

Experimental investigation of coupled instabilities in built-up CFS girders with corrugated web

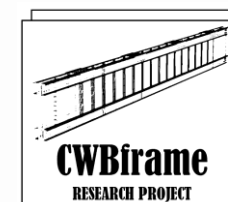
Ivan Lukačević · Andrea Rajić · Ivan Ćurković · Viorel Ungureanu



SVEUČILIŠTE U ZAGREBU
GRAĐEVINSKI FAKULTET
UNIVERSITY OF ZAGREB
FACULTY OF CIVIL ENGINEERING



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LWT-FLOOR System

- introduction to the project and system

Experimental testing

- specimens and test procedure

Results and discussion

- main experimental results and observed failure modes

Conclusions

Motivation:

OPTIMAL UTILISATION OF STRUCTURAL STEEL AND CONCRETE



DEMOUNTABILITY



HOT ROLLED



COLD FORMED



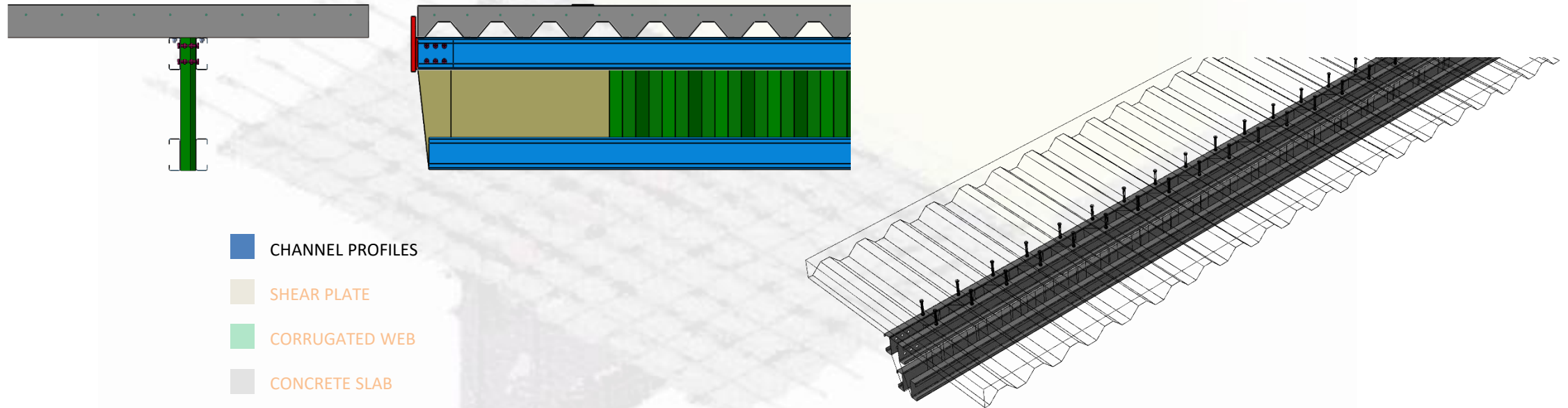
LONG SPAN CAPABILITY



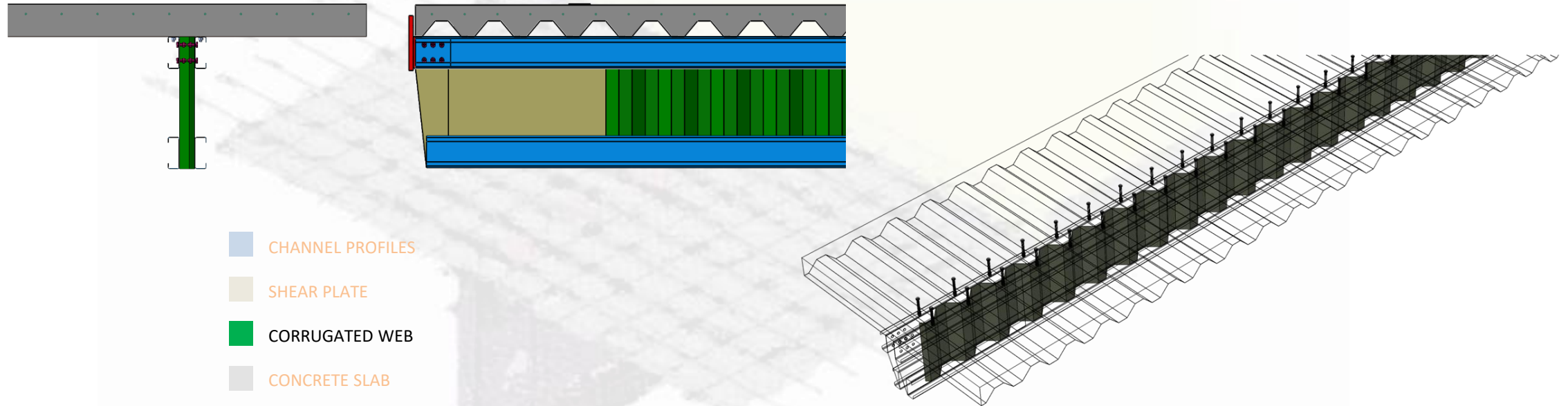
REUSABILITY



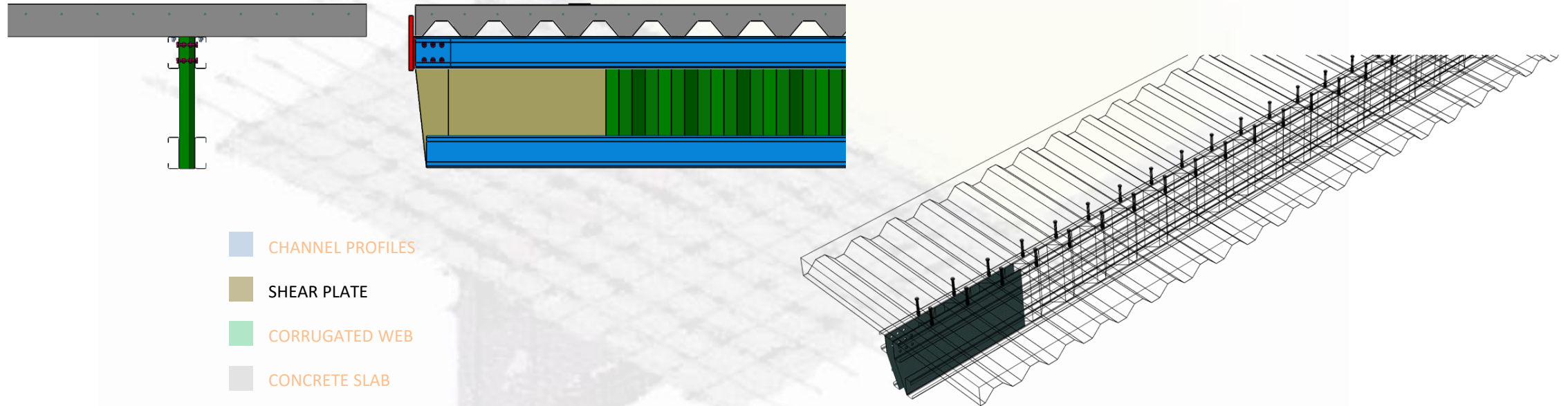
System components:



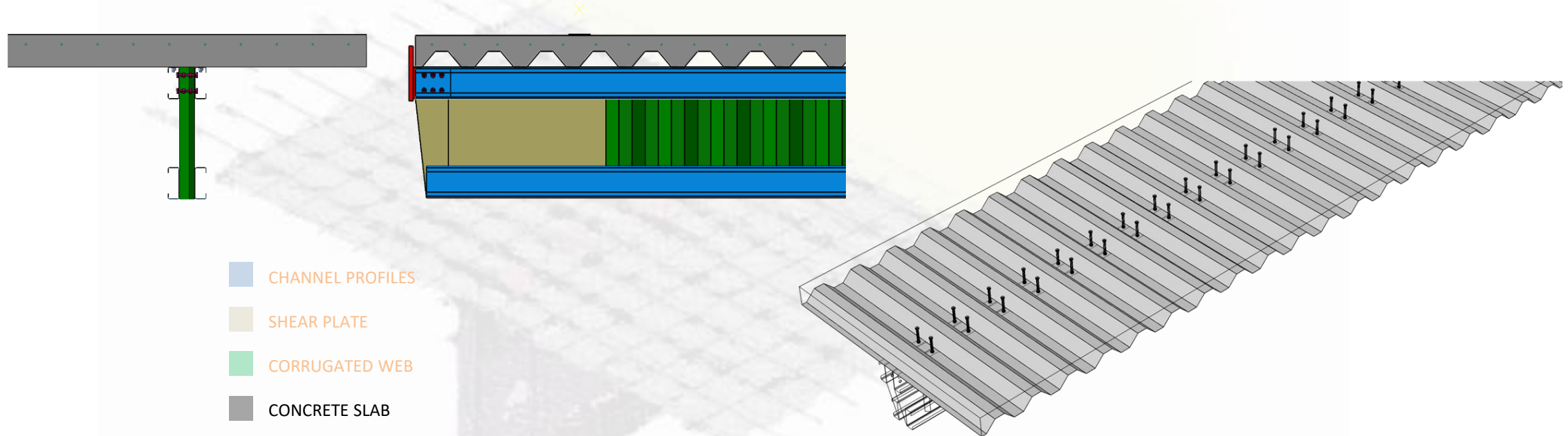
System components:



