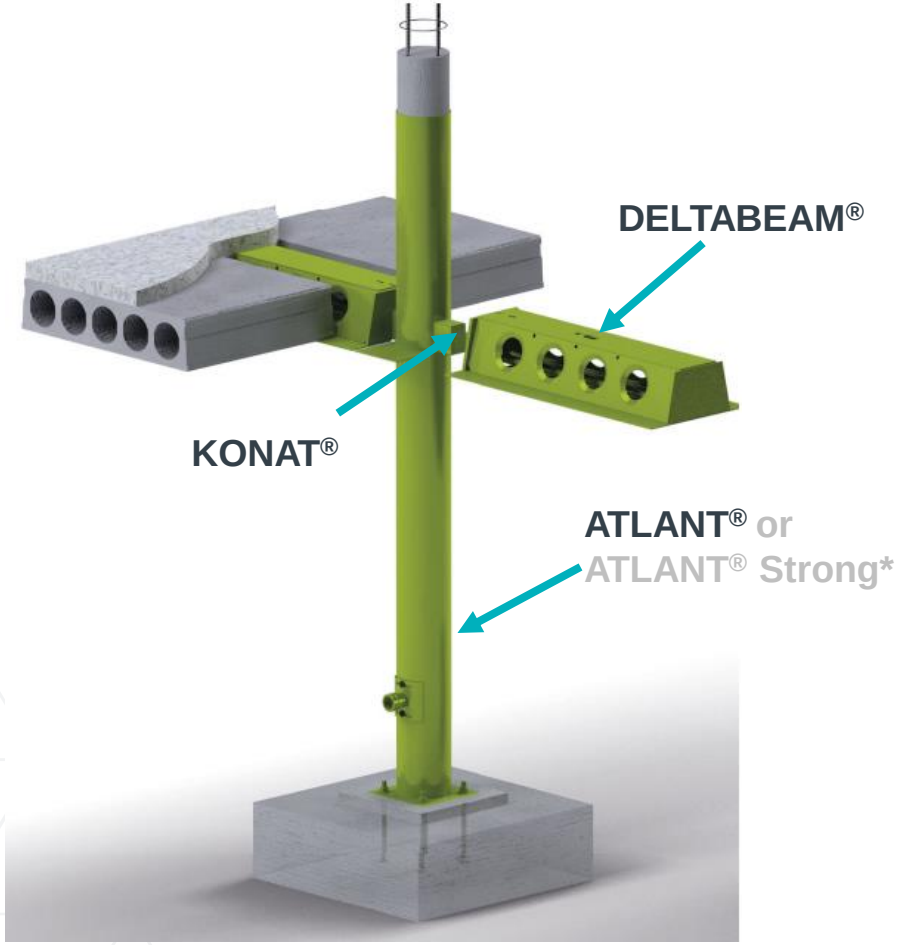
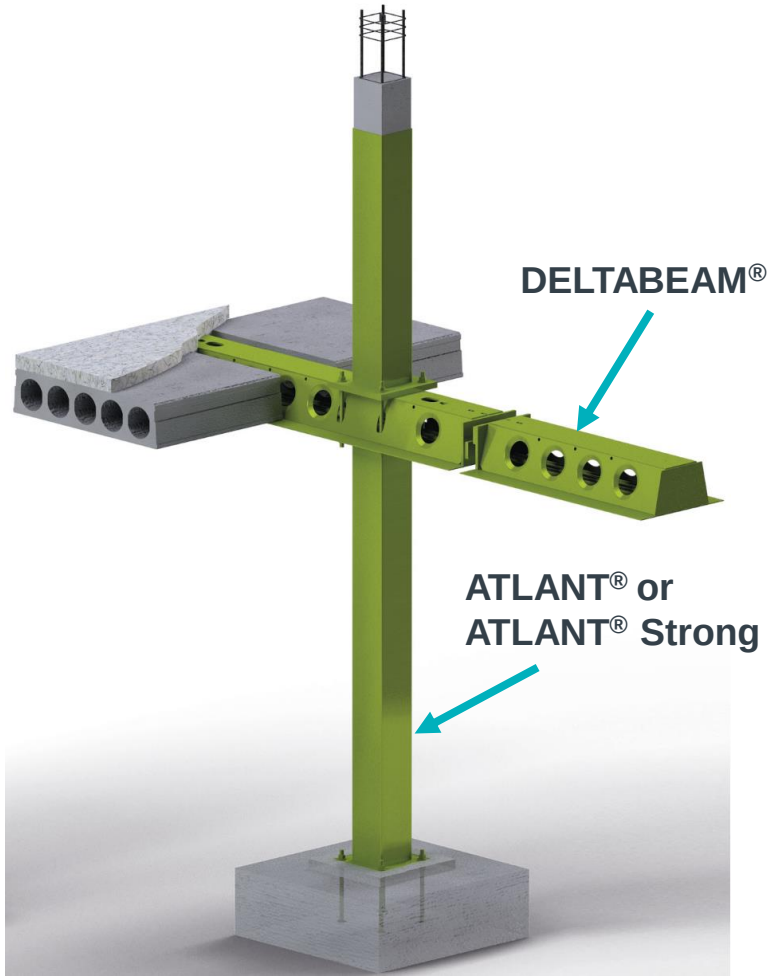
# Recent Developments, Design and Application of Composite Columns

