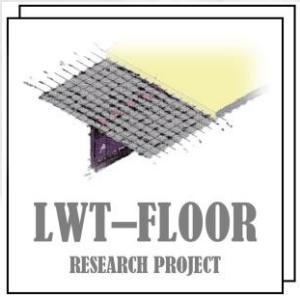
Project title: **Innovative lightweight cold-formed steel-concrete composite floor system**
Acronym: **LWT-FLOOR** Project ID: **UIP-2020-02-2964**
4th LWT-FLOOR Project Workshop

Behavior of dual steel frame with innovative double skin cold-formed steel concrete composite shear wall

Emanuel Krupa-Jurić, Ivan Lukačević



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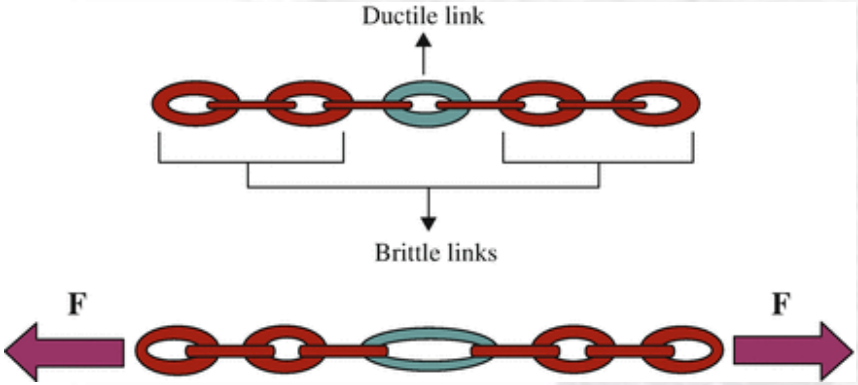
Seismic design

- Modern codes → dissipation of seismic energy through plastic deformation
- Capacity design



STRUCTURE

Brittle members → Elastic behaviour

Ductile members → Plastic behaviour → Energy dissipation

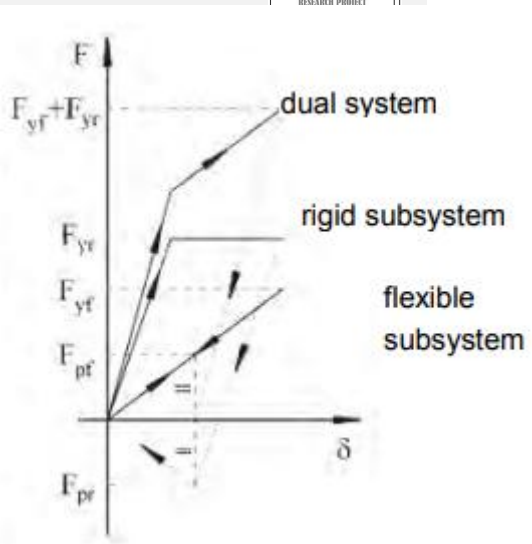
REPAIR?

Dual systems

- The dual system consists of:

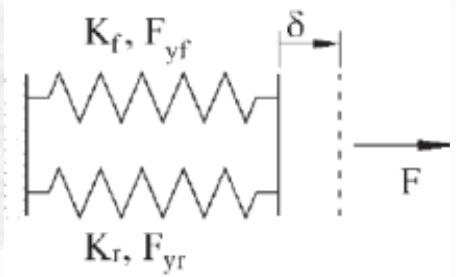
1. Moment resisting frame (MRF)

- Remains elastic
- Enables recentering of the structure
- Enables stability during repair



