Simulation and testing of wall-to-diaphragm connections in masonry buildings

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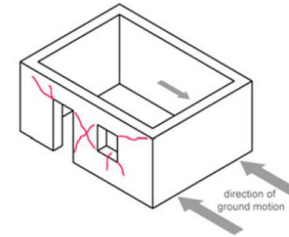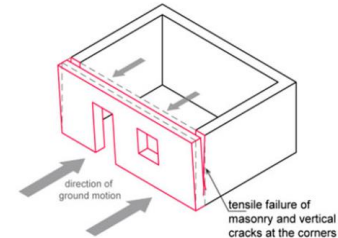
ISISE, University of Minho, Portugal

Why?

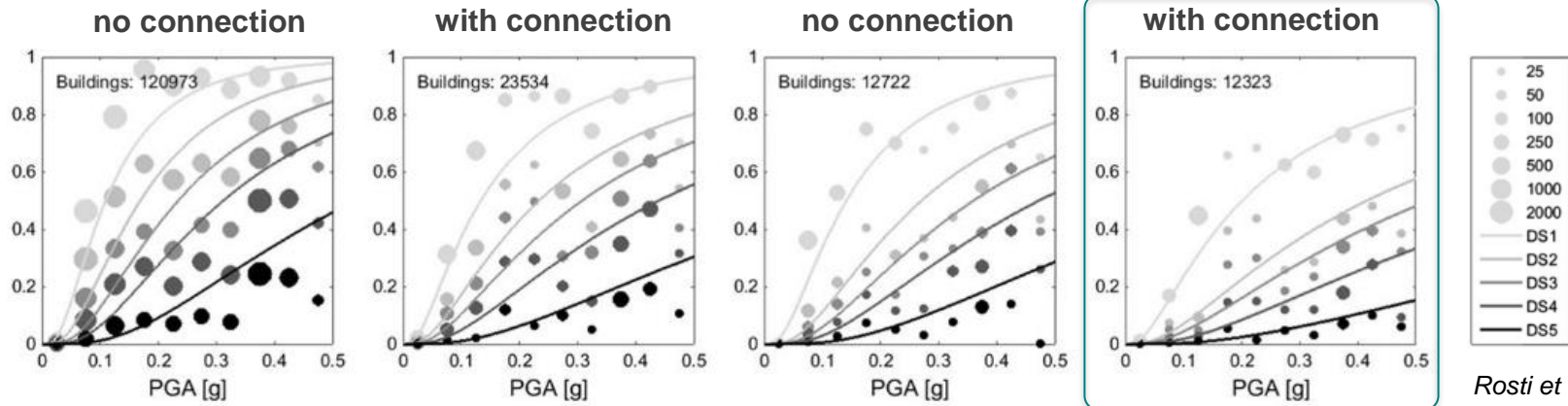Fatalities attributed to earthquakes (20th century)

75% – Failure of buildings

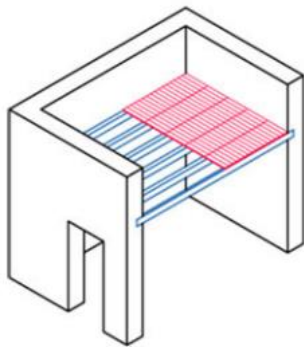**60% - Failure of URM buildings**
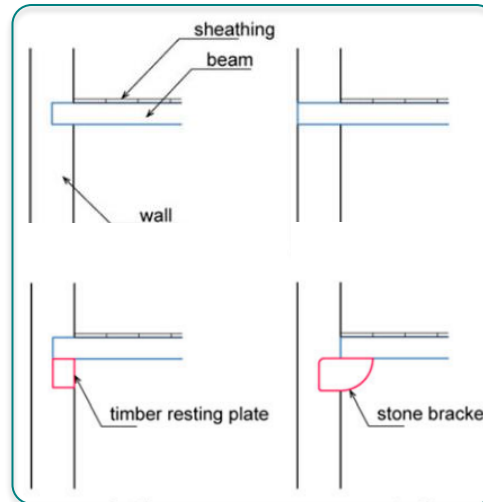