Šarūnas Kelpša

# DELTABEAM® Frame

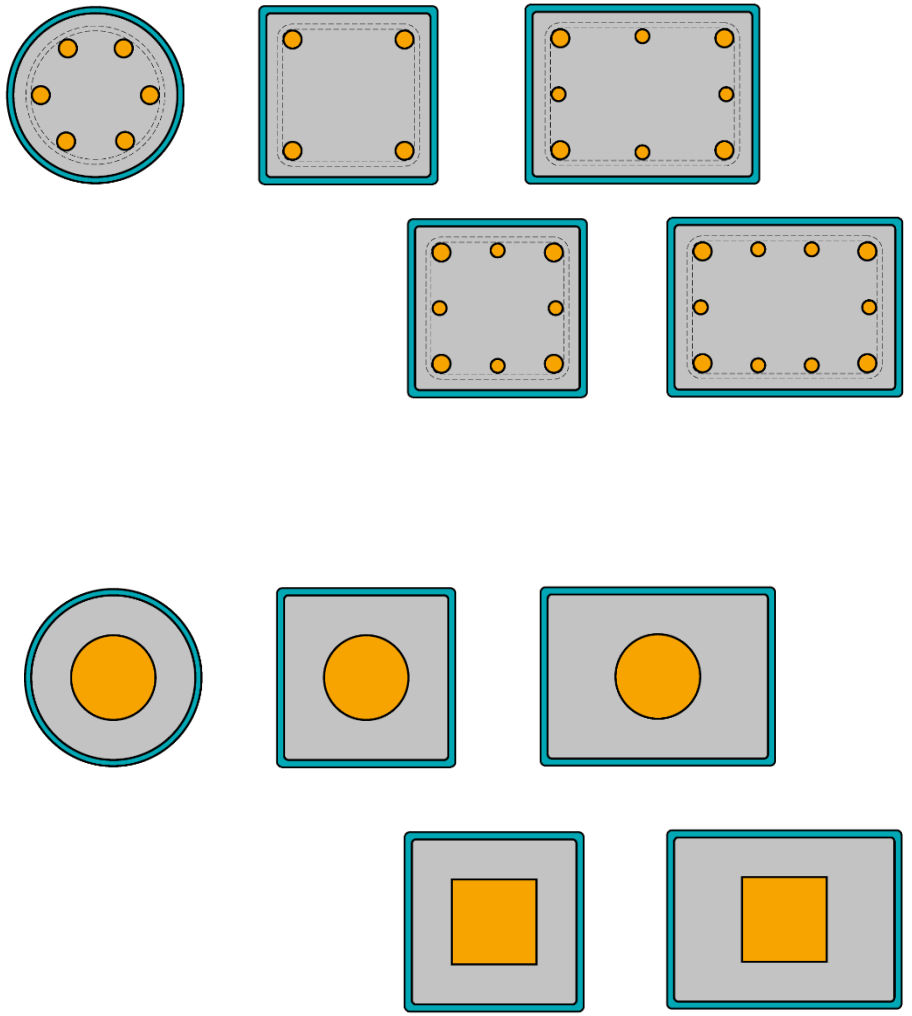



Multi-storey ATLANT® family columns




Single-storey ATLANT® family columns

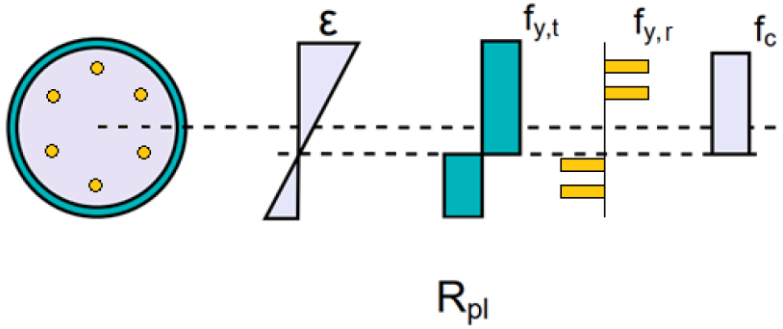
# ATLANT® Composite Columns Family

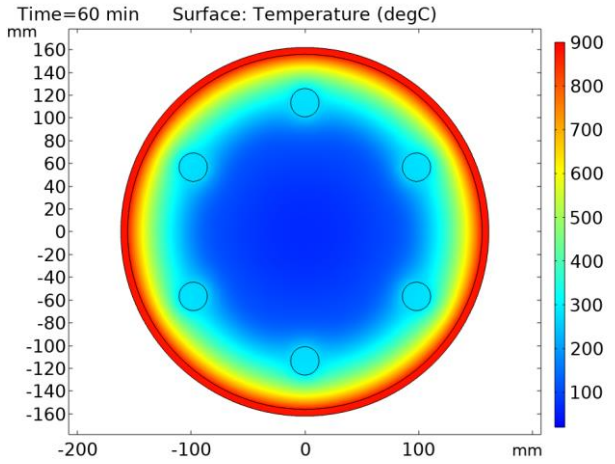



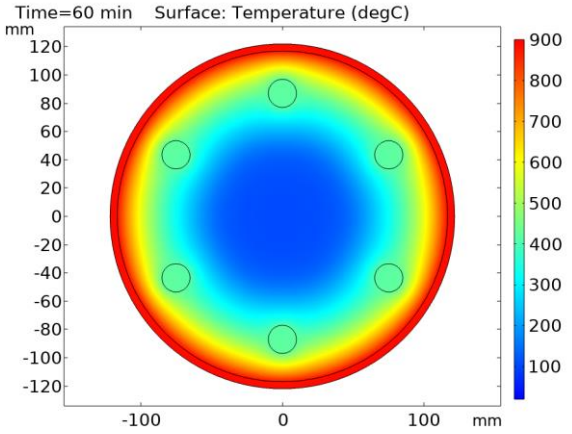
https://www.peikko.com/products/deltabeam-frame/atlant/

# ATLANT® design

- **Erection stage** EN 1993-1-1 or EN 1994-1-1
- **Final stage** according to EN 1994-1-1 Simplified method of design
- **Fire situation** according to EN 1994-1-2
  Simple calculation model with adjustments / calibration

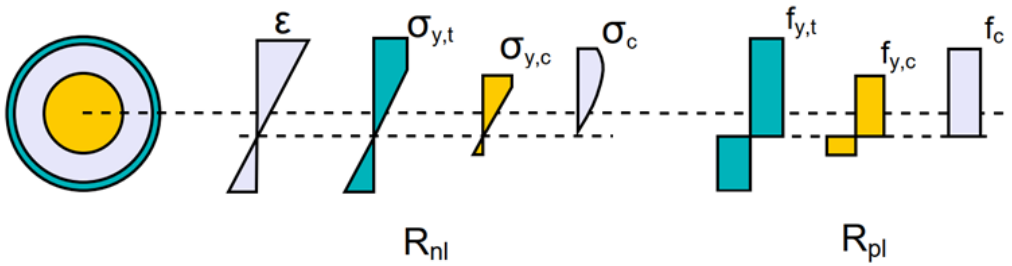


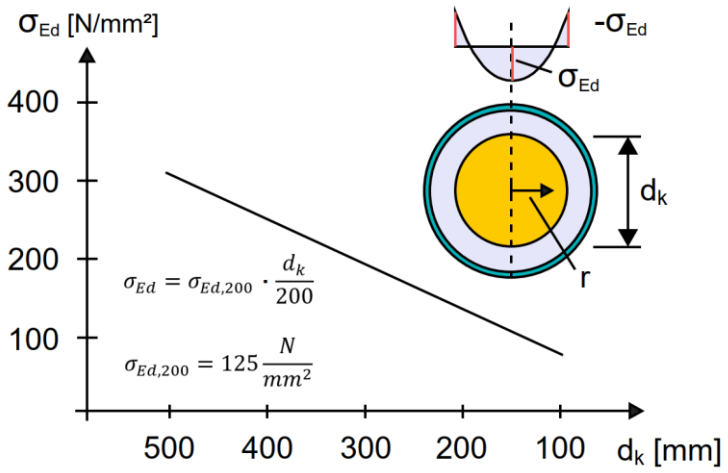



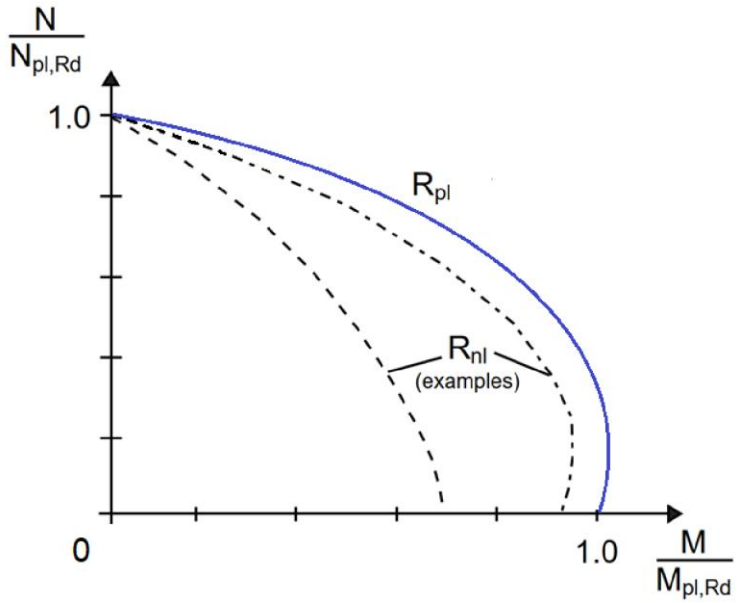



# ATLANT® Strong design

- **Erection stage** EN 1993-1-1 or EN 1994-1-1
- **Final stage** according to EN 1994-1-1
  General method of design
- **Fire situation** according to EN 1994-1-2
  Advanced calculation model

