Project title: **Innovative lightweight cold-formed steel-concrete composite floor system**
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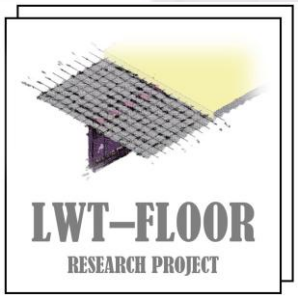
4th LWT-FLOOR Project Workshop

Numerical Investigation of Double-skin Cold-formed Steel Shear Wall Filled with Concrete

Vlaho Žuvelek | Ivan Ćurković | Ivan Lukačević | Andrea Rajić



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

Agenda

- Introduction
- Finite element (FE) model
- Validation of FE model
- Parametric study
- Results and discussion
- Conclusion

1. Introduction

Cost Effectiveness

Systems that offer convenient modular design

High Strength

High in-plane strength and stiffness due to the cross sectional shape of the sheet

Efficient Mechanical Assembly

Enables the quick and easy integration of thin-walled systems, optimizing construction time and resources

Recyclable components

Ensure sustainability and environmental responsibility

1. Introduction

Extensive Application of CFS in Construction

Widely used in curtain walls, exterior walls, floor systems, and roof systems for low-rise and mid-rise structures.

Insufficient Absorbtion of Horizontal forces

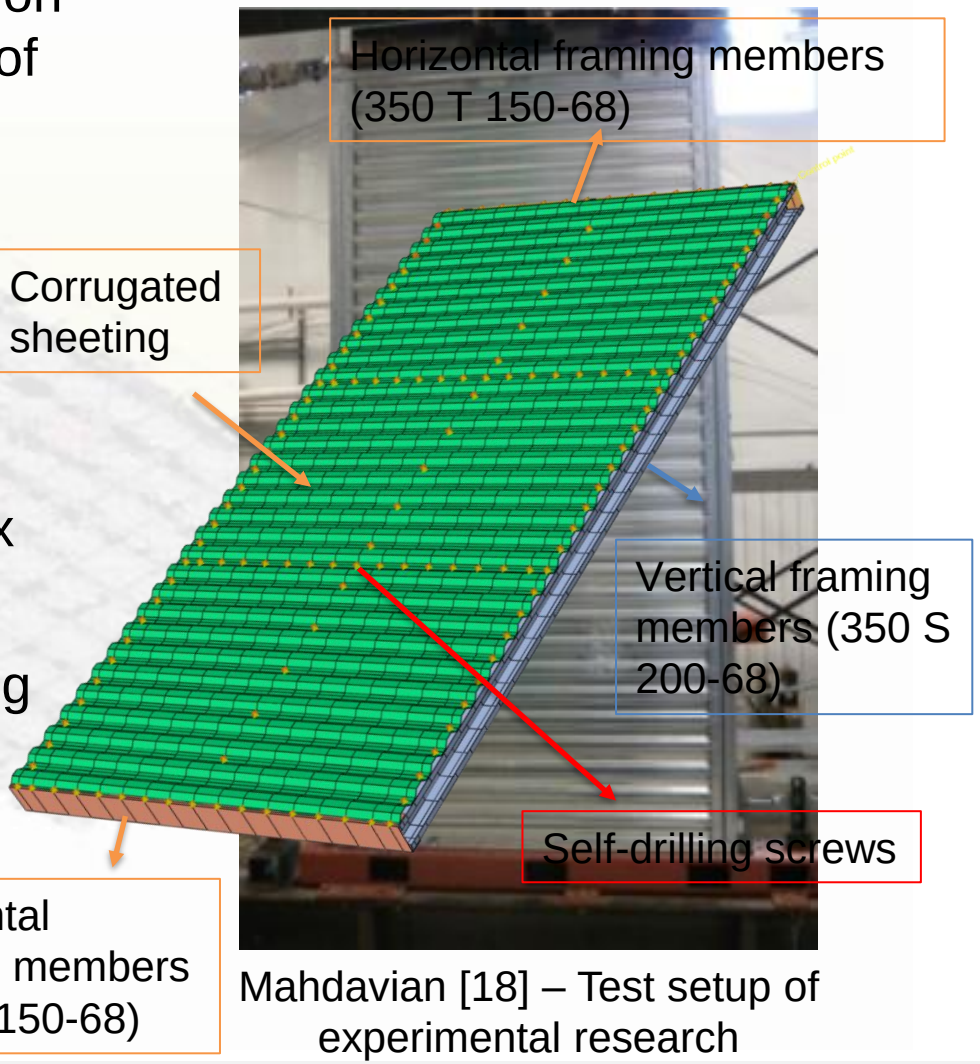
The lack of CFS thin-walled system in mid-rise and high-rise buildings

