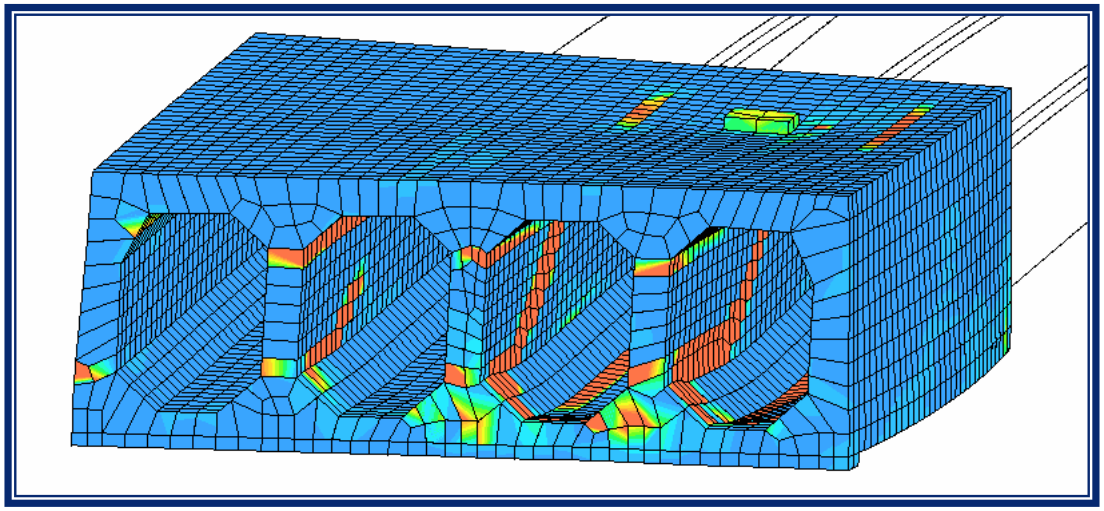
Shear and torsion in hollow core slabs: How advanced modelling can be used in design



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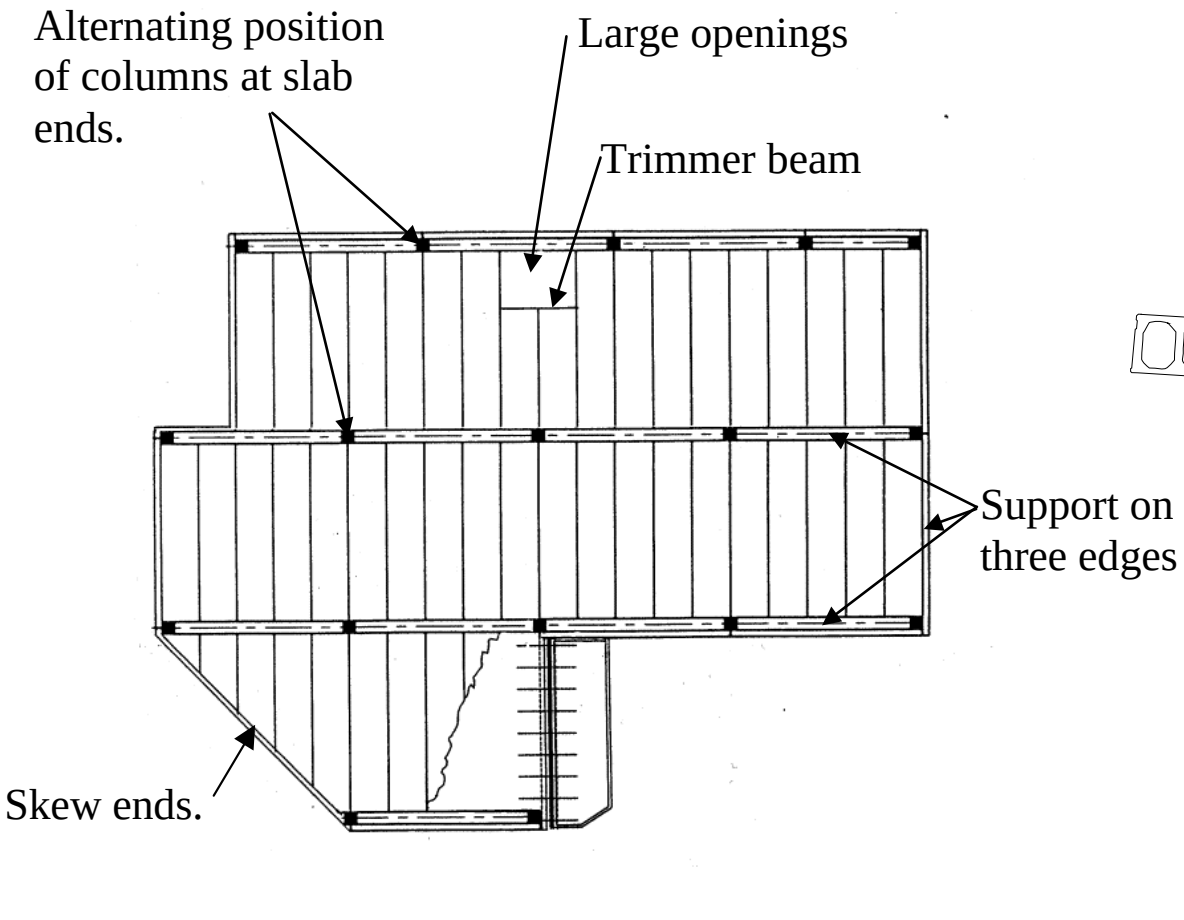
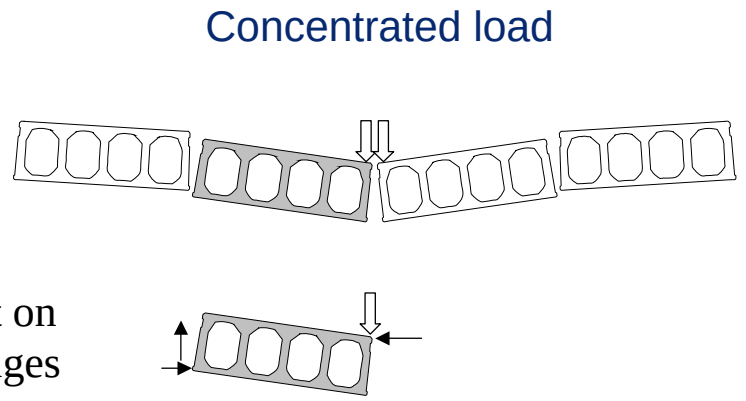
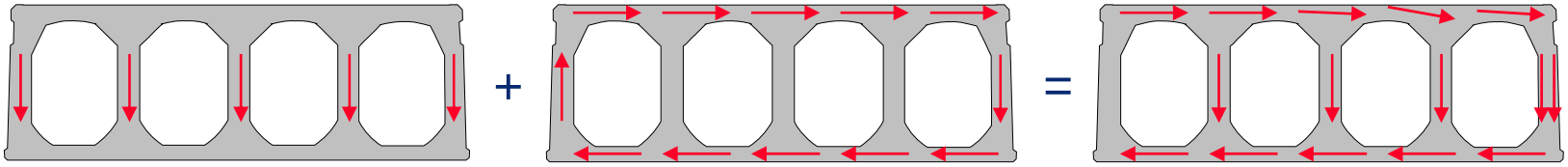
Examples of torsion





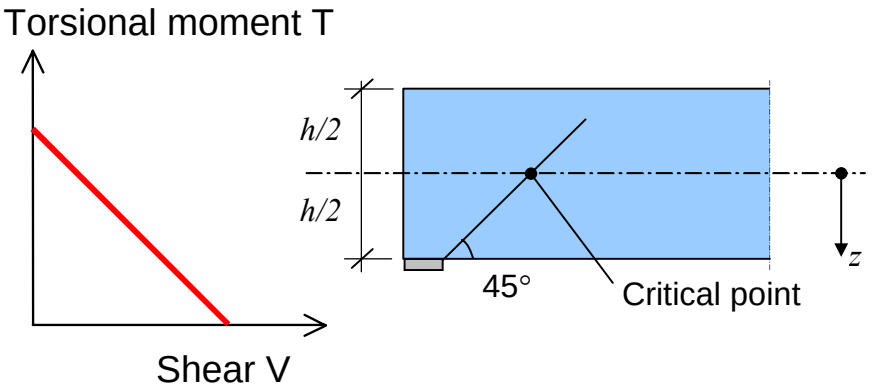
Combined shear and torsion in a hollow core unit



Shear Torsion Interaction

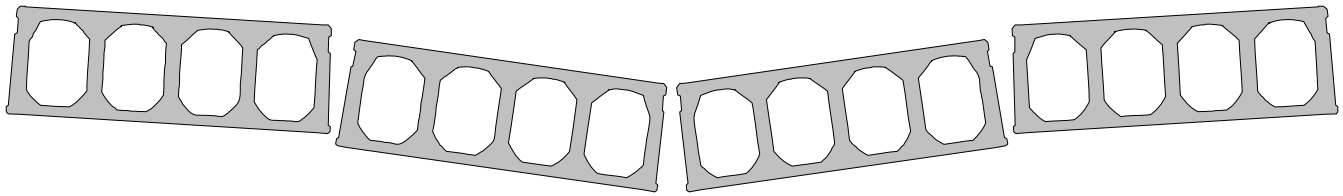
Design method used today in EN 1168:

- Cracking means failure
- Only crack in web is considered
- One critical point
- Stresses are added linearly

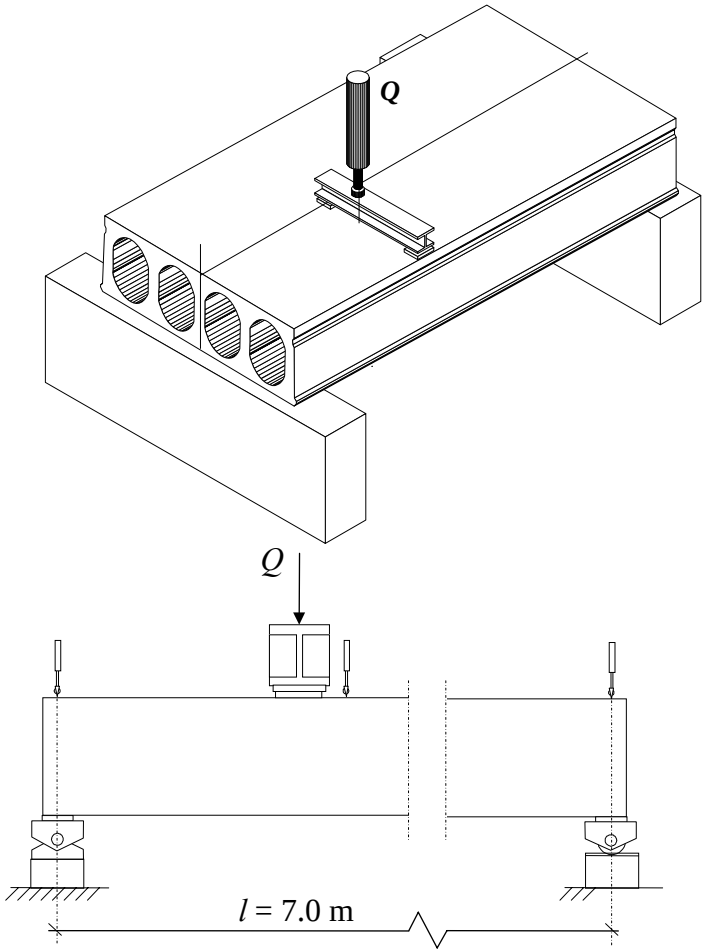


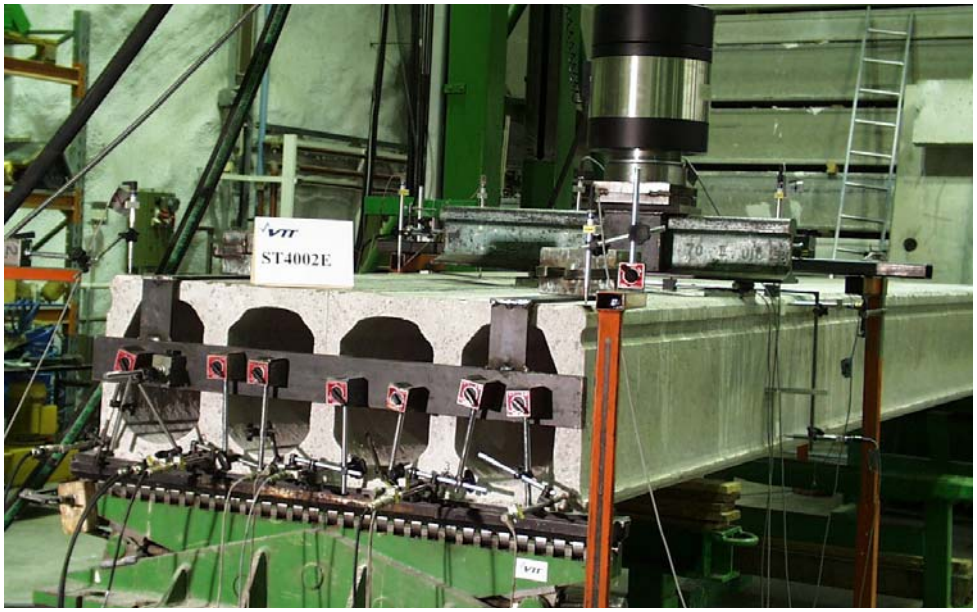
Aim of the project

- To use the capacity of the hollow core slabs better
- To develop methods to design for combined shear and torsion in hollow core slabs
  - Single units
  - Whole floors

