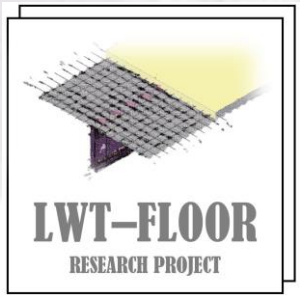
Procjena ponašanja točkastih zavara kod hladno oblikovanog čelika

-Performance evaluation of cold-formed steel spot weld connections-

Andrea Rajić, Ivan Lukačević, Ivan Ćurković, Vlaho Žuvelek



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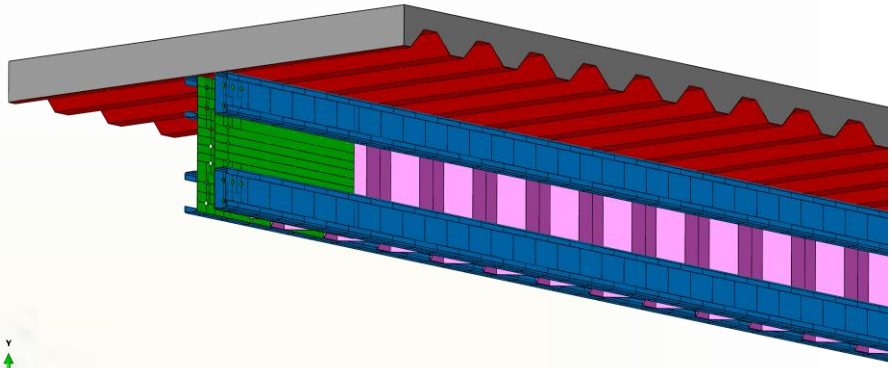
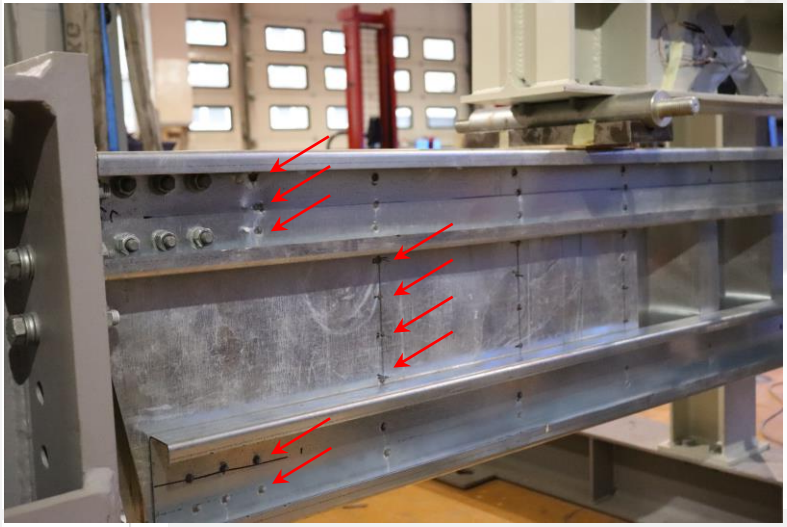
1. Idea
2. Laboratory research
3. Analytical approach
4. Numerical FE model
5. Results
6. Conclusions

Idea

Advantages of CFS:
- Reduced self-weight
- Easier handling
- Built-up sections → Type of connection?
  - continuous?
  - discrete:
    - bolts/screws
    - welds