Meeting Industry Demand

A noncombustible CFS shear wall system with high structural performance

2. Finite element (FE) model

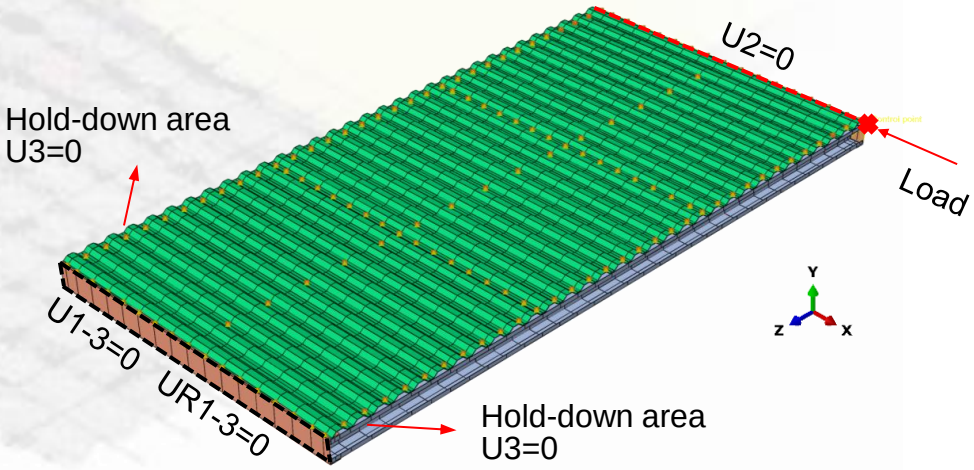
- FE model was developed based on experimental research (Test 54) of Mahdavian [18]
- Abaqus Explicit solver (quasi – static analysis)
  - To address geometrical and material nonlinearities
- Dimension of the shear wall 2.4 x 1.2 m :
  - Vertical and horizontal framing members
  - Corrugated steel sheeting
  - Self-drilling screws



Mahdavian [18] – Test setup of experimental research

2. Finite element (FE) model

- Boundary and load condition simplified compared to experimental specimens
  - Bottom horizontal framing members
    - Fully rigid boundary conditions
  - Vertical framing members
    - Hold-down area simulated preventing the vertical displacements
  - Top horizontal framing members
    - Out-of-plane displacements were prevented to simulate lateral support