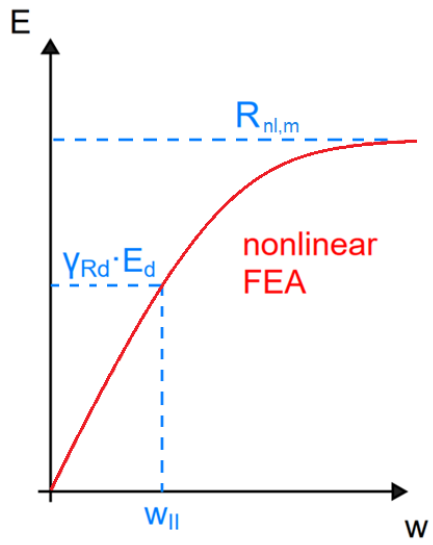


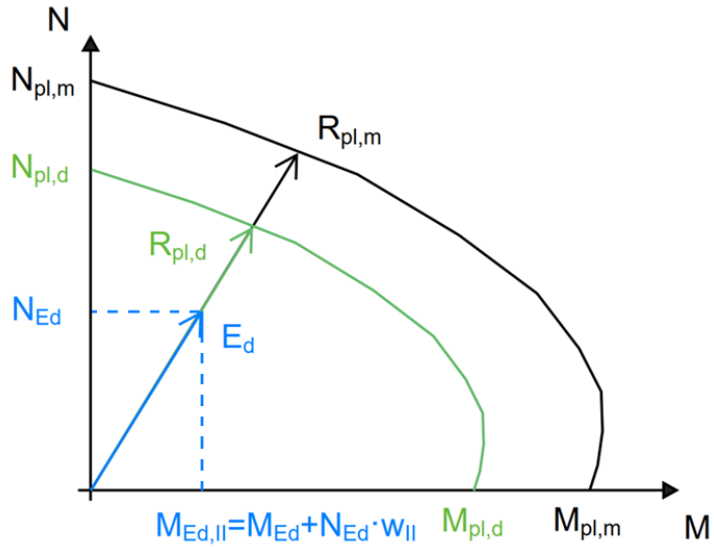



# General method of design

- **Overall partial factor**
- **GMNIA**
  - Nonlinear behavior of materials
  - Geometrical imperfections
  - Residual stresses in steel core
  - Concrete creep
  - Etc.
- **Calibrated model**




$$\gamma_{Rd} E\left(\gamma_g G_k + \gamma_q Q_k\right) \leq R\left(\frac{R_{nl,m}}{\gamma_0}\right) \qquad \gamma_0 = \frac{R_{pl,m}}{R_{pl,d}}$$

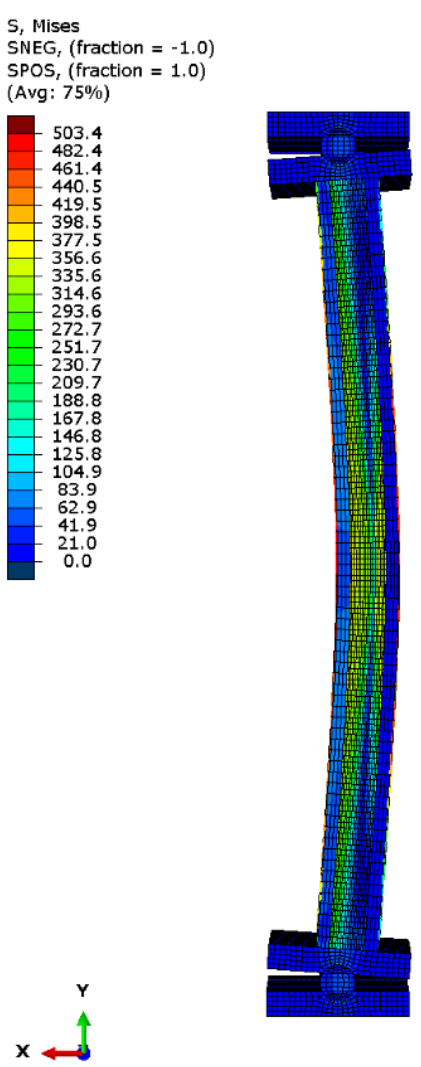
Open Access paper:
https://onlinelibrary.wiley.com/doi/epdf/10.1002/cepa.2717