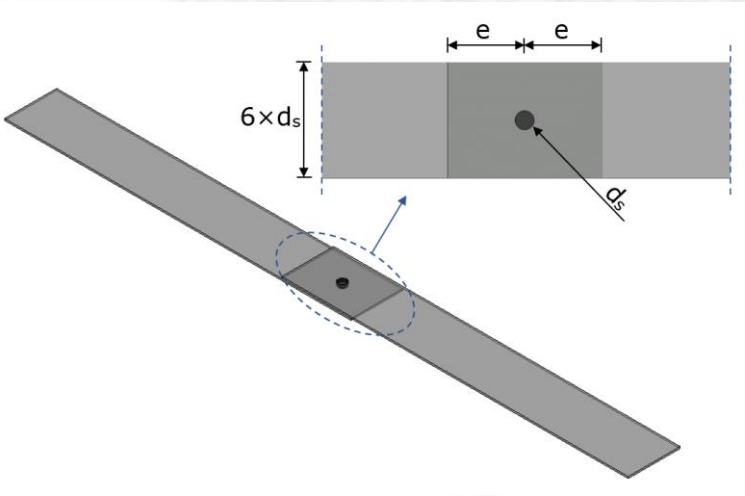
Idea





LWT-FLOOR beam

Laboratory research



SW 0.8-1.0

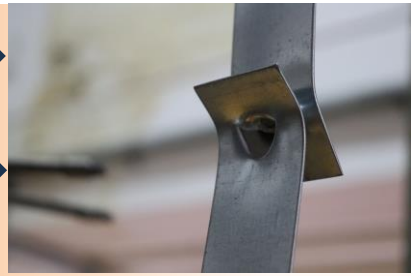
SW 0.8-2.5

SW 0.8-3.0

SW 1.0-1.5

SW 1.5-2.5

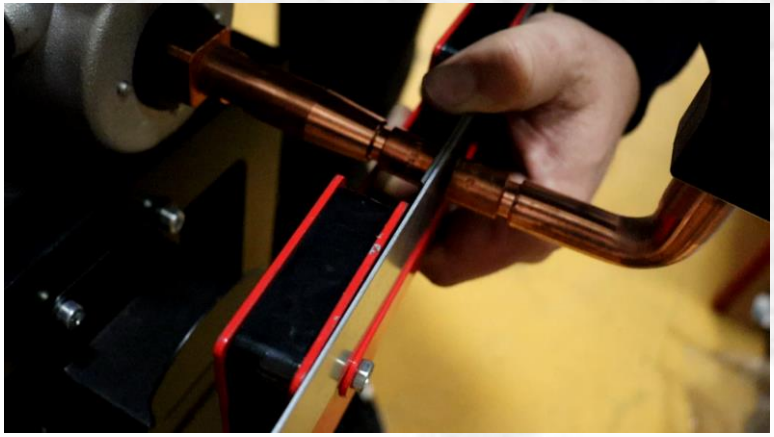
SW 1.5-3.0

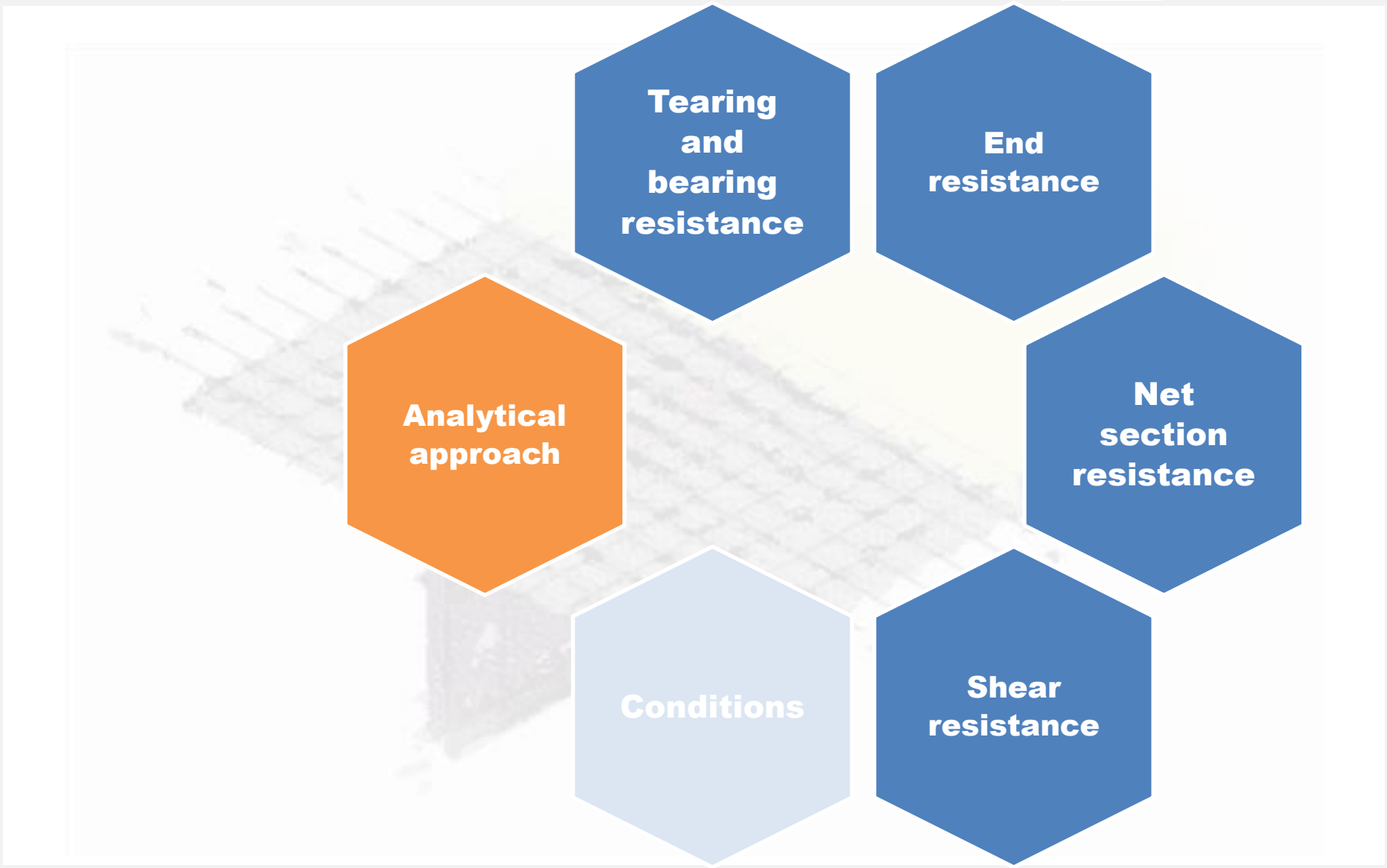


SW 2.5-2.5

SW 2.5-3.0

Laboratory research




Tearing and bearing resistance
End resistance
Analytical approach
Net section resistance
Conditions
Shear resistance

- if $t \le t_1 \le 2.5t$:

$$F_{tb,Rk} = 2.7 \cdot \sqrt{t} \cdot d_s \cdot f_u$$

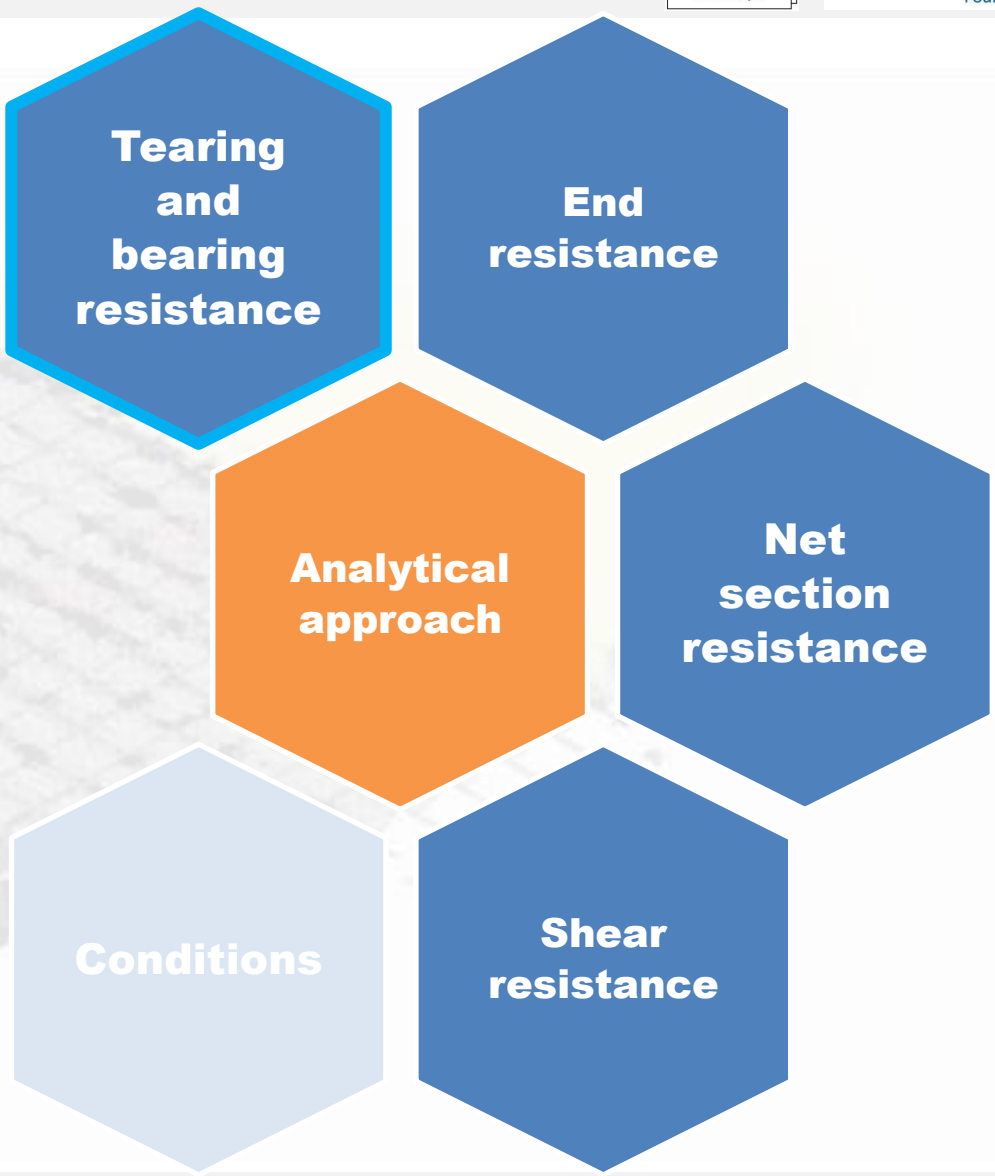
- if $t_1 > 2.5t$:

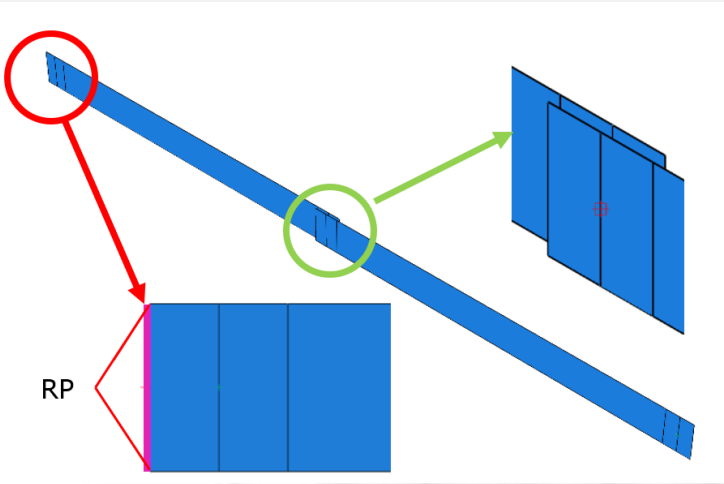
$$F_{tb,Rk} = 2.7 \cdot \sqrt{t} \cdot d_s \cdot f_u$$

- but:

$$F_{tb,Rk} \le 0.7 \cdot d_s^2 \cdot f_u$$

$$F_{tb,Rk} \le 3.1 \cdot t \cdot d_s \cdot f_u$$



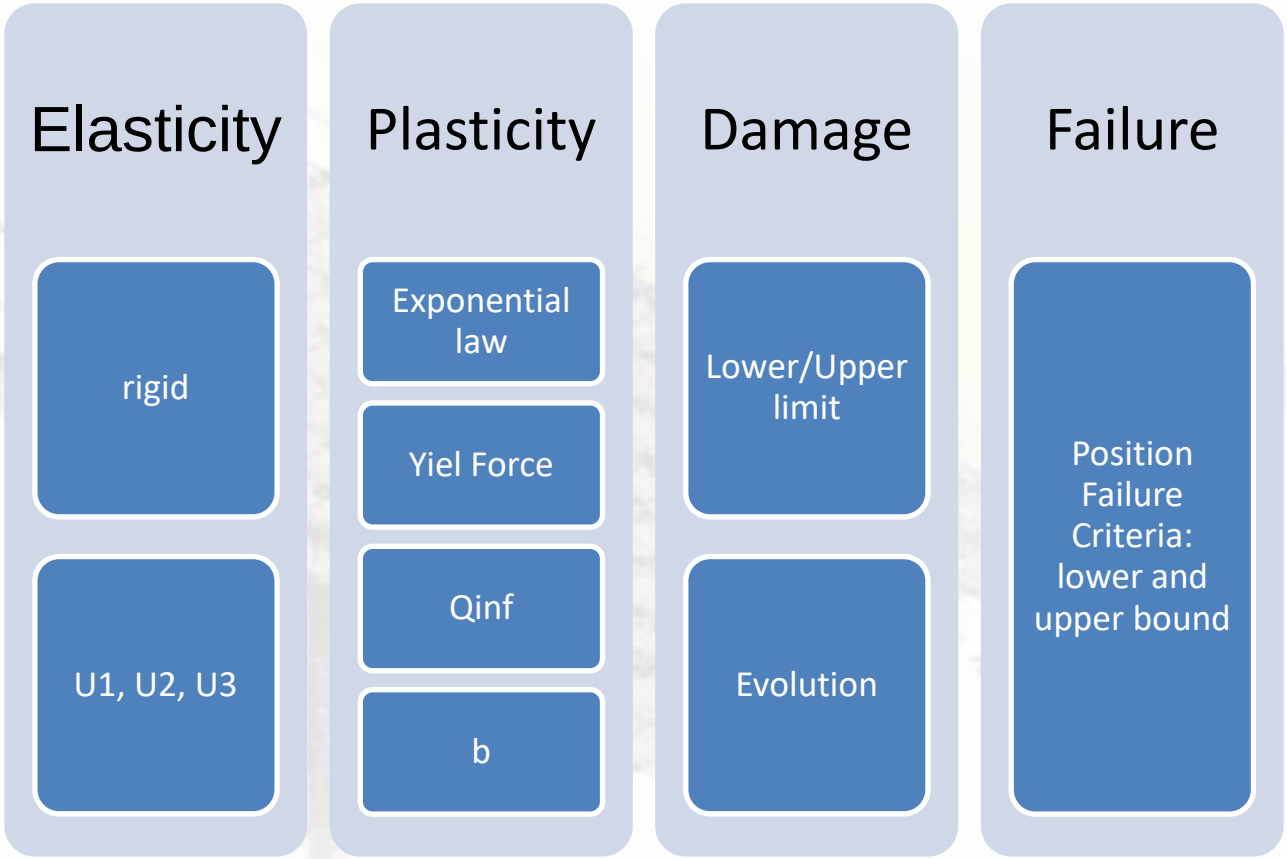


Numerical FE model

Type of connector section: bushing

Connector section behaviour:

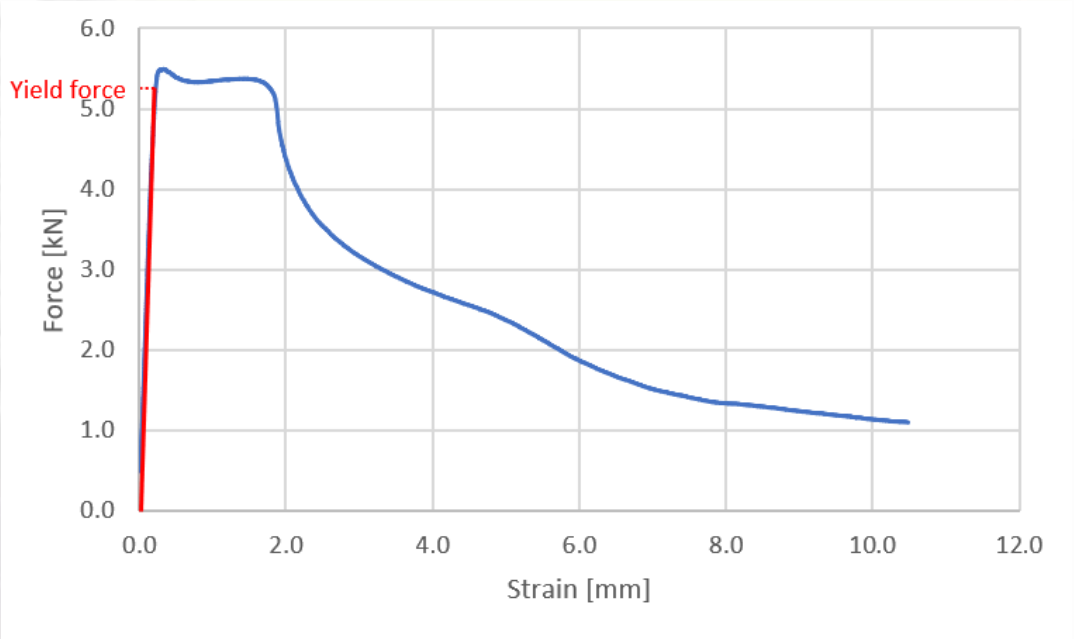
- Elasticity
- Plasticity
- Damage
- Failure


Elasticity
rigid
U1, U2, U3
Plasticity
Exponential law
Yiel Force
Qinf
b
Damage
Lower/Upper limit
Evolution
Failure
Position Failure Criteria: lower and upper bound