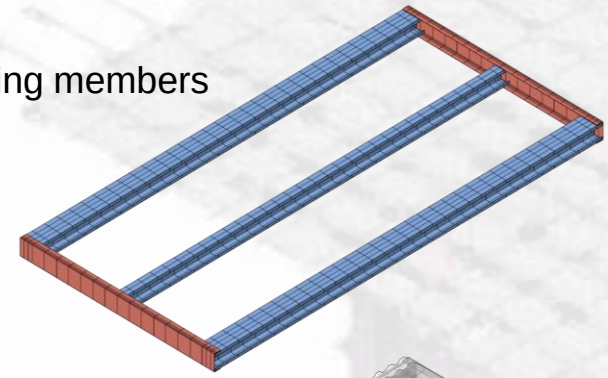
2. Finite element (FE) model

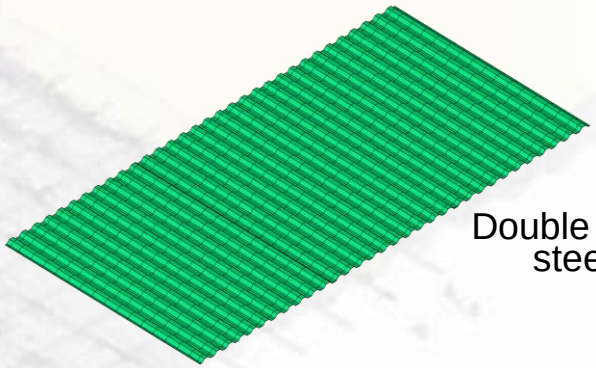
- Constitutive models
  - CFS elements
    - Defined by the bilinear elastic-plastic material model based on the experimental results.
  - Self-drilling screws
    - Screw stiffness is defined in the vertical and horizontal directions based on the connection test results [18].
- Interaction
  - Normal behaviour
    - Hard contact
  - Tie constraints between framing members

2. Finite element (FE) model

- Numerical model based on Test 54 by Mahdavian [18] serve as a benchmark model for modelling a double-skin CFS shear wall filled with concrete (DCSWC)

