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U.PORTO

FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Modelling RC masonry infilled frames under earthquake loading: from accurate micro-models to simplified macro-models.

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Motivation and objectives

- Based on the observations of several recent earthquakes, the vulnerability of the masonry-infilled RC frames is clear.



a) Infill shear and minor frame damages, Nepal 2015



b) Infill shear and major frame damages, Chania 2008



c) A collapsed soft storey apartment building in the Marina District, San Francisco 1989 (Loma Prieta Earthquake)



d) Damage to an apartment building with a soft first storey in Bordj-Kiffan city, Algeria 2003

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Motivation and objectives

- Based on the observations of several recent earthquakes, the vulnerability of the masonry-infilled RC frames is clear.
- In order to assess the structural contribution of the infill panel to the structural behaviour, a realistic model for the infill panel is urgently needed.

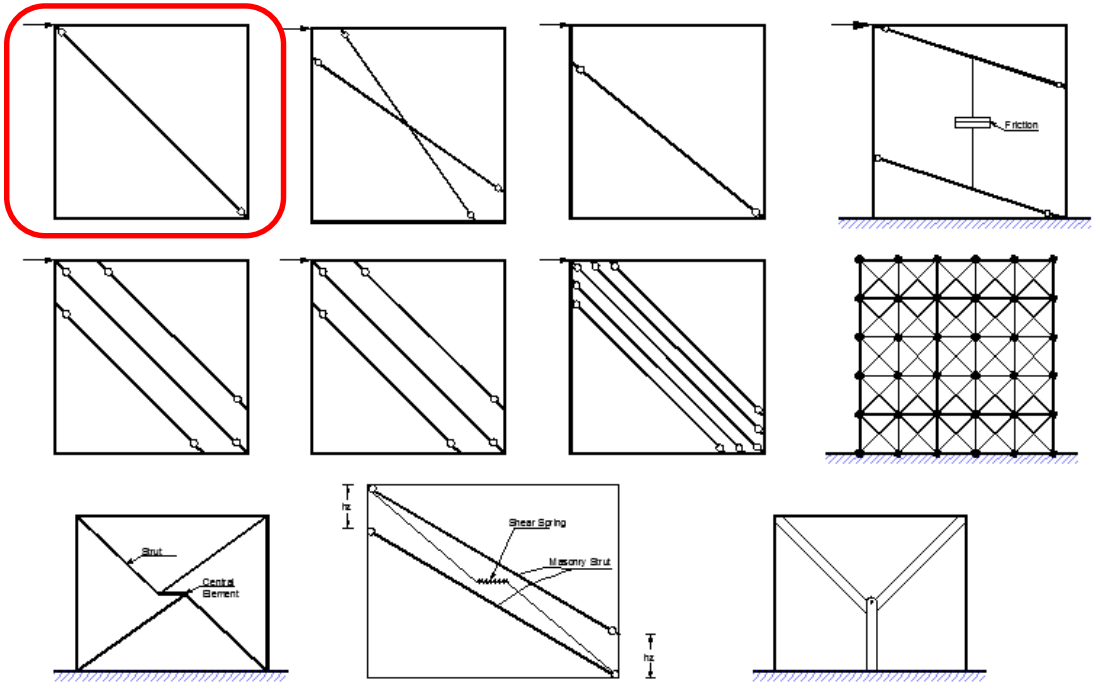
Tasks

- Define the best model to simulate the behaviour of masonry-infilled RC structures.
  - A comprehensive review of existing macro-models (single strut model)
  - Numerical calibration of the proposed models' parameters (based on stiffness or strength characteristics)
  - Experimental calibration of the proposed models' parameters
  - Micro-modelling approach as a proxy for the experimental data

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A comprehensive review of the existing macro-models (strut model)

- Polyakov's experimental observation on the late 1950s
- Several attempts have been carried out to define the configuration and structural parameters of this equivalent element.



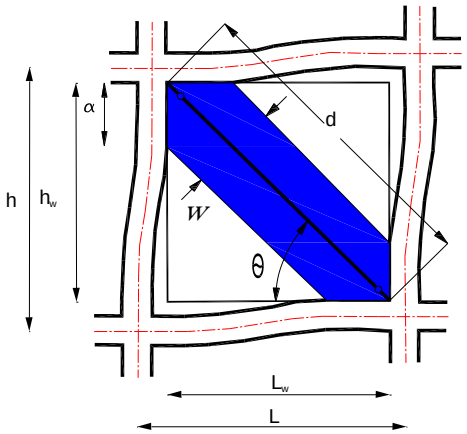
Various examples of strut models

A comprehensive review of the existing macro-models (strut model)

