Estimation of actuator parameters for a Reaction Wall through Pushover Analysis

Master's thesis presentation

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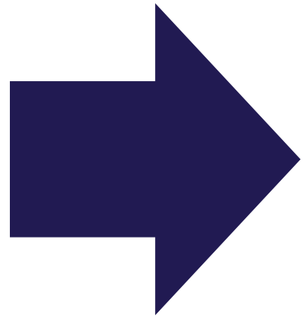
Supervisor: Lars Damkilde

Censor: Jens Peder Ulfkjær

Agenda

Master’s Thesis Presentation



Introduction

Seismic testing

- History
- Modern seismic codes
- Bulgaria's needs - R&D community and education
- Future facility – biggest on Balkan Peninsula
- Facility types and scaling factor

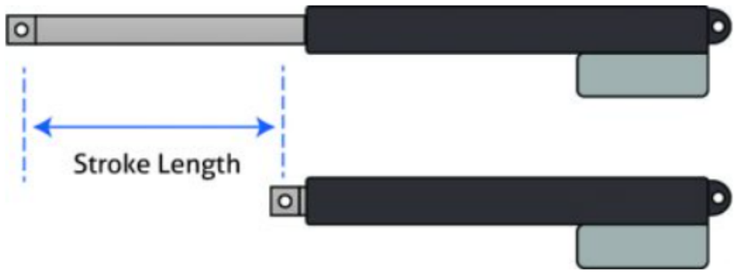

E-Defence,

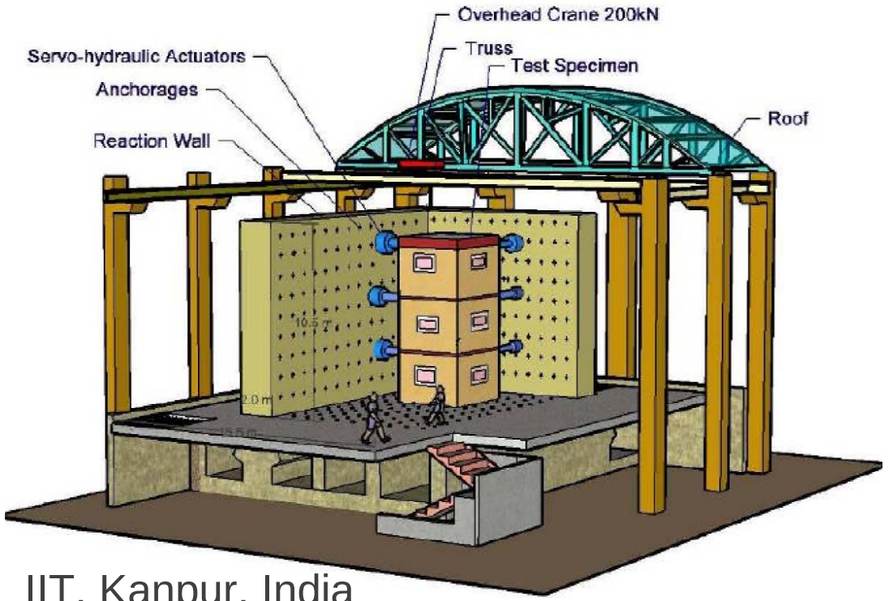

Machu Picchu, Peru


ELSA, Italy

Reaction wall – strong floor

Country	Name	Max height [m]	Actuator capacity [kN]	Actuator stroke [m]
Japan	Building Research Institute (BRI)	25.0	1000	±0,5
Taiwan	NCREE	15.0	1000	±0,25 to ±0,5
Italy	ELSA	16.0	3000	±0,25 to ±0,5
US	NEES, Leigh University	15.2	2000	±0,5
India	IIT Kanpur	10.5	-	-
Greece	NTUA	6.0	500	-





IIT, Kanpur, India

Problem formulation

Problem formulation

Choose, analyze & design an appropriate Prototype from steel. Perform a suitable numerical simulation and find the necessary actuator capacity and stroke to accommodate it in the new RWSF facility.

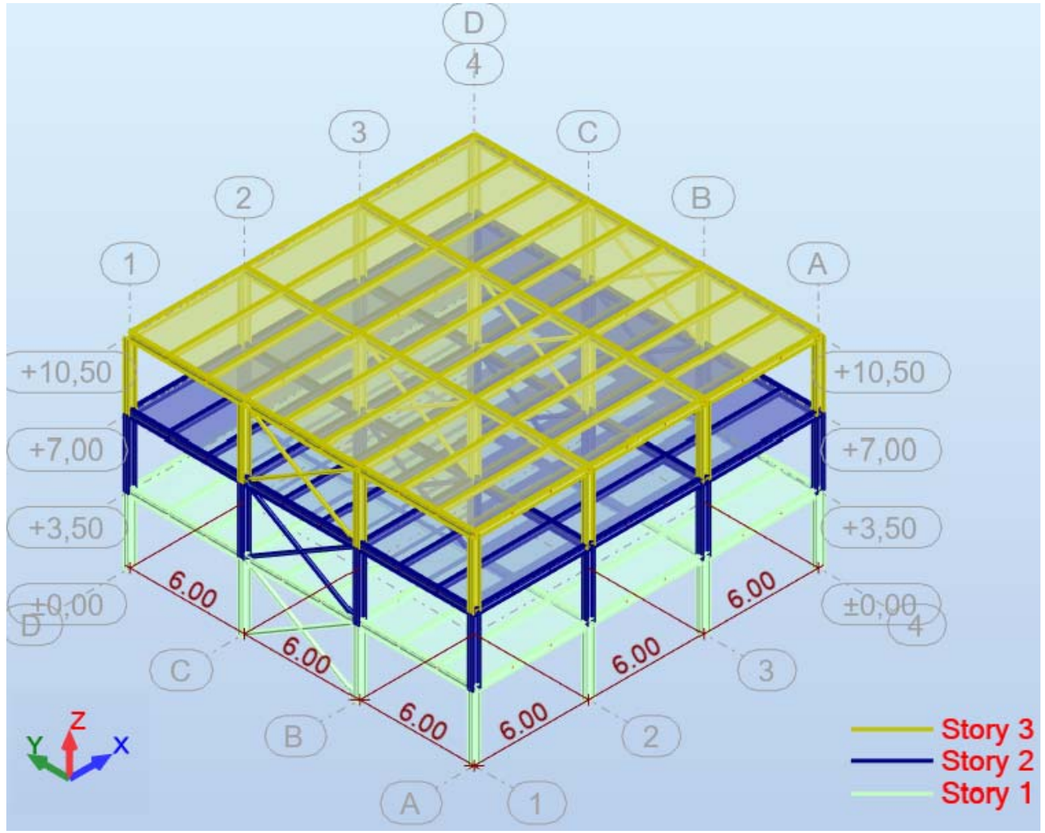
Prototype

Choice of prototype

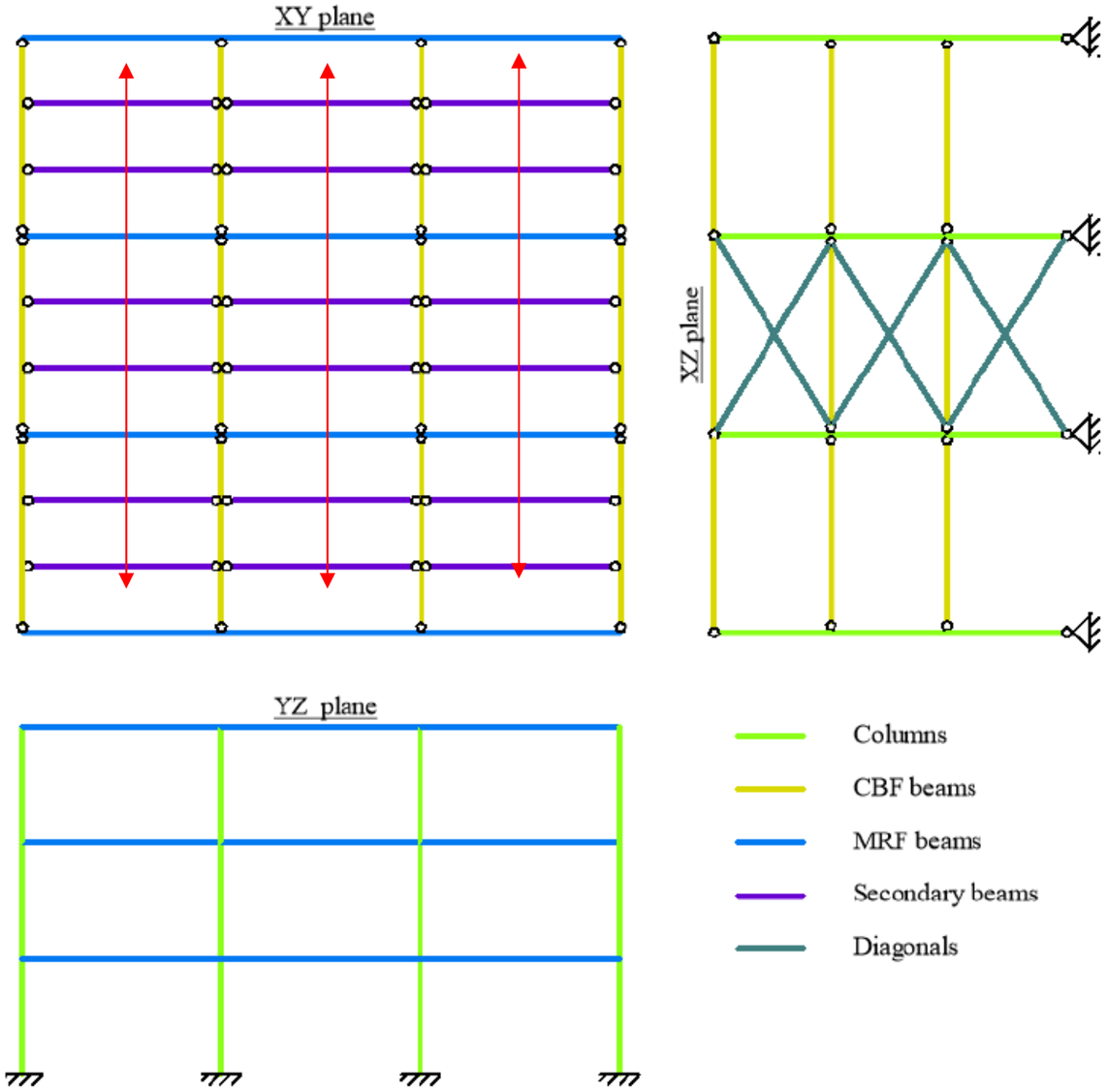
- Materials

Member type	Section	Material according to EC
Columns	HEB 400	S460 N/NL
Diagonals (storey 3)	CF SHS 100x3	S235 JR
Diagonals (storey 2)	CF SHS 120x4	S235 JR
Diagonals (storey 1)	CF SHS 140x4	S235 JR
Secondary beams	IPE 270	S275 JR
MRF beams	IPE 360	S275 JR
CBF beams	IPE 400	S275 JR