2. Bracing system

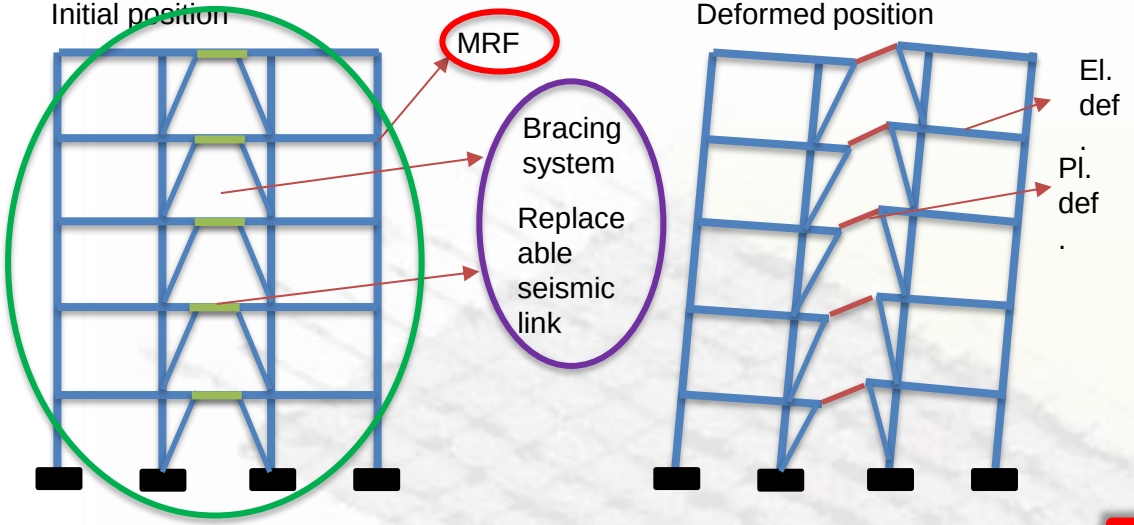
- Replacable
- Ductile

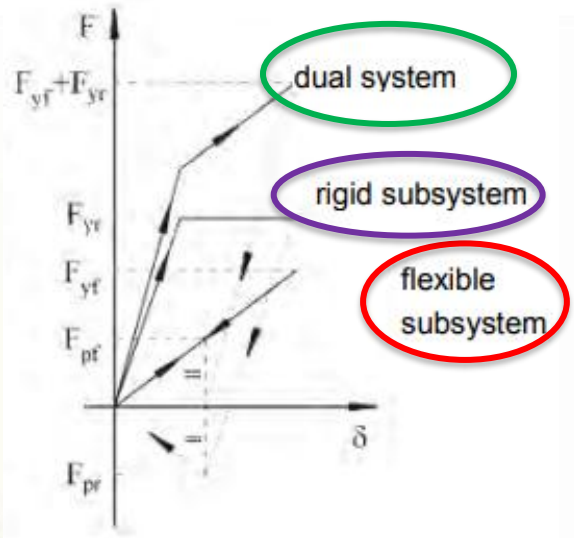


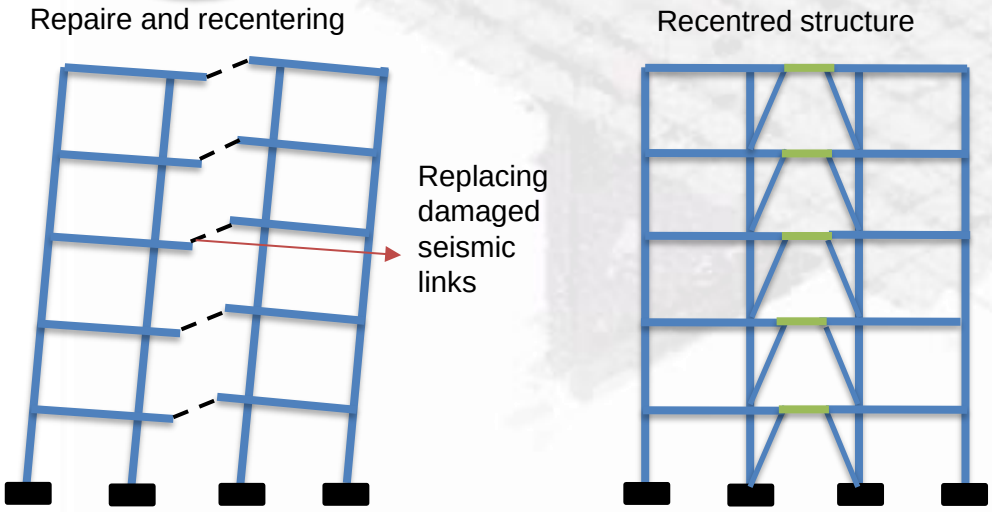
- Dissipates seismic energy trough yielding

Dual systems – Seismic links

- Variant with replaceable seismic links







2 variants

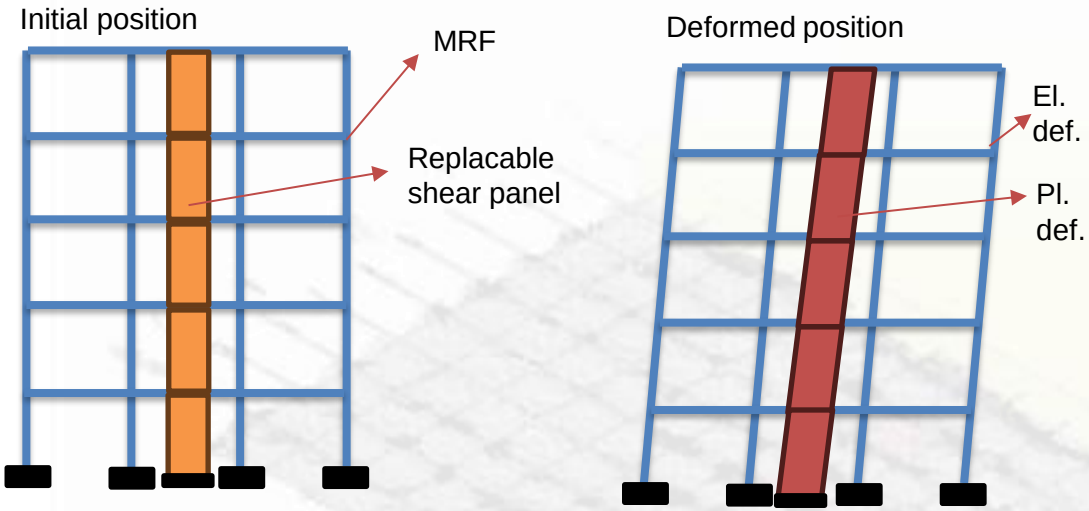
1. Short seismic links: dissipation of seismic energy through shear
2. Long seismic links: dissipation of seismic energy through bending

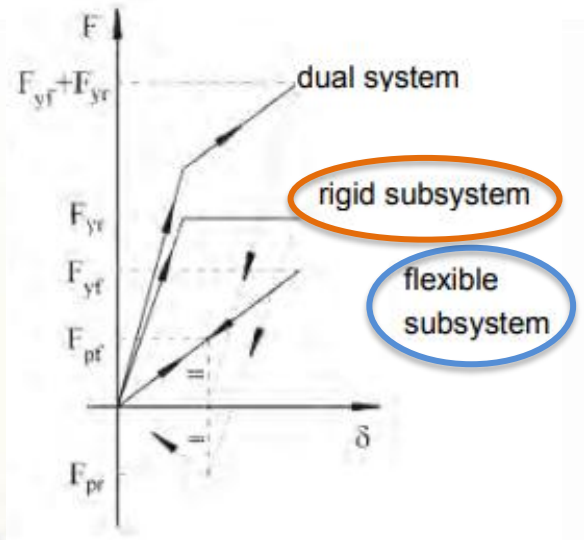
In both variants, MRF's remain elastic and enable recentering.

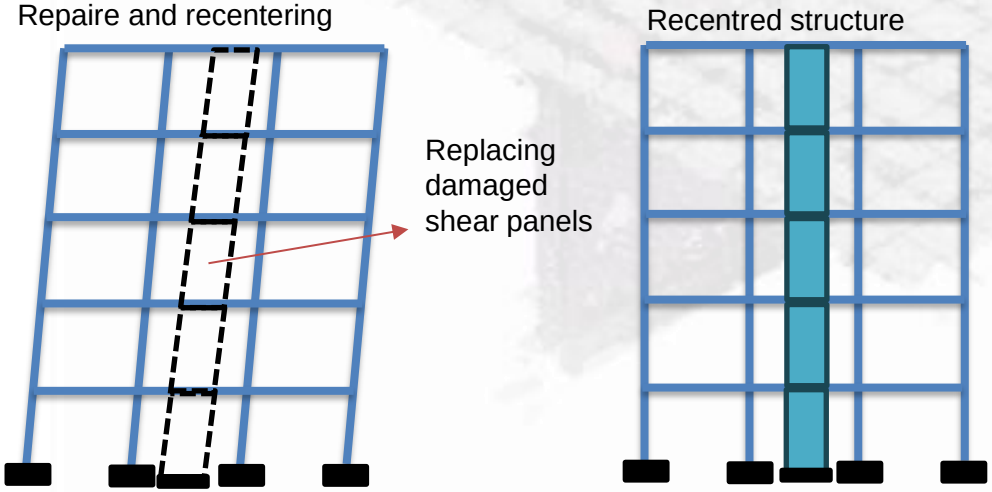
Detailed numerical analysis of the behavior of such systems is described in paper by Lukačević, I., Maleta, T., Dujmović, D.