Ortega et al. (2018)

Flexible floors

no connection   **with connection**

Stiff floors

no connection   **with connection**

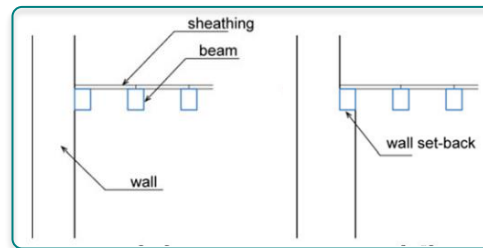*Rosti et al. (2021)*

WTD connections
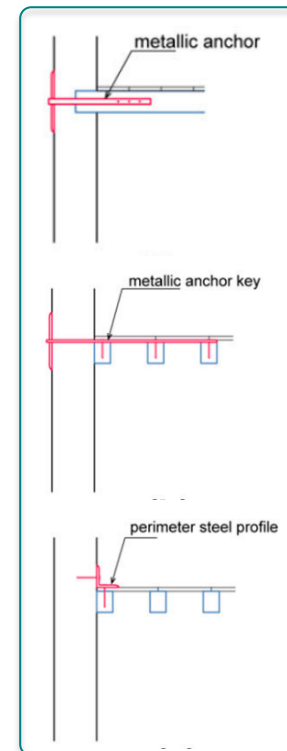

Ortega et al. (2018)

⊥ direction

// direction
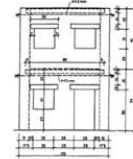

strengthening

Masonry buildings with timber floors
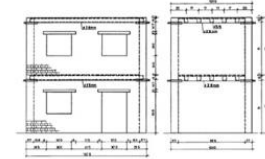
Refined FE models