Elasticity

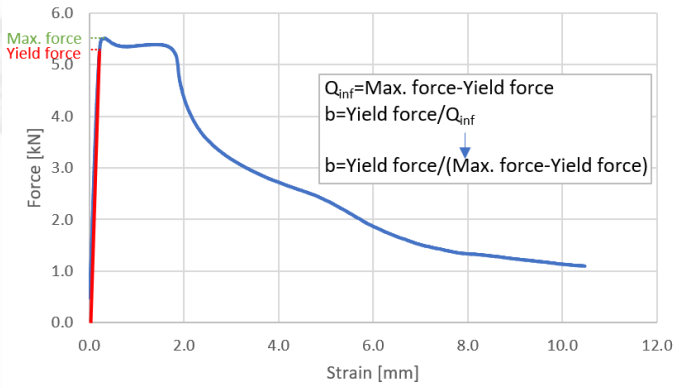
rigid

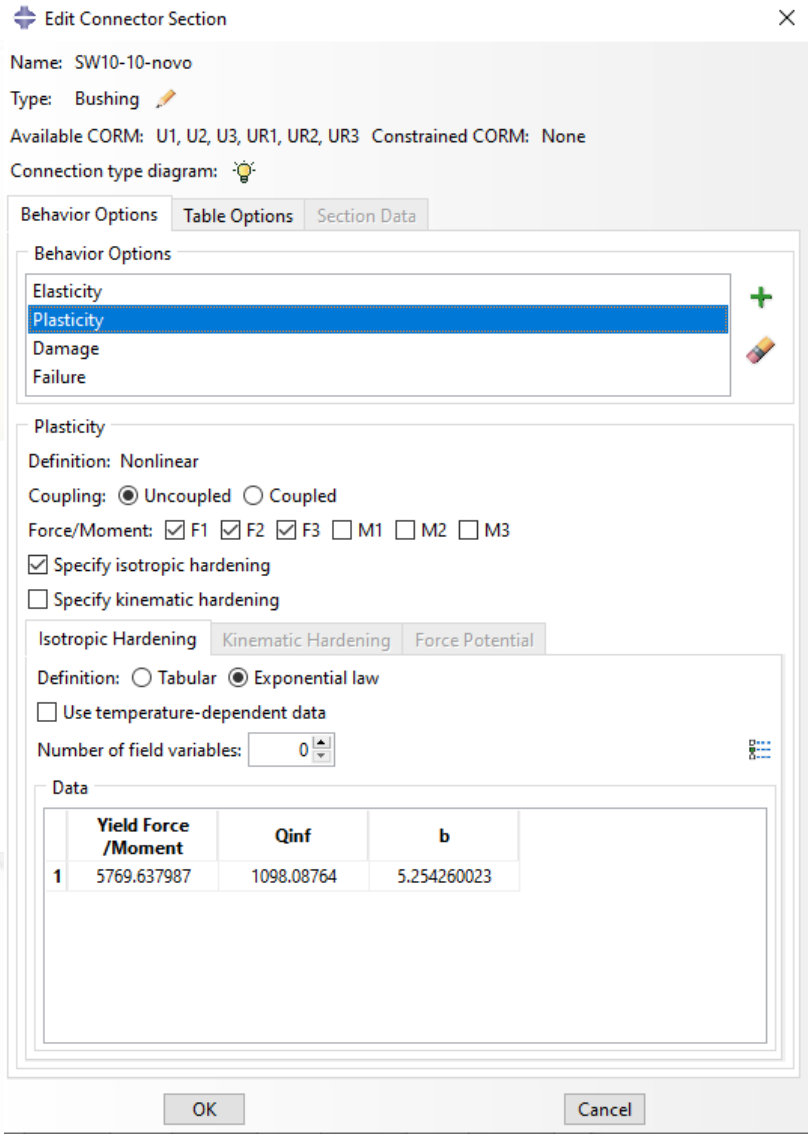
U1, U2, U3



Plasticity

- Exponential law
- Yield Force
- Qinf
- b

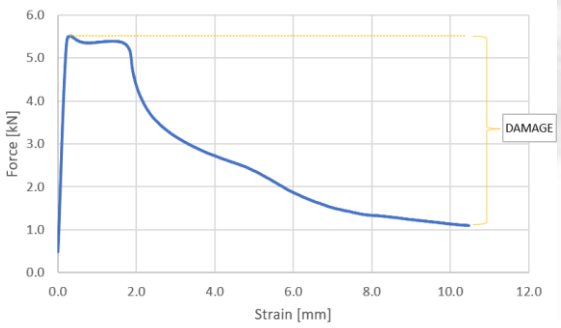


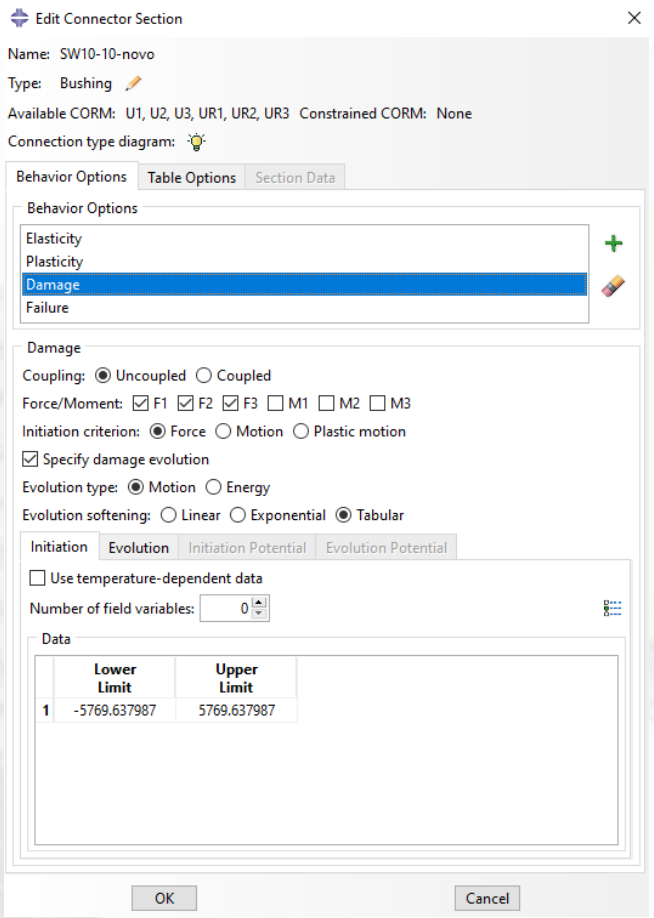


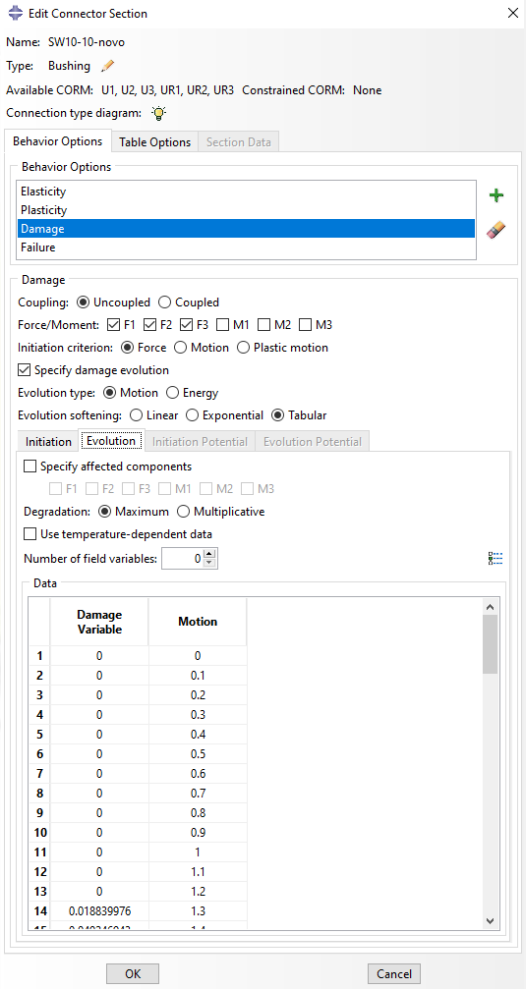
Damage