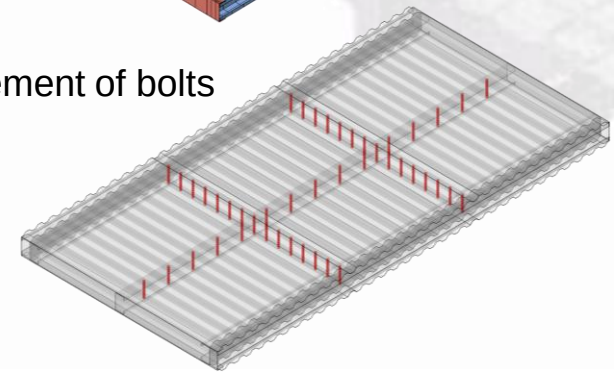
Framing members

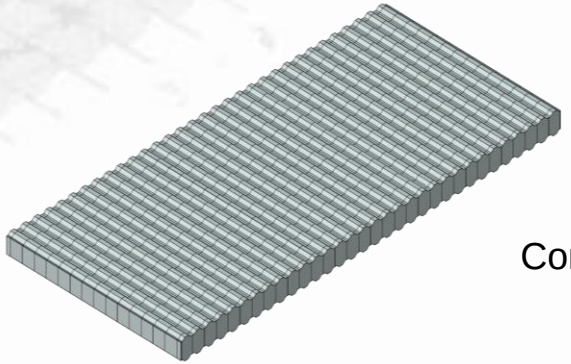




Double skin corrugated steel sheeting

Arrangement of bolts

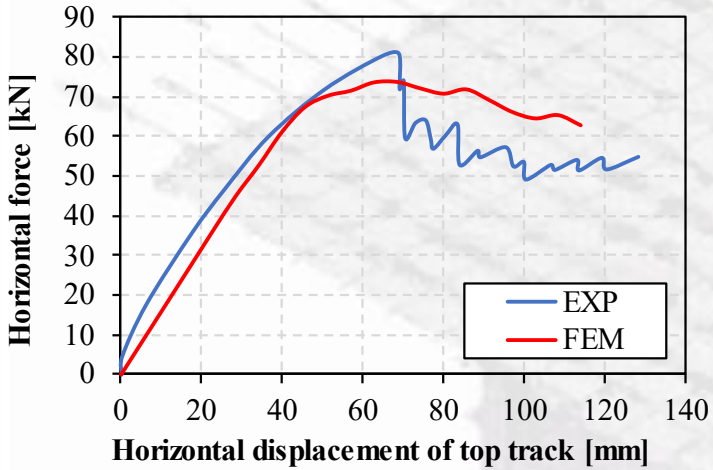


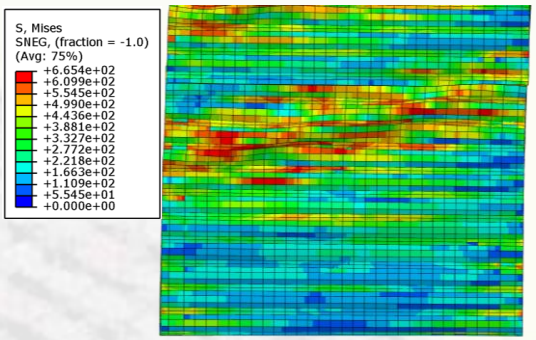


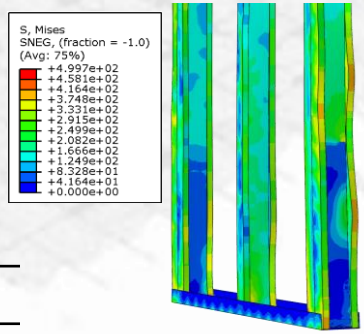
Concrete layer

3. Validation of FE model

- Results of the numerical analysis were compared with the experimental results of Test 54 by Mahdavian [18]
- Good agreement between experimental and numerical simulation



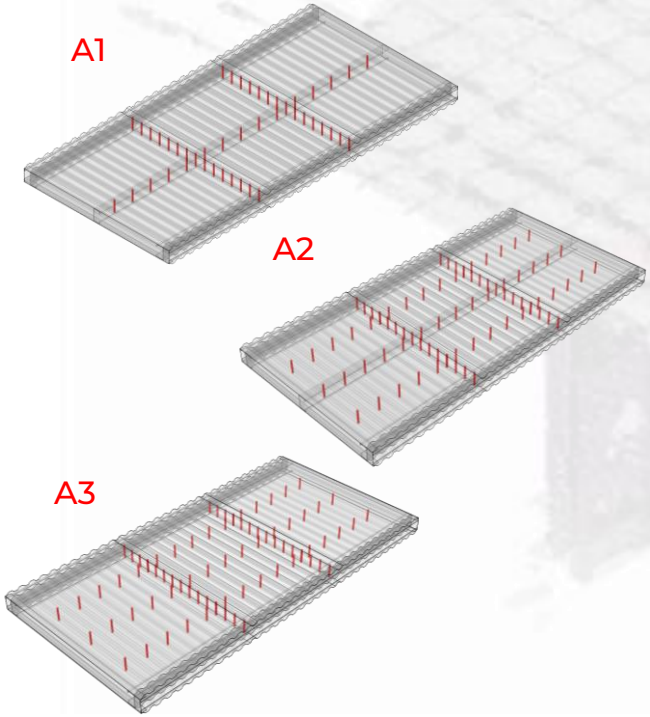




	P_{ult} [kN]	Ratio	Δ_{ult} [mm]	Ratio
Experimental	80.8	**0.92**	68.4	**1.00**
Numerical	73.9		68.5	

4. Parametric study

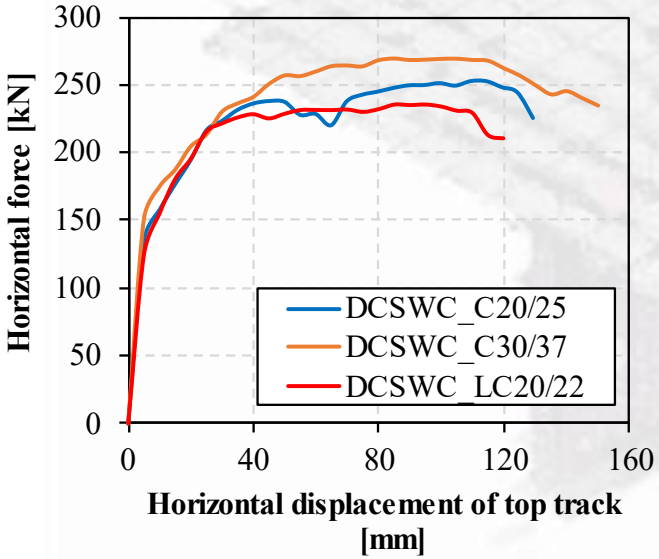
- The parametric analysis provides an even better insight into the behaviour of DCSWC.
- Different parameters assumed to influence the behaviour:
  - Concrete strength
  - Thickness of the corrugated sheeting
  - Diameter and arrangement of the bolts