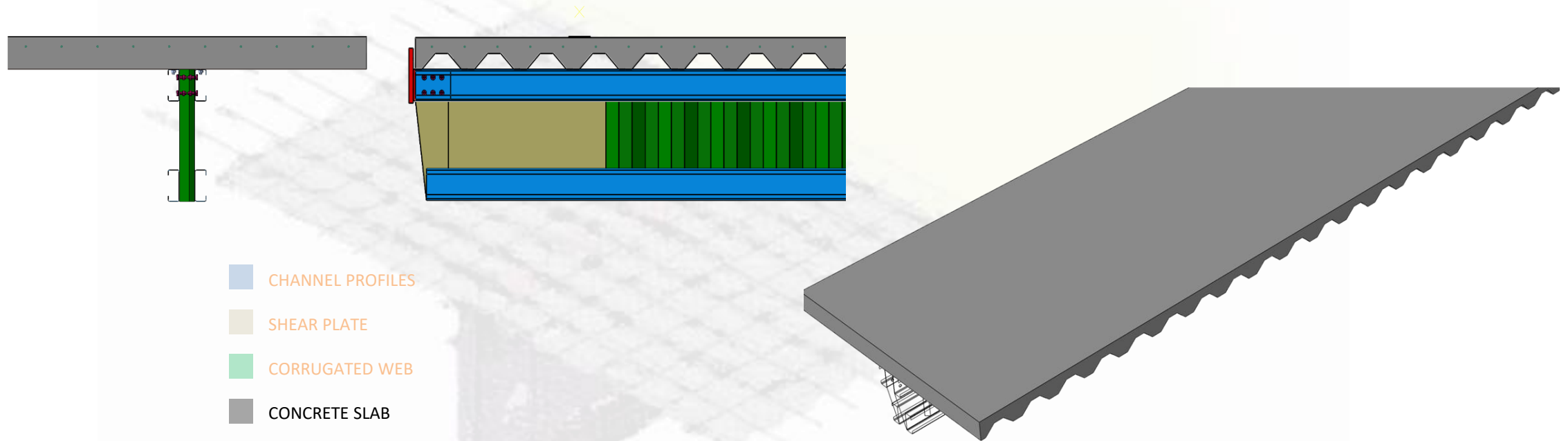
System components:



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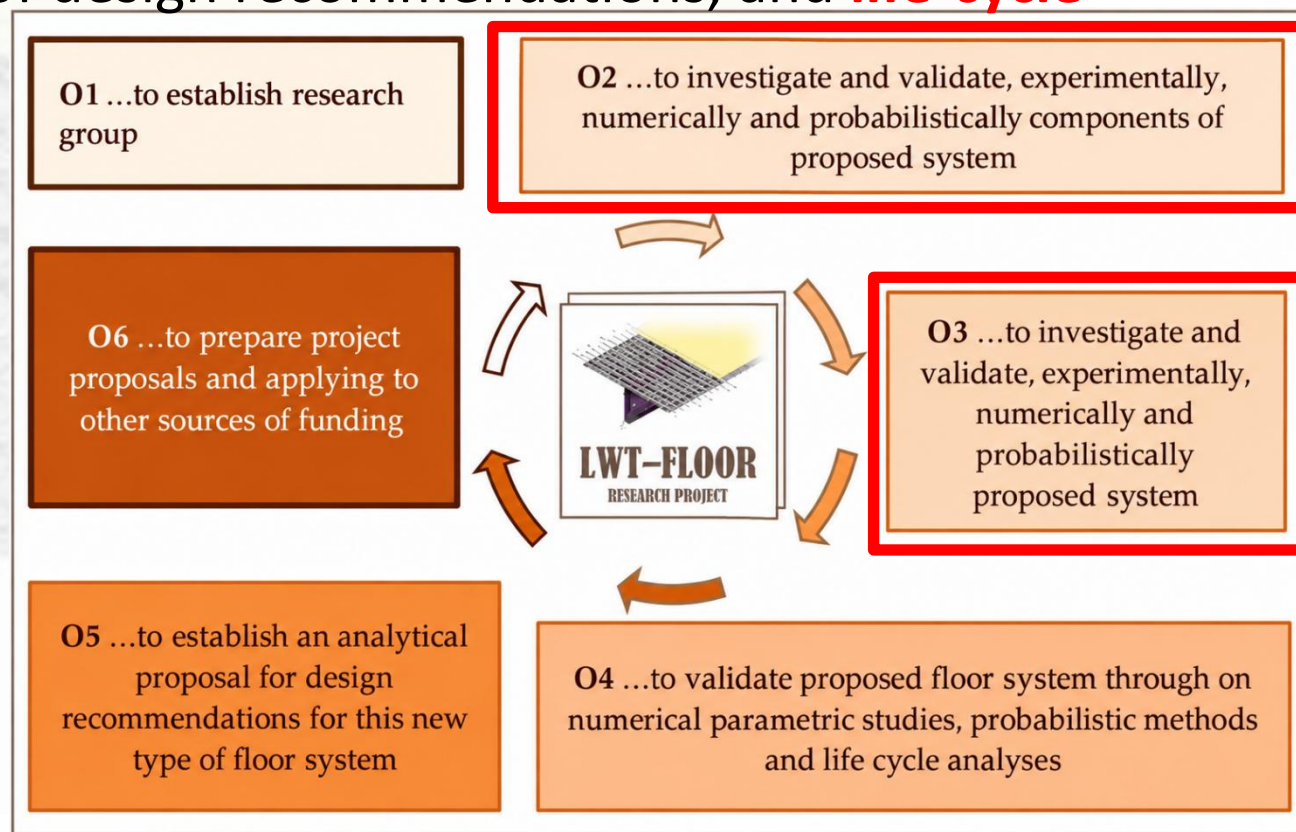
System components:



The **LWT-FLOOR project** investigates lightweight composite floor systems based on built-up cold-formed steel sections with corrugated webs and a concrete slab.