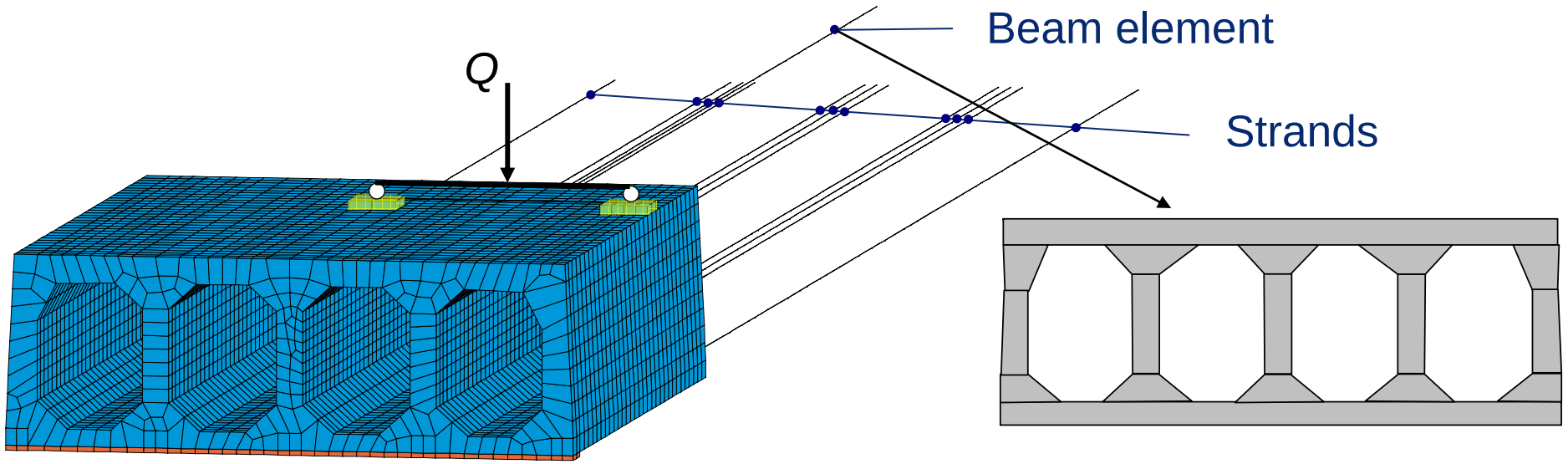


Experiments on hollow core units loaded in shear and torsion

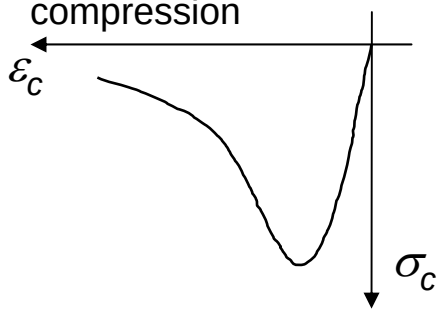




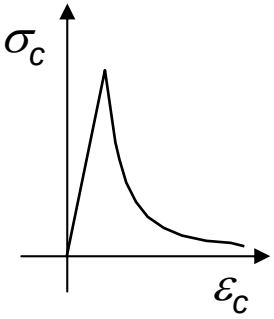
FE-model of hollow core unit



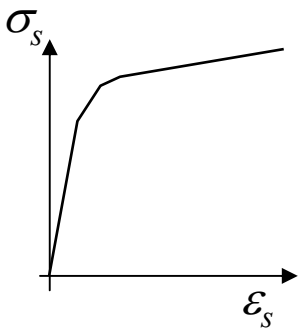
Concrete in compression



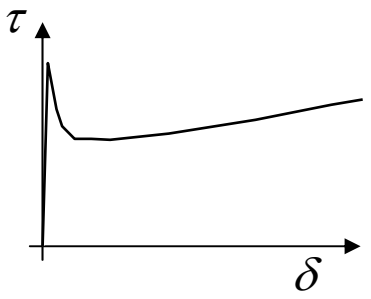
Concrete in tension



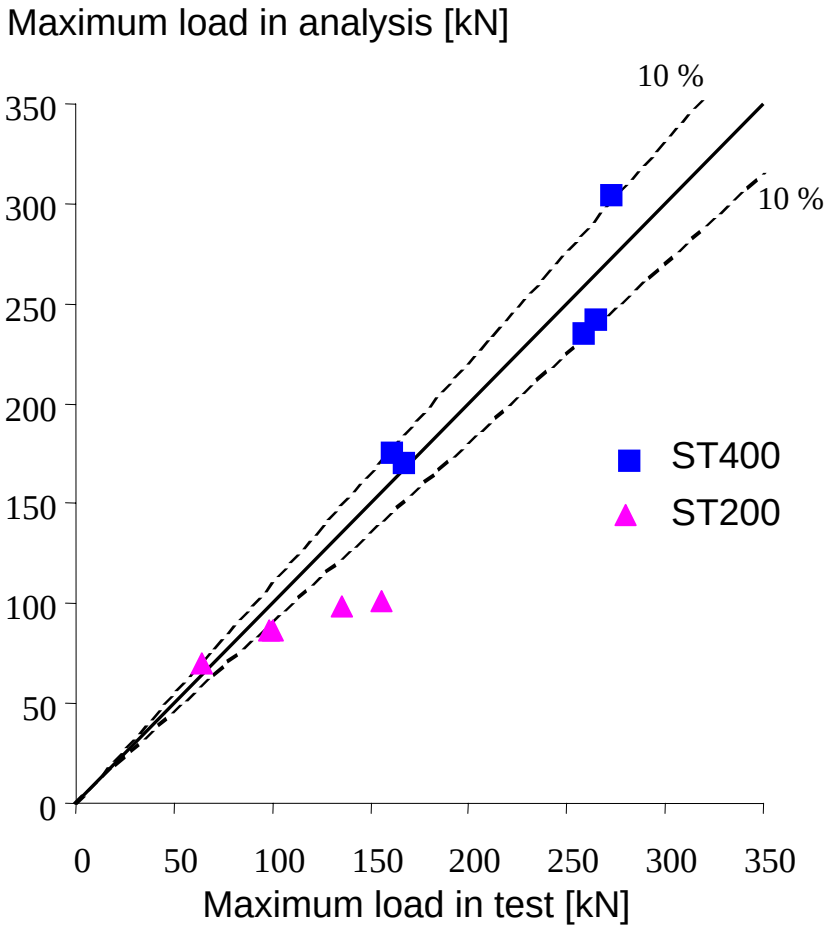
Steel in tension



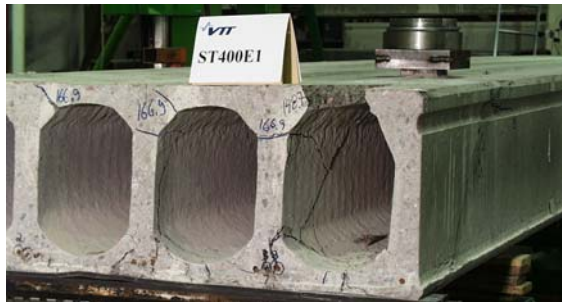
Bond-slip relation

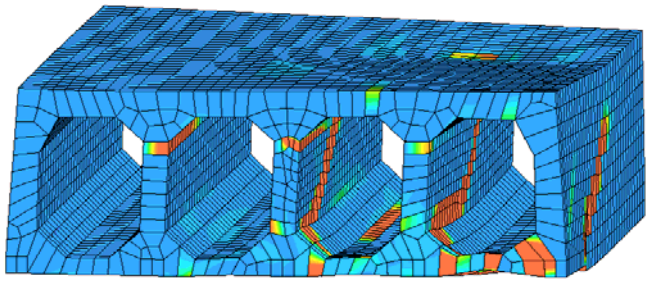


Comparison of results



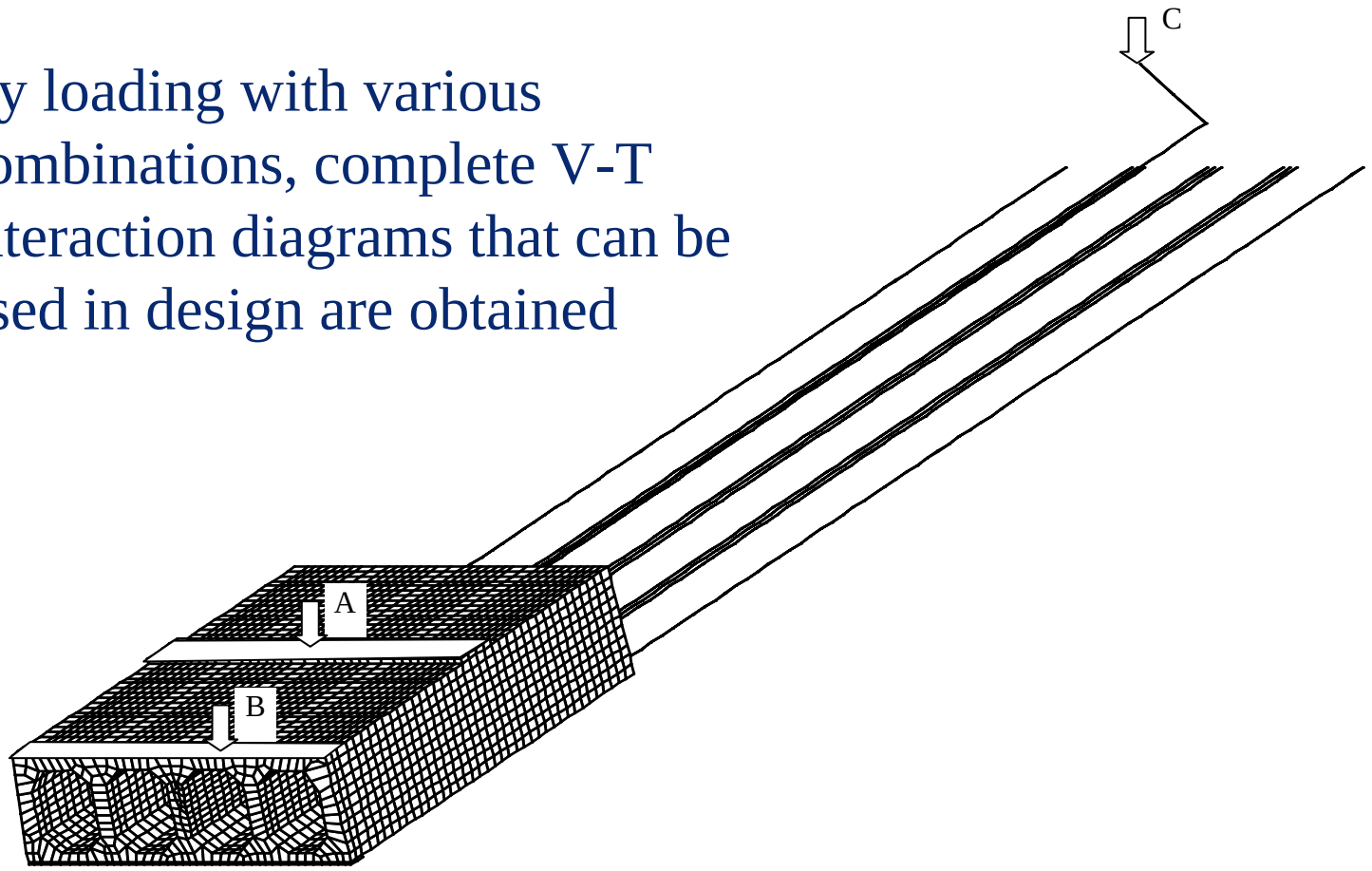
- Maximum load
- Load versus deflection
- Failure mode
- Crack pattern



