average	2.95
	bottom C profile	min	2.87
		max	3.11
		average	2.95
	CW	min	1.45
		max	1.53
		average	1.49
	SP	min	1.47
		max	1.56
		average	1.51
SW resistance [kN]	Region 1		22.48
	Region 2		13.78
	Region 3		14.97
	Region 4		14.97

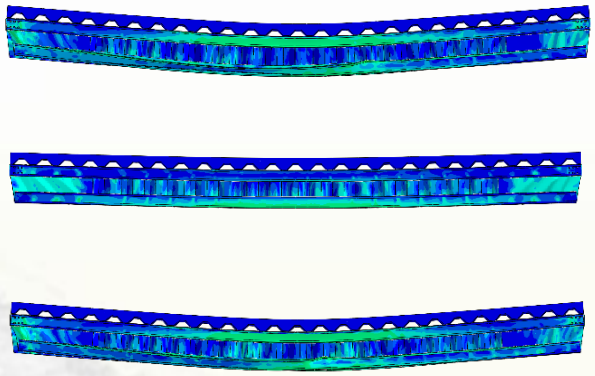
4 Sensitivity analysis

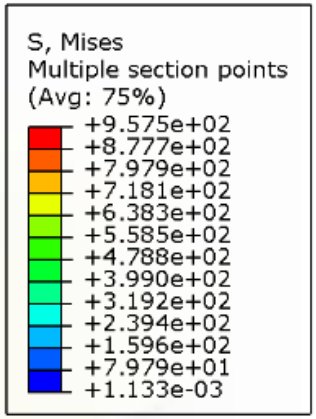
Nomenclature

	yield strength	ultimate strength	thickness	SW resistance
SA0	average	average	average	Region 1
SA1	average	average	**minimum**	Region 1
SA2	average	average	**maximum**	Region 1
SA3	average	average	average	**Region 2**
SA4	average	average	average	**Regions 1, 2, 3, 4**
SA5	average	average	average	**Region 4**
SA6	**minimum**		average	Region 1
SA7	**maximum**		average	Region 1

5 Results and discussion







	yield strength	ultimate strength	thickness	SW resistance
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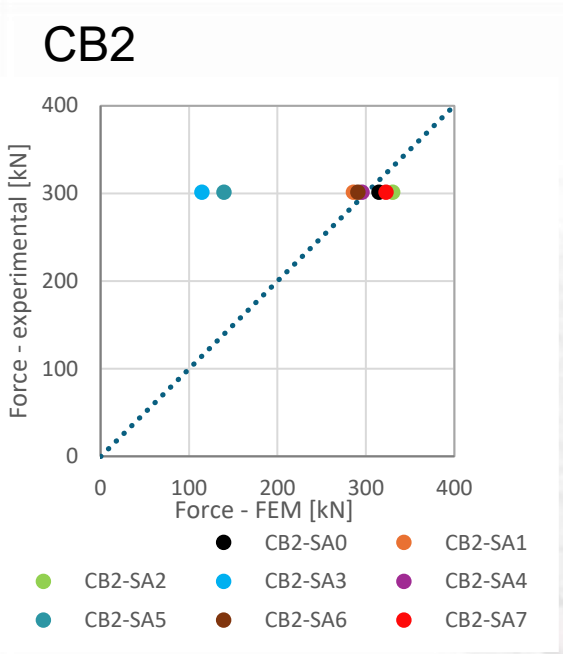
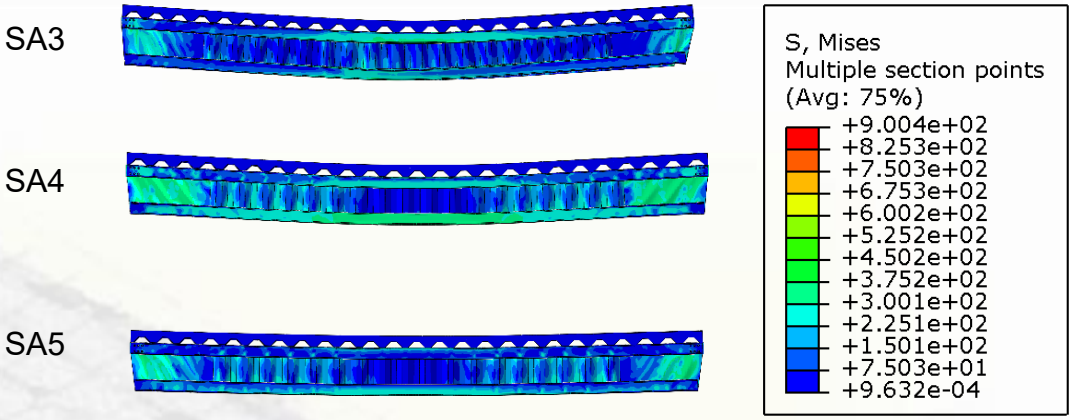
SA4	average	average	average	**Regions 1, 2, 3, 4**
SA5	average	average	average	**Region 4**
SA6	**minimum**		average	Region 1
SA7	**maximum**		average	Region 1

In the CB1-SA4 model, channel profiles achieved lower stress levels than models CB1-SA3 and CB1-SA5. In addition, the CB1-SA4 model failed at a smaller displacement than CB1-SA3 and CB1-SA5.