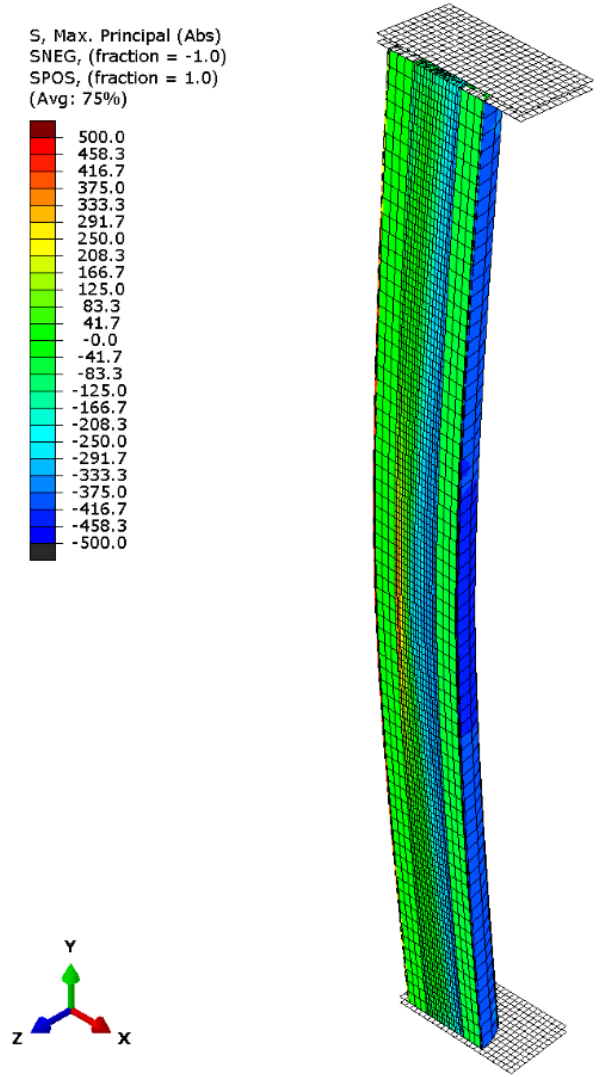
peikko®

# Initial and Final Finite Element Analyses (FEA)

**ABAQUS simulations:**

- Sensitivity analysis
- Parametric study
- Calibration with tests results

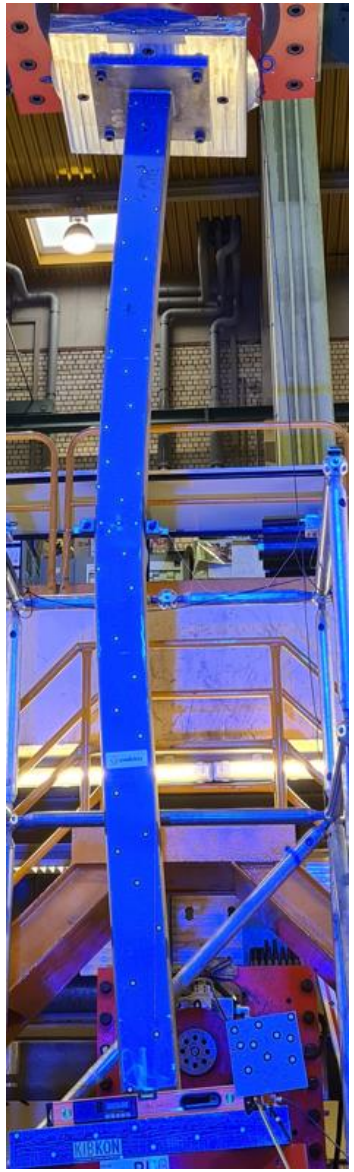


# Full-scale tests

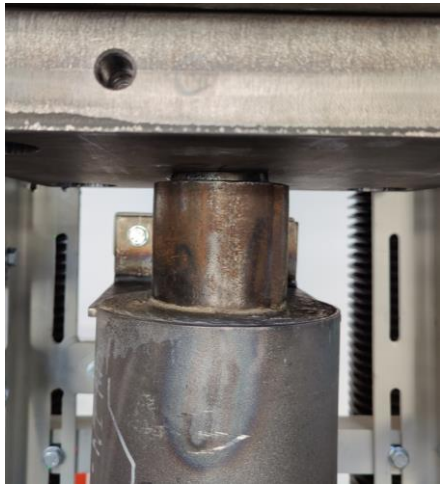
- Tests at Ruhr University Bochum (Germany)
- 4 pcs. 4.0 m long columns
- Various cross-section parameters

| Test | Col-1 | Col-2 | Col-3 | Col-4 |
|---|---|---|---|---|
| $D_{tube}$ / A × B [mm] | 177.8 | 406.4 | 180×180 | 300×300 |
| $t_{tube}$ [mm] | 4.0 | 8.0 | 5.0 | 8.0 |
| $D_{core}$ / A × B [mm] | 100 | 200 | 60 | 180×180 |
| $F_{max}$ [kN] | **1 710** | **10 019** | **2 267** | **8 561** |



# Small-scale tests

- Tests at Kaunas University of Technology (Lithuania)
- Hinge tests
- 17 pcs. 2.2 m long columns
- Various column parameters

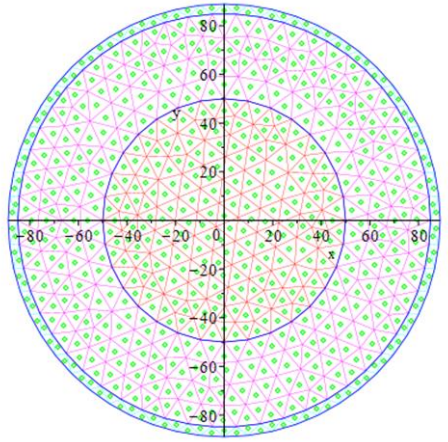


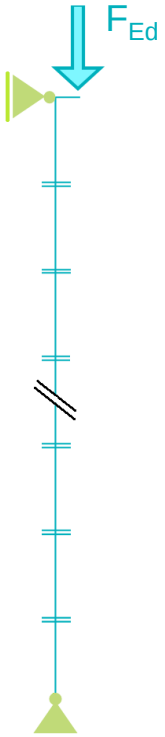

# Preparations and additional tests

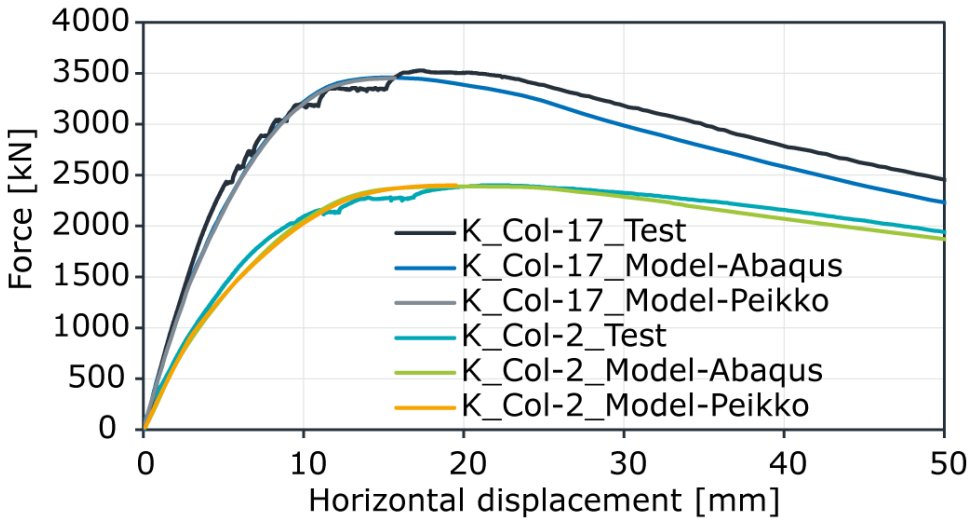
- Measurements of production tolerances
- Material tests
- Disassembly after tests


# Design method calibration

- **Calibration:**
  - Tests results
    vs
    Sophisticated FEA results
  - Sophisticated FEA results
    vs
    Practical FEA results
- ≤ 5% deviation from tests results

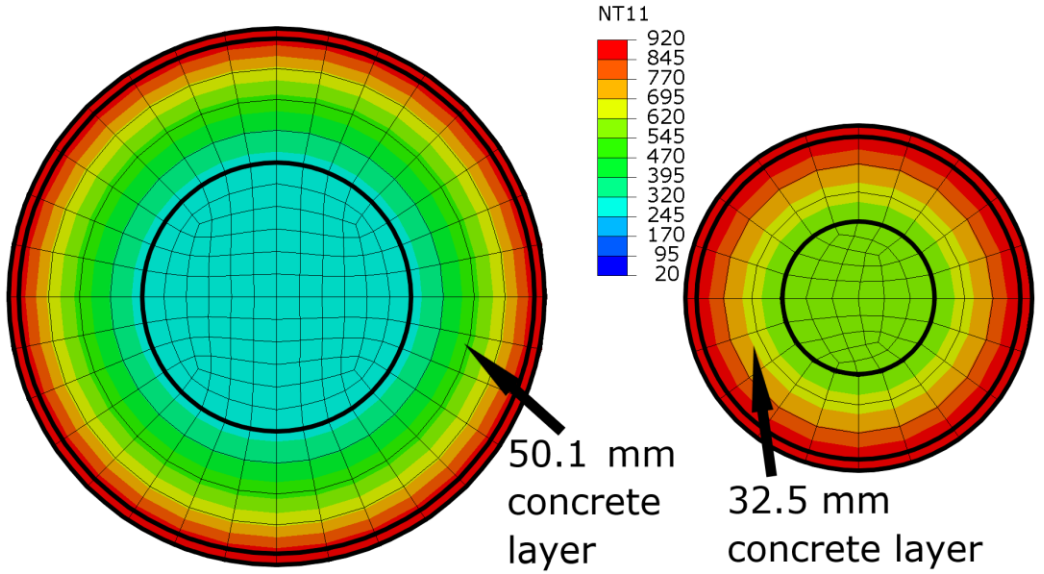


# Design for fire situations

- **Design method calibrated with tests results**
- **Concrete insulates steel core**
- **Observed sensitivity on:**
  - Initial imperfections
  - Column boundary conditions
  - FEA model parameters
  - Thermal material properties
  - Thermal expansion strains