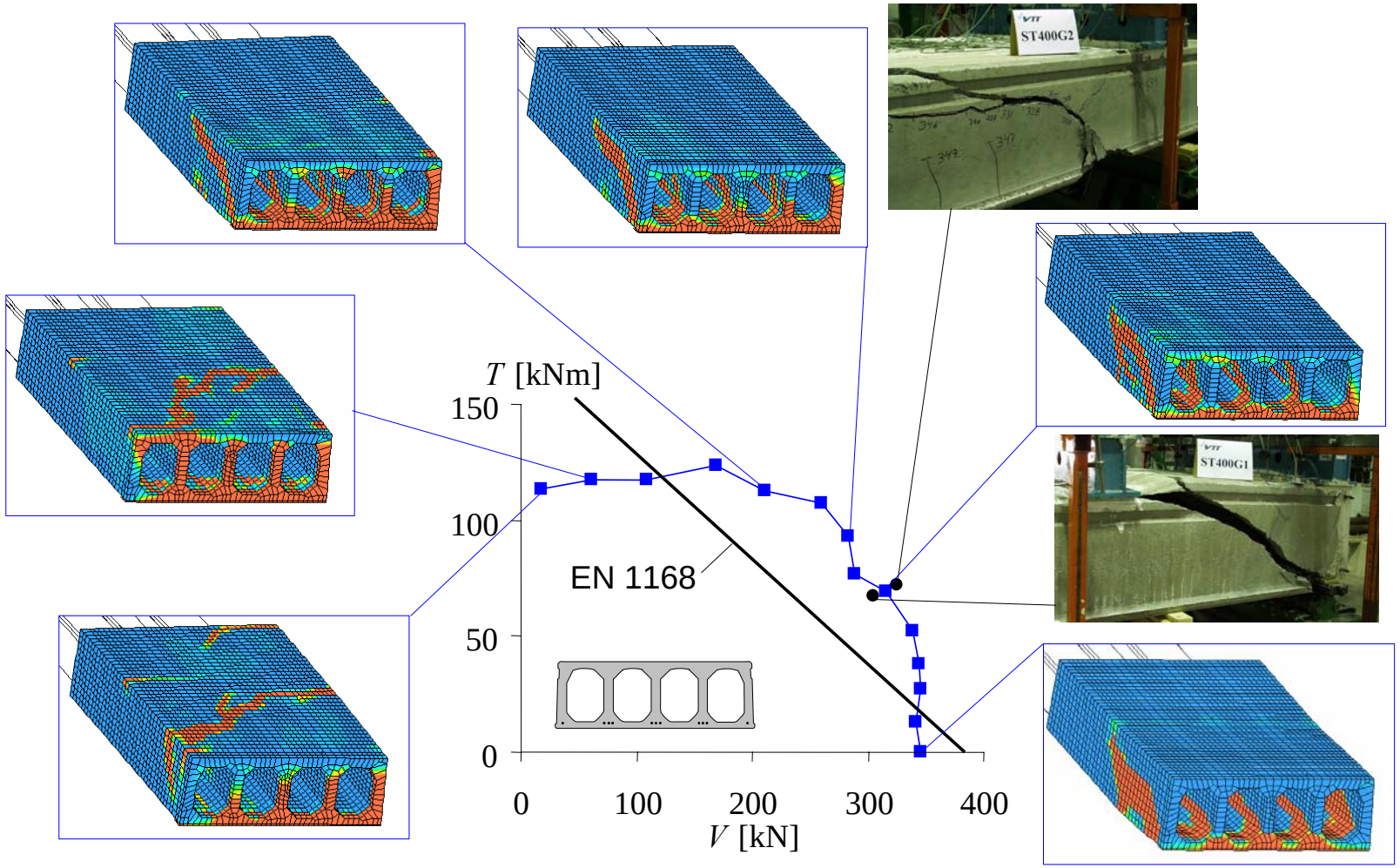


FE-analyses for design

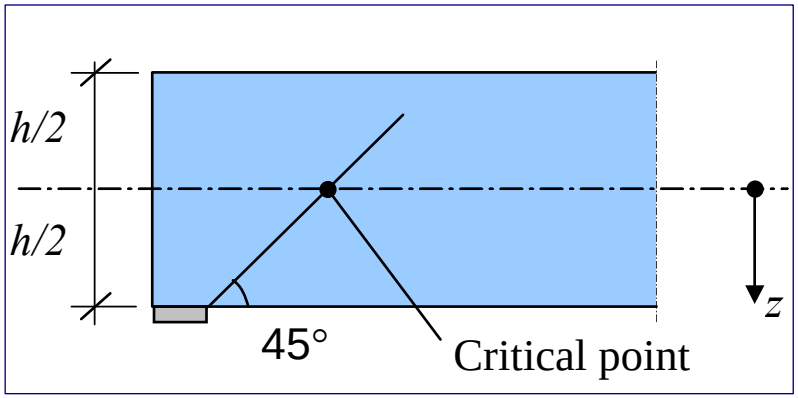
By loading with various combinations, complete V-T interaction diagrams that can be used in design are obtained