- Dimensions and geometry
- Regularity

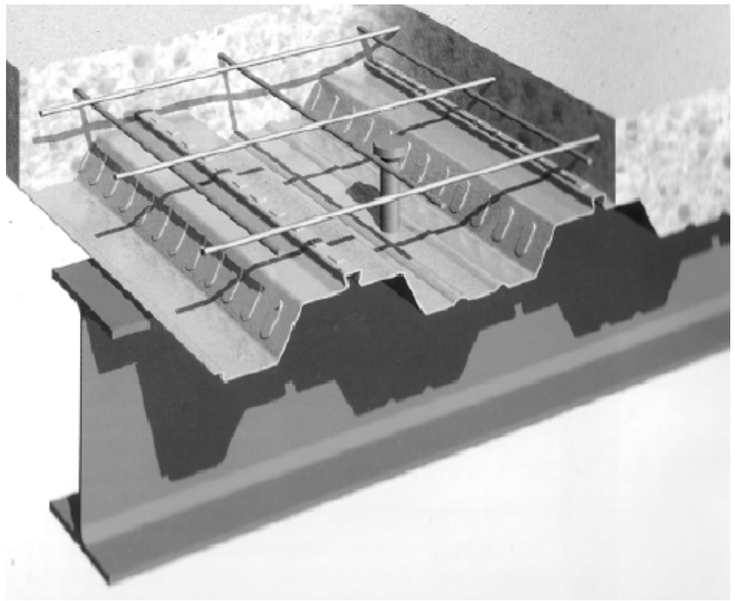


Structural systems



- MRF & CBF load deflection characteristics
- Avoid torsion

- Diaphragm

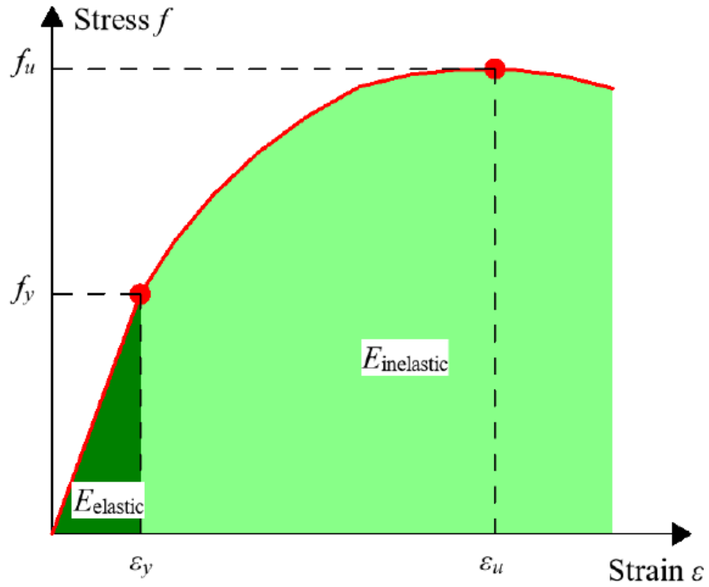


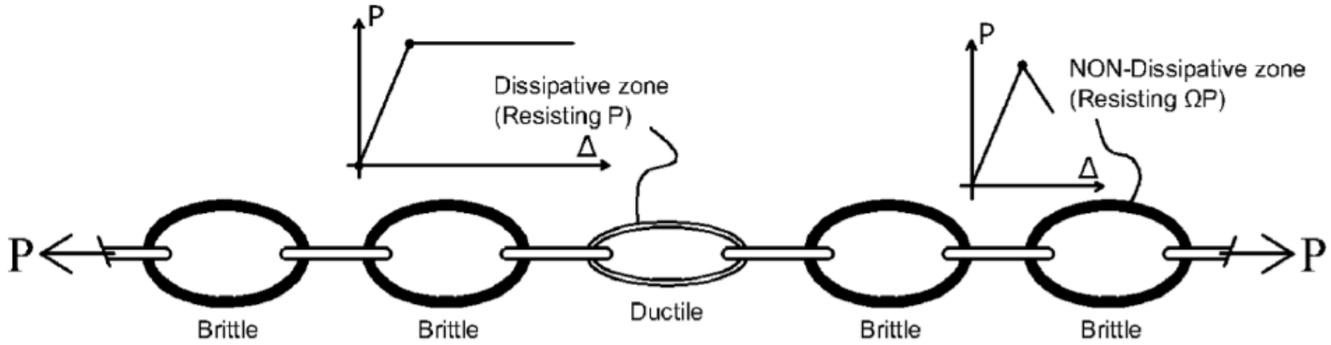
Linear Analysis & Design

Choice of ductility level

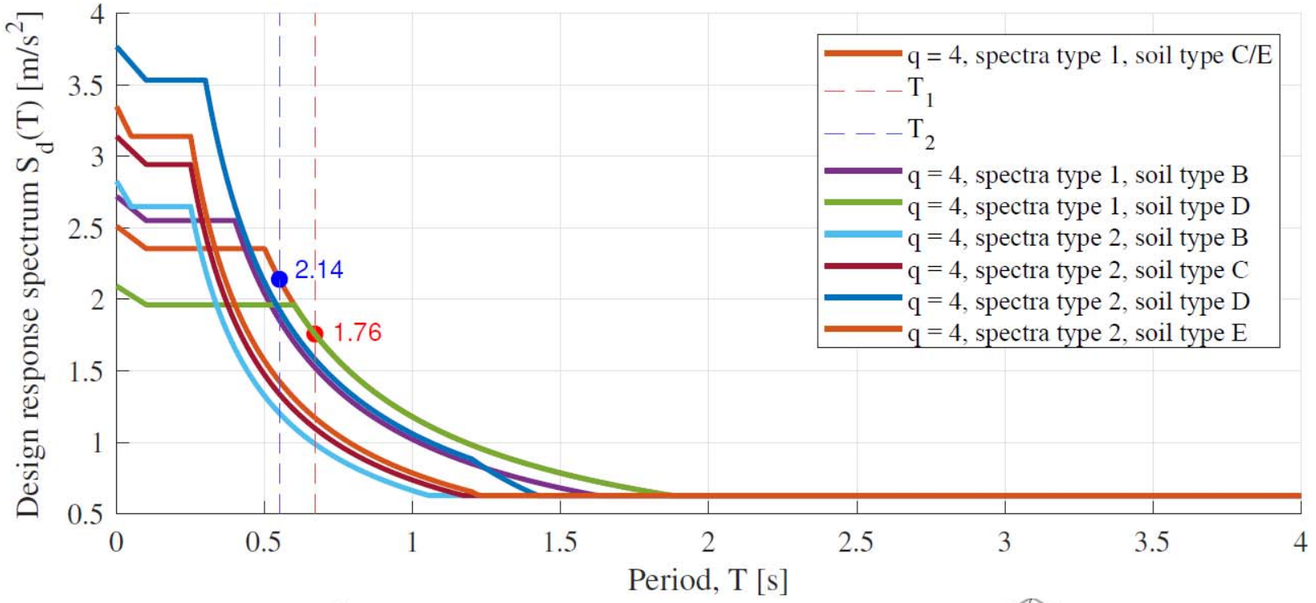
- Ductility and energy dissipation
- Earthquake design
- Capacity design and dissipation mechanism
- MRF beams
- CBF diagonals