Dual systems – Shear panels

- Same idea, different bracing system







WHY shear panels?

Numerical analysis of the shear wall

- Analysis was conducted in Abaqus Explicit solver

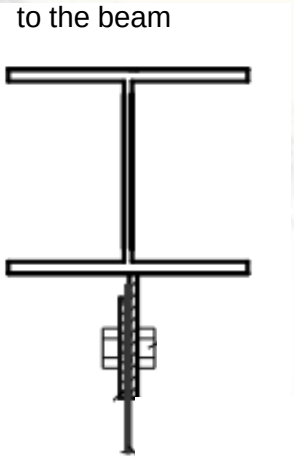
Idea: Exploitation of advanteges of both materials

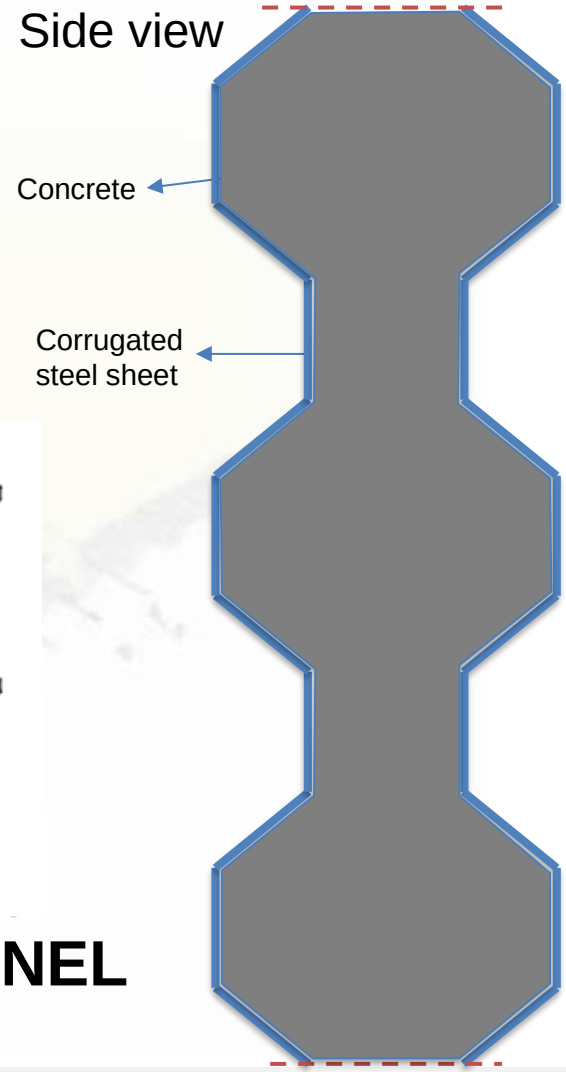
- **Steel**: ductility
- **Concrete**: stiffness,stability of corrugated steel sheets