Project goal: **numerical**, **experimental** and **probabilistic** investigation and evaluation of the system and its components, development of design recommendations, and **life-cycle assessment** of the proposed system.

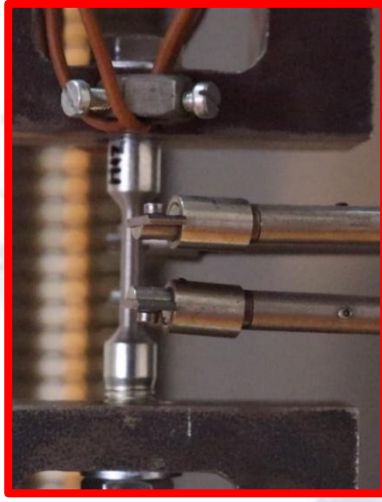
www.grad.unizg.hr/lwtfloor



Experimental research - five phases:



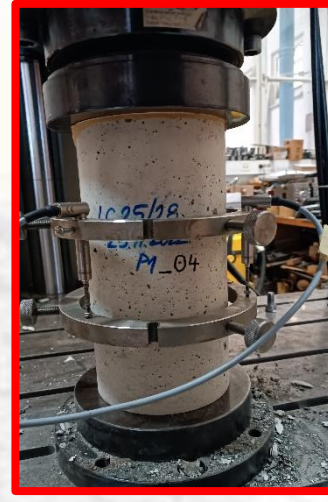
Steel sheets: 0,8 mm, 1,0 mm, 1,25 mm, 1,5 mm, 2,0 mm, 2,5 mm and 3,0 mm, steel grades DX51 and GD 350 for 3,0 mm only, **135 specimens**



Bolts: M12 and M16, grade 8.8, **11 specimens**



Reinforcement: bars 8 mm and mesh 10 mm, B500, **10 specimens**



Concrete: LC 20/22 and NC 20/25, **43 specimens**



Spot welds: different combinations of steel sheet thicknesses, **558 specimens**



Shear connections: different types (with concrete dowels (LC and NC) and demountable types with and without additional corrugated web (NC only)), **30 specimens**