- Diaphragms:
  Linear elastic behaviour
  Input from codes and tests

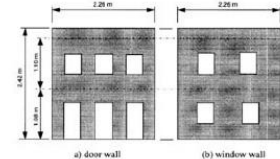- WTD connections:
  Hinged or fixed

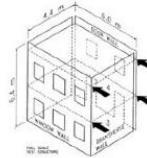## Pushover analysis

- Seismic input
- Control node

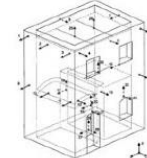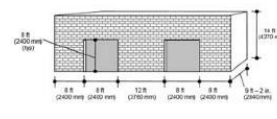Tomaževič et al. [71] Tomaževič et al. [72] Costley and Abrams [73]
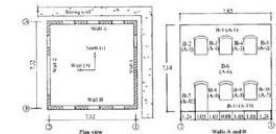
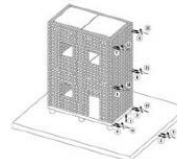Magenes and Calvi [74] Benedetti et al. [75] Juhásová et al. [76]
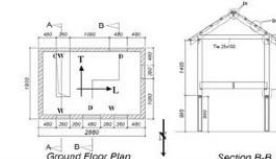
Cohen [77] Yi et al. [29, 78] and Moon et al. [79] Dolce et al. [38]
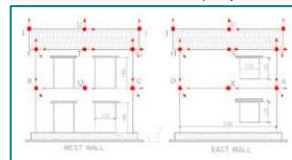
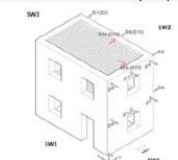Tomaževič et al. [80] Bothara et al. [81] Mazzon et al. [82]
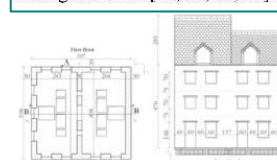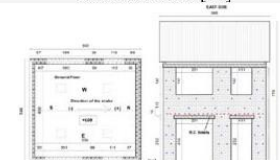
Magenes et al. [39, 83, 84, 85] Mendes [86] Vintzileou et al. [87]
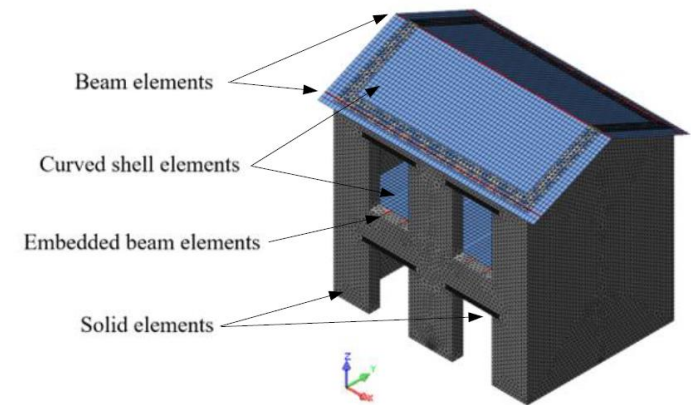
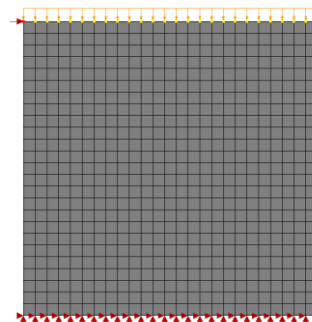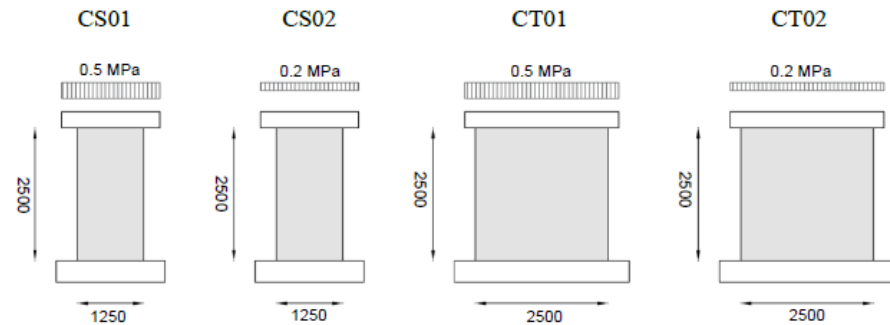Senaldi et al. [88] Graziotti et al. [89] Graziotti et al. [90]

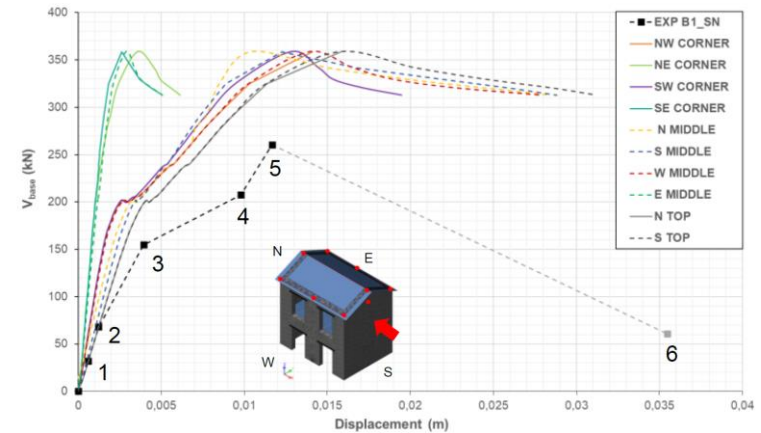# Numerical simulation of EUCENTRE building
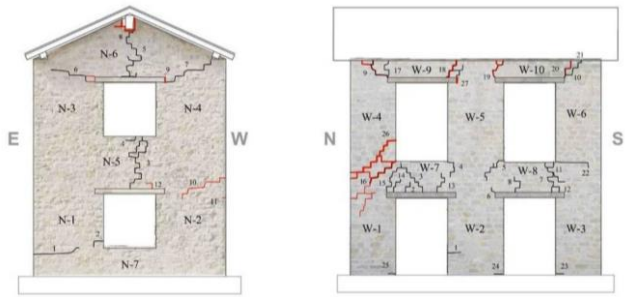

Magenes et al. (2010)