5 Results and discussion





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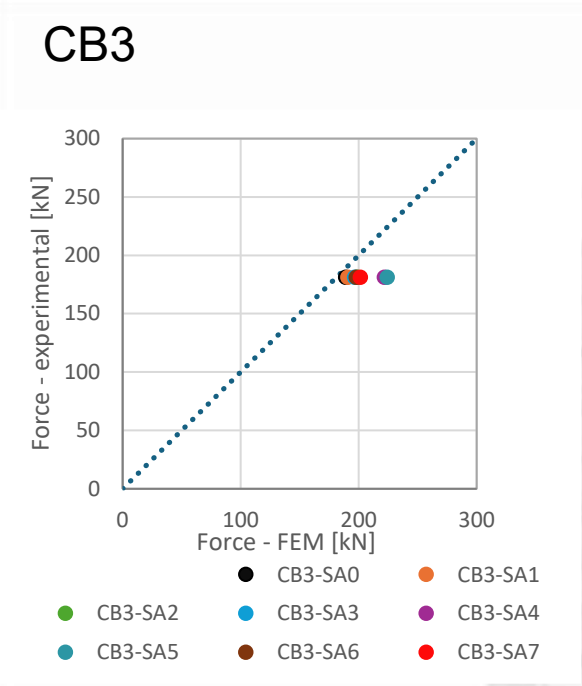
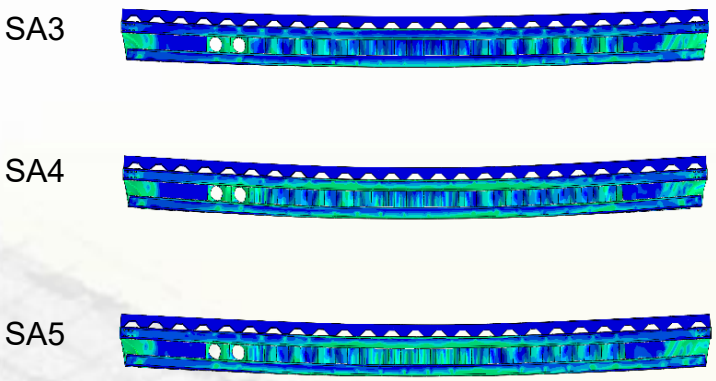
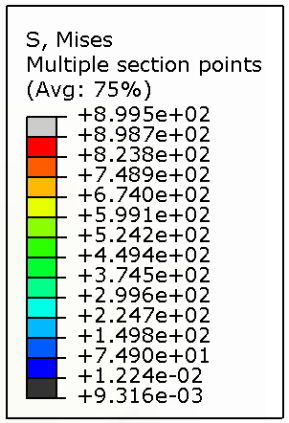
SA5	average	average	average	**Region 4**
SA6	**minimum**		average	Region 1
SA7	**maximum**		average	Region 1

A larger stress level is achieved for model CB2-SA4 in channel profiles than is the case for CB2-SA3 and CB2-SA5. A tension field action was formed in all analysed models.

5 Results and discussion







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SA4	average	average	average	**Regions 1, 2, 3, 4**
SA5	average	average	average	**Region 4**
SA6	**minimum**		average	Region 1
SA7	**maximum**		average	Region 1

The results of models CB3-SA4 and CB3-SA5 differ the most from the rest of the results. Also, this difference in results is smaller than in the case of CB1 and CB2 beams. The stress levels achieved at maximum force in all three analysed models are close.

6 Conclusions

- for all three types of analysed beams (CB1, CB2, CB3), the largest differences in the results were observed in the models where the characteristics of the spot welds were changed,
- variability in material properties has a negligible influence on systems' resistance
- steel thickness variability has a small influence on the resistance of the system

This analysis will serve as a basis for further system behaviour assessments through analytical and probabilistic analyses.

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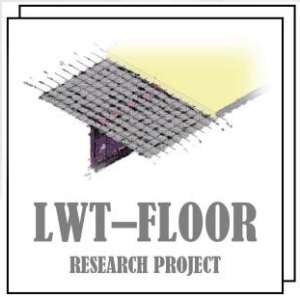

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