Full-Scale **steel** and **composite** beam tests

Full-Scale **steel** and **composite** beam tests



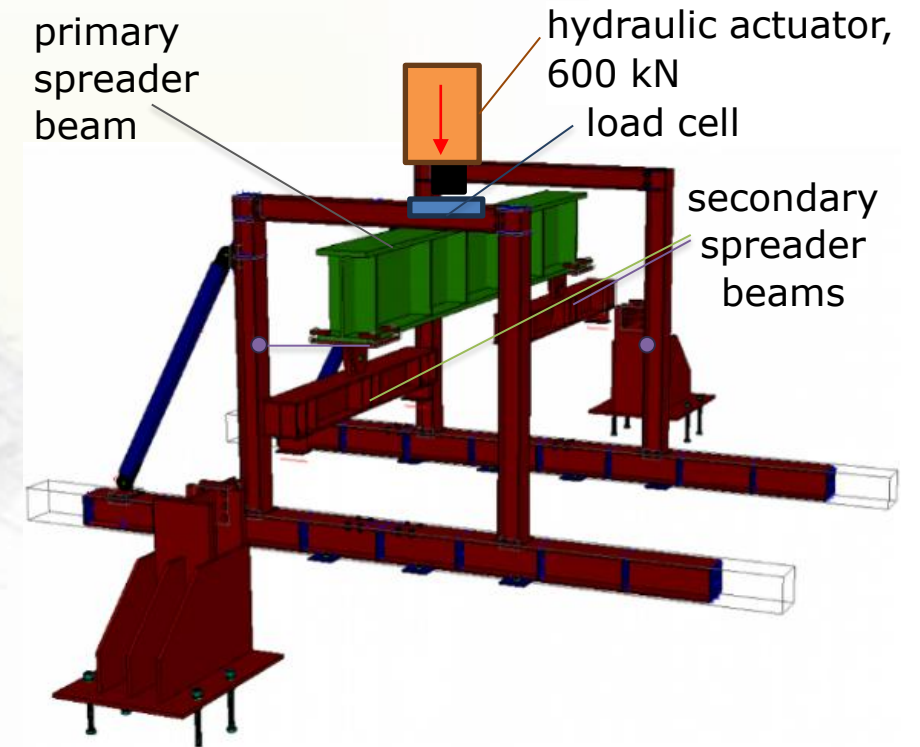
Spot-welding of built-up CFS



Fabricated composite specimens

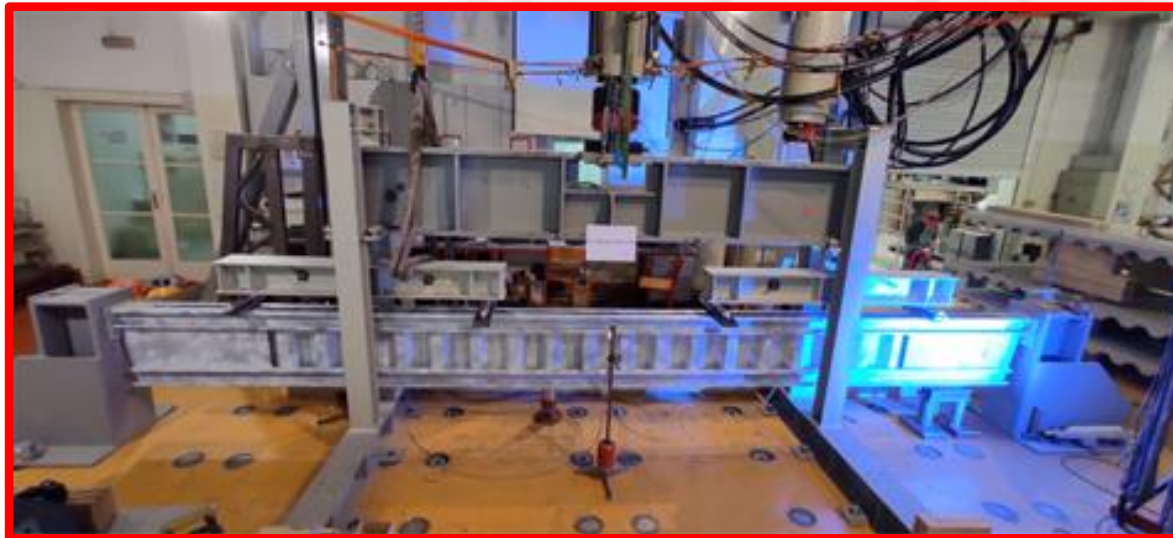


Fabricated steel specimens

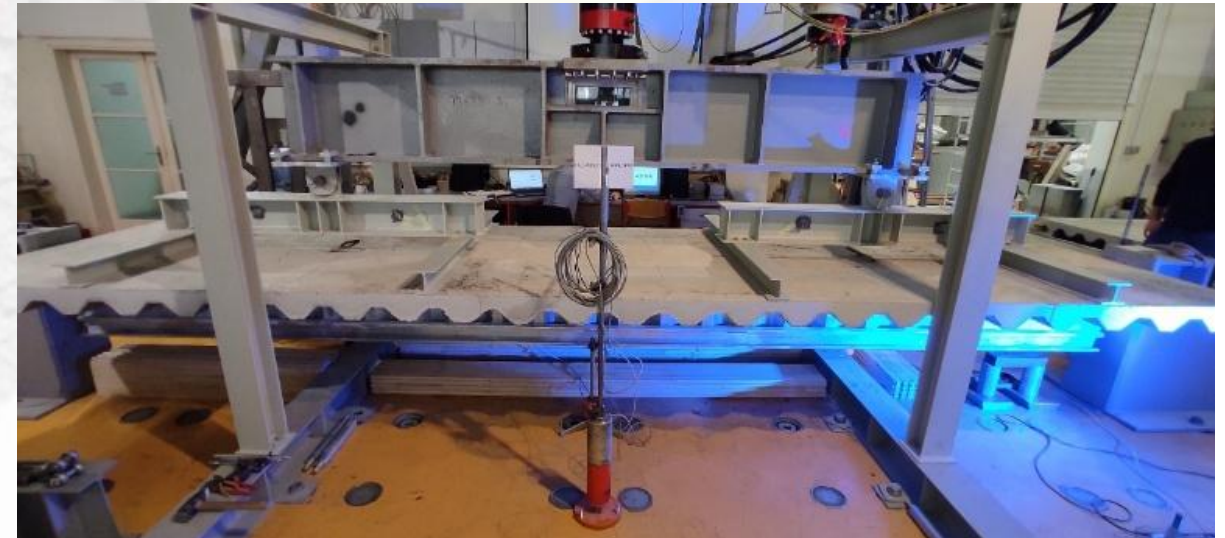


Full-Scale **steel** and **composite** beam tests

CWB beam				
	height [mm]	channel thickness [mm]	CW thickness [mm]	Shear plate thickness [mm]
SB1 (CB1)	400	2.5	1.0	1.0
SB2 (CB2)	500	2.0	1.0	1.0
SB3 (CB3) WO	400	3.0	1.5	1.5