Results

- Overestimation of V_{max} (+35%)
- Fairly simulated the IP failure mechanisms
- Not consistent damage in the OOP walls
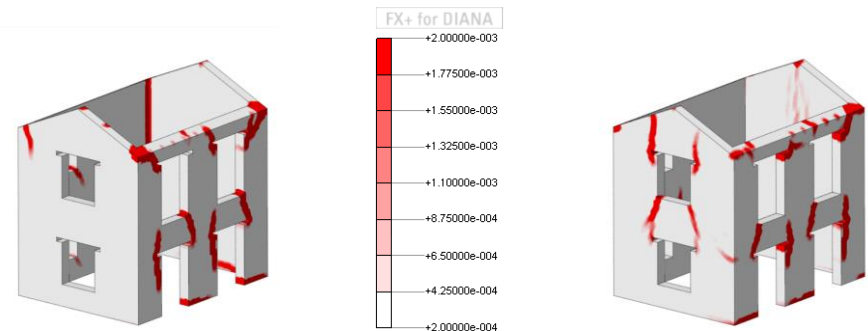- → Need for WTD behaviour

Pushover (SN direction)

Experimental results

Senaldi (2012)

Numerical model
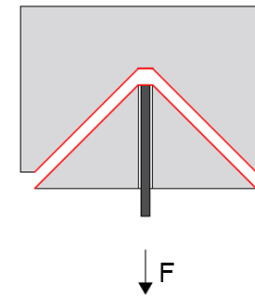
Injection anchors

Common technique to improve WTD connections
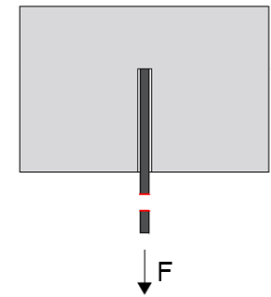
Several possible failure modes