The shear wall

Two cold formed corrugated steel sheets

Concrete

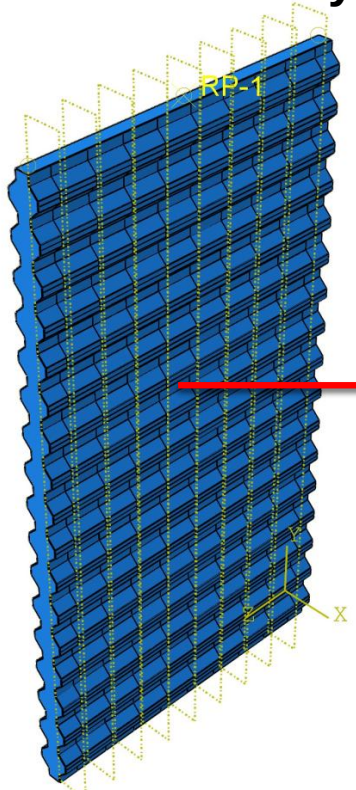




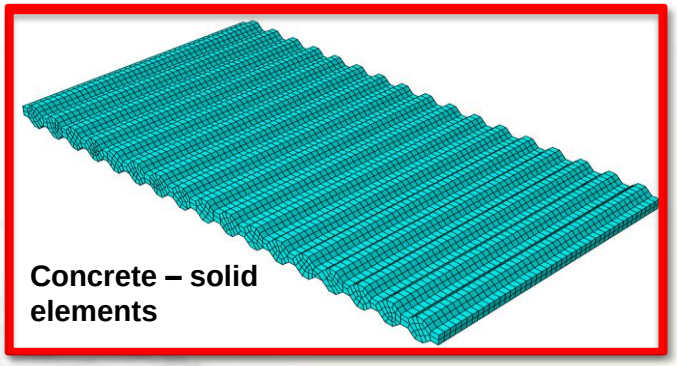
SANDWICH STEEL-CONCRETE-STEEL PANEL

Numerical analysis of the shear wall

Numerical model-
work in progress
Paramatric analysis

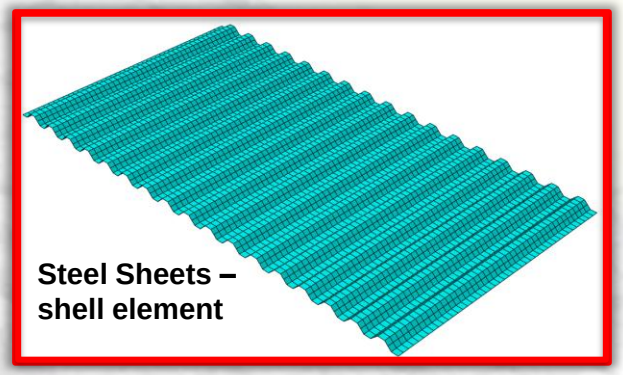


Numerical model :
CCFSSW_01



Concrete – solid elements

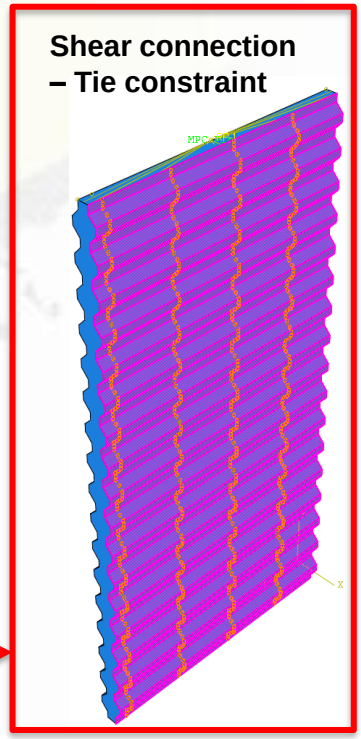
Material:
C25/30
C30/37
CDP model



Steel Sheets – shell element

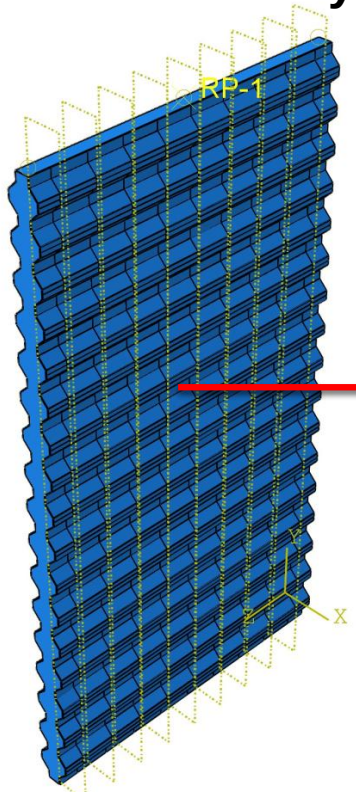
Material – exp. obtained:
M10
M30
True stress-strain ralation

Shear connection – Tie constraint

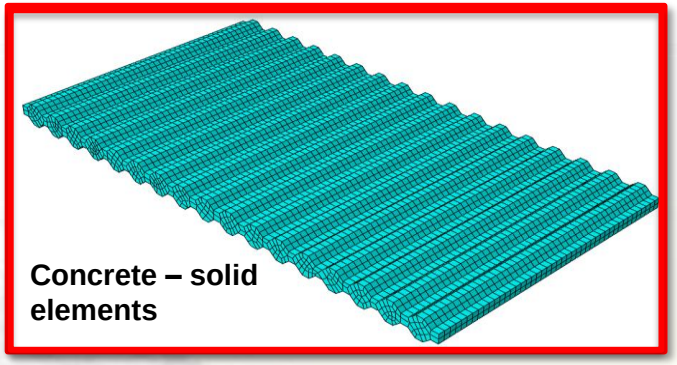


Numerical analysis of the shear wall

Numerical model-
work in progress
Paramatric analysis



Numerical model:
CCFSSW_04

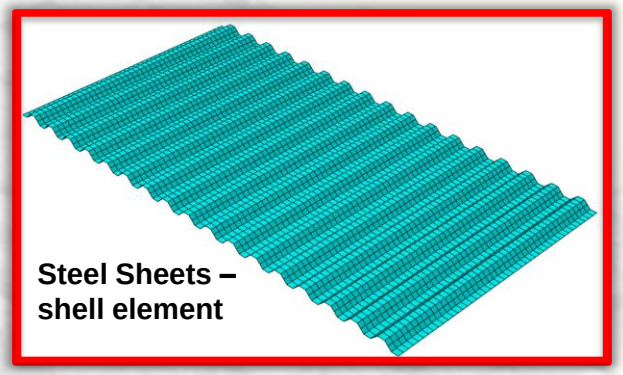


Concrete – solid elements

Material:
C25/30
C30/37
CDP model

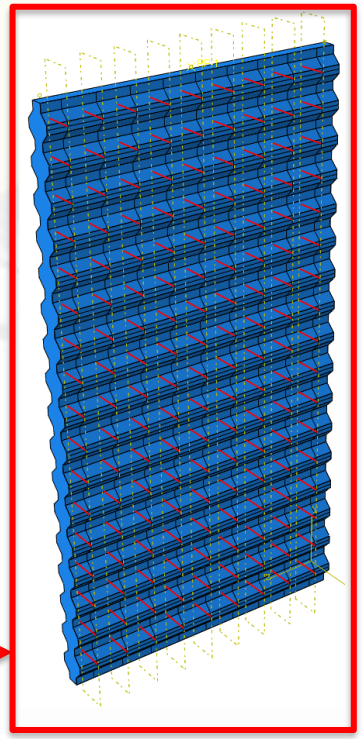
Shear connection
– Bolts M12
– Bolts M12
Configuration 1