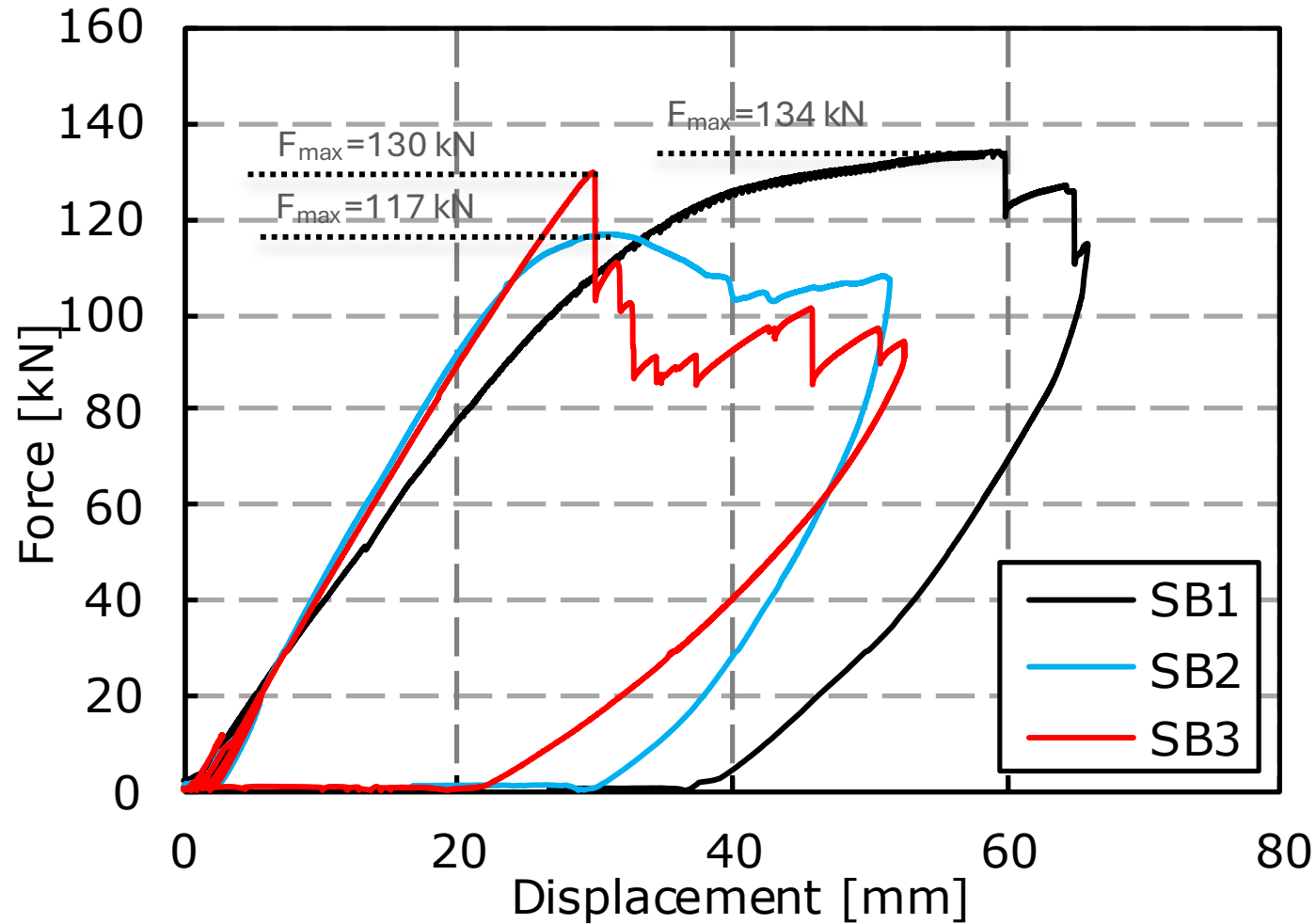


Steel beam SB1 during testing – this study



Composite beam CB1 during testing

Force-displacement curves:



SB1

134 kN

highest capacity; extended nonlinear response

SB2

117 kN

lowest capacity; earlier local instability

SB3

130 kN

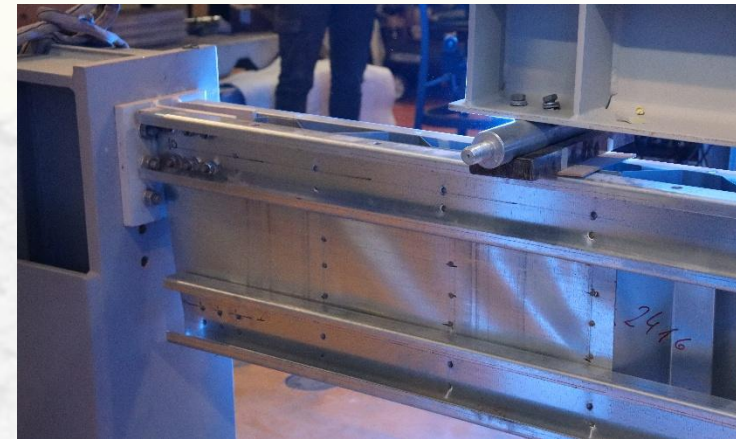
instability, redistribution and premature spot welds failures