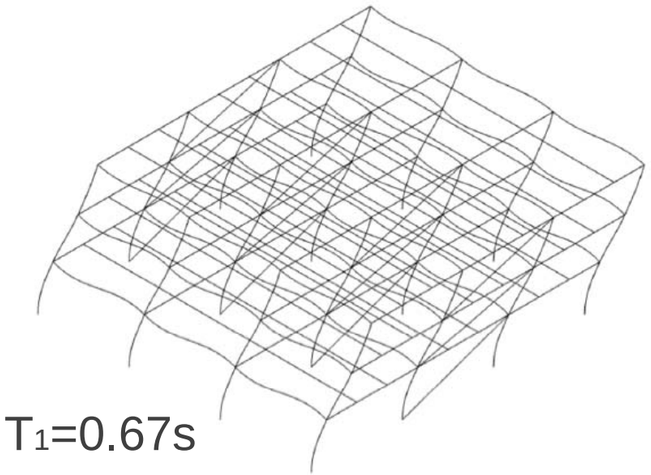
- EC8: DCL, DCM and DCH



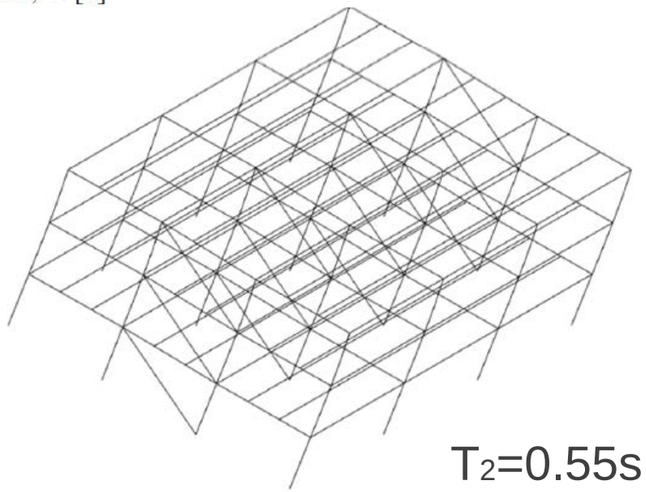


Choice of response spectrum





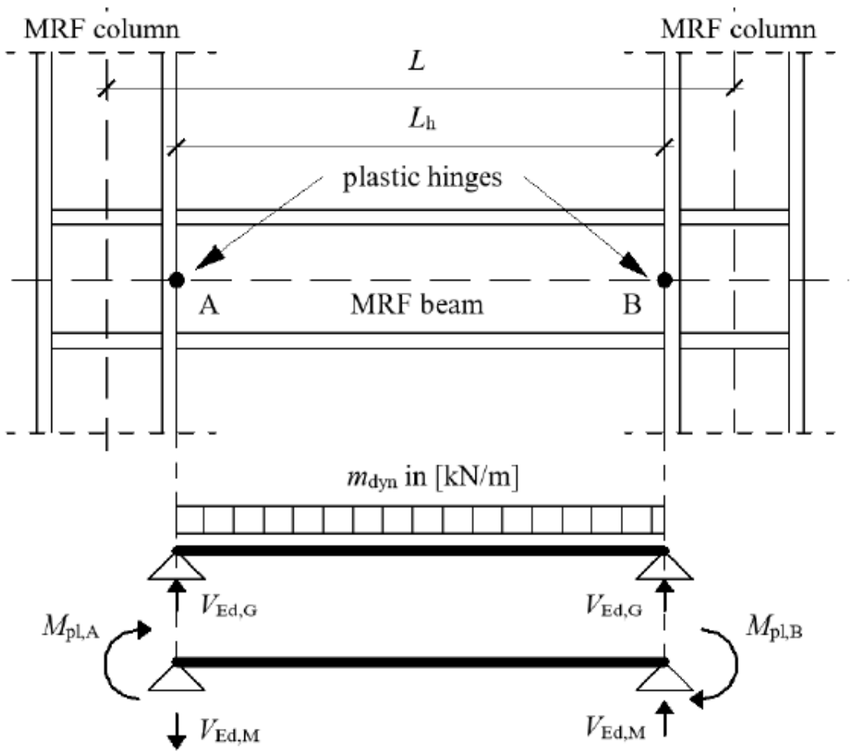
T_1=0.67s



T_2=0.55s

Design consideration – MRF stability

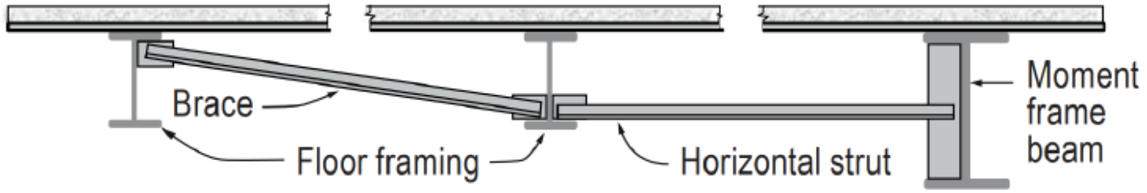
- Lateral stability problems in MRF beam segment close to the column – local failure

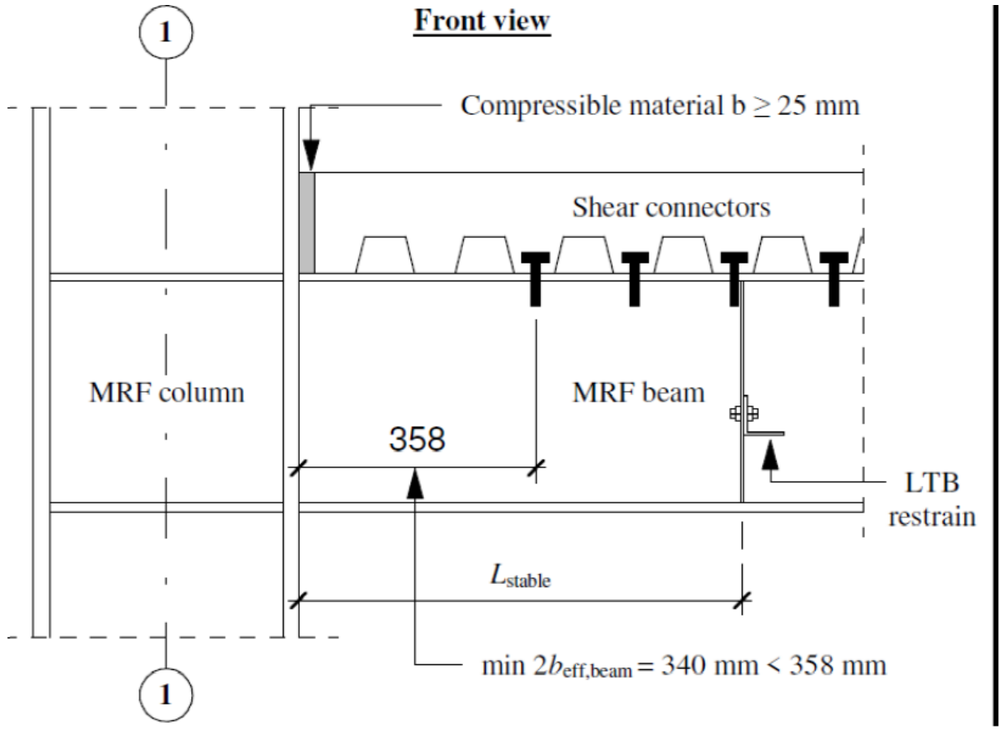


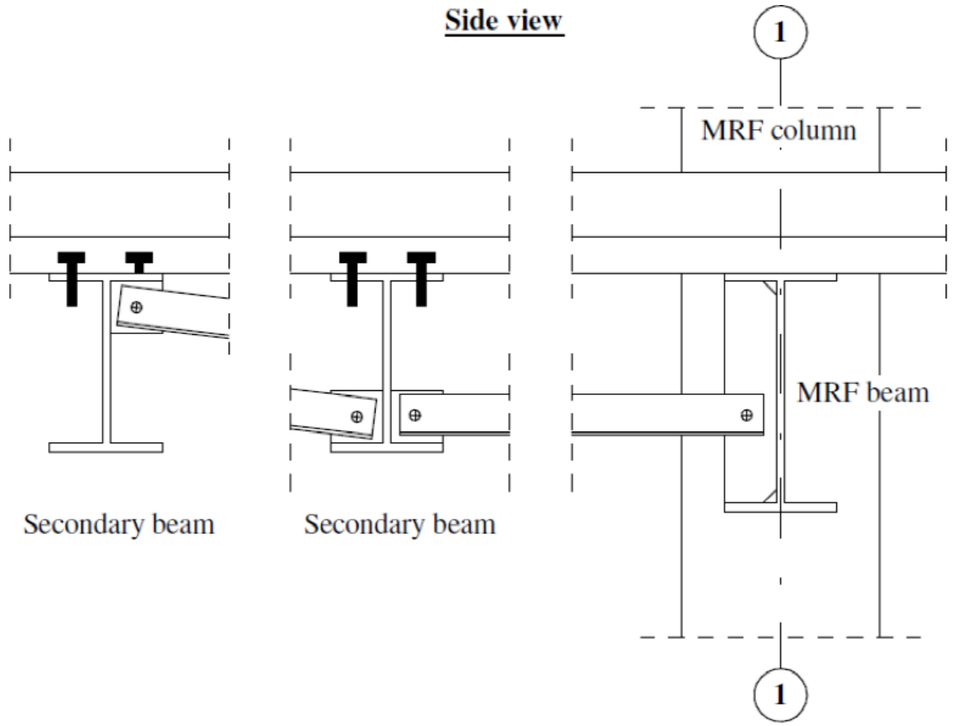
- Possible solution: diagonal kicker brace

Design consideration – MRF stability

- Alternate solution



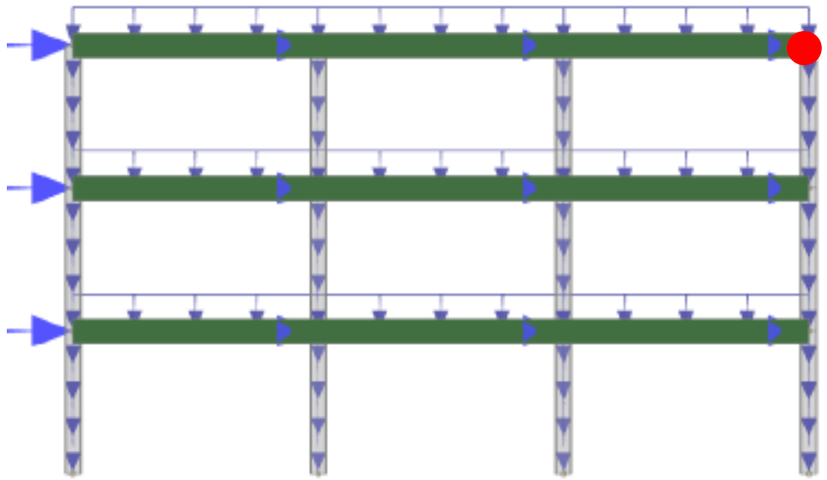




Non-linear response

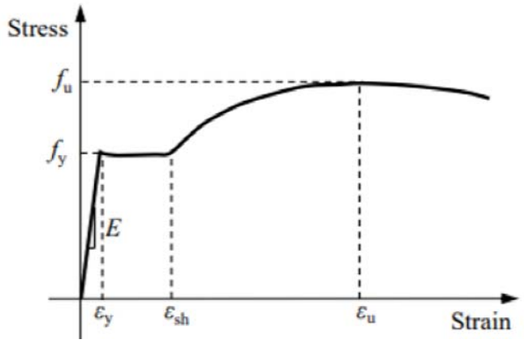
Pushover analysis

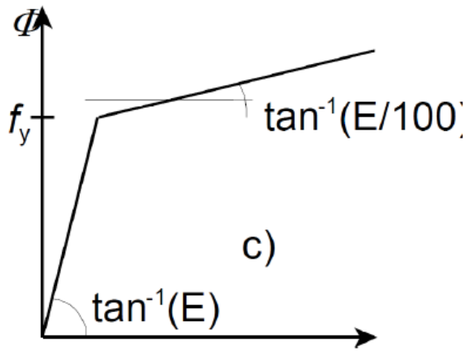
- Choice of control node
- Mass



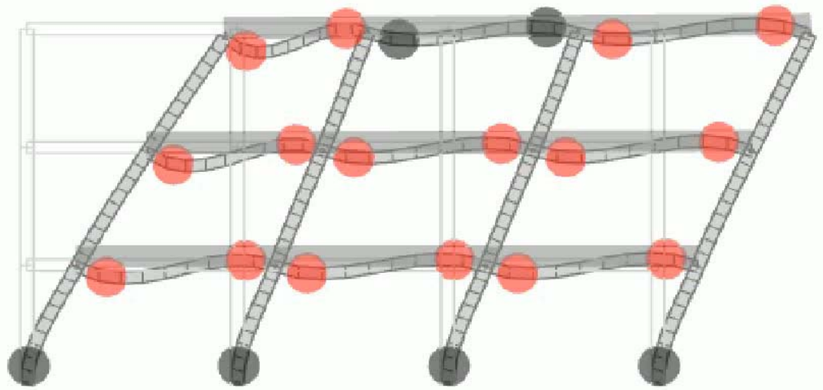
- Modelling of CBF diagonals

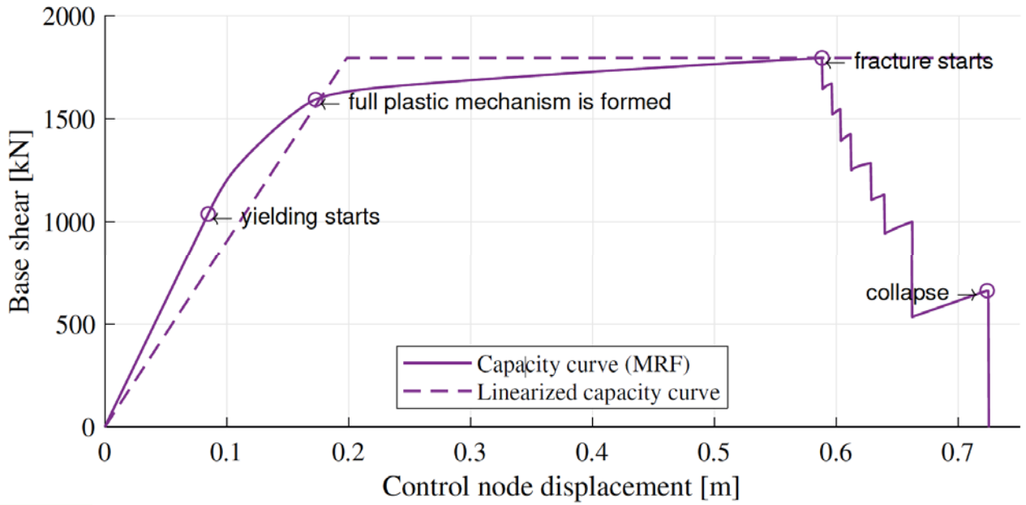
- Non-linearities
- Geometric (P-delta)
- Material (constitutive model)