Material– exp. obtained:
True stress-strain ralation



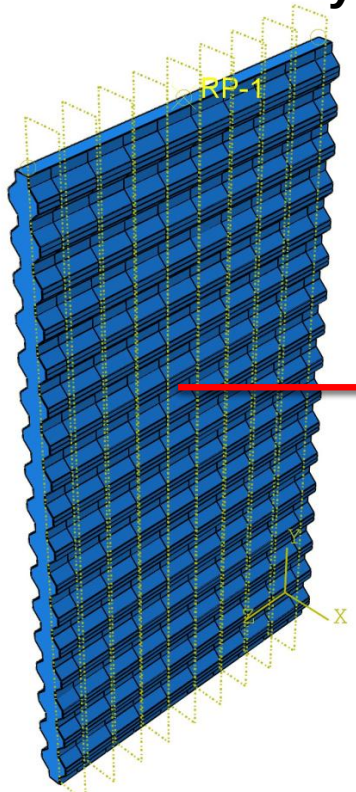
Steel Sheets – shell element

Material – exp. obtained:
M10
M30
True stress-strain ralation

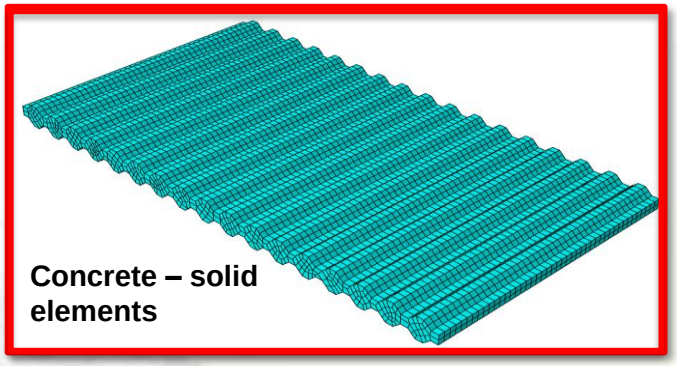


Numerical analysis of the shear wall

Numerical model-
work in progress
Paramatric analysis



Numerical model:
CCFSSW_03

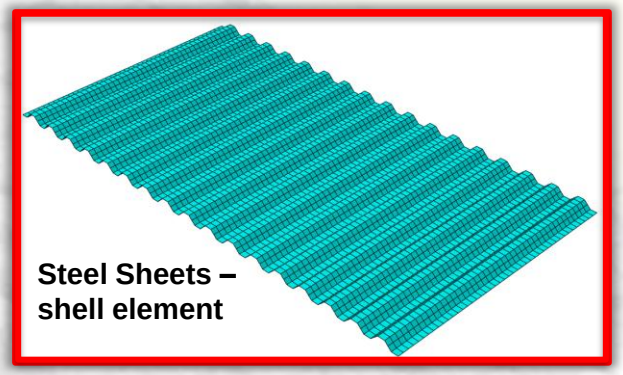


Concrete – solid elements

Material:
C25/30
C30/37
CDP model

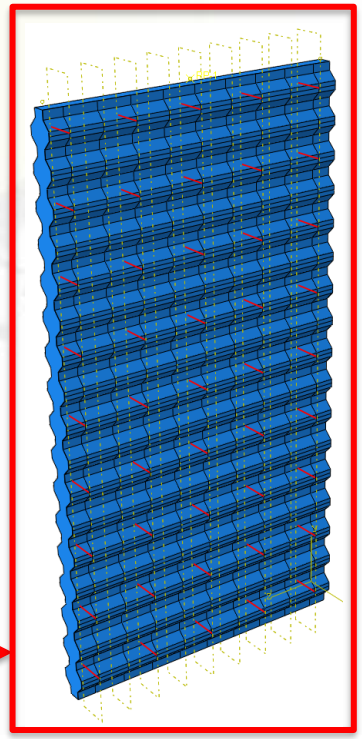
Shear connection
– Bolts M12
– Bolts M12
Configuration 2