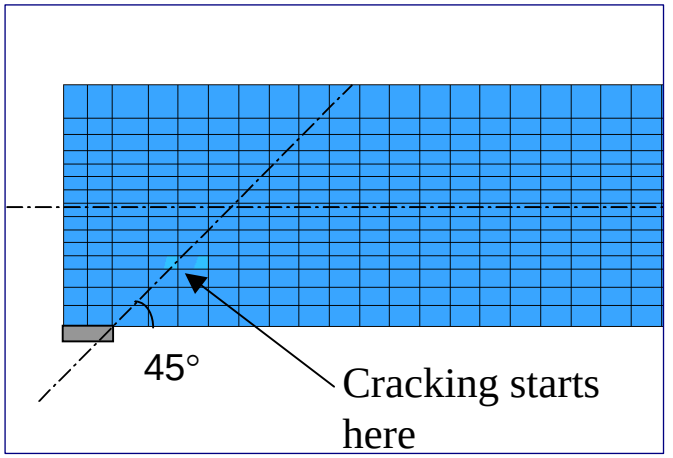
Interaction diagram for 400 mm unit



Critical section

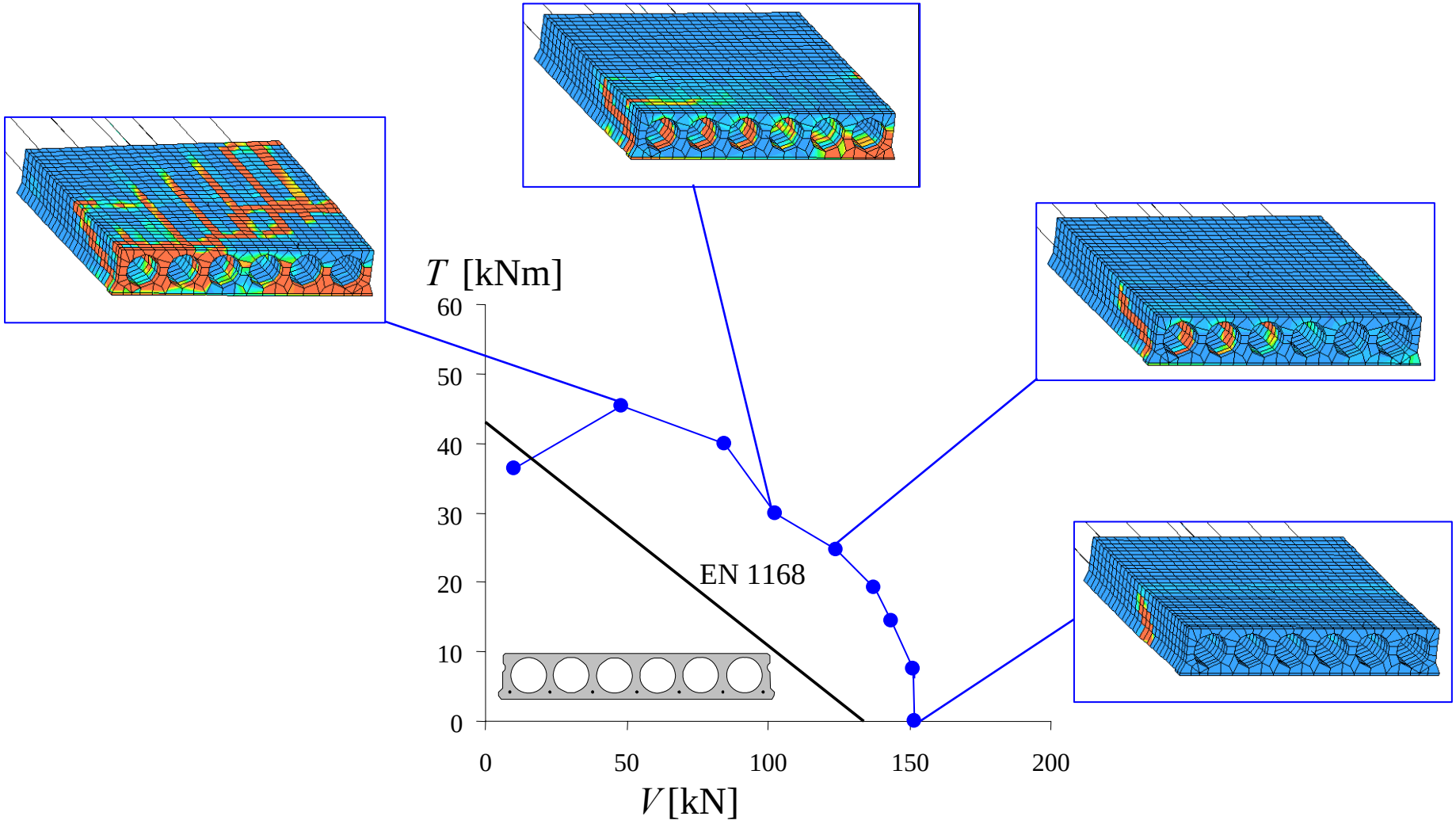


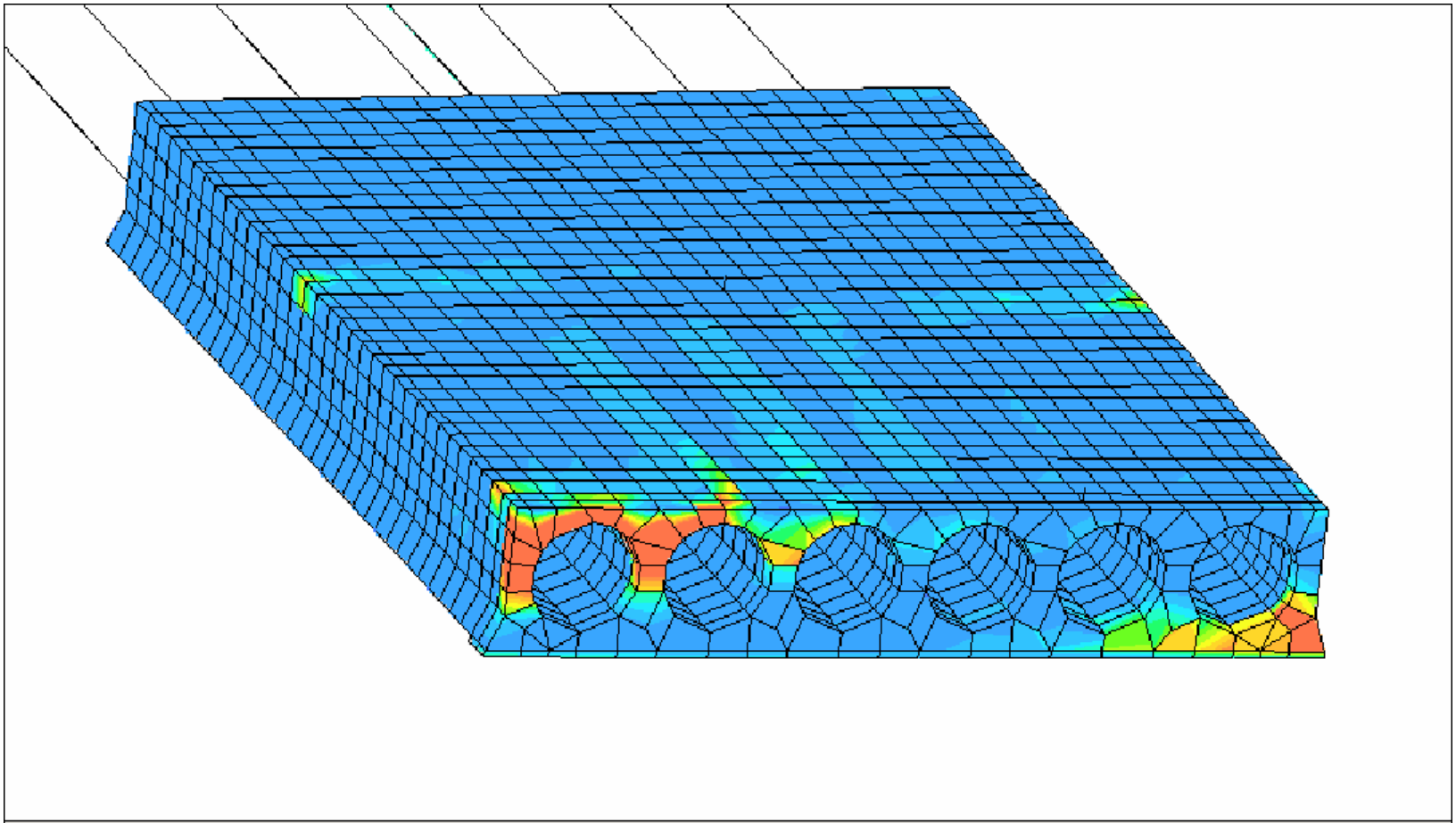
Analytical model



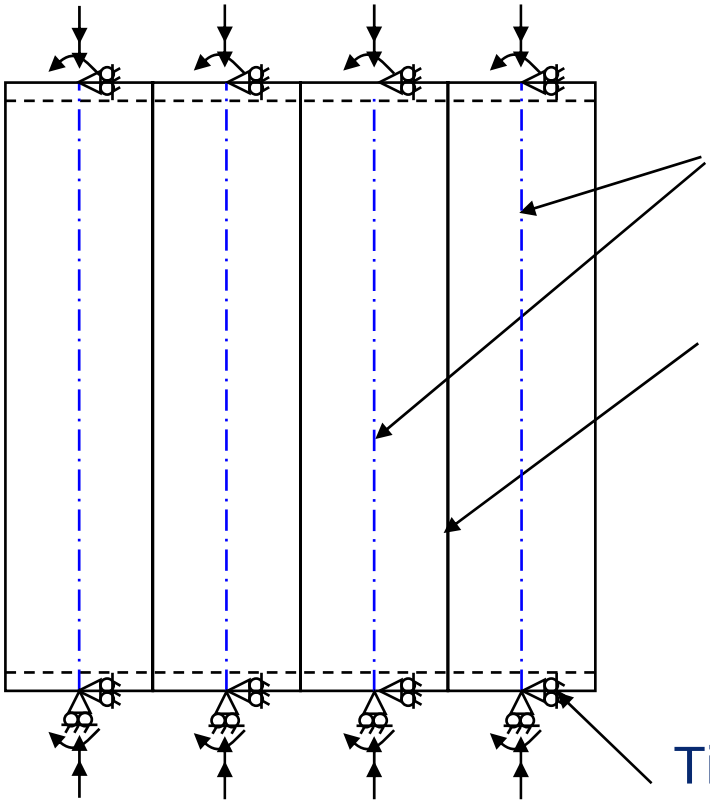
FE-analysis, pure shear

Interaction diagram for 200 mm unit

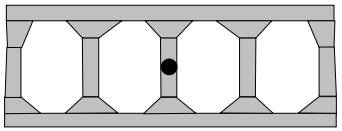



vt2b.avi

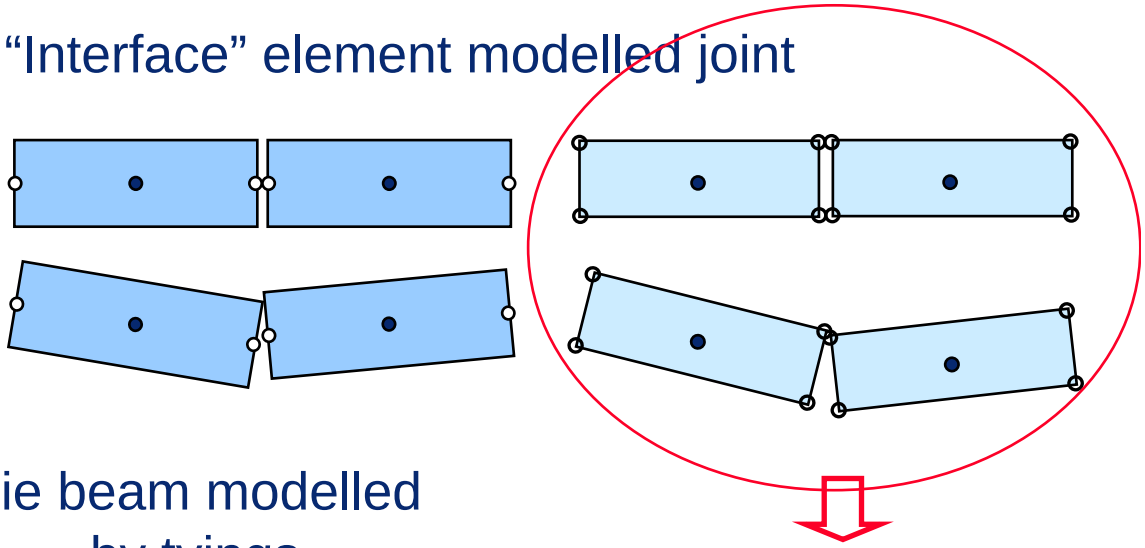
FE model of hollow core floor



Beam element modelled a hollow core unit