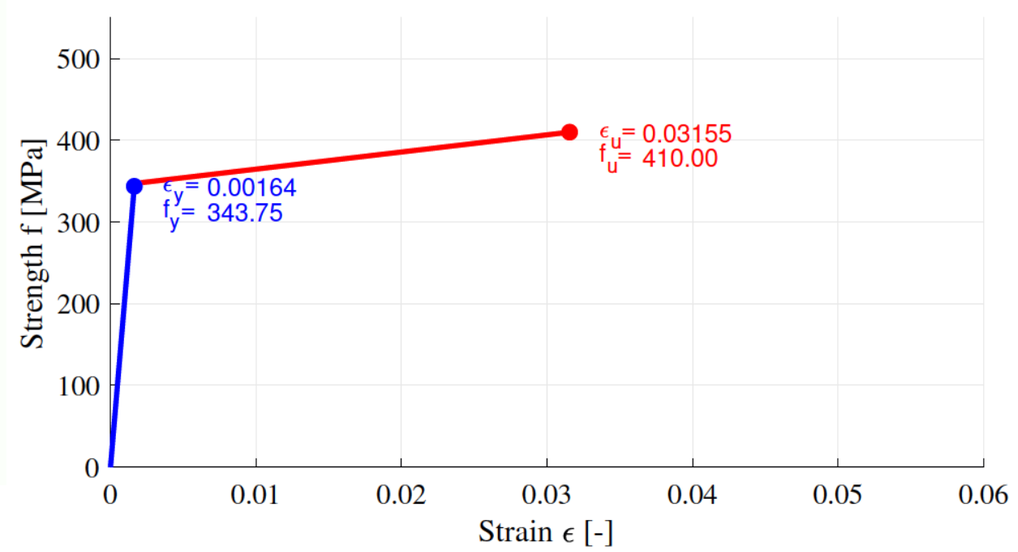




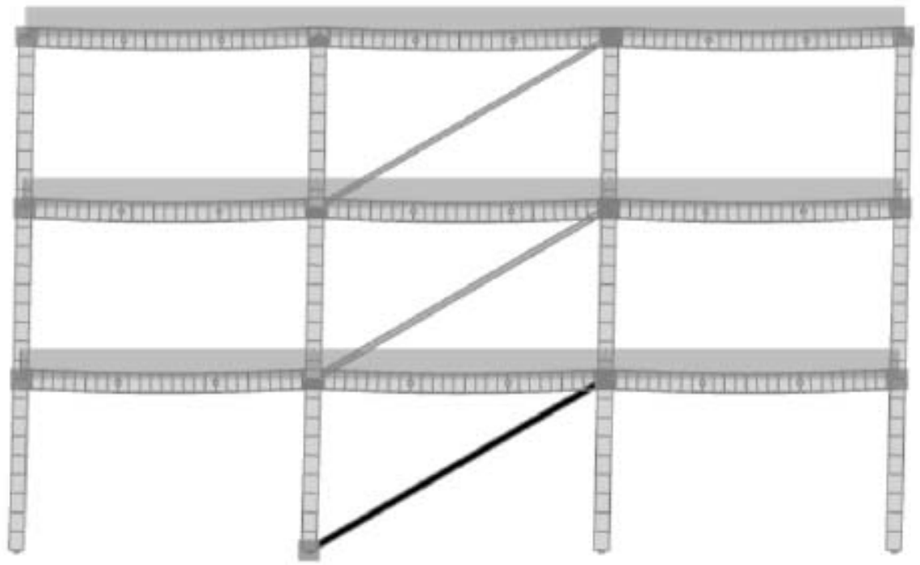
MRF

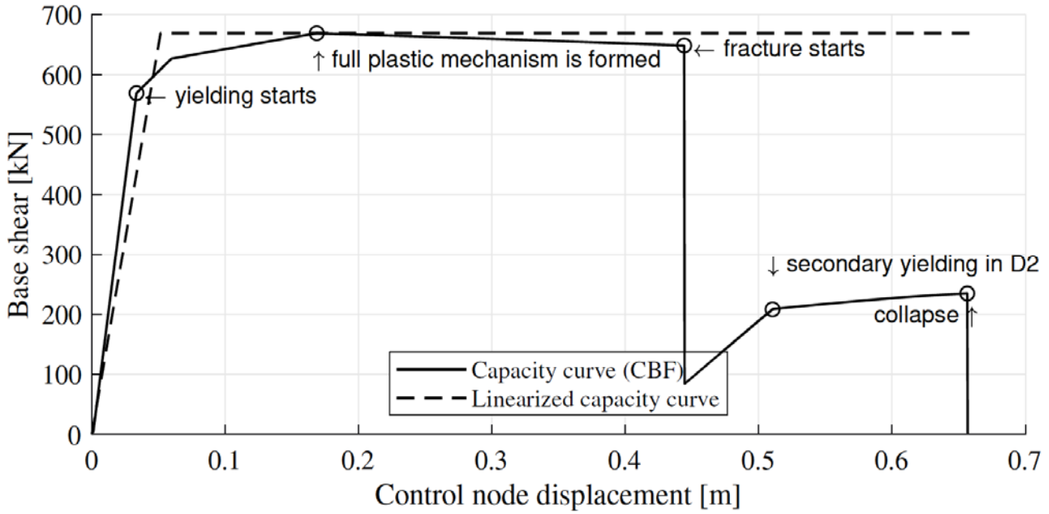


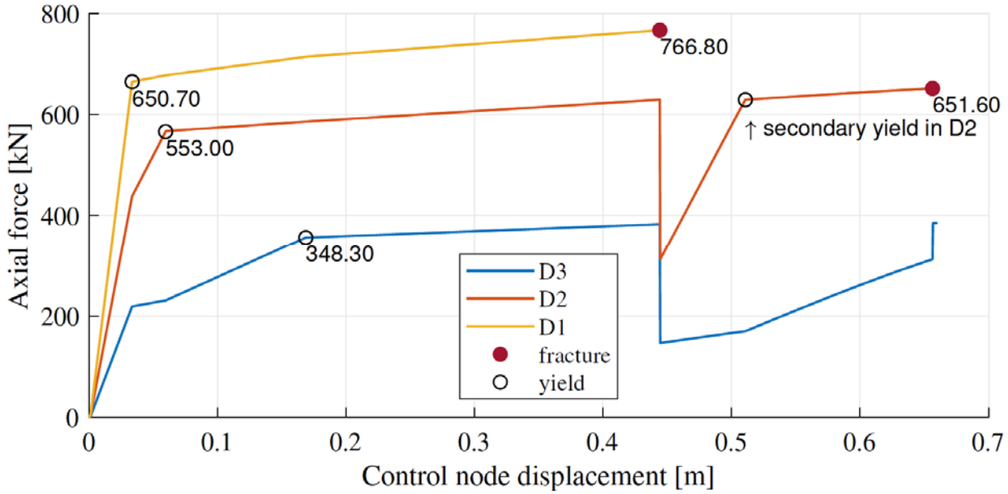

Base shear [kN]
Control node displacement [m]
yielding starts
full plastic mechanism is formed
fracture starts
collapse
Capacity curve (MRF)
Linearized capacity curve