When used in stone masonry:
- Little experimental evidence of their structural behaviour
- No specific design formulas in current building codes and guidelines
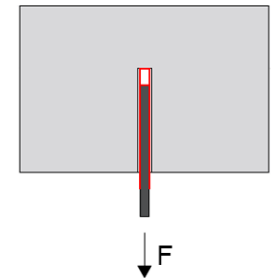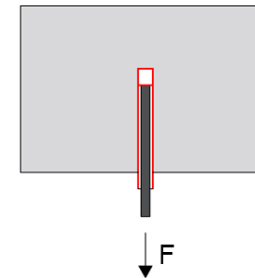
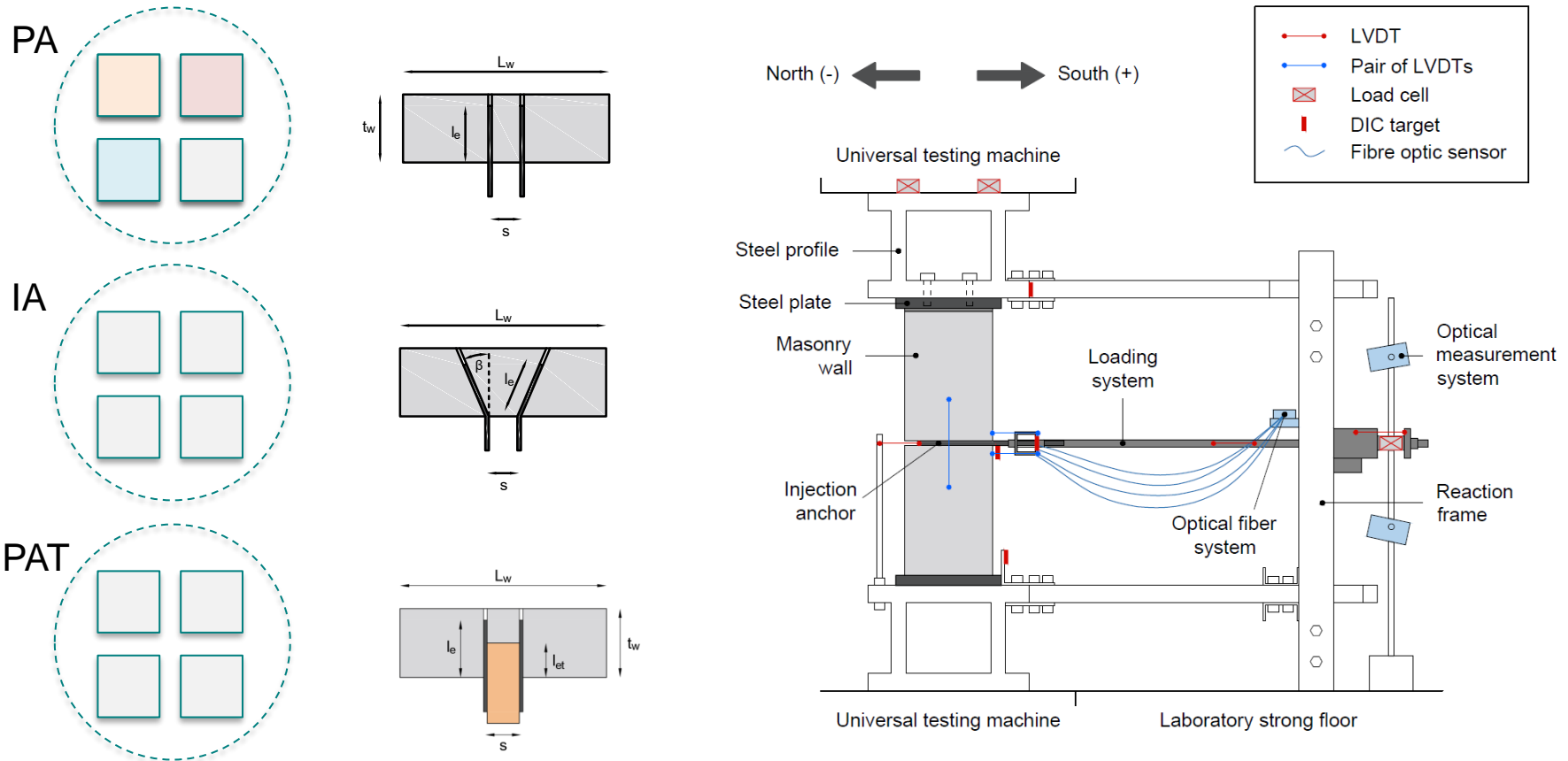Masonry breakout failure · Tensile failure of the rod