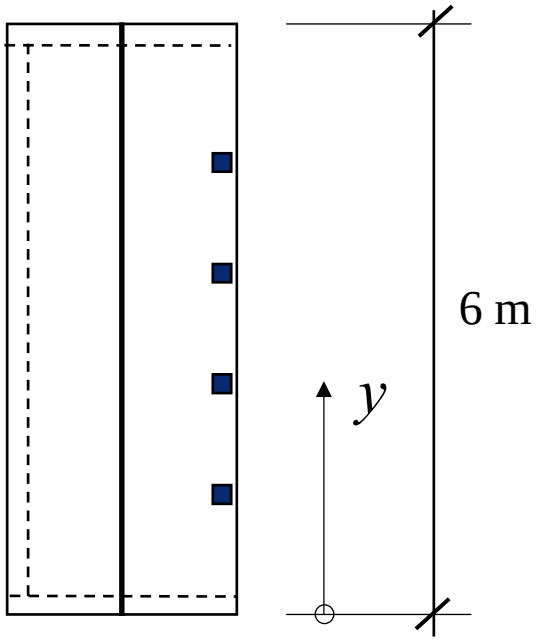
“Interface” element modelled joint

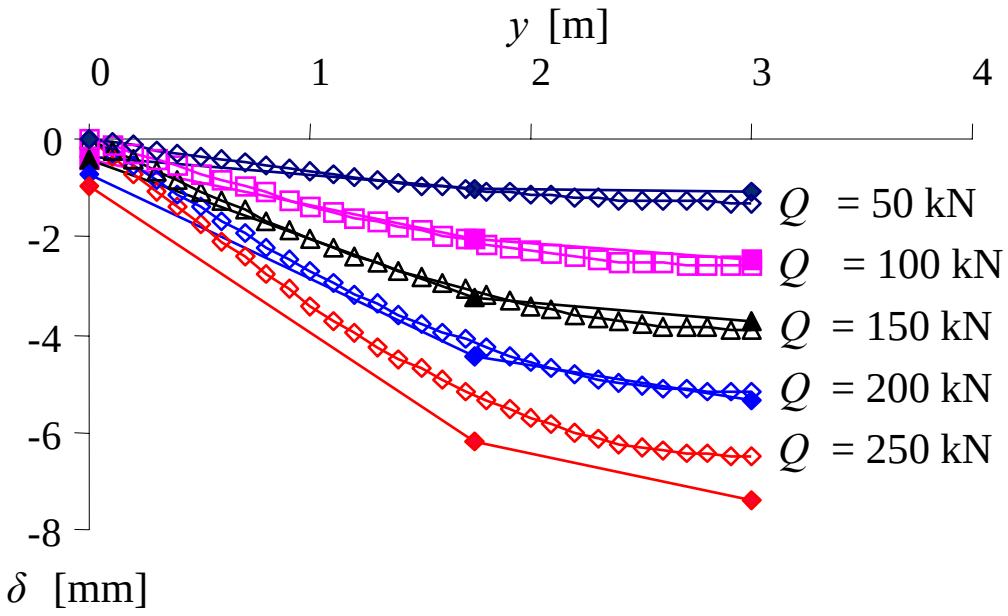


Tie beam modelled by tyings

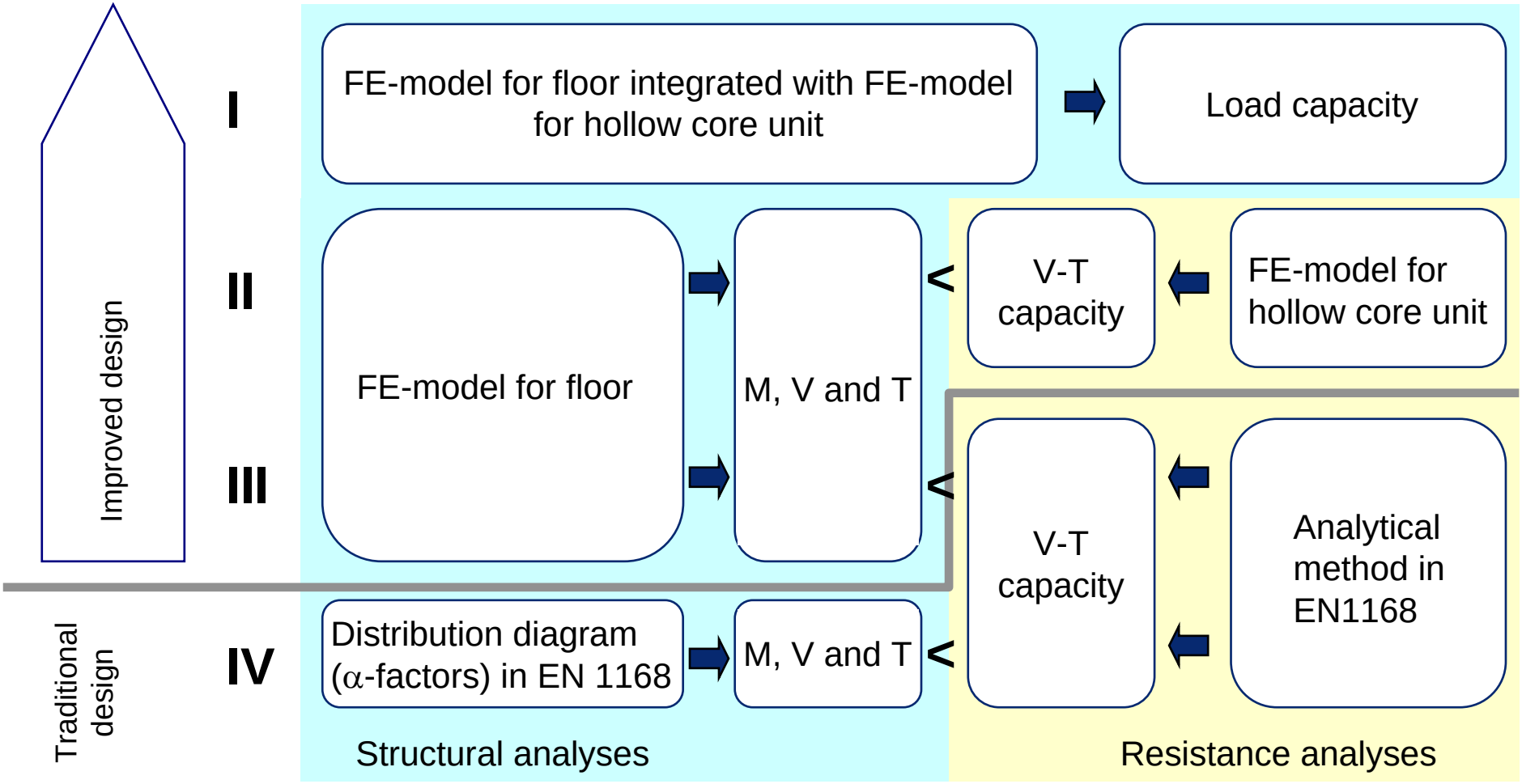
Reduced torsional moment

Results 3-sided supported hollow core floor

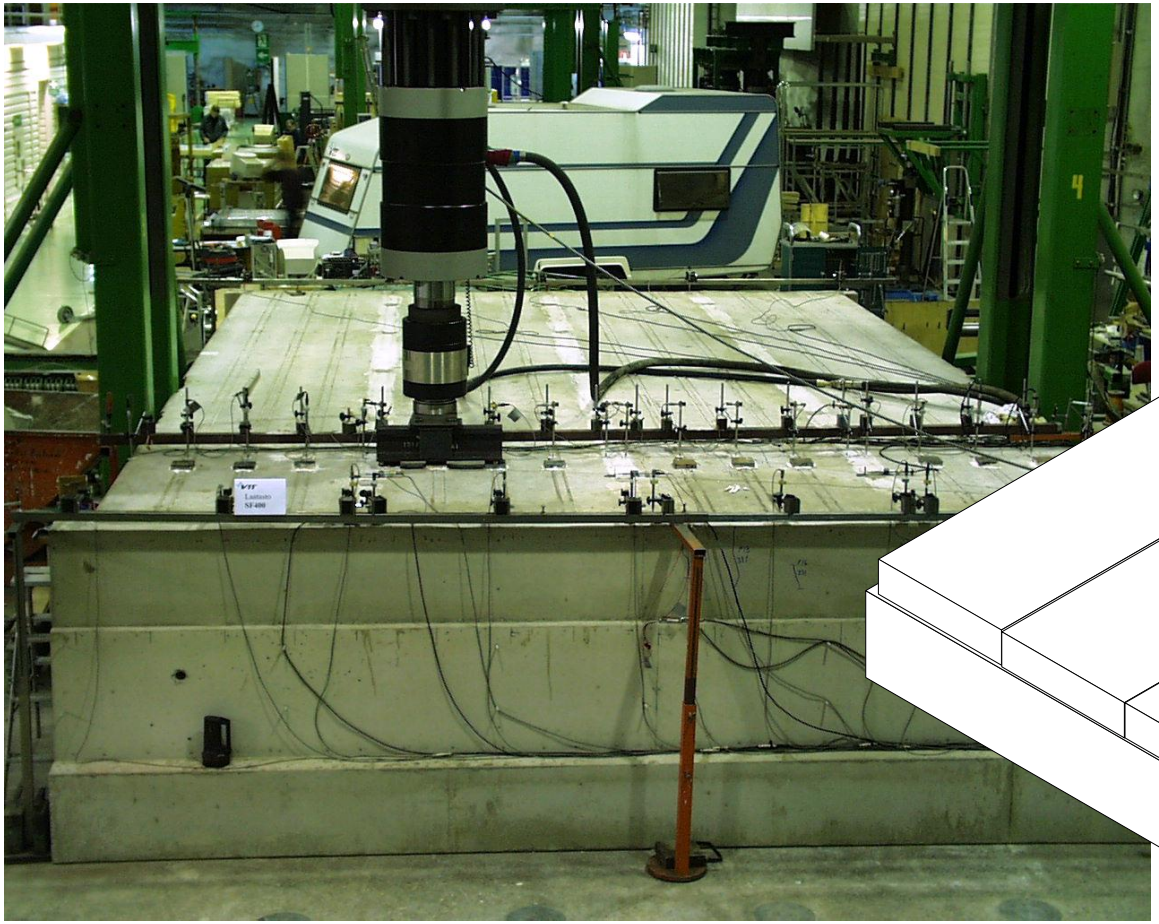


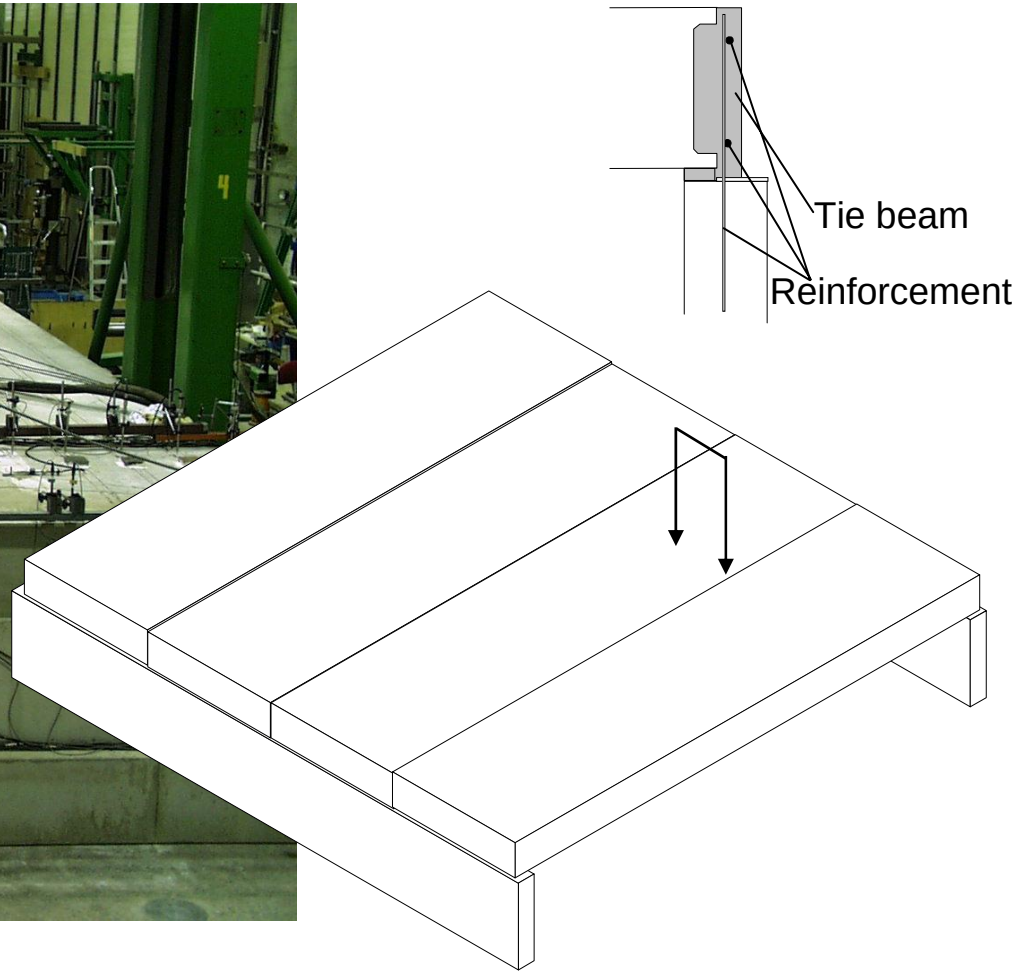


Design of hollow core slabs

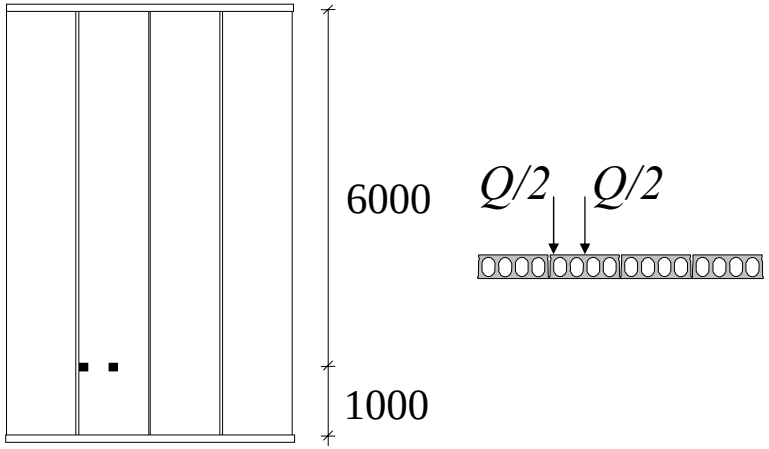


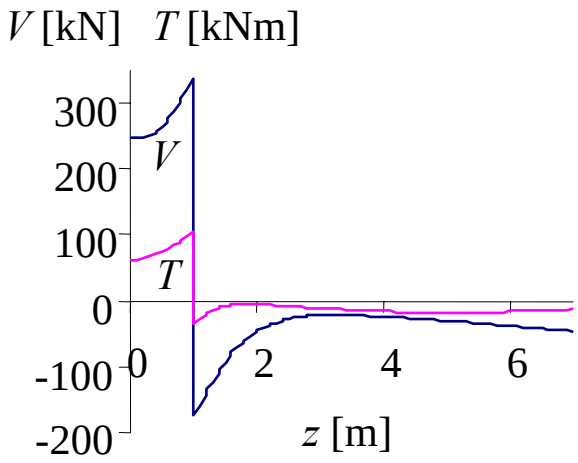
Floor test