Strength f [MPa]
Strain ϵ [-]
ϵy= 0.00164
fy= 343.75
ϵu= 0.03155
fu= 410.00

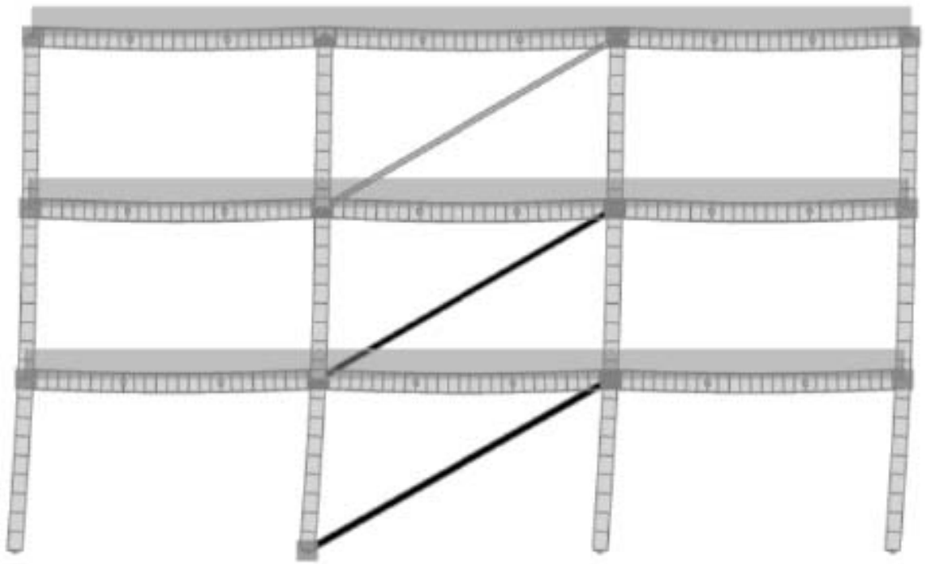
CBF

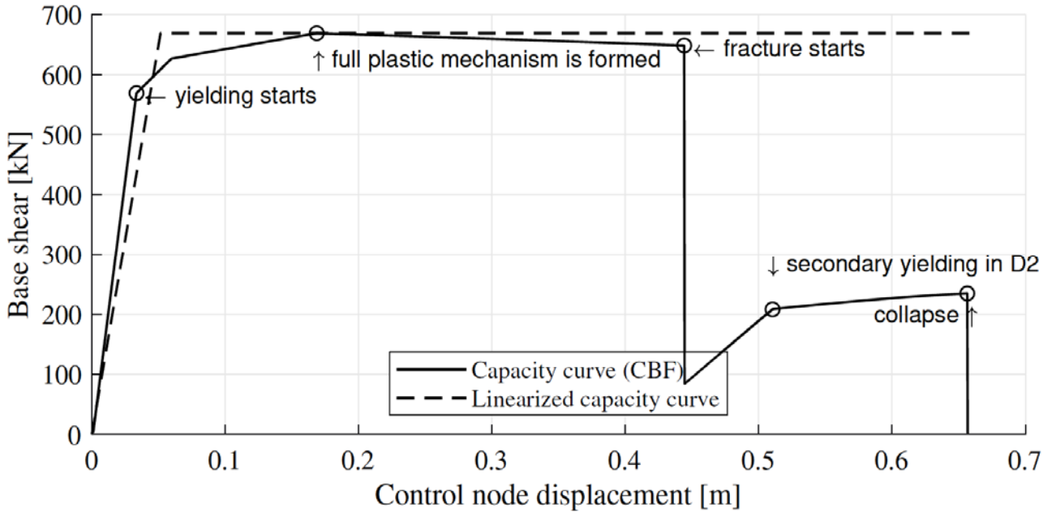



Base shear [kN]
Control node displacement [m]
↑ full plastic mechanism is formed
← fracture starts
← yielding starts
↓ secondary yielding in D2
collapse ↑
Capacity curve (CBF)
Linearized capacity curve


Axial force [kN]
Control node displacement [m]
766.80
650.70
553.00
651.60
↑ secondary yield in D2
348.30
D3
D2
D1
fracture
yield

CBF

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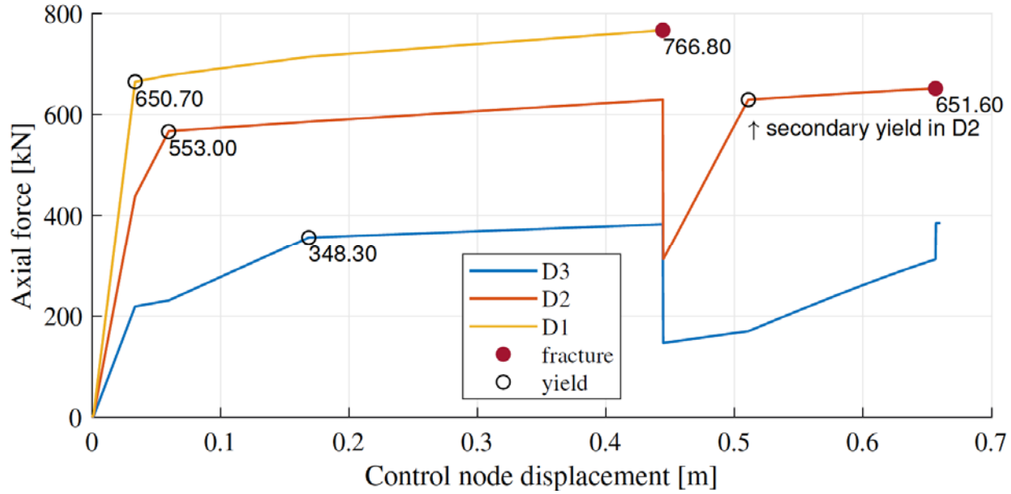
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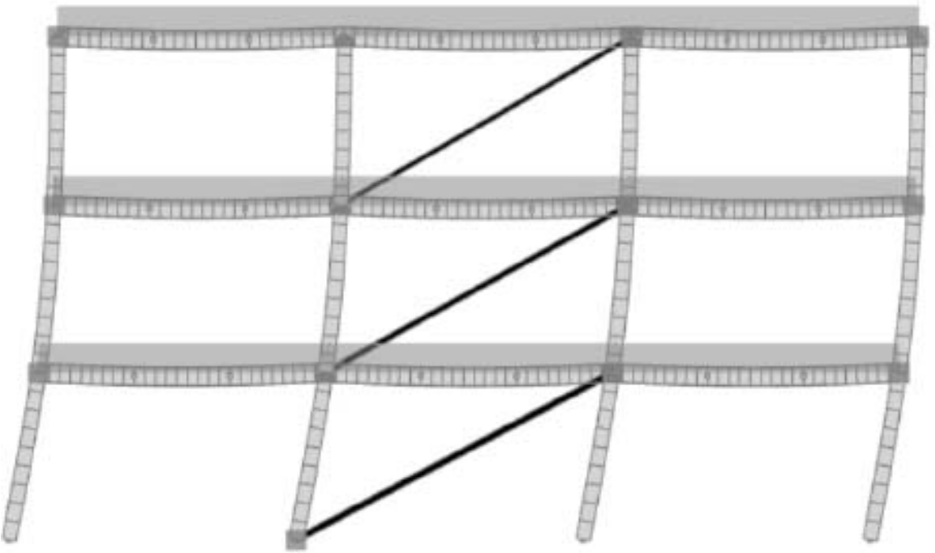

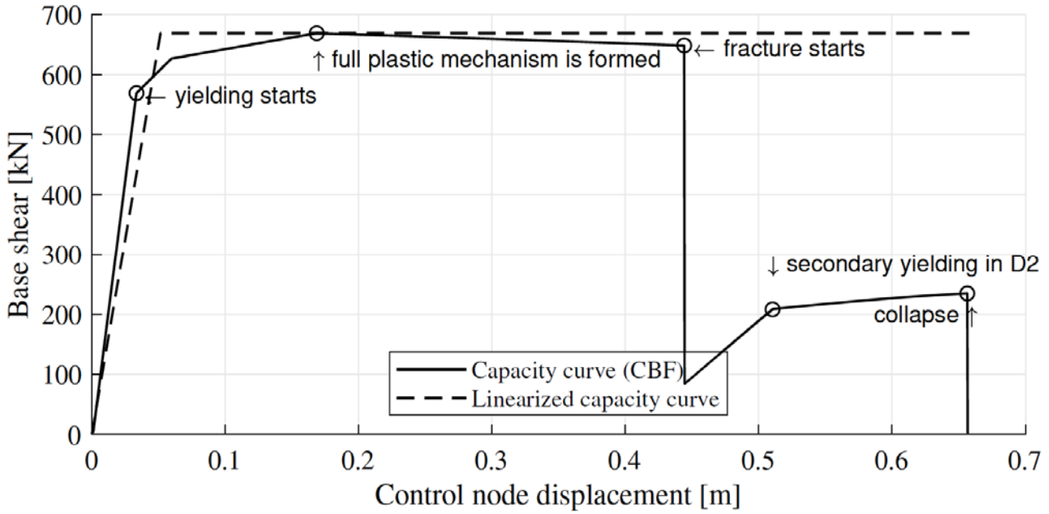
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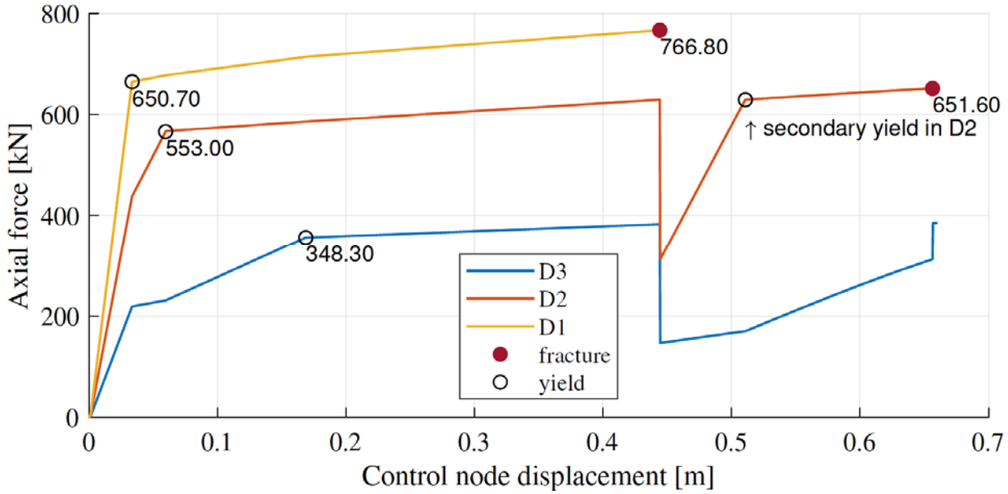
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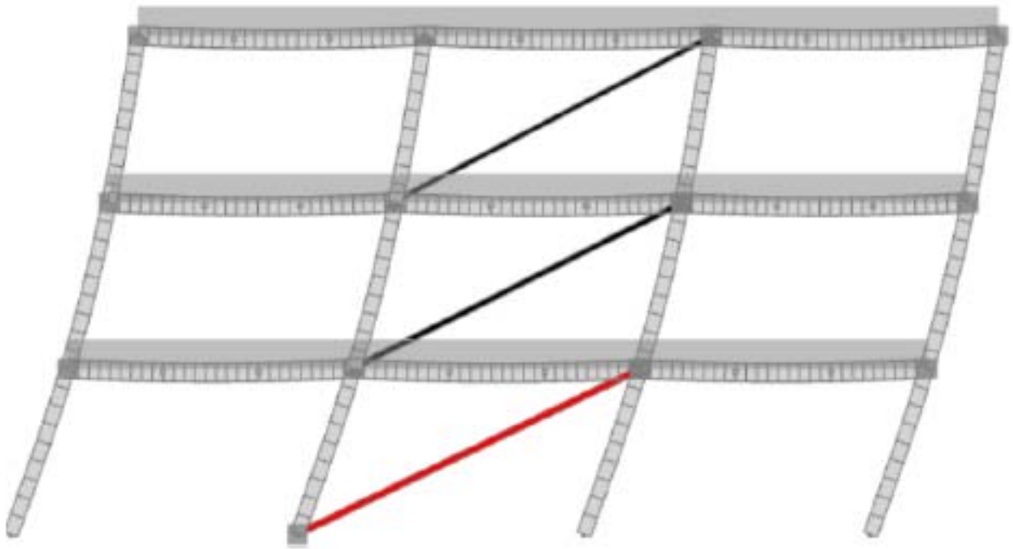