SB1: instability governs the response



134 kN

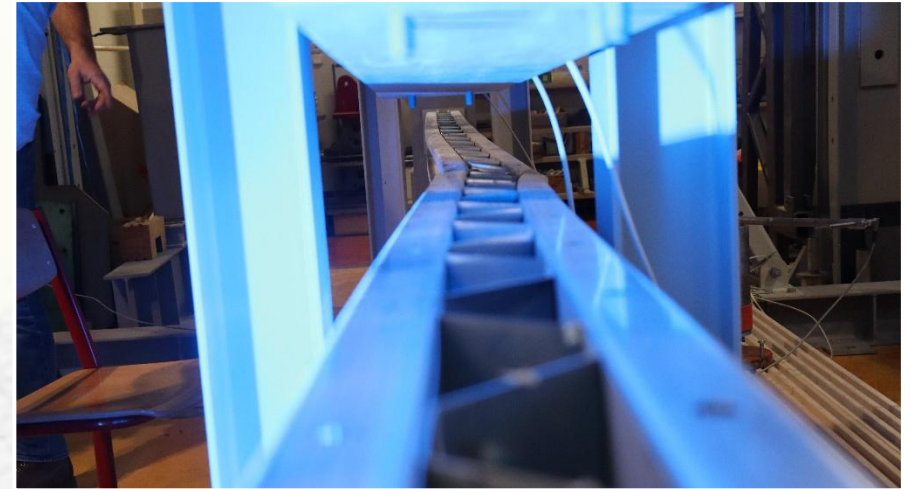
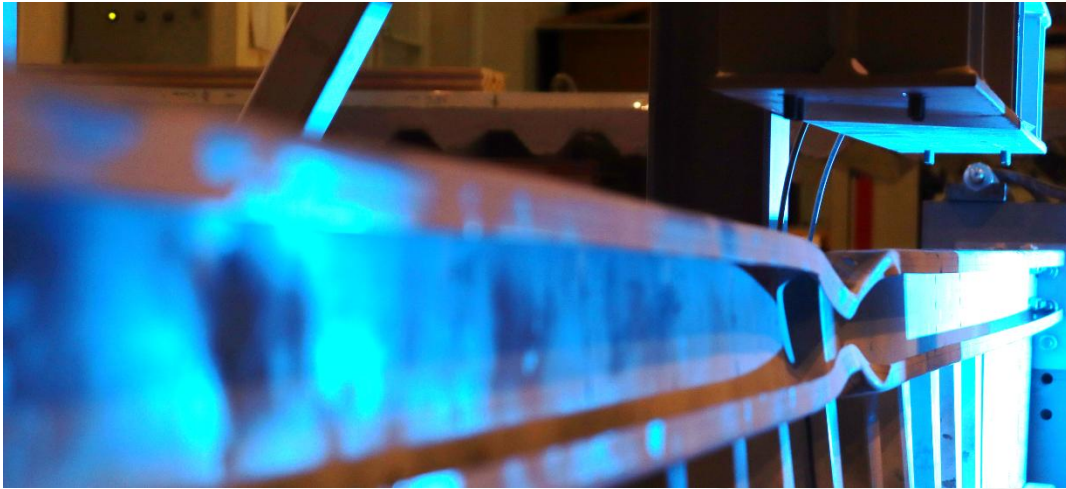
maximum measured load



Shear-field development in the shear plate
Distortional buckling of the channel section.

Buckling of the channel sections leads to lateral deflection.