Masonry · Rod · Injection material

Bond failure at the interfaces

Pull-out tests

$\sigma_v = 0.1 - 0.3$ MPa

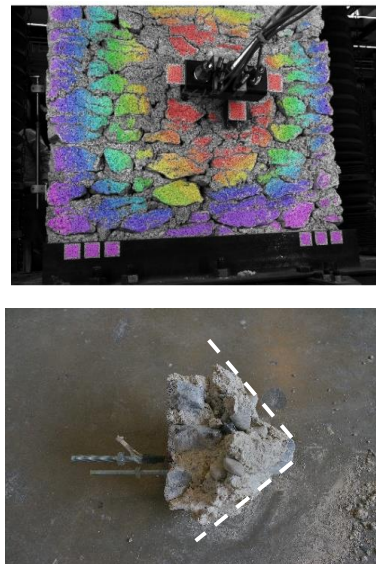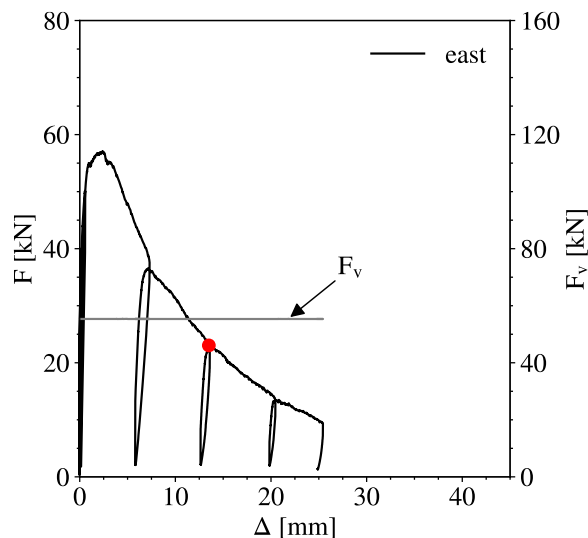