- Polyakov's experimental observation on the late 1950s
- Several attempts have been carried out to define the configuration and structural parameters of this equivalent element.
- Using a single strut element provides a simplified and efficient way to represent the effect of the infill panel on the structural behaviour of the building

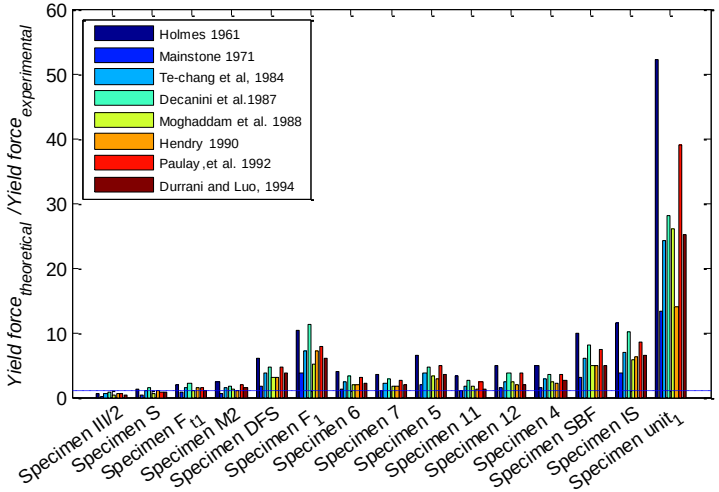
Calibration of the single strut model

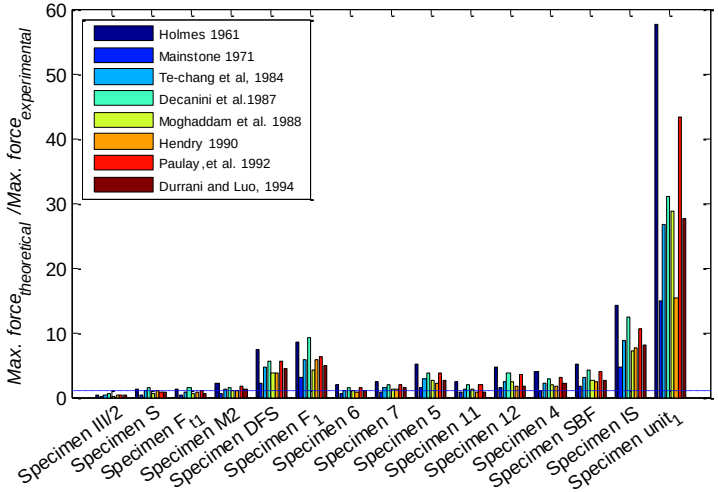
- Based on the literature, the calibration of the single strut model could be done through main approach:
  - ✓ Stiffness approach.
    - ❑ Area of strut (several formulas are found)
    - ❑ Constitutive model for the equivalent material. *(based on the masonry compressive strength f_m)*
  - ✓ Strength approach
    - ❑ Force-displacement backbone curve.

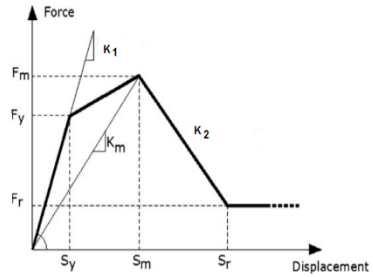


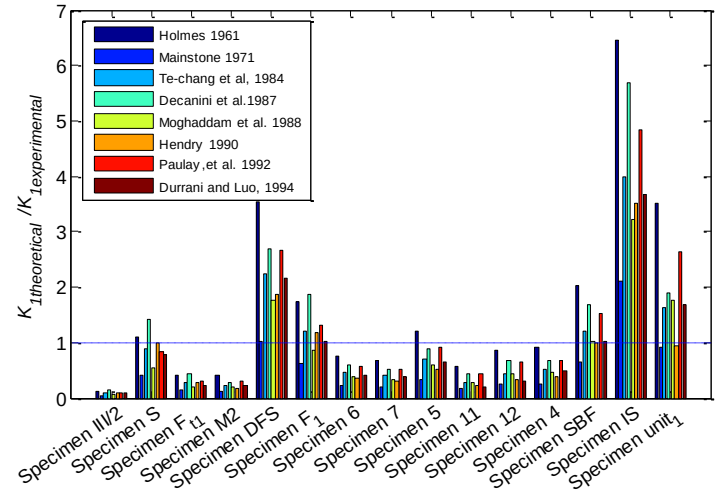
Stiffness approach.