Lower/Upper limit

Force initiation criterion and Motion evolution type

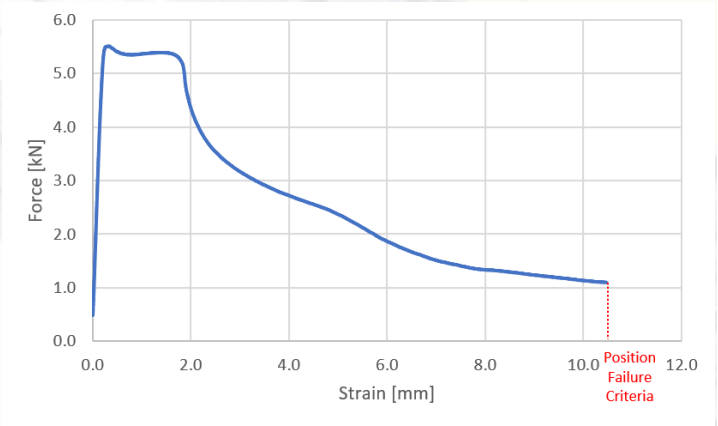


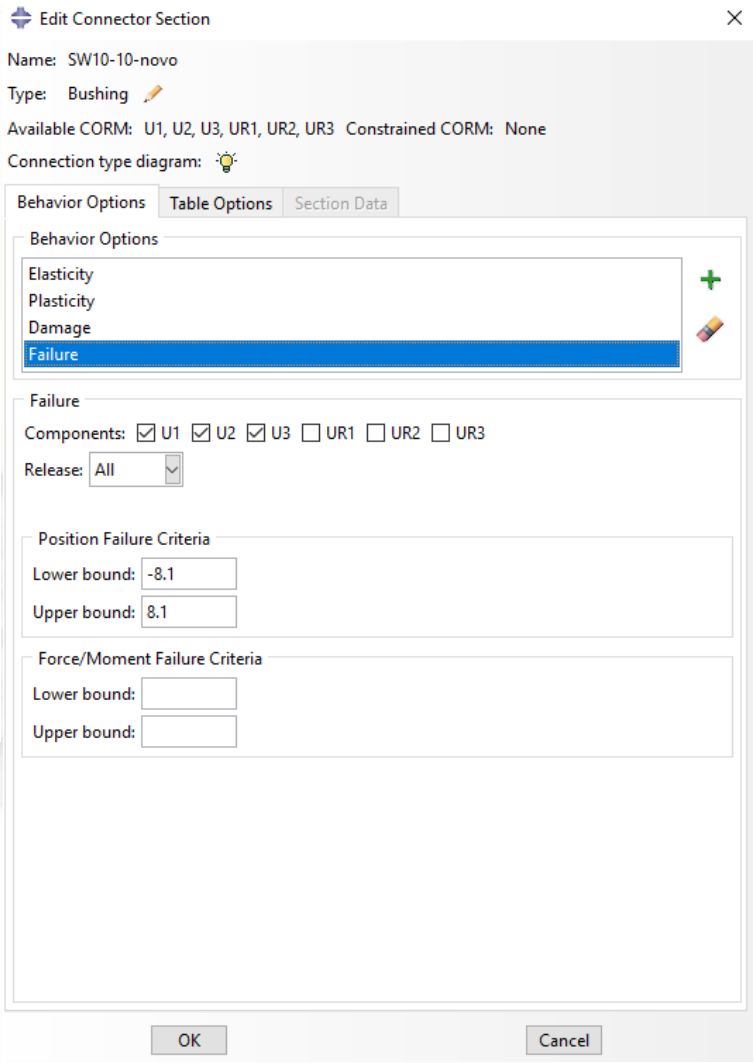




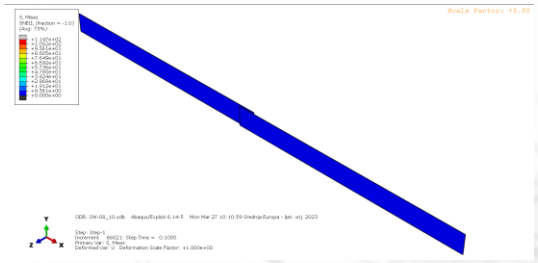
Failure

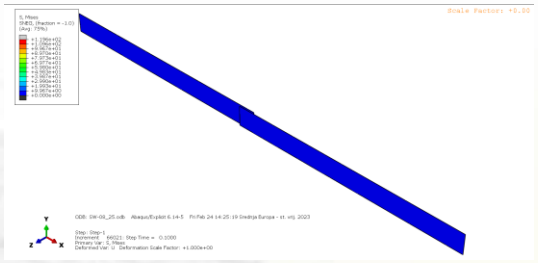
Position Failure Criteria: lower and upper bound