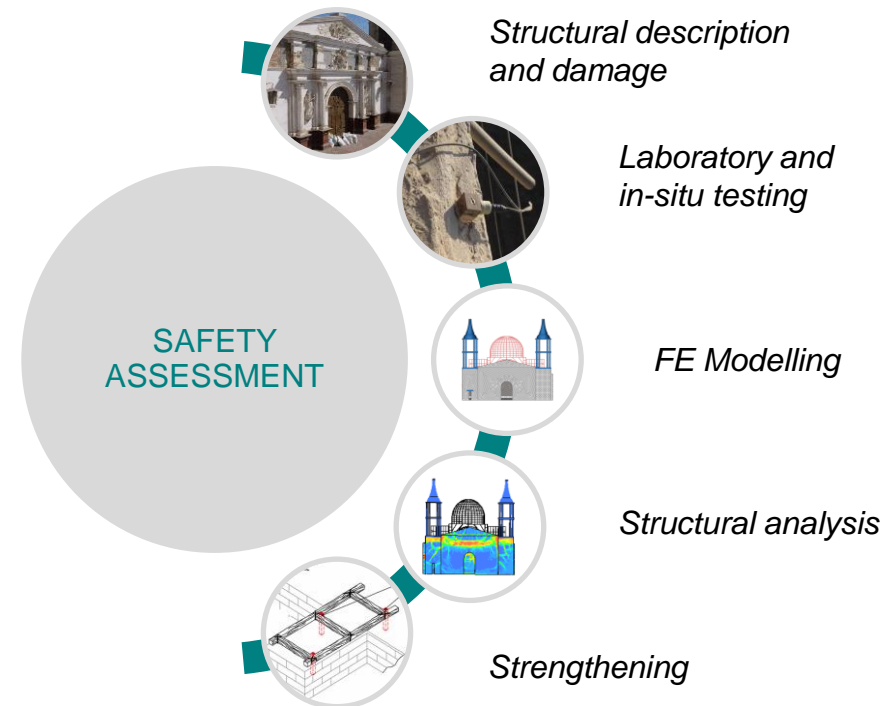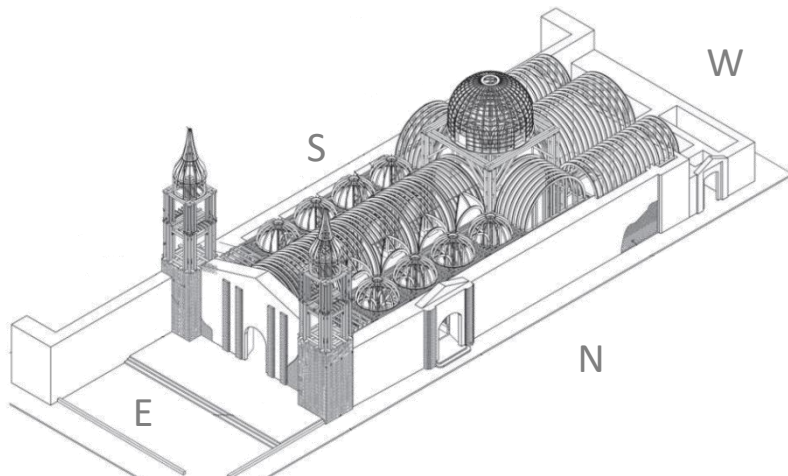# Results
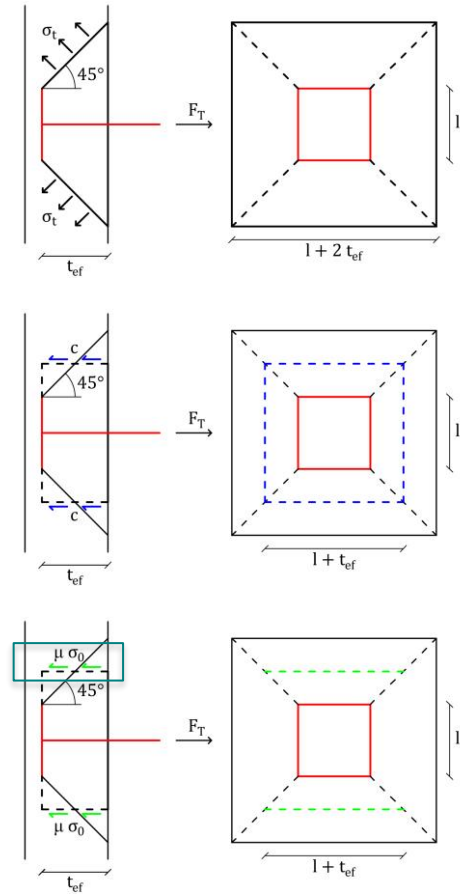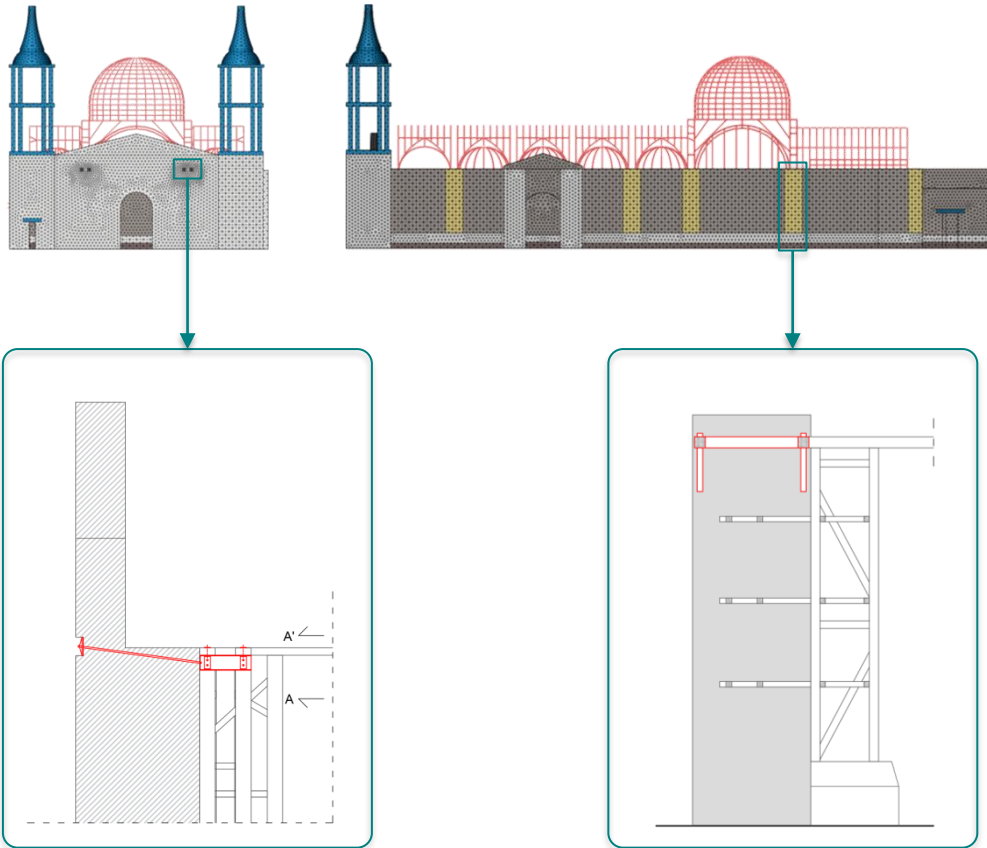
- F-Δ curves & damage
- Test existing formulas for F_{max}