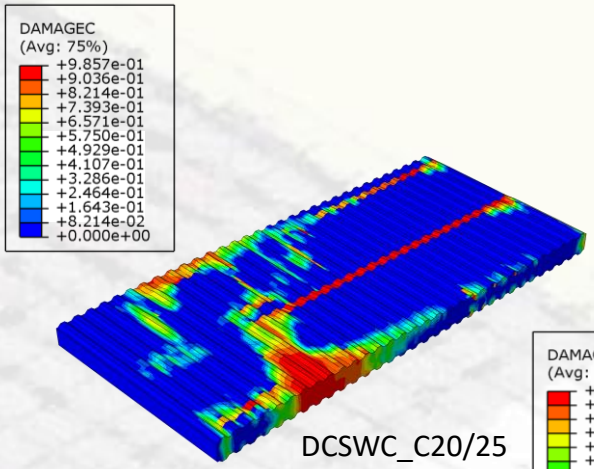


Model name [DSWC_xx]	Concrete class	Thickness of corrugated sheeting [mm]	Diameter of bolts	Arrangement of bolts
C20/25	C20/25			
C30/37	C30/37	0.68	M12	A1
LC20/22	LC20/22			
CS068		0.68		
CS10	C20/25	1.0	M12	A1
CS15		1.5		
M10			M10	
M12	C20/25	0.68	M12	A1
M16			M16	
A1				A1
A2	C20/25	0.68	M12	A2
A3				A3

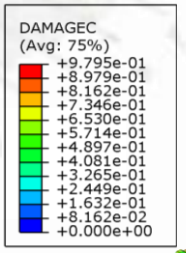
5. Results and discussion

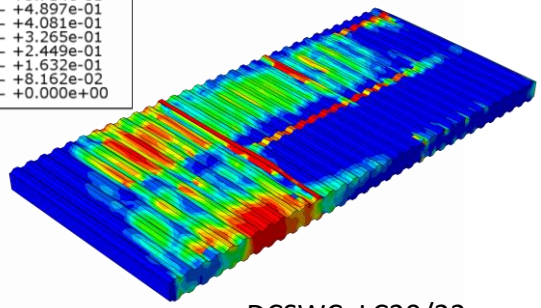
- All models experienced same failure mode
  - Buckling of vertical framing members
  - Diagonal damage and damage in the slab along the central frame member
- Results revealed that enhancing the strength of the concrete leads to increased shear wall resistance