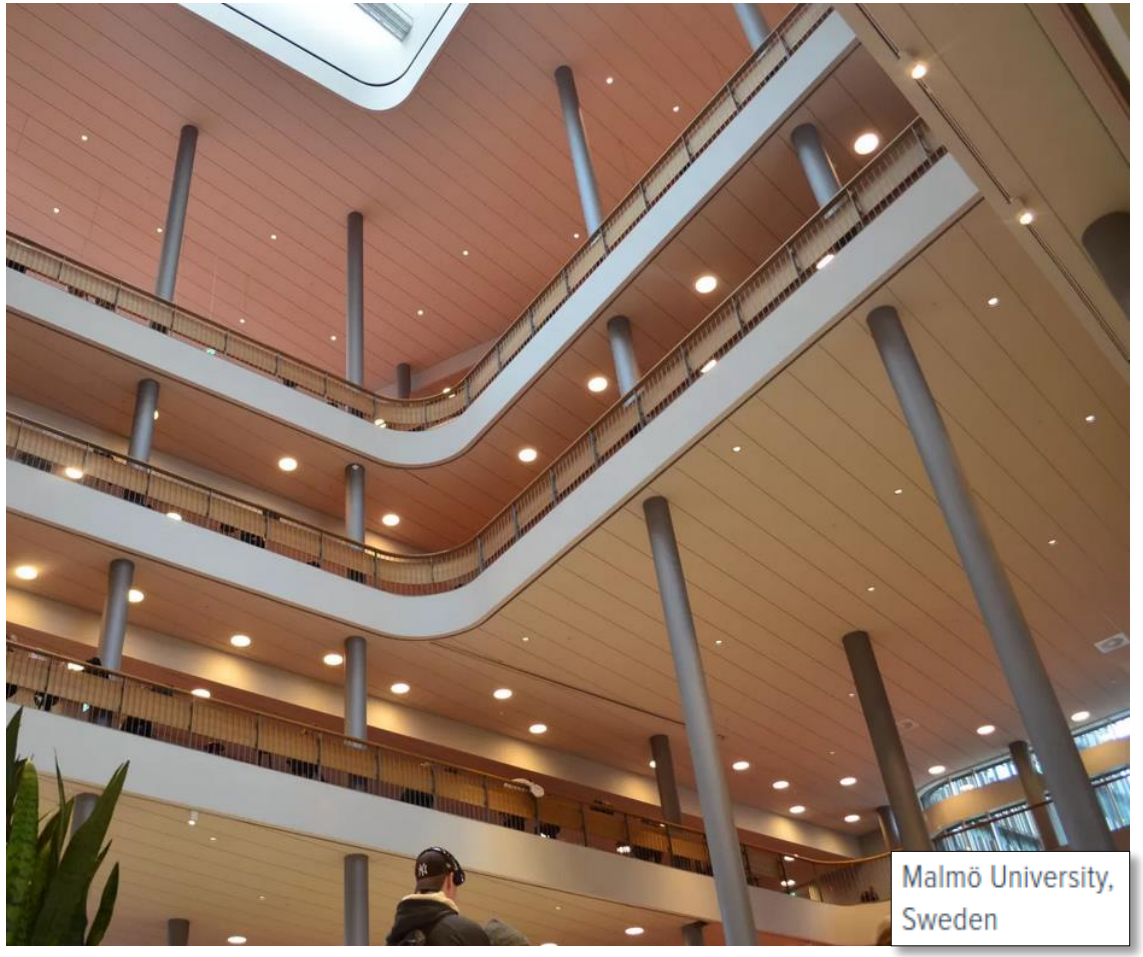
# Applications of ATLANT ® Composite Columns Family (1)


Elementary and Middle School Burgerspitalwiese, Austria

Library of Kangasala, Finland

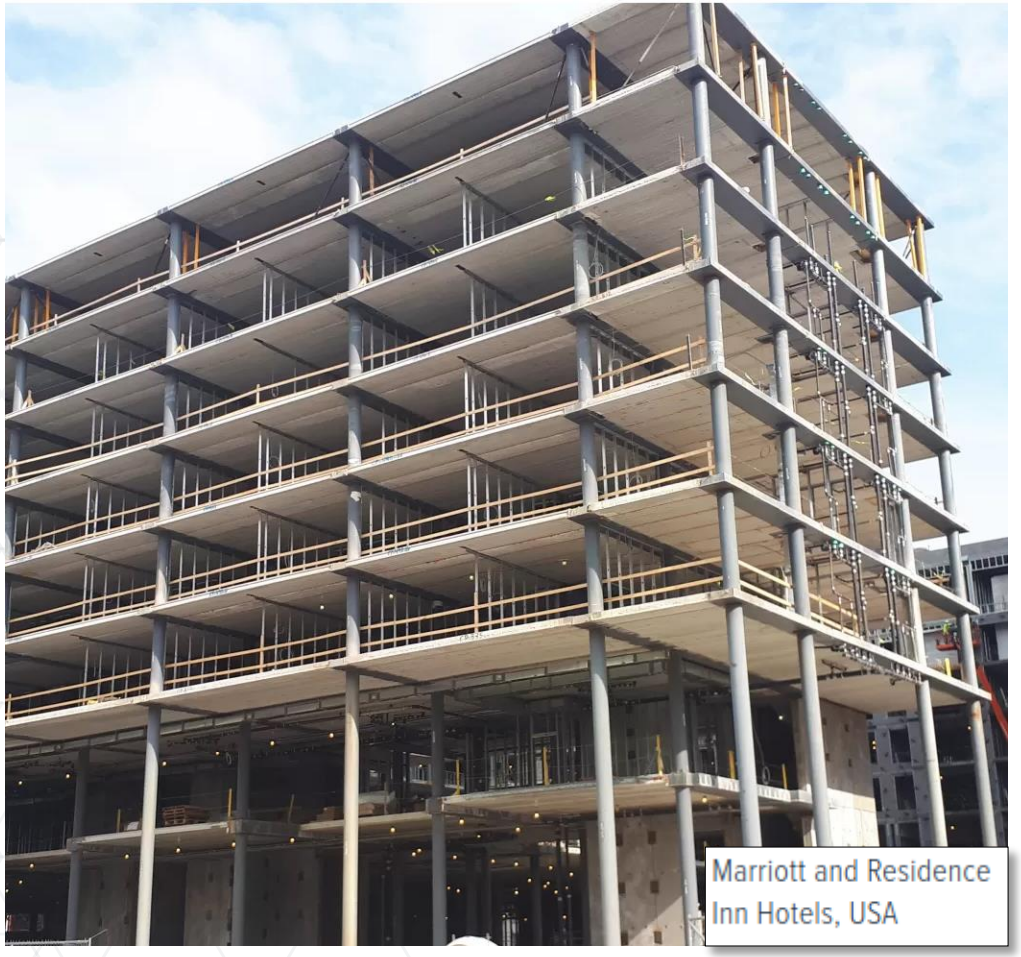
# Applications of ATLANT ® Composite Columns Family (2)