→ Need for an analytical model with σ_v

Ica Cathedral

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Structural description and damage

Laboratory and in-situ testing

SAFETY ASSESSMENT
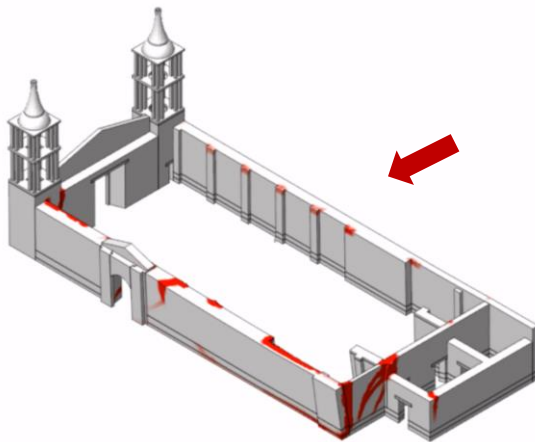
FE Modelling
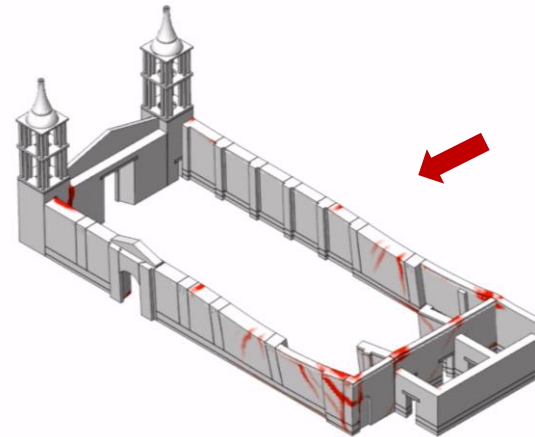
Structural analysis
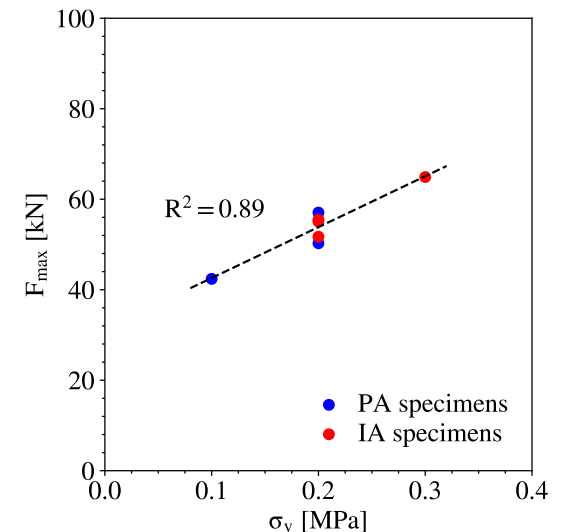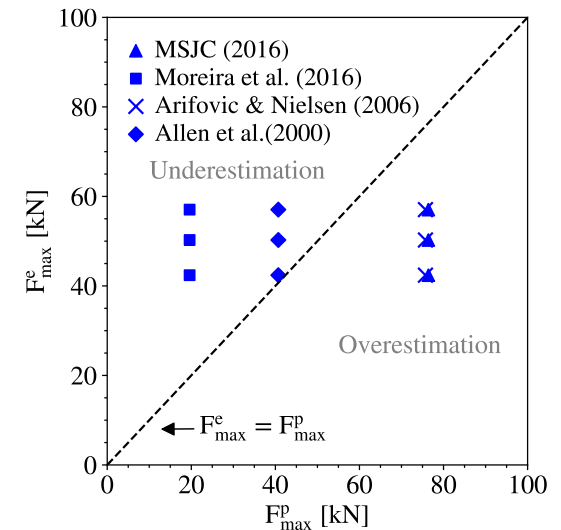
Strengthening

Strengthening

Results

Unstrengthened model (0.28g)

Strengthened model (0.45g)

Final remarks

Focus on WTD connections

Benchmark numerical study

- Applicability of common assumptions in current practice
- Simulation of IP walls
- Need to enhance the contribution of WTD in the building response

Laboratory test campaign

- Experimental data
- Different configurations and σ_v
- Need for an analytical model specific for anchors in rubble stone masonry

Application to a real case study

- Recommendation and simplified formulas for WTD strengthening

Thank you

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