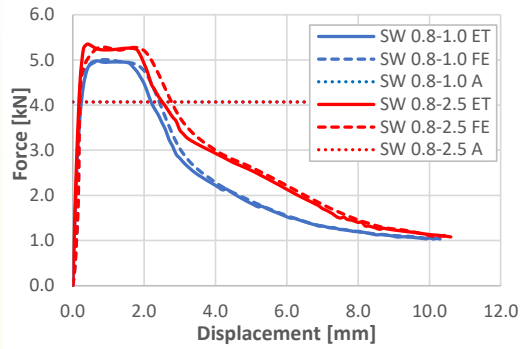


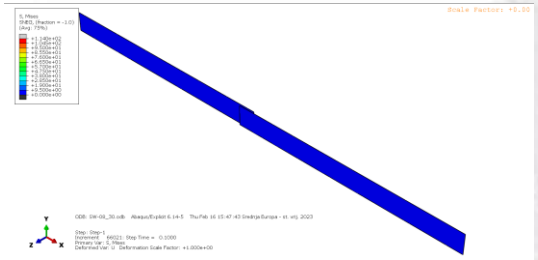


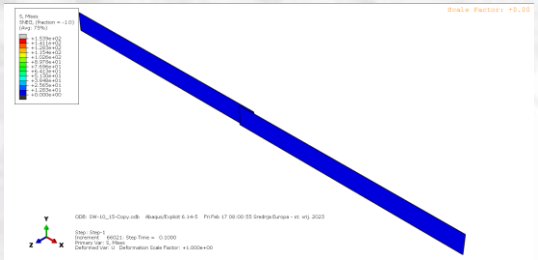
Results

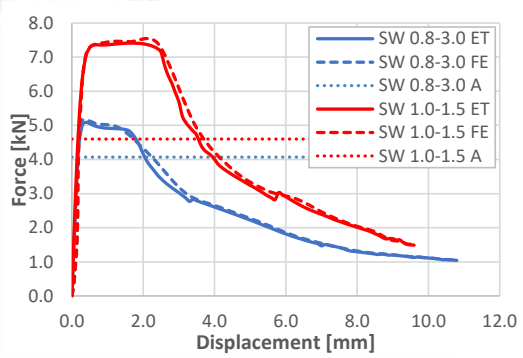




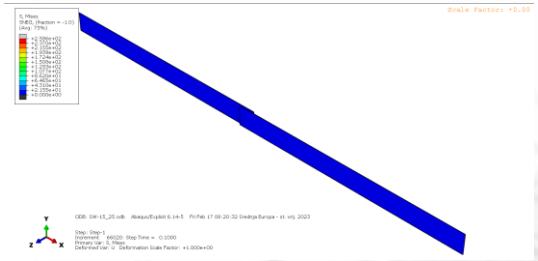

SW 0.8-1.0 ET
SW 0.8-1.0 FE
SW 0.8-1.0 A
SW 0.8-2.5 ET
SW 0.8-2.5 FE
SW 0.8-2.5 A
Force [kN]
Displacement [mm]
0.0
1.0
2.0
3.0
4.0
5.0
6.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0

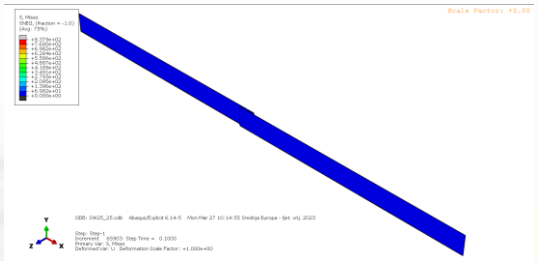


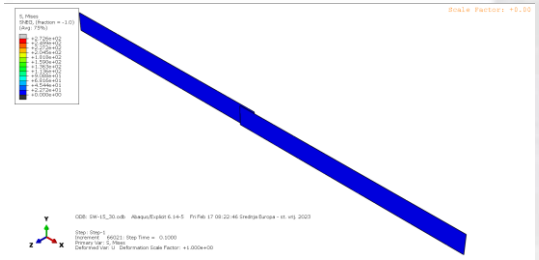


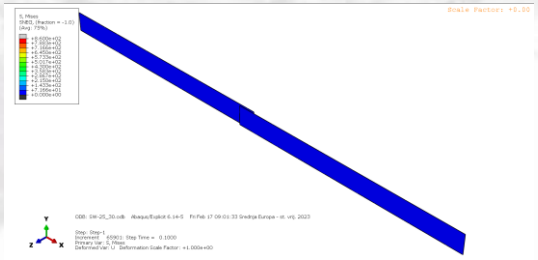

SW 0.8-3.0 ET
SW 0.8-3.0 FE
SW 0.8-3.0 A
SW 1.0-1.5 ET
SW 1.0-1.5 FE
SW 1.0-1.5 A
Force [kN]
Displacement [mm]
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0

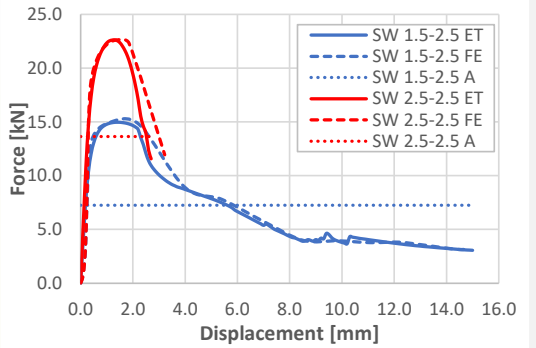
Results

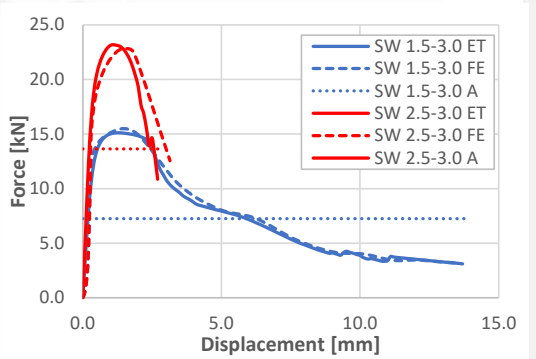






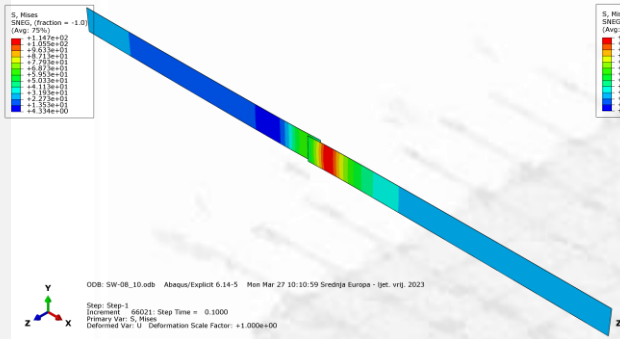



25.0
20.0
15.0
10.0
5.0
0.0
Force [kN]
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Displacement [mm]
SW 1.5-2.5 ET
SW 1.5-2.5 FE
SW 1.5-2.5 A
SW 2.5-2.5 ET
SW 2.5-2.5 FE
SW 2.5-2.5 A