Kiefel Packaging office, Austria



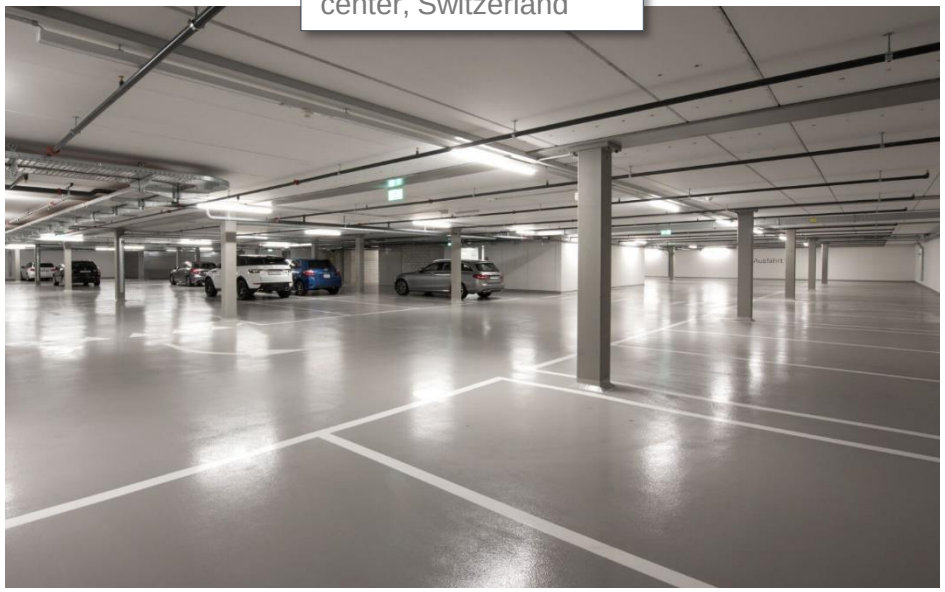
Malmö University, Sweden

# Applications of ATLANT ® Composite Columns Family (3)



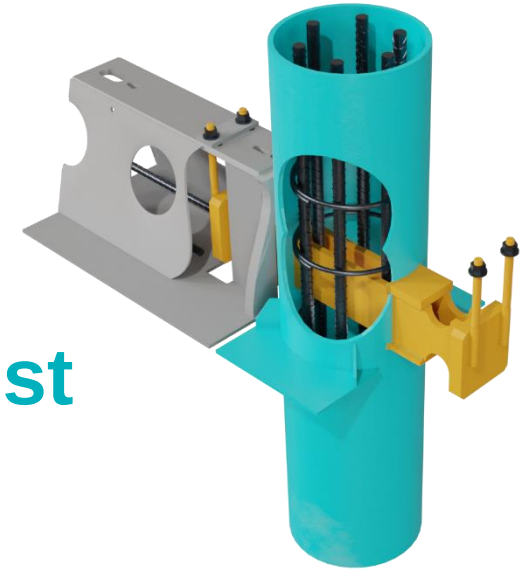
Marriott and Residence Inn Hotels, USA

Multiplex with shopping center, Switzerland

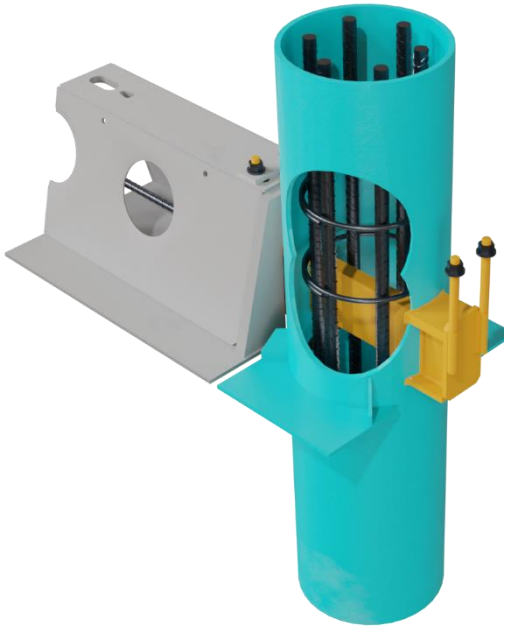


# KONAT® consoles

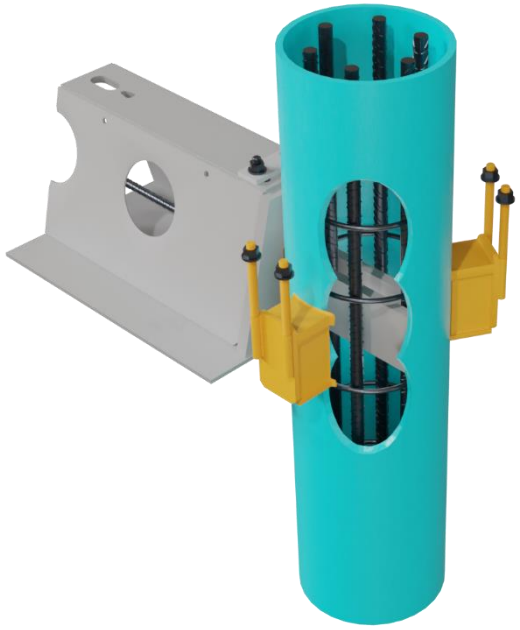
## KONAT® Robust



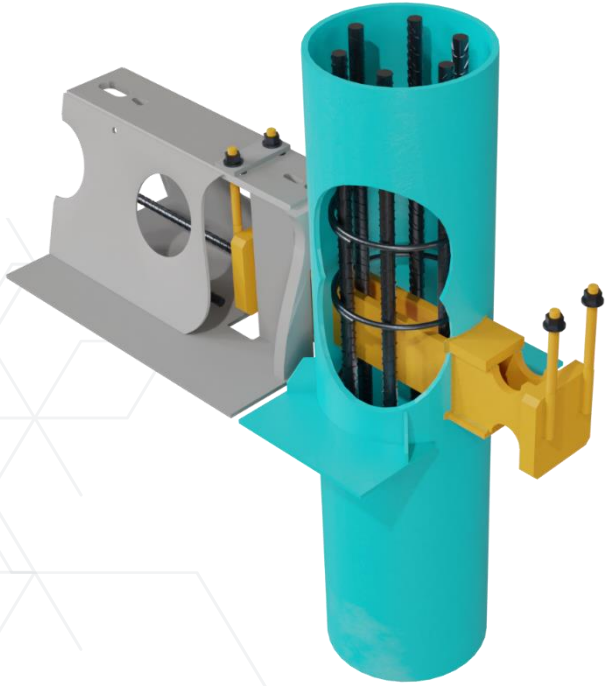
## KONAT®



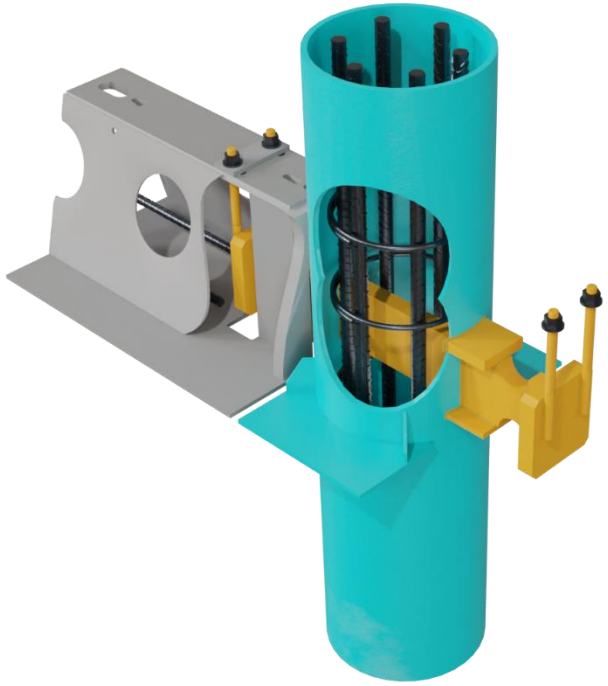
## KONAT® Multi



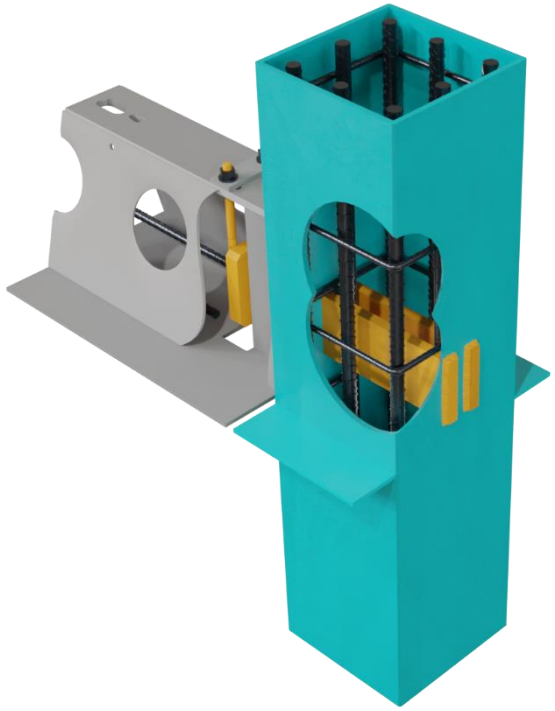
# KONAT® Robust



2 gusset plates, two-sided console



1 gusset plate, two-sided console



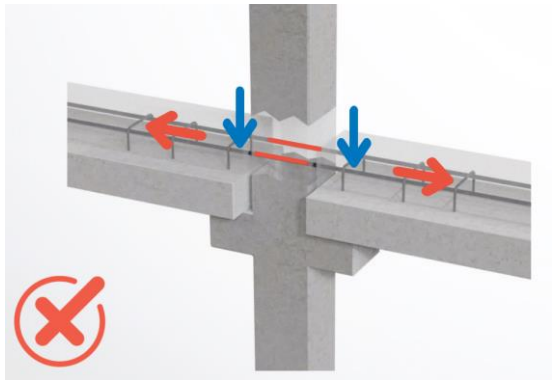
2 gusset plates, one-sided console

## Load classes

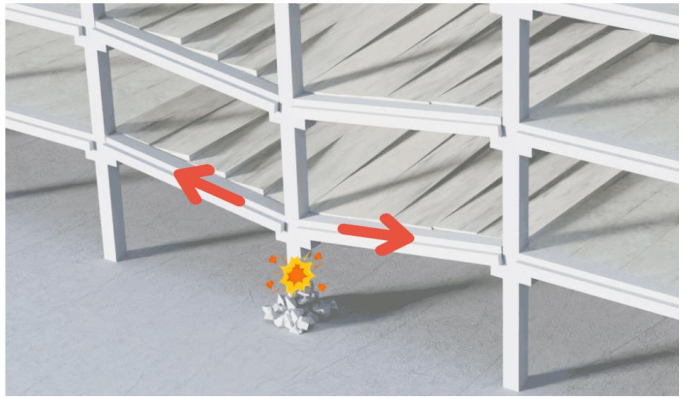
| 3 | 5 | 7 | 10* | 15* |
|---|---|---|---|---|
| 300 kN | 500 kN | 700 kN | 1000 kN | 1500 kN |