Material– exp. obtained:
True stress-strain ralation

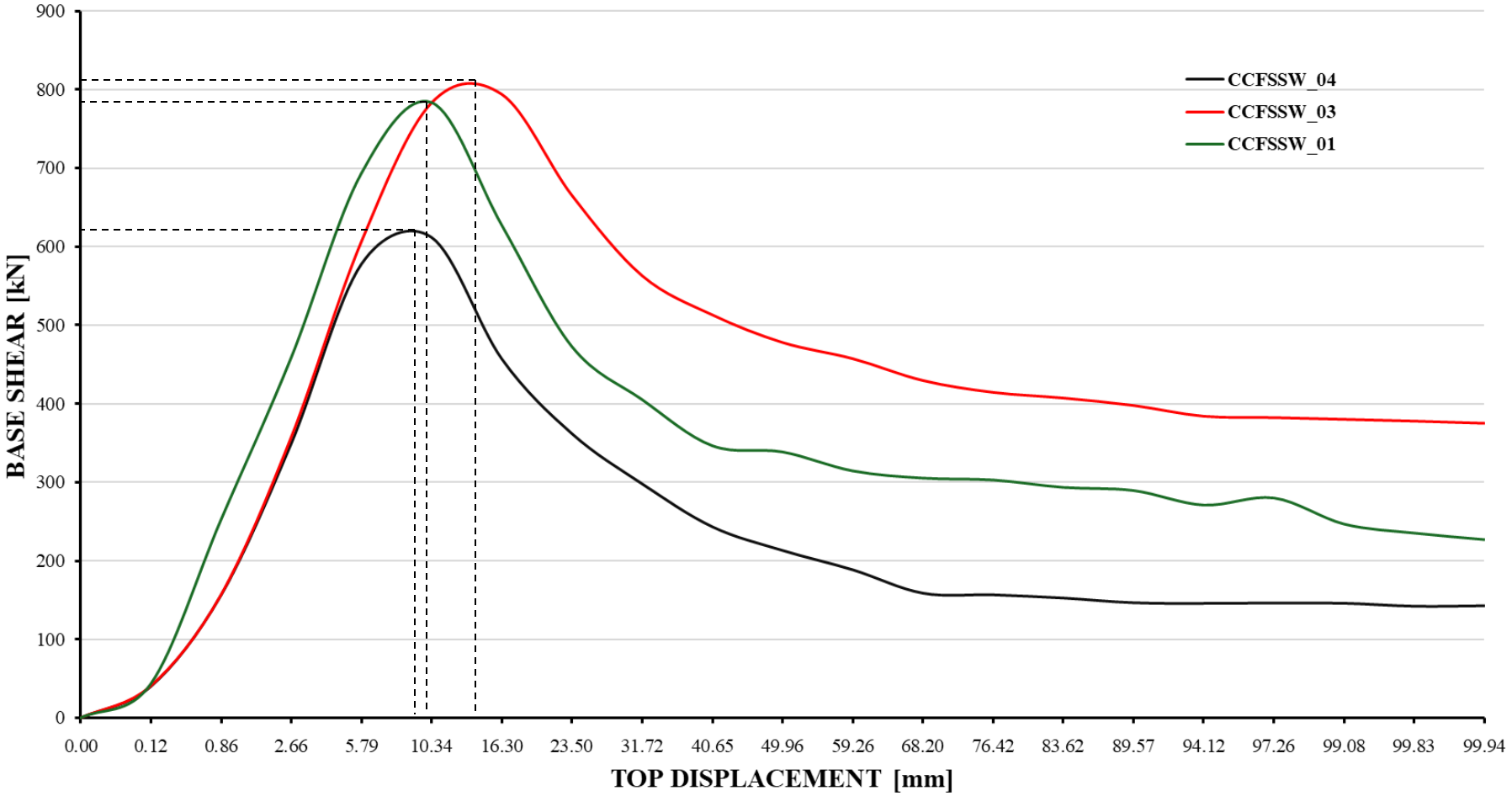


Steel Sheets – shell element

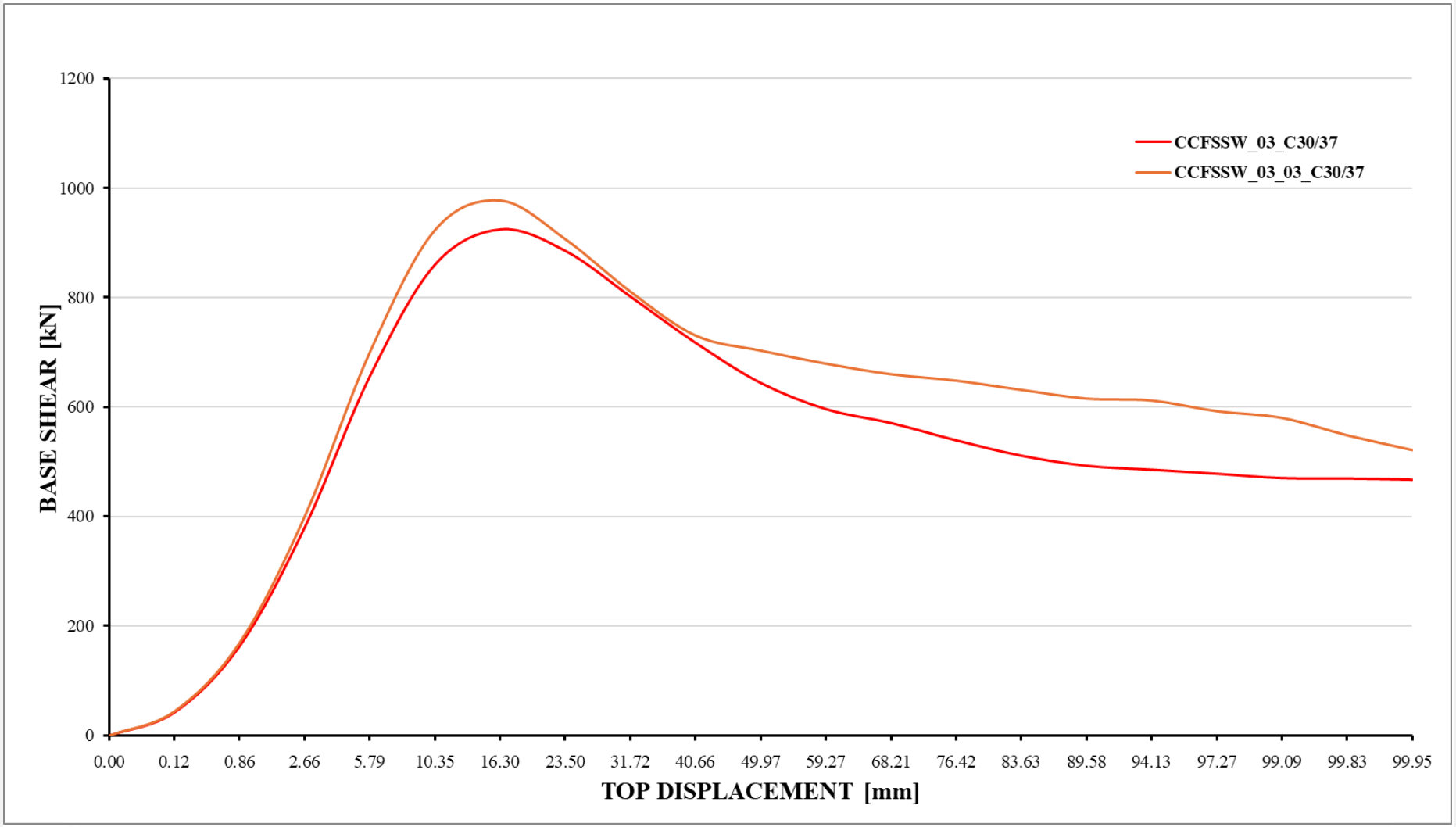
Material – exp. obtained:
M10
M30
True stress-strain ralation