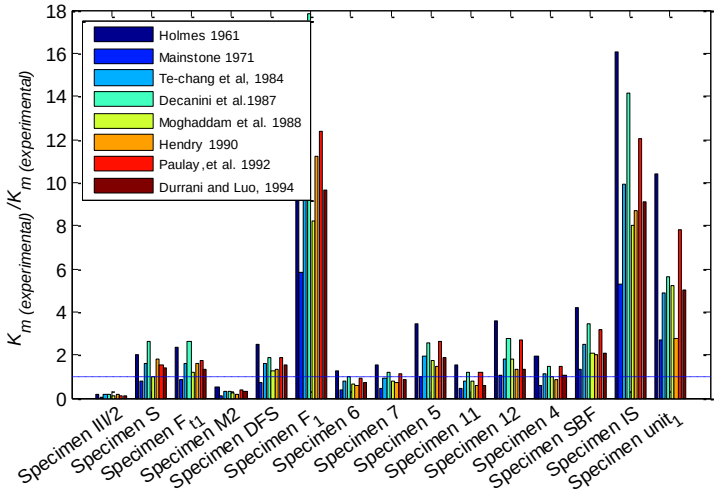
- **8 different formulas** were used to evaluate the **width of the strut** for 15 fully infilled specimens from 10 experimental campaigns







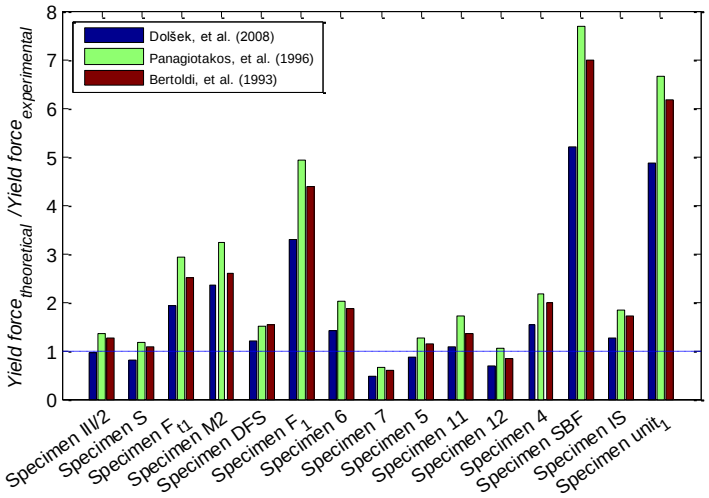


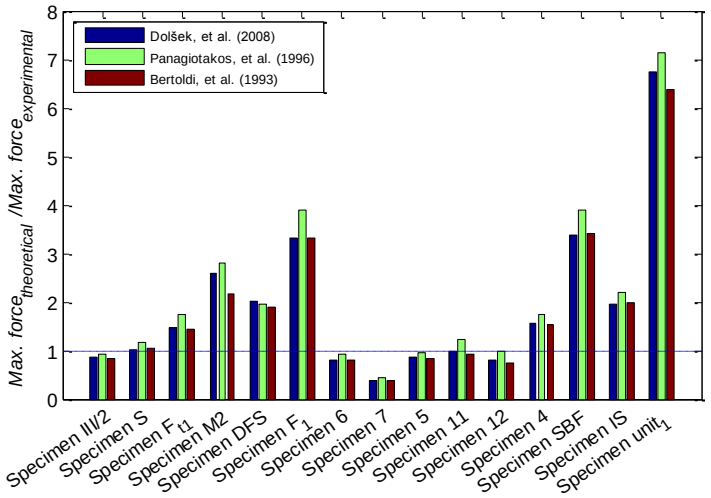


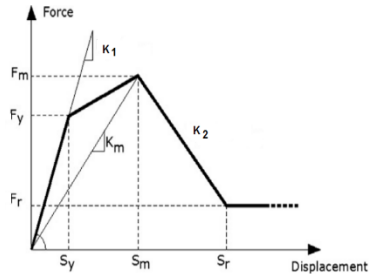
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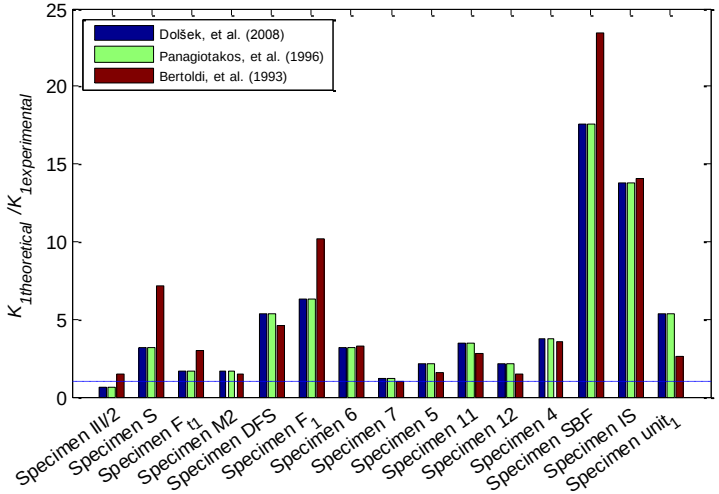
Strength approach.