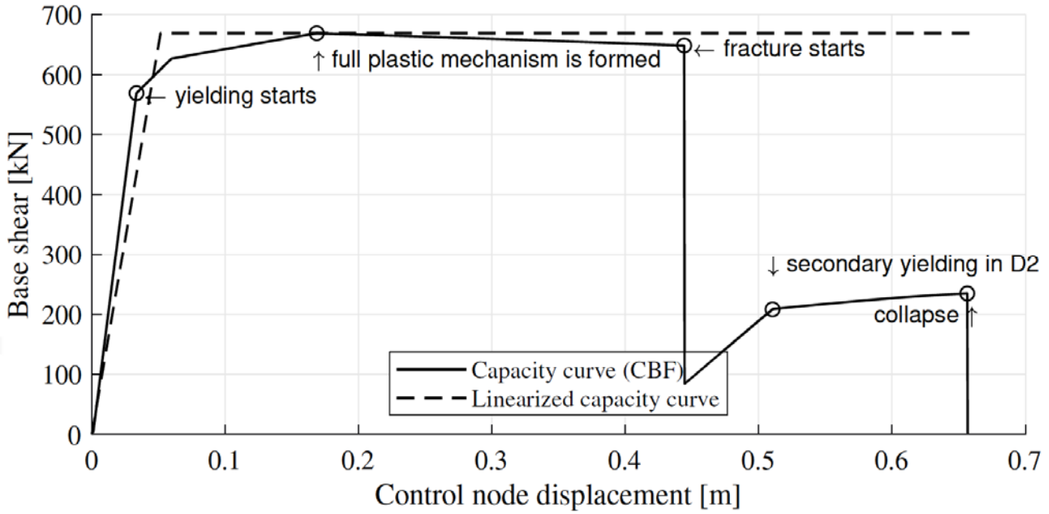
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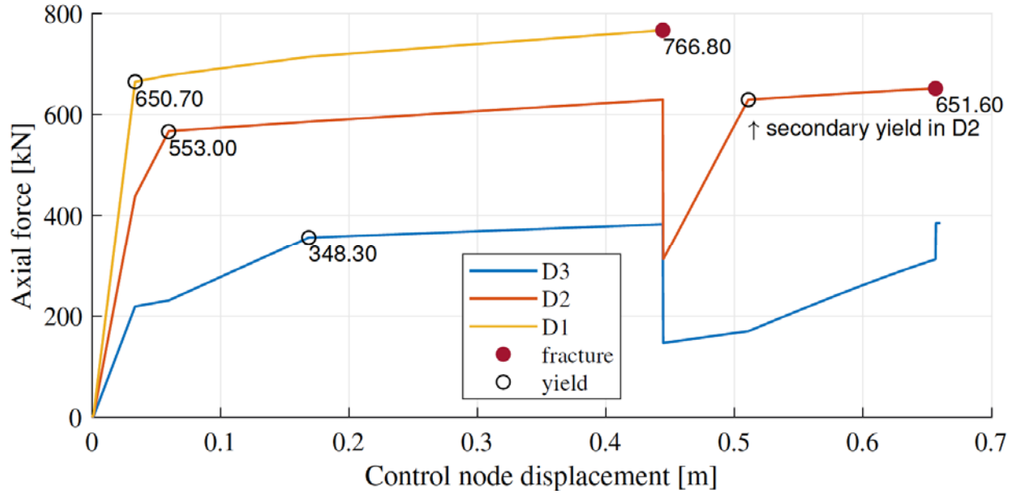
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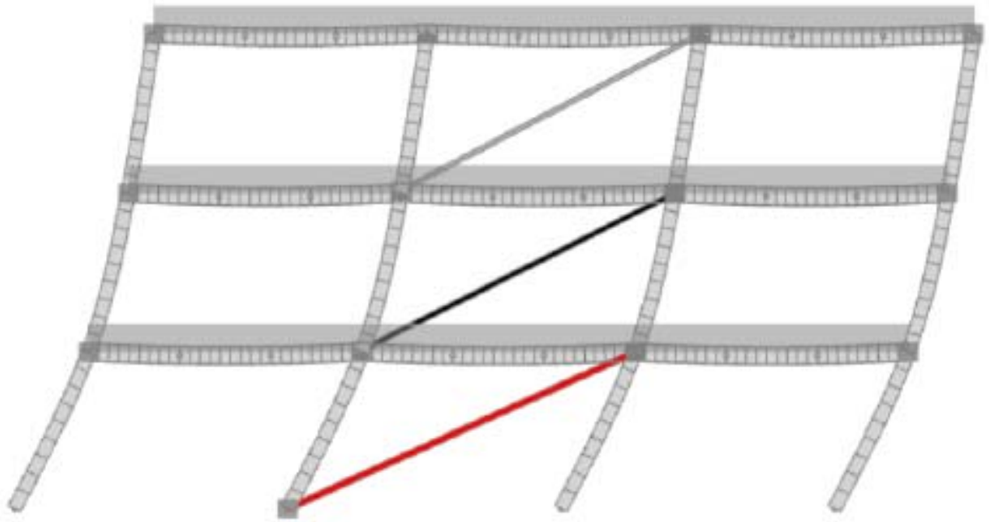

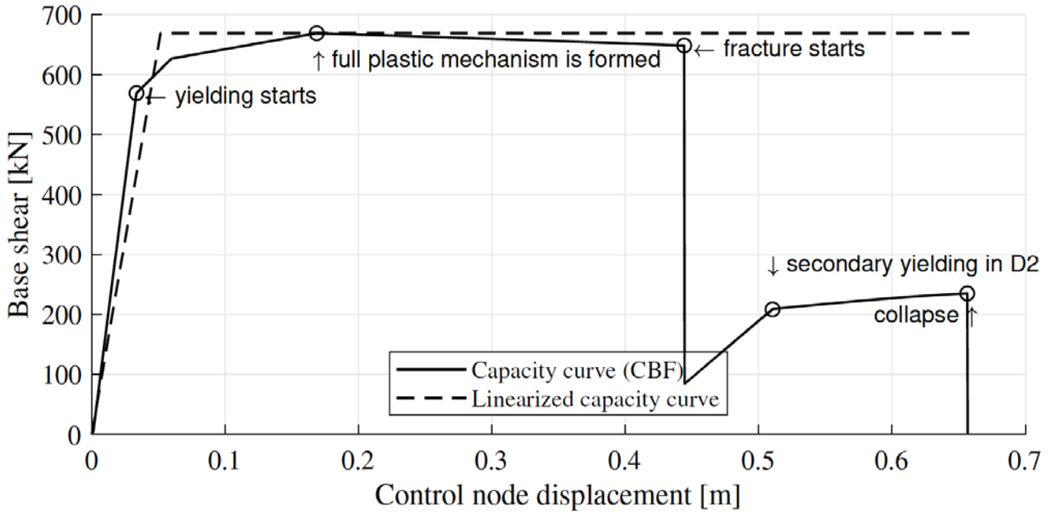
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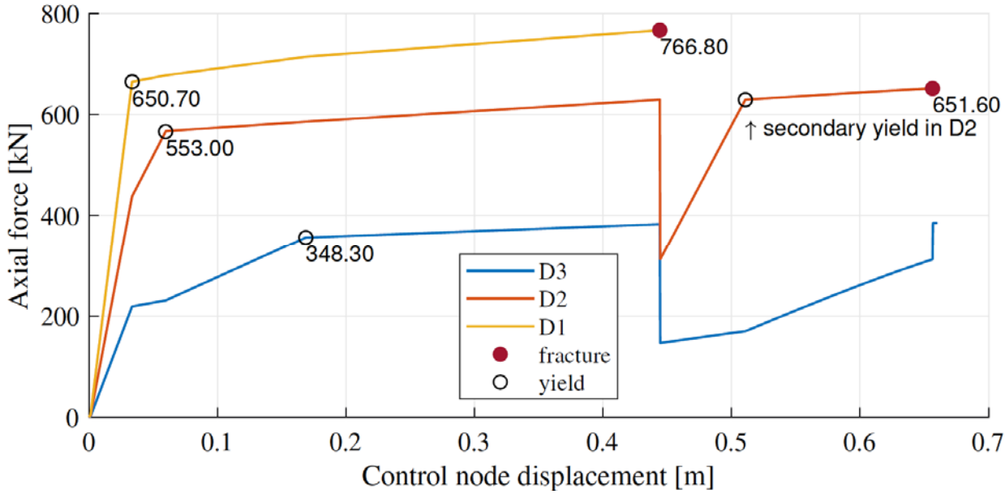
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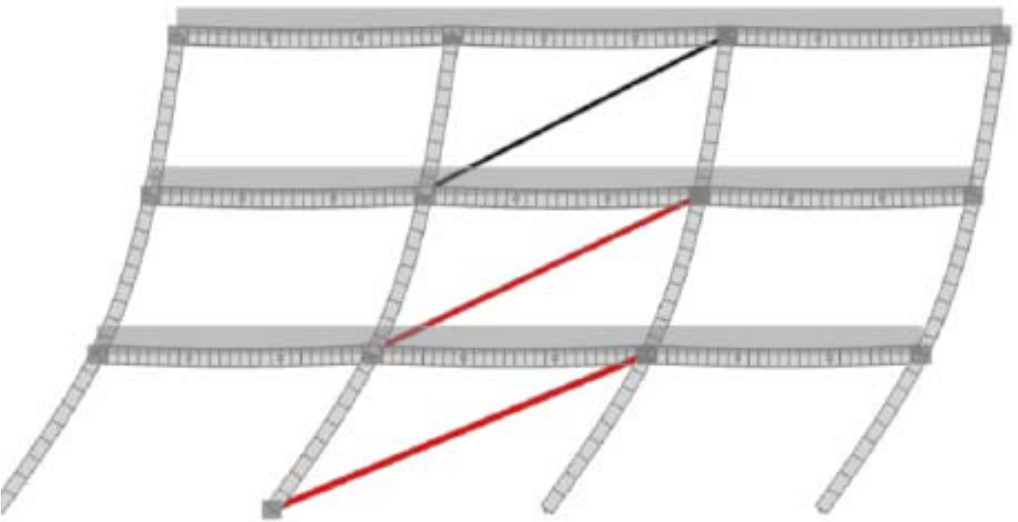