# Benefits of KONAT® Robust

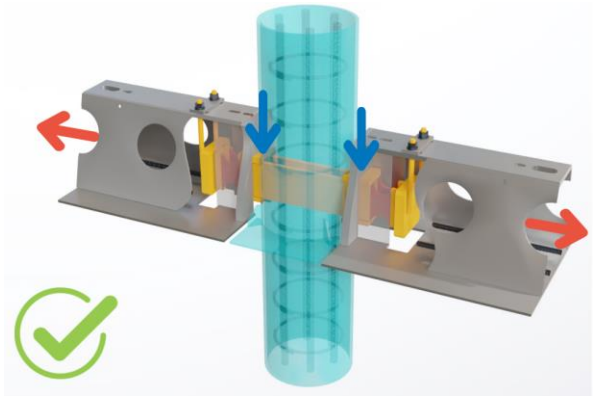
Normal exploitation situation



Inconvenient anchoring to reinforced concrete column

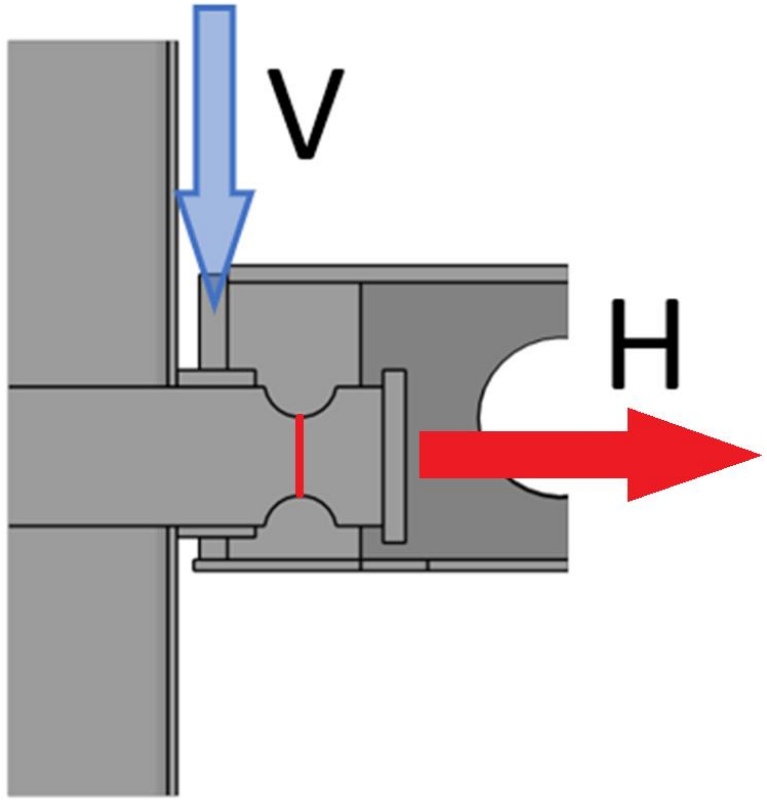


Accidental situation



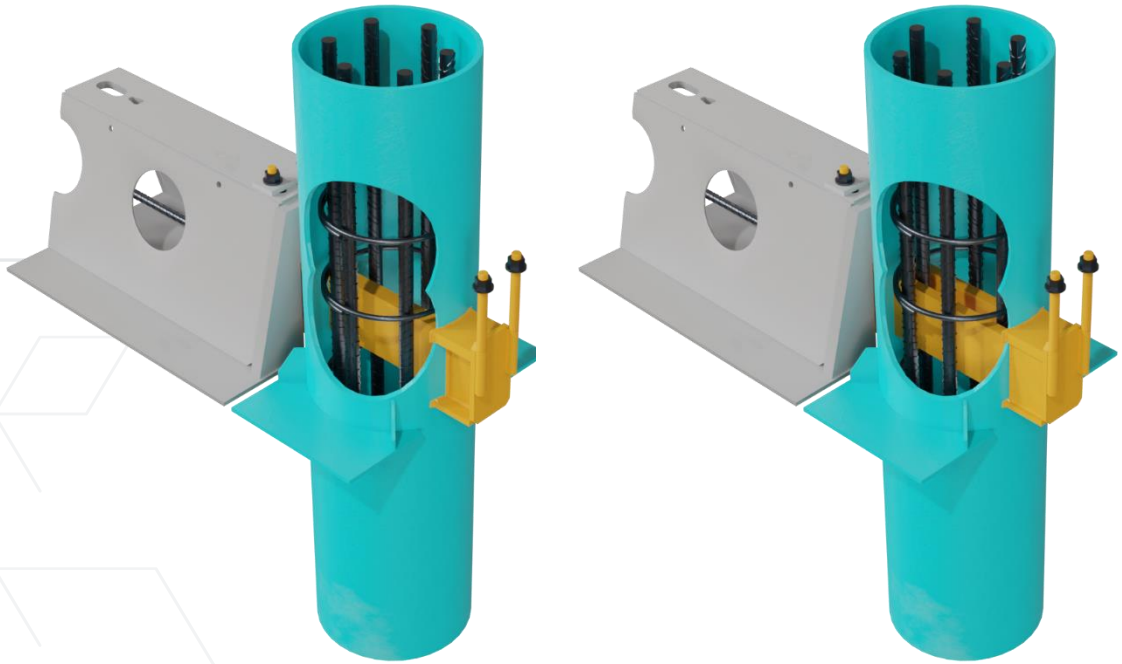
KONAT® Robust designed for normal and accidental situations

**Fulfilled robustness requirements** against progressive collapse acc. to EN 1991-1-7



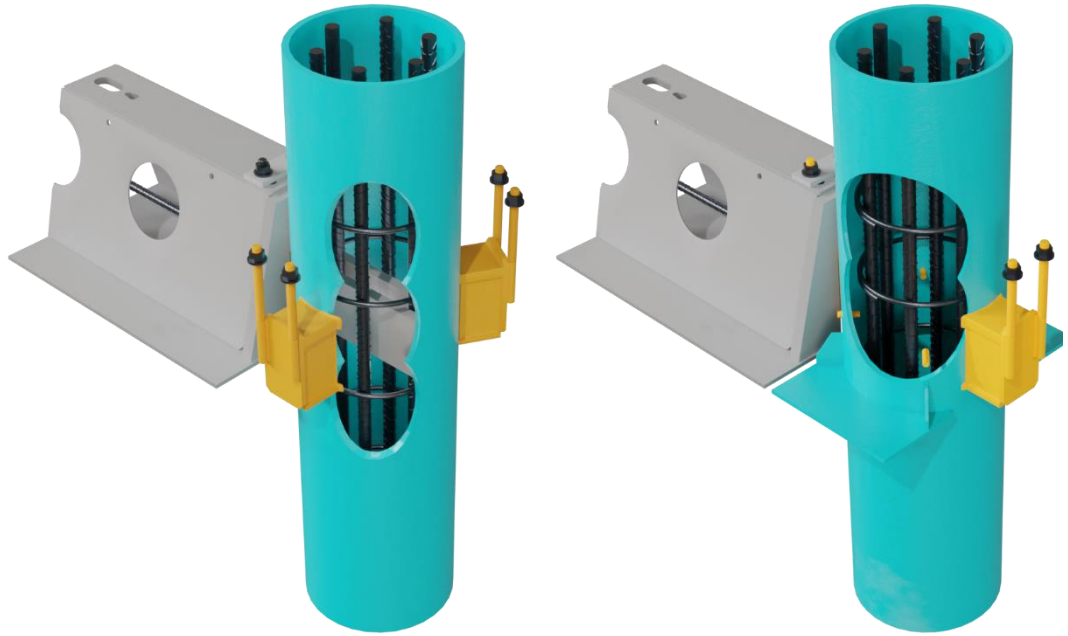