SB2: increased girder depth does not compensate for thin channel sections



117 kN

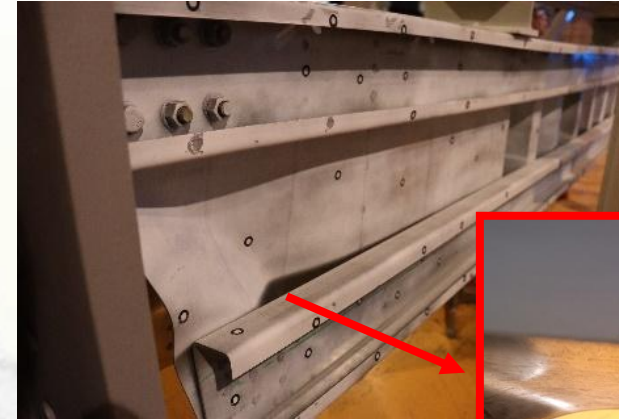
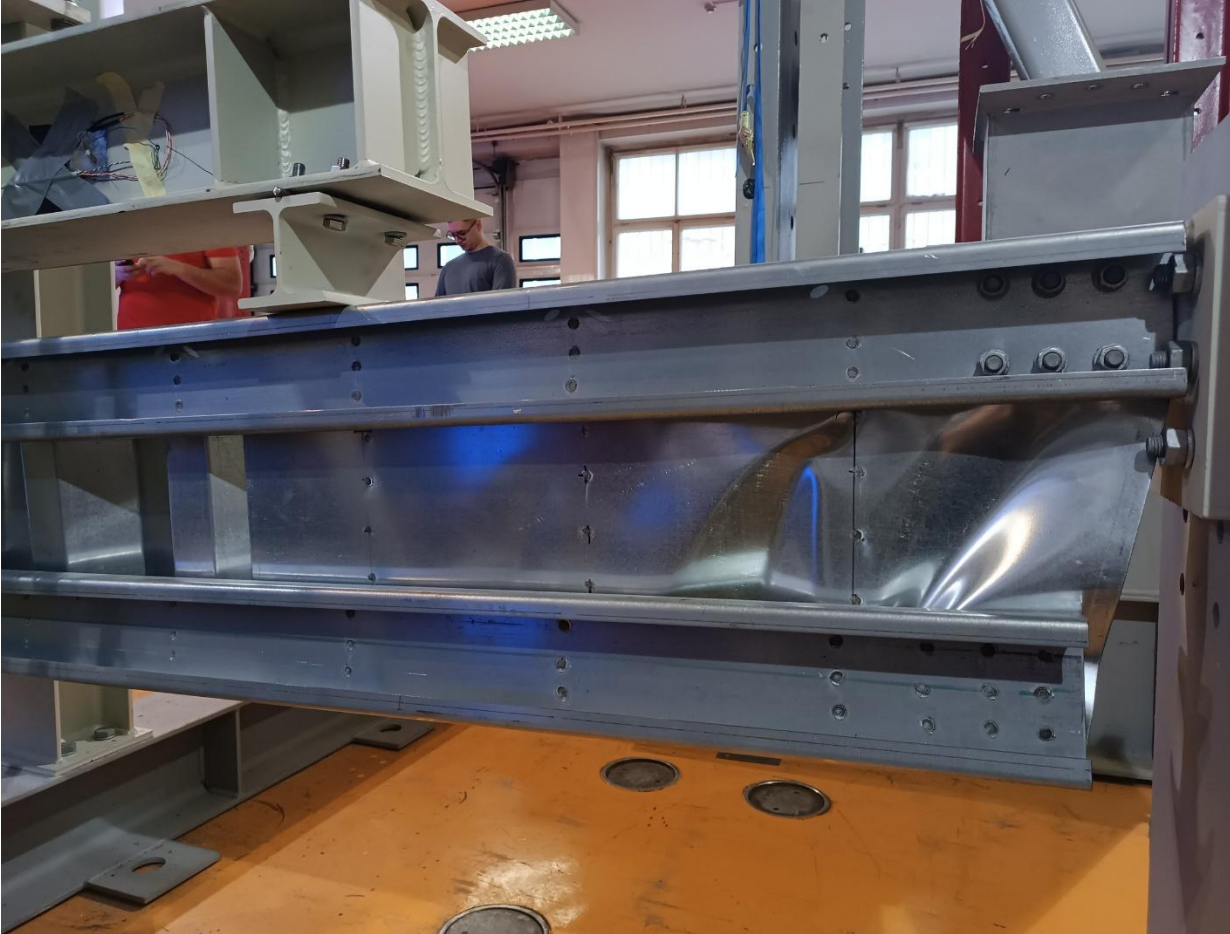
lowest ultimate load

Local buckling begins under the load-introduction points.

It develops into distortional deformation.

Greater depth increases stiffness, but thin elements reduce resistance.

SB3: non-ductile weld failure controls collapse



130 kN

maximum load before spot-welds failure

Instability-induced redistribution increases demand on the support-region welds, leading to brittle interfacial fracture.

Mean spot-weld resistances and failure modes:



Sheet pair [mm-mm]	Mean [kN]	Observed mode
1.0-1.0	6.5	Full button pull-out
1.5-1.5	13.7	Full button pull-out
1.5-3.0	14.7	Mixed
2.0-2.0	18.2	Mixed
2.0-2.5	20.6	Mixed
3.0-3.0	22.7	Interfacial fracture

Increasing sheet thicknesses coincides with a shift toward more brittle fracture.

- The load-bearing capacity and failure modes are influenced by the **geometric characteristics** of the steel elements (thickness and height) and the **performance of the spot weld connections**.
- Premature **failure of spot welds** can significantly **limit the load-bearing capacity** of steel beams and can change the expected failure mechanisms, as clearly demonstrated in the behaviour of SB3.
- The tested beams exhibited a **coupled instability-connection response**, rather than a single isolated failure mechanism.
- Local buckling initiated the nonlinear response, followed by distortional deformation, with associated stiffness reduction and redistribution of internal forces.
- For SB1 and SB2, the response was primarily governed by instability phenomena; connection deterioration occurred only after significant deformation.
- For SB3, local and distortional buckling and shear-field development occurred before the brittle interfacial spot-weld failure, which ultimately governed the collapse.

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