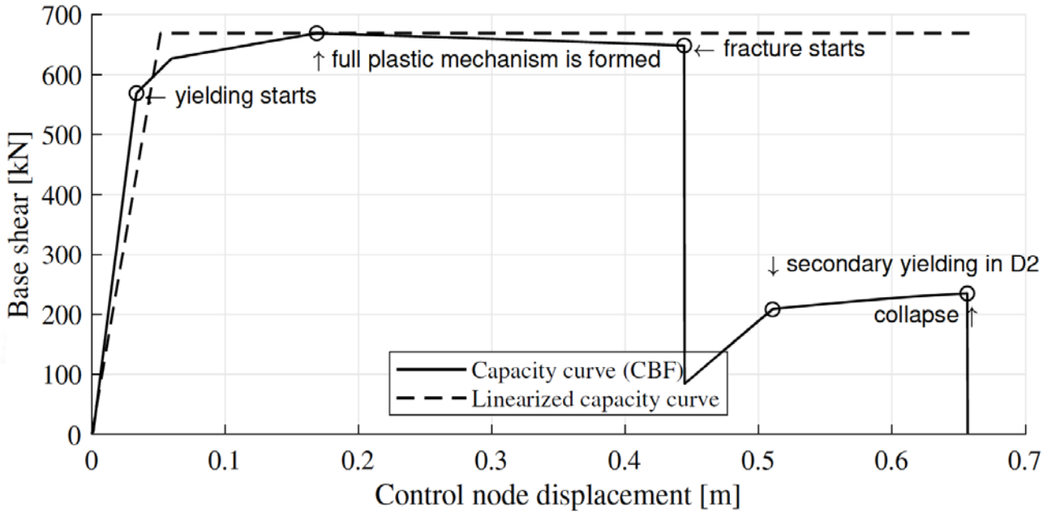
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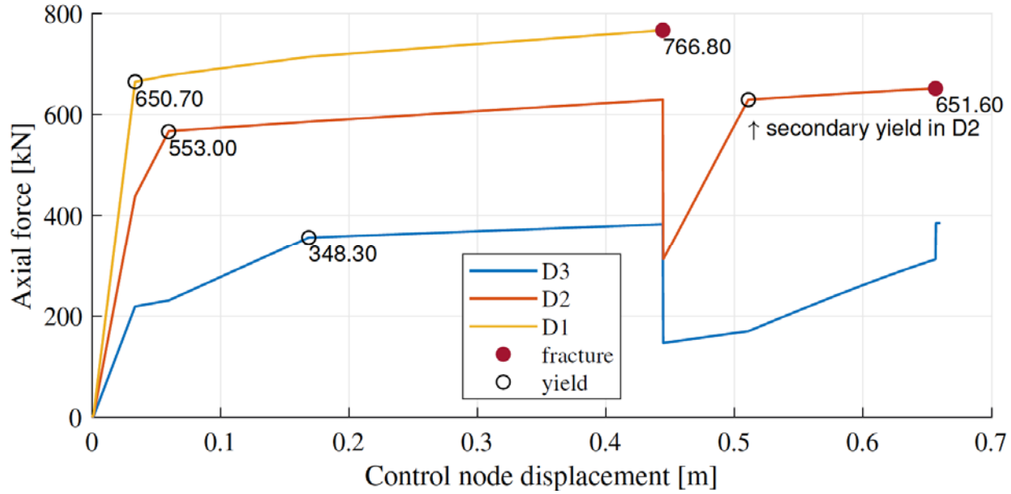
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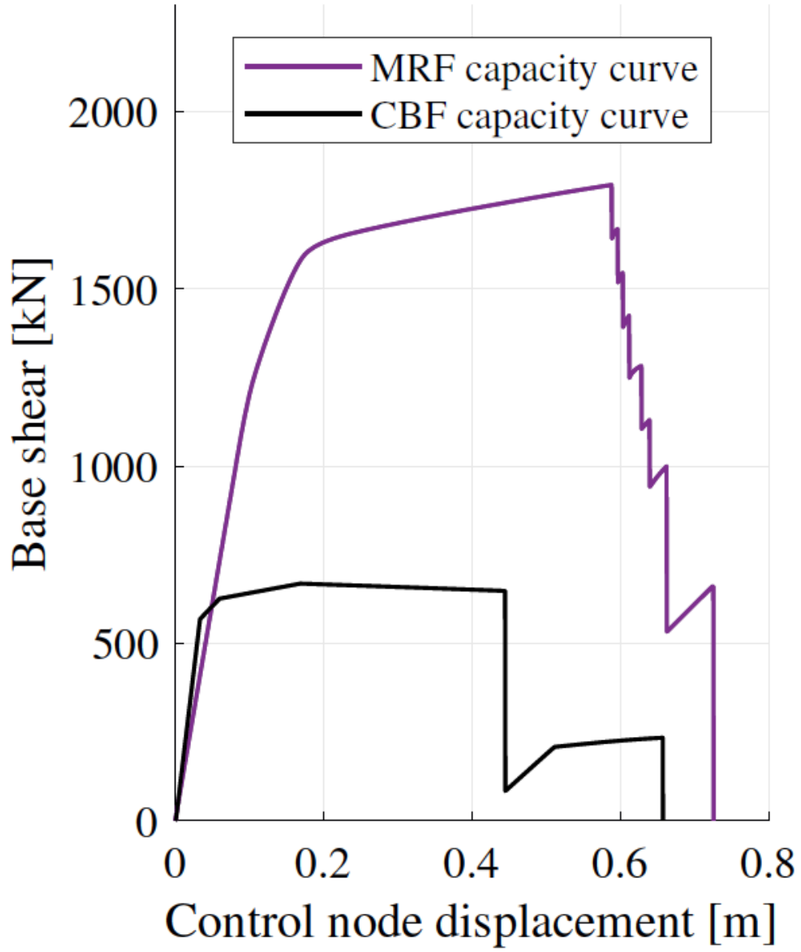
Comparison

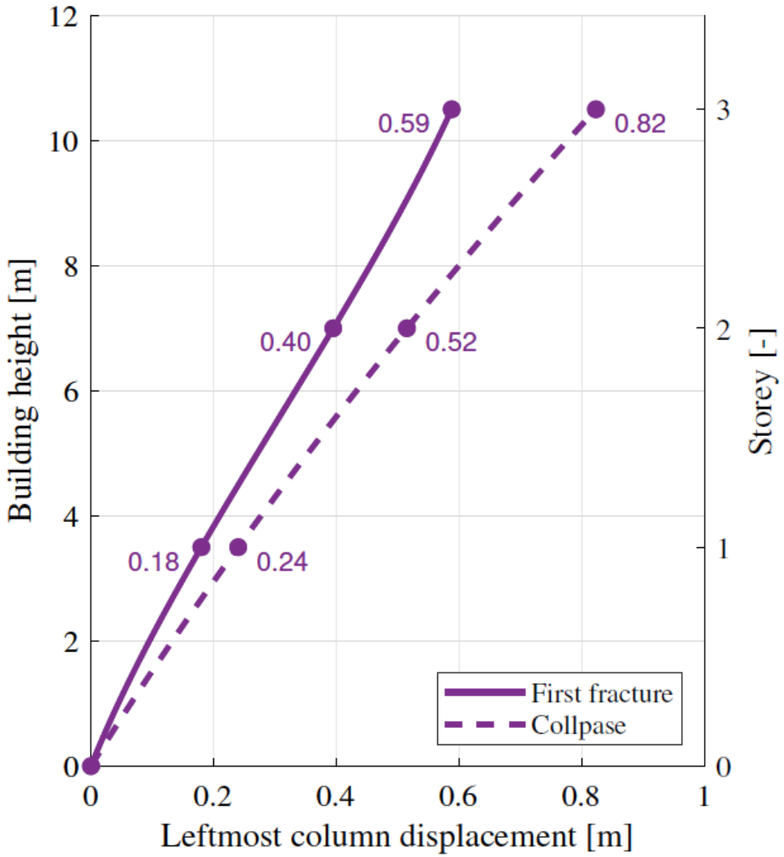
- Elastic stiffness
- Strain hardening
- Ductile behavior
- 20% rule
- Strain hardening

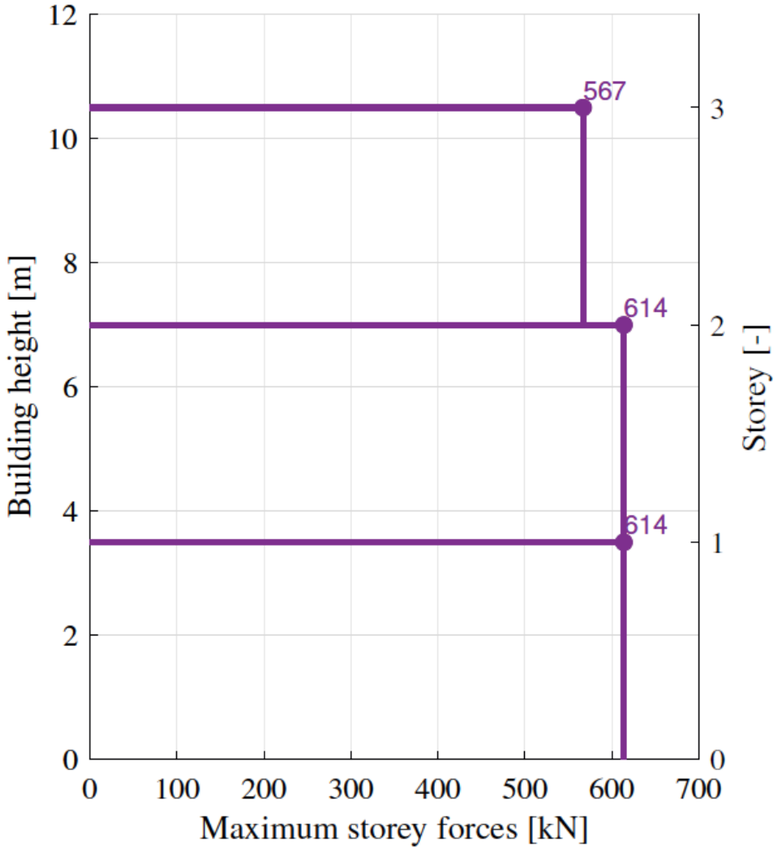
- MRF: max displacement and base shear
- CBF: reactions



Conclusion

Actuator capacity and stroke – MRF





- Avoiding actuator saturation
- Educated guess: increase displacement and forces by 20% - 30%

Answering the problem statement

Problem formulation

Choose, analyze & design an appropriate Prototype from steel. Perform a suitable numerical simulation and find the necessary actuator capacity and stroke to accommodate it in the new RWSF facility.