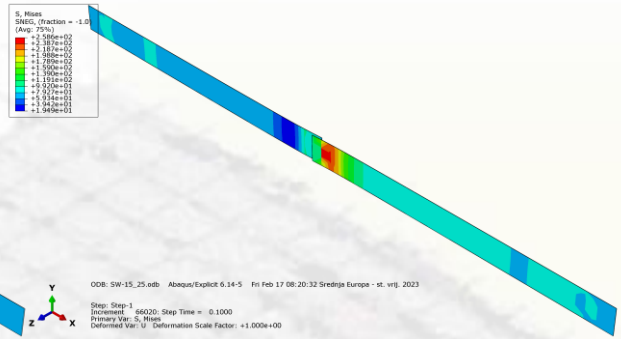

25.0
20.0
15.0
10.0
5.0
0.0
Force [kN]
0.0
5.0
10.0
15.0
Displacement [mm]
SW 1.5-3.0 ET
SW 1.5-3.0 FE
SW 1.5-3.0 A
SW 2.5-3.0 ET
SW 2.5-3.0 FE
SW 2.5-3.0 A

Results

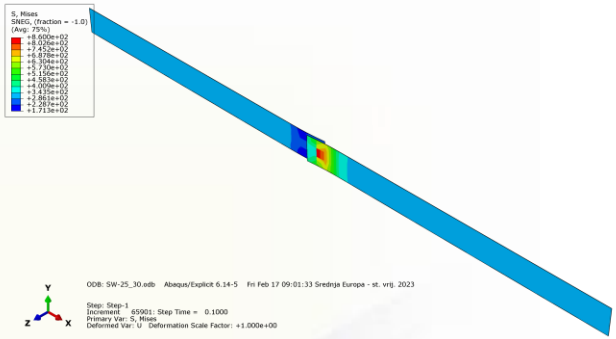
0.8-1.0



1.5-2.5



1.5-2.5

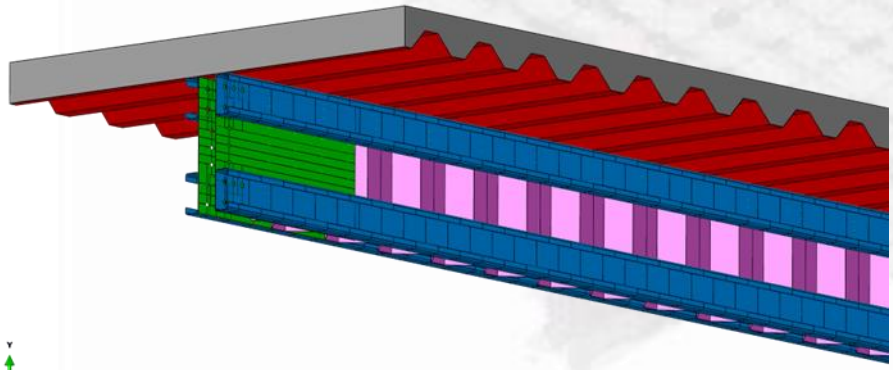


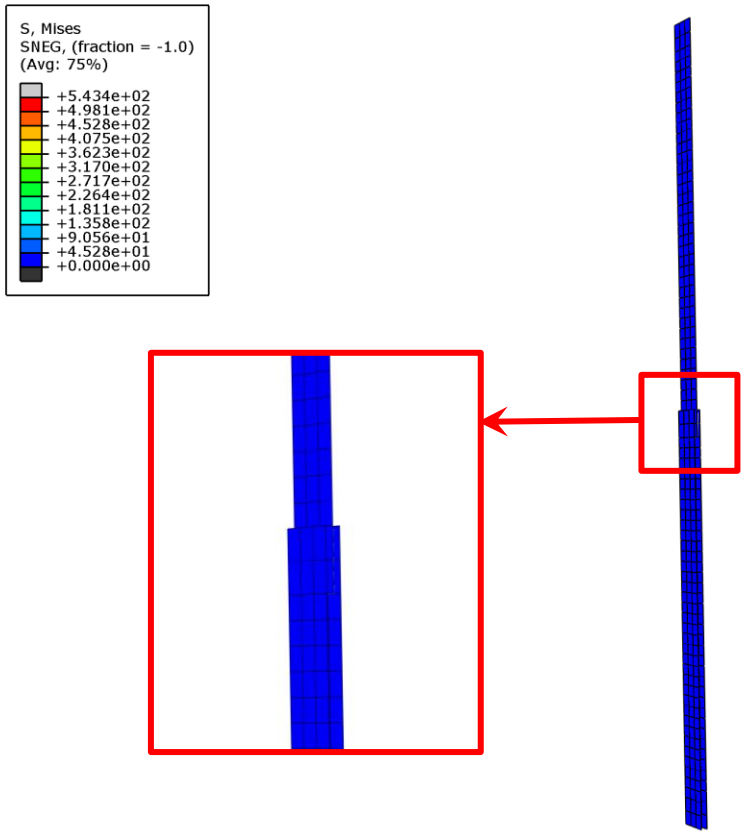
Conclusions

- Laboratory tests and numerical results of different combinations of spot-welded samples have shown that the thinner sheet in the spot-welded sample defines the failure mode. Furthermore, by increasing the thickness of any sheet in the spot-welded sample, the resistance can be significantly improved.
- Laboratory tests have shown that the failure mode for samples formed with sheets of thickness less or equal to 2.0 mm is full button pull-out, while spot-welded samples that are formed with sheets of thickness 2.5 mm and 3.0 mm observed interfacial fracture failure. The same conclusion can be given when observing the distributions of von Mises stresses in numerical models.
- Comparing numerical and laboratory test results with analytical resistances calculated according to EN 1993-1-3, it can be concluded that all tested combinations of spot-welded samples reach the values of analytically calculated characteristic resistances.
- Calibrated numerical models which use Point-based Fasteners as spot welds reliably describe the behaviour of spot welds.
- The feasibility of a simplified FE analysis method applied to the spot-welded connections is verified. It is concluded that it could be acceptable for the global modelling of the systems with a large number of spot welds.

Further research

- probabilistic analysis of spot weld tests results





Procjena ponašanja točkastih zavara kod hladno oblikovanog čelika

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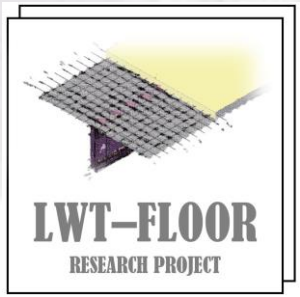

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