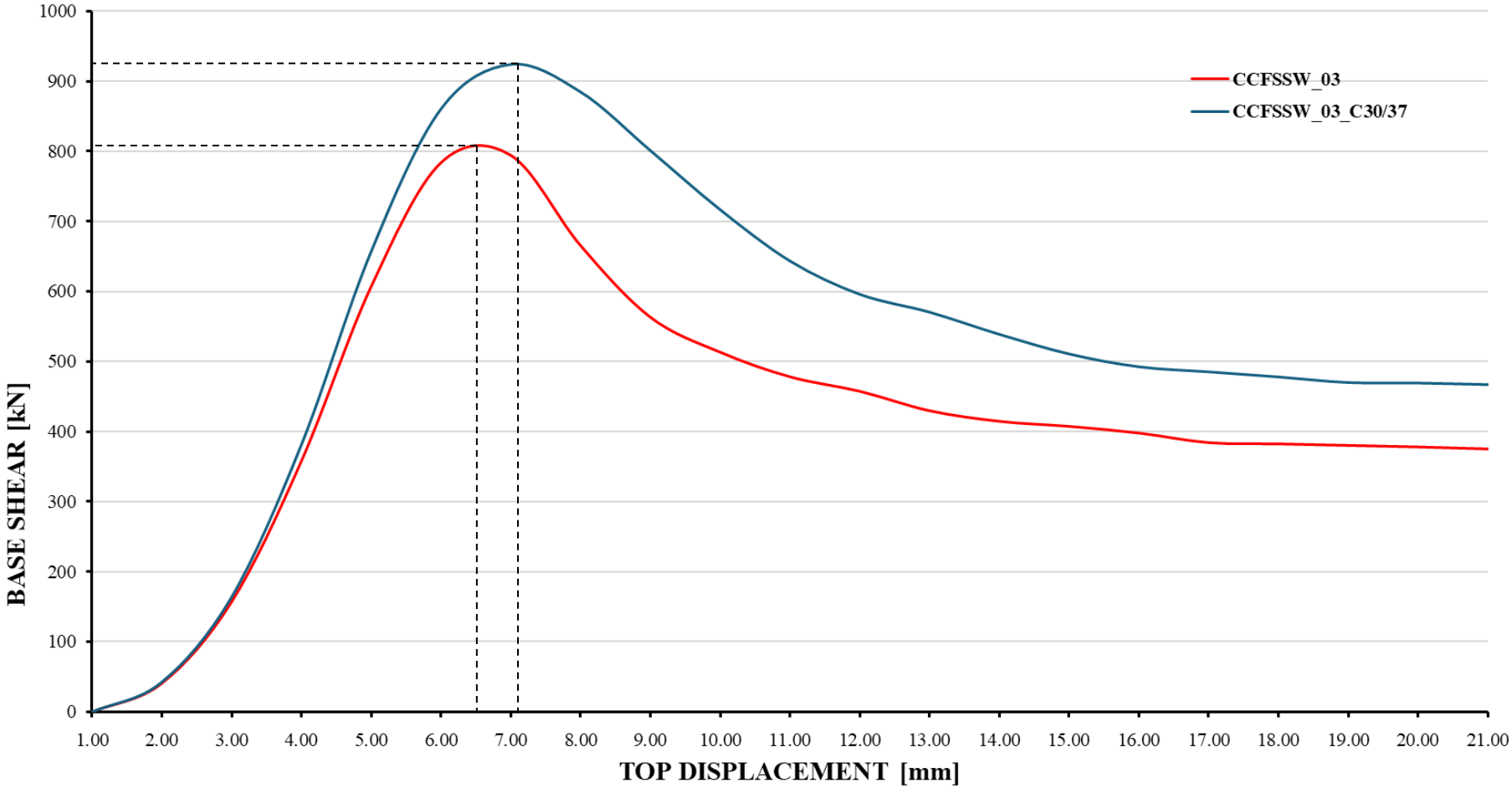
Numerical analysis - Results



Numerical analysis - Results

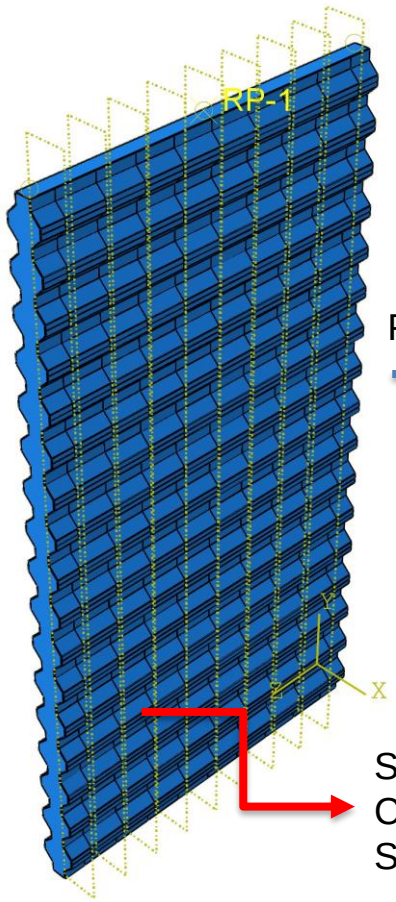


Numerical analysis - Results



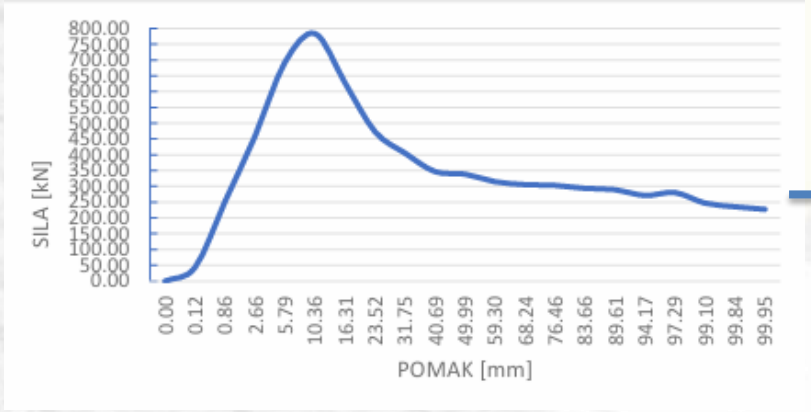
Numerical analysis of the shear wall

Numerical model - No. 1



Pushover

Capacity curve of the shear wall (Force-top displacement curve)



GLOBAL MODEL

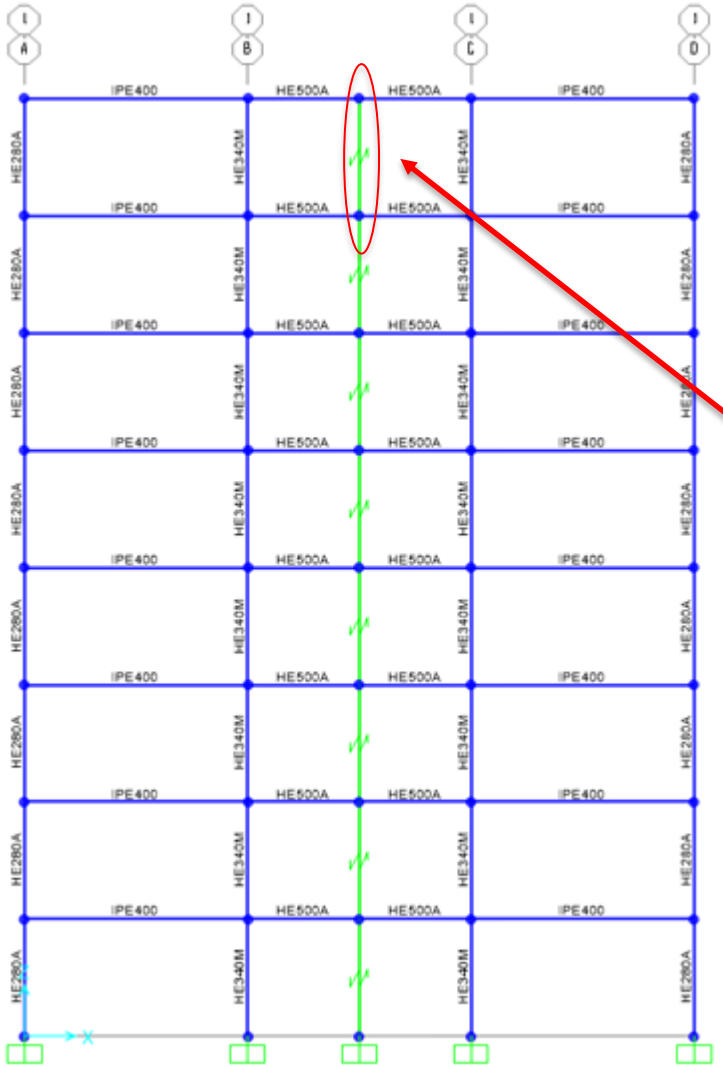
Steel Sheets – shell element
Concrete – solid elements
Shear connection – Tie constraint