DCSWC_C20/25

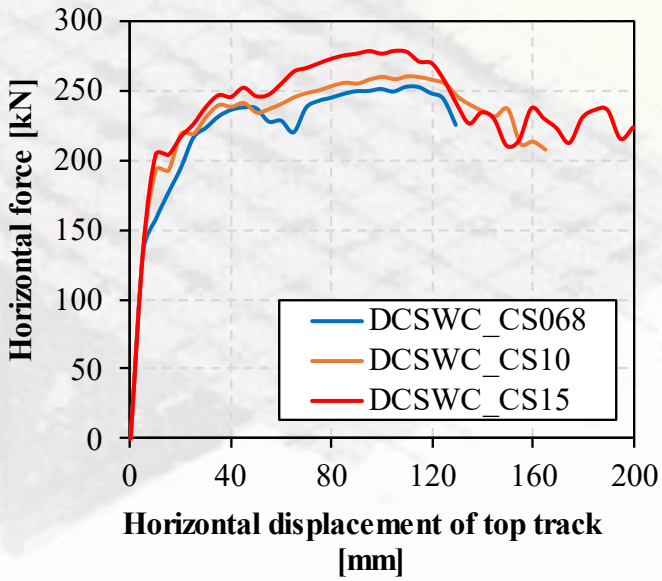




DCSWC_LC20/22

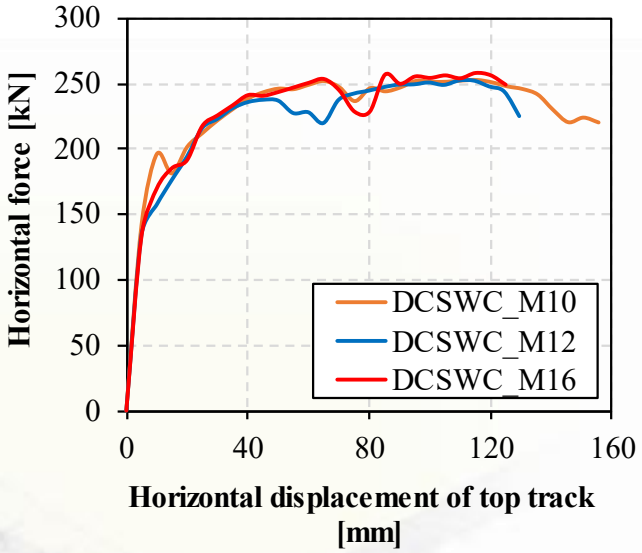
5. Results and discussion

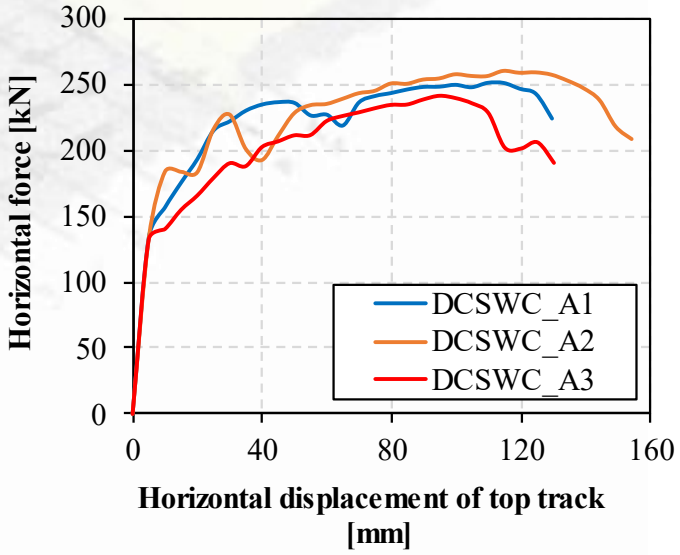
- All models experienced same failure mode
  - Buckling of vertical framing members
  - Diagonal damage and damage in the slab along the central frame member
- Thicker corrugated steel sheething leads to slight increase in capacity



5. Results and discussion

- All models experienced same failure mode
  - Buckling of vertical framing members
  - Diagonal damage and damage in the slab along the central frame member
- Influence of bolt diameter showed no significant effect on the behaviour of the shear wall
- Arrangement of the bolts highlighted the essential contribution of the central frame element to the behaviour of the shear wall





6. Conclusion

- The change in concrete strength contributes to the increase in shear wall resistance. In addition, when using lightweight concrete, it is possible to achieve similar resistances to normal concrete, while remarkable reducing the weight of the system itself.

- Models with lightweight concrete cause more sudden fractures in the concrete and insufficient formation of diagonal damages in the concrete slab.

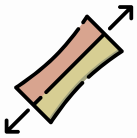
- Changing the thickness of the corrugated sheeting slightly affects the resistance of the shear wall. In addition, increasing the thickness of the corrugated sheeting tends to result with a higher yield strength of the shear wall.

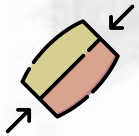
- The diameter of the bolts that are embedded into the concrete has no significant influence on the behaviour of the shear wall. However, it was found that the arrangement of the bolts as well as the presence of the central frame member can significantly influence the behaviour of the shear wall in terms of resistance and ductility.

Further research

Further experimental and numerical studies

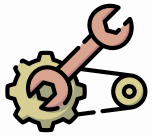
Experimental and numerical studies under cyclic loading are required, which will give a better insight into the behaviour of the shear wall





Connection detail

The connection of the CFS shear wall to the steel frame structure needs further research so that the wall can be dismantled after its inelastic deformation and replaced by a new CFS shear wall.



Thank you for attention!

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