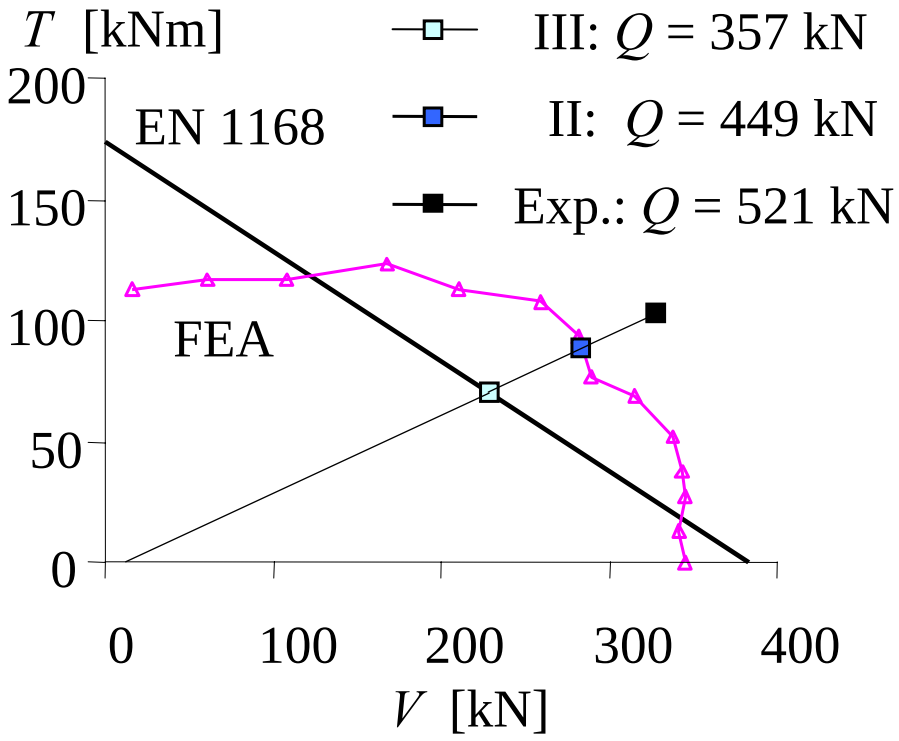




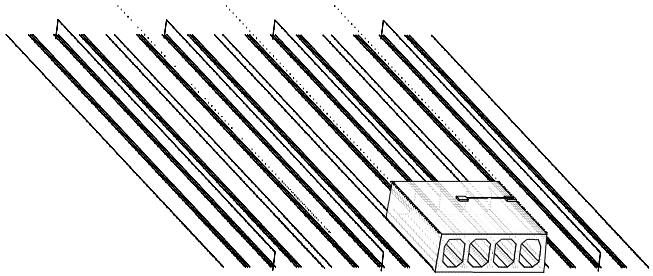
Design level III and II

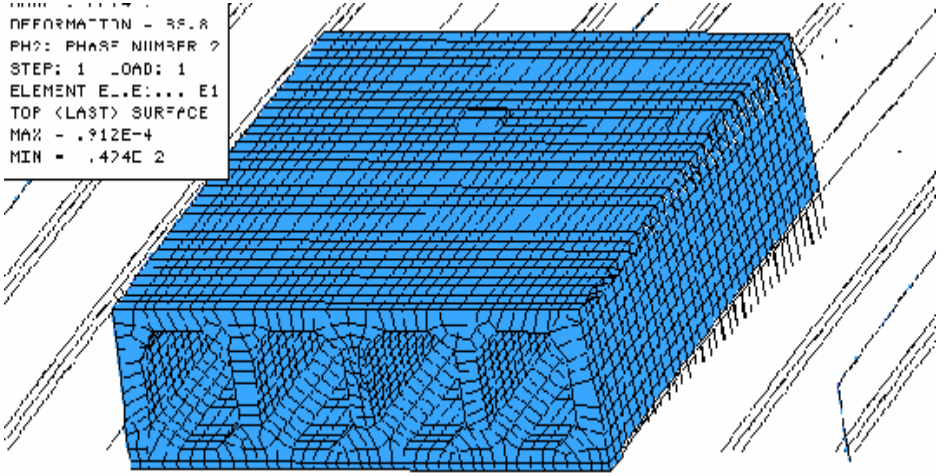


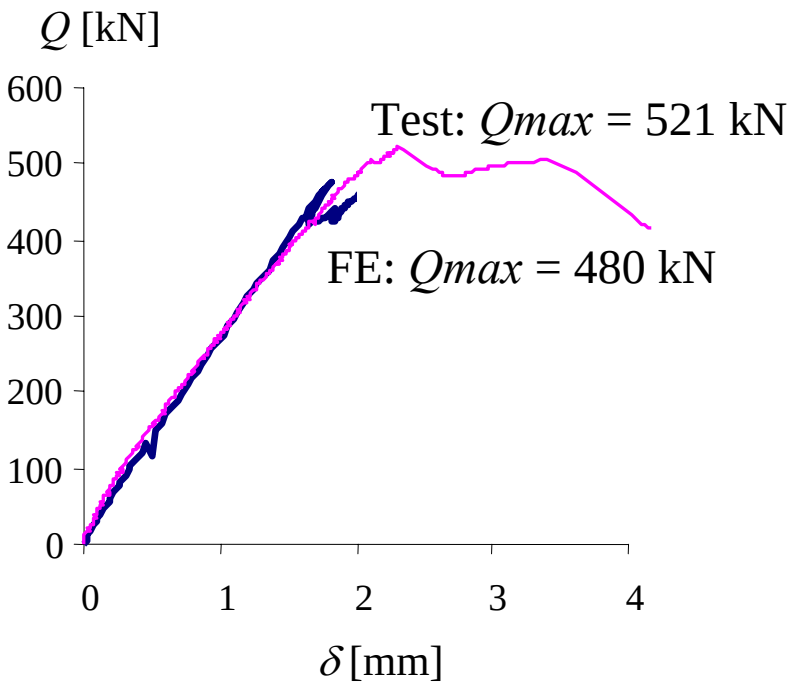


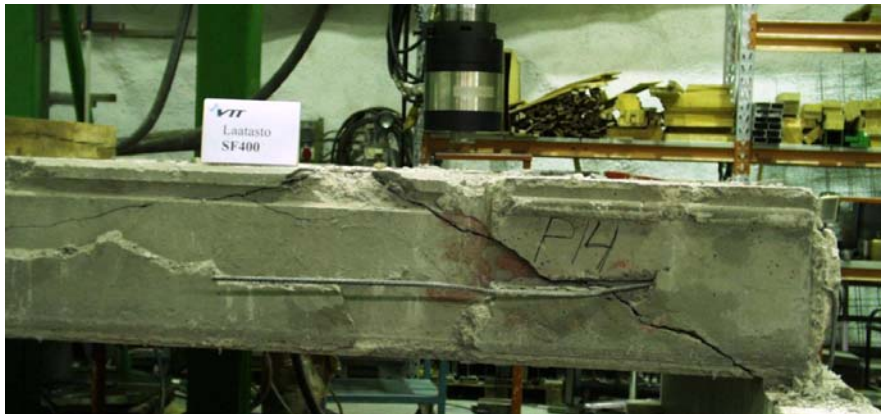


Design level I

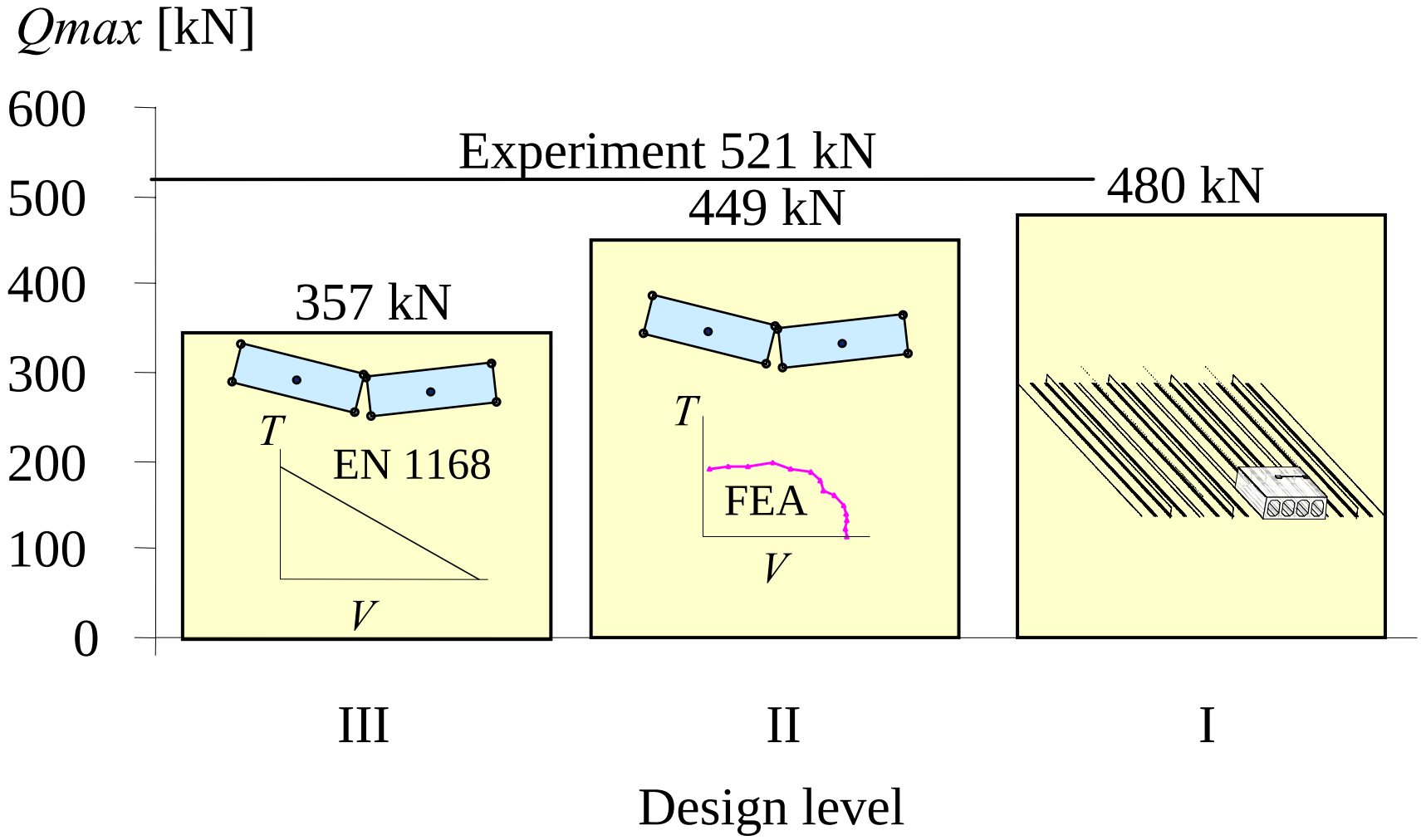








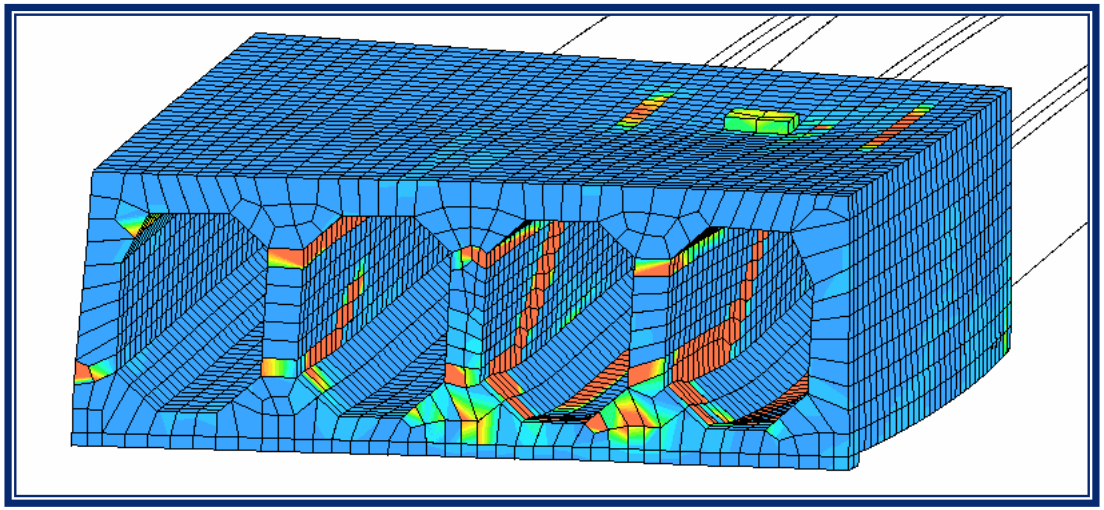
Floor, design example



Conclusions

- Modelling methods developed
  - Single hollow core units ⇒ Capacity V-T
    - Higher capacity than in analytical model
  - Hollow core floors ⇒ Cross-sectional forces V, T and M
    - Reduced torsional moment compared to traditional design method
- The capacity of the hollow core slabs can be used better

Thanks !



Financers and collaboration partners

- European Commission
- International Prestressed Hollow Core Association
- Bundesverband Spannbeton-Hohlplatten
- Castelo
- Consolis
- Echo
- Strängbetong
- VTT
- Chalmers

Interaction diagram for 200 mm unit