PUSHOVER (N2) – SAP 2000

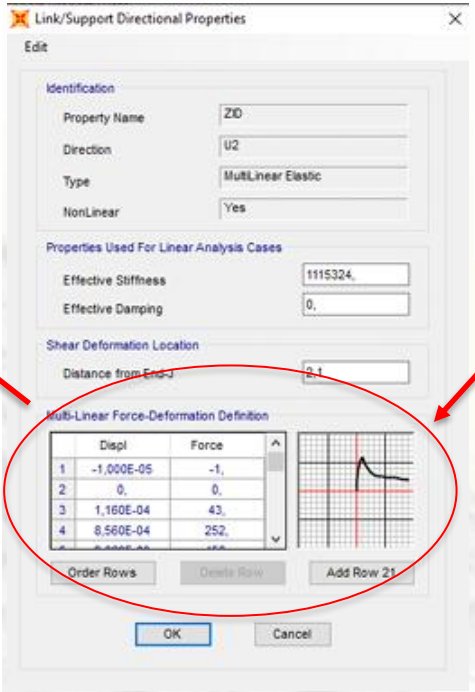
- To test the dual behavior of the system Pushover analysis is performed
- Pushover analysis gives us key information on behavior of the system:
- Collapse mechanism
- Capacity curve – relation between base shear and roof displacement
- Overstrength ratio
- Behavior factor
- **GOAL**: to show that moment-resisting frames remain elastic while composite shear walls yield and thus dissipate seismic energy

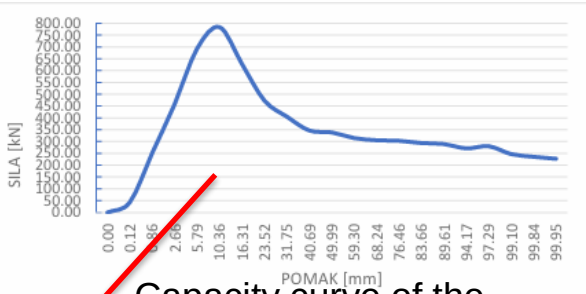
PUSHOVER (N2) – SAP 2000

Numerical model in SAP2000



Defining behavior of the link elements in SAP2000



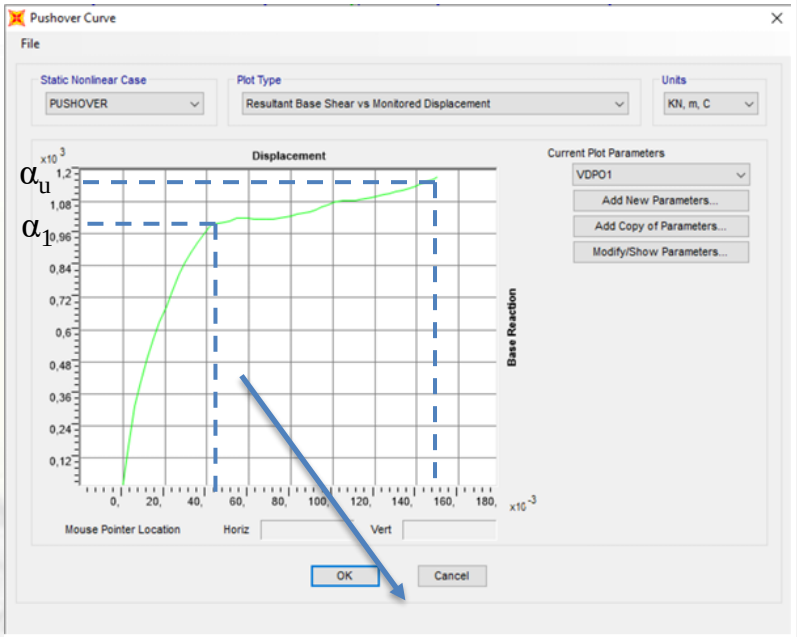


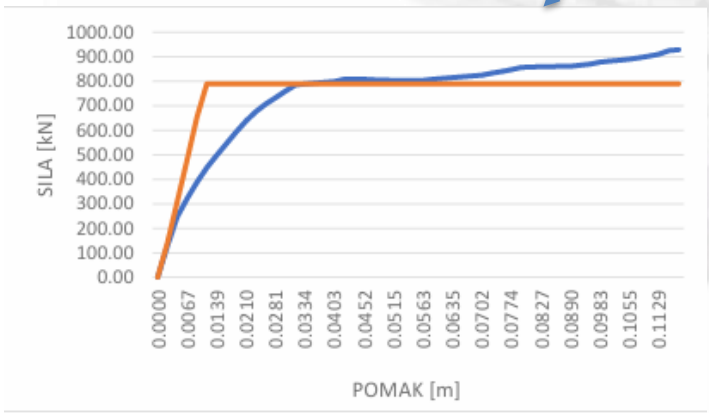
Capacity curve of the individual shear wall obtained from nonlinear analysis in ABAQUS

- Plastic hinges, hinges defined with M_{pl},
- assigned to each beam and column –Nonlinear behavior of the material is included while geometric nonlinearities were not (structure is not sensitive to PΔ effects)
- Pushover is performed with the displacement control method

Results

- The result of the analysis is a characteristic pushover curve ie. Base shear – roof displacement curve
- MDOF curve → Γ → SDOF curve
- SDOF curve → Bilinearisation





F_y^*- yield force

d_y^*- yield displacement

d_{et}^*- targe displacement

α_u/α_1 = 1,18 - overstrenght ratio

$q=q_0 * \alpha_u/\alpha_1$ =5,31- behavior factor

Conclusion

- During the analysis no plastic hinges appeared in beams or colums which confirms the dual behavior of the analysed system
- Shear walls yielded as predicted
- Global behavior of the system is ductile
- Obtained behavior factor is 5 which means that elements can be designed using much smaller forces thanks to the ductility of the system
- Composite shear wall - work in progress

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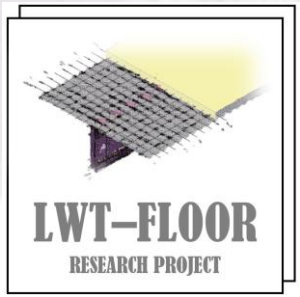

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