Principal scheme of actions and critical section in accidental situation

# KONAT® and KONAT® Multi



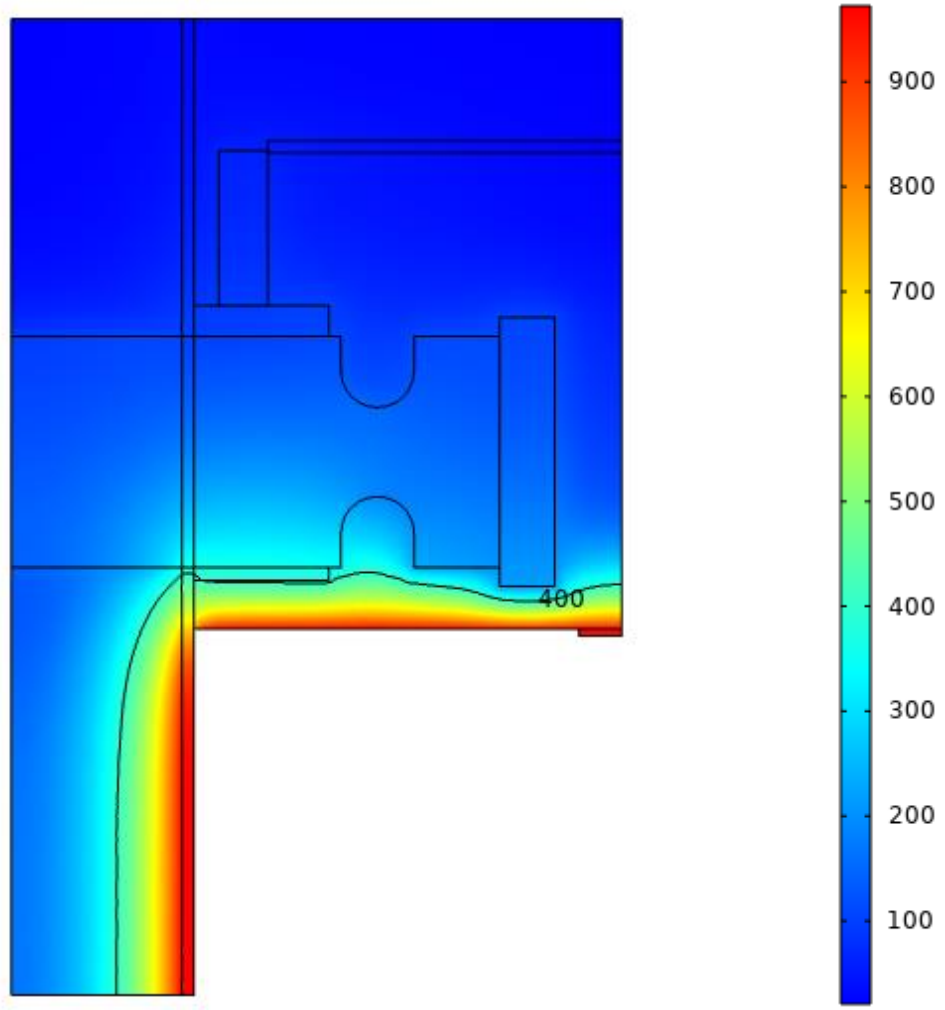
Two-sided KONAT® consoles with 1 and 2 gusset plates

Solutions with KONAT® Multi



# Design in Fire situation

- Concrete layer insulates steel components
- Example: FEA simulated temperature distribution in a joint with KONAT® Robust after 90 minutes of fire exposure



# Thank You for Your Attention
# Any Questions?

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