Main points
- Conservative choice of prototype
- Linear Analysis & Design
- Suitable numerical simulation for RWSF
- Actuator parameters

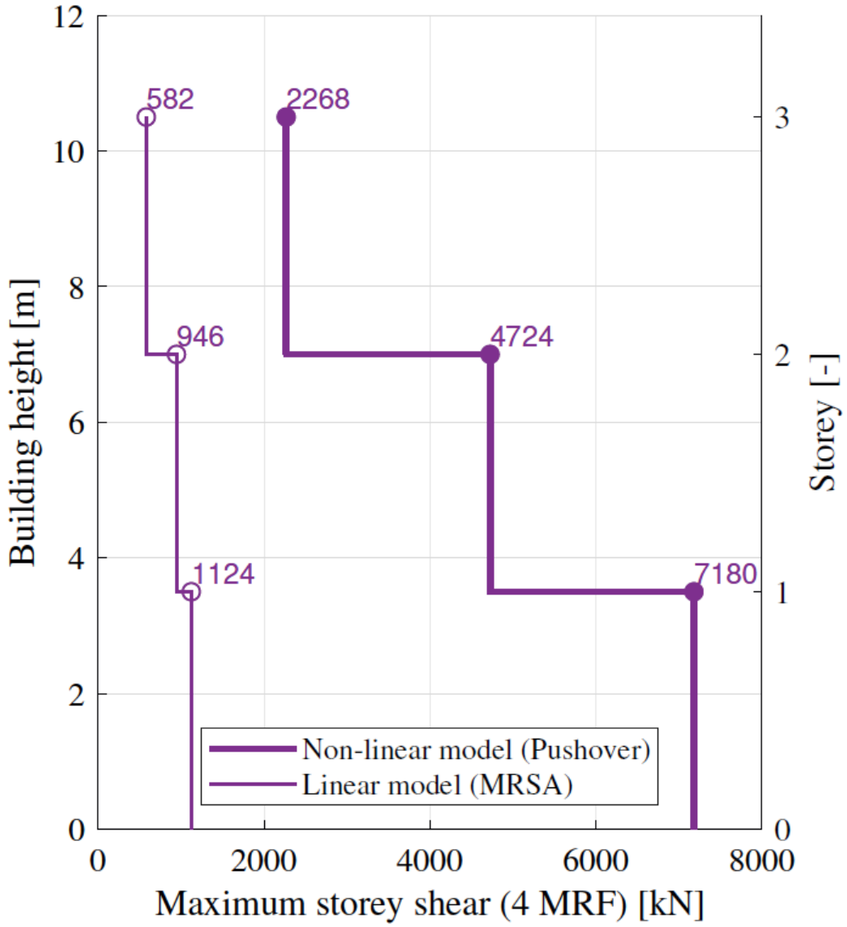
Added value:
- Studying RWSF test methods
- Prototype preliminary design level (joints)
- Reactions for design of SF

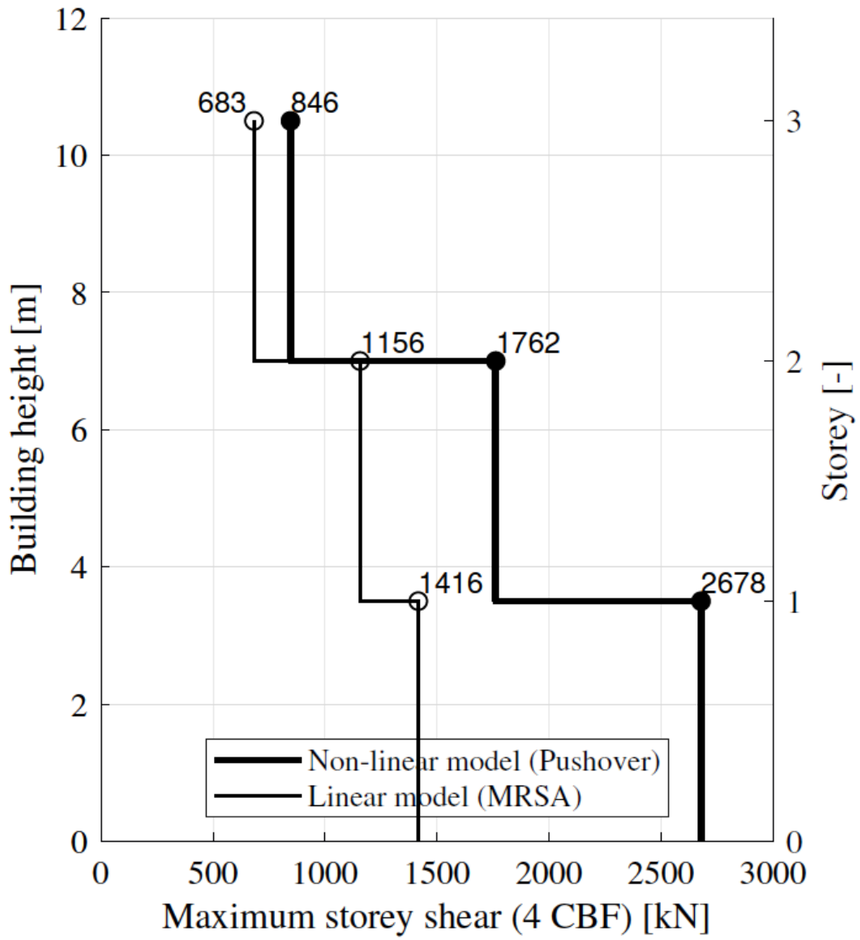
Next steps..

- Numerical study on structure in DCL (obtain higher base shear)
- Concrete shear wall
- Steel MRF

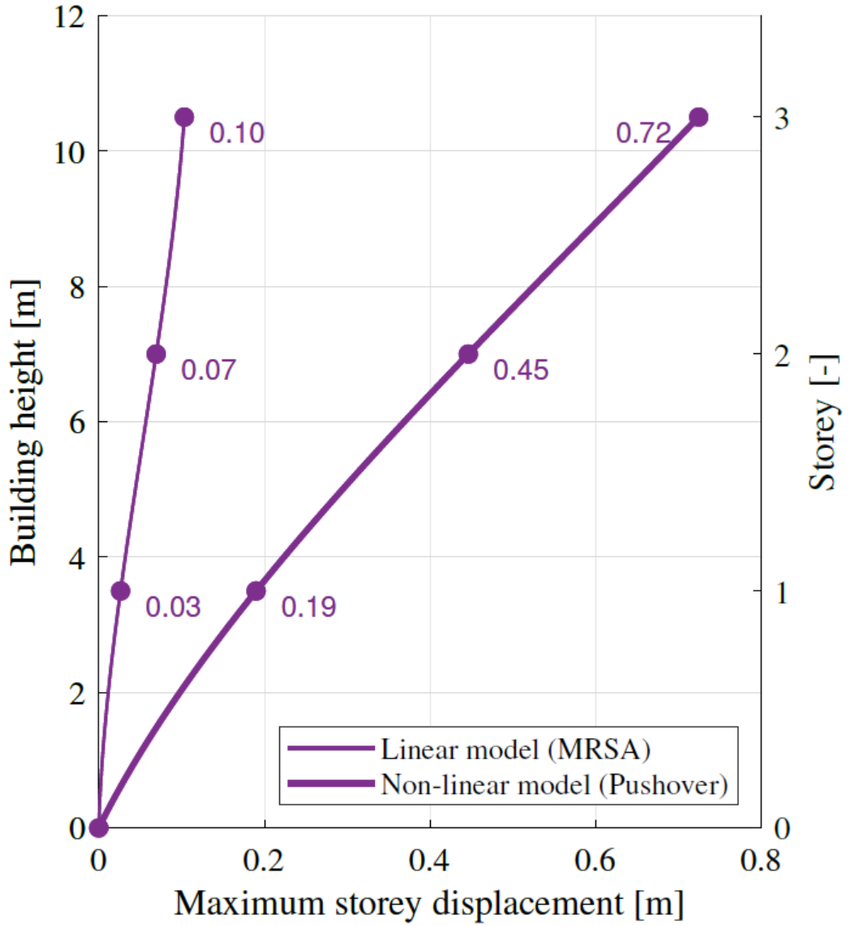
- Test a full-scale spatial (or planar) model of the Prototype
- Calibration of instruments
- Actuator saturation boundaries
- Verification of numerical models

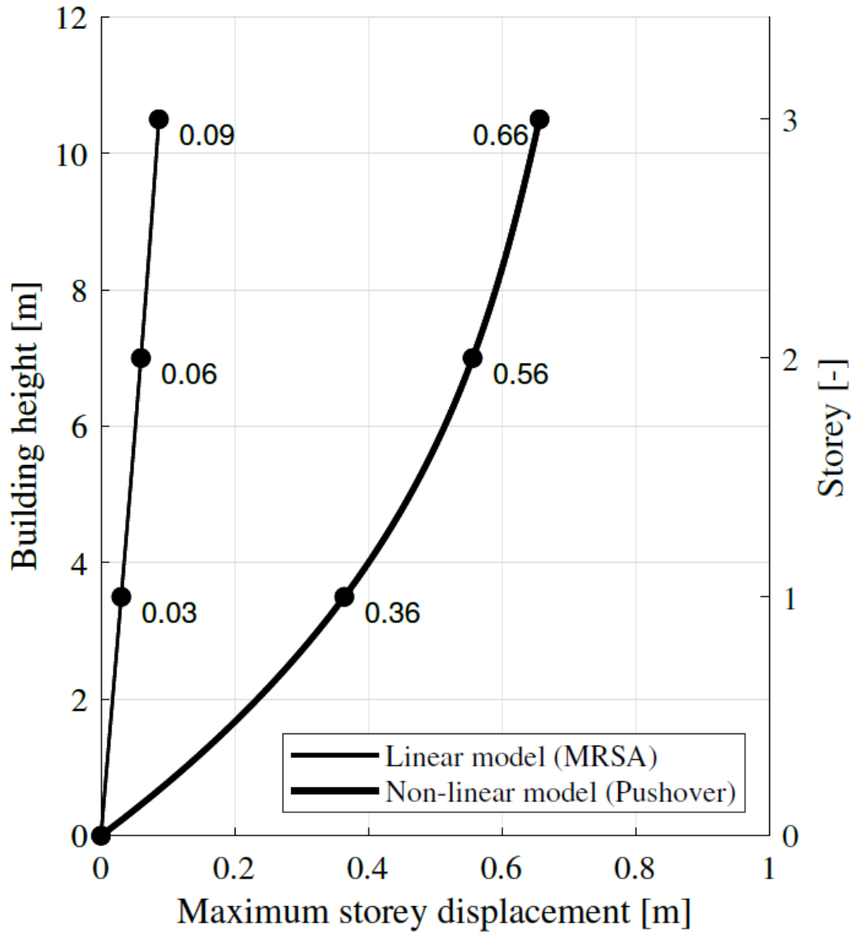
Linear vs non-linear: base shear





Linear vs non-linear: displacements





Thank you!