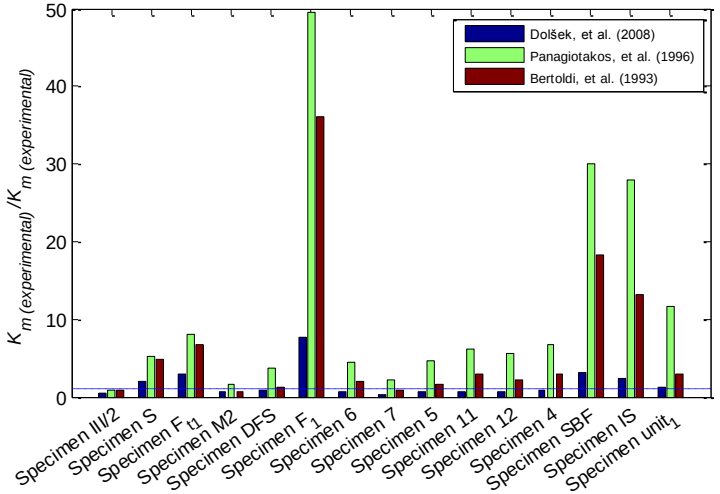
- **3 different formulas** were used to evaluate the **force-displacement curve of the strut** for 15 fully infilled specimens from 10 experimental campaigns











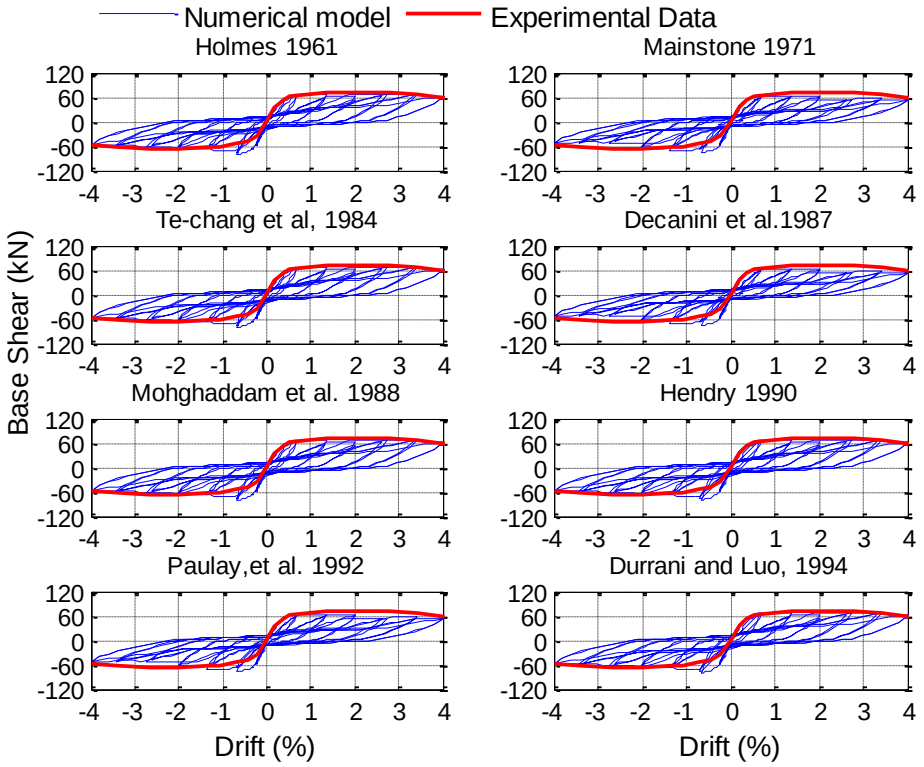
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Experimentally-based calibration

- Force-displacement curve is defined
- Several formulas are used to estimate the area of the strut.
- Based on the max. force and the numerical area of the strut obtained, a fictitious strength is calculated. This strength defines the material of the strut instead of the real masonry material.

❖ Fully infilled specimens
- specimen M2
- specimen S

❖ Partially infilled specimens
- specimen DO2
- specimen DX1
- specimen WO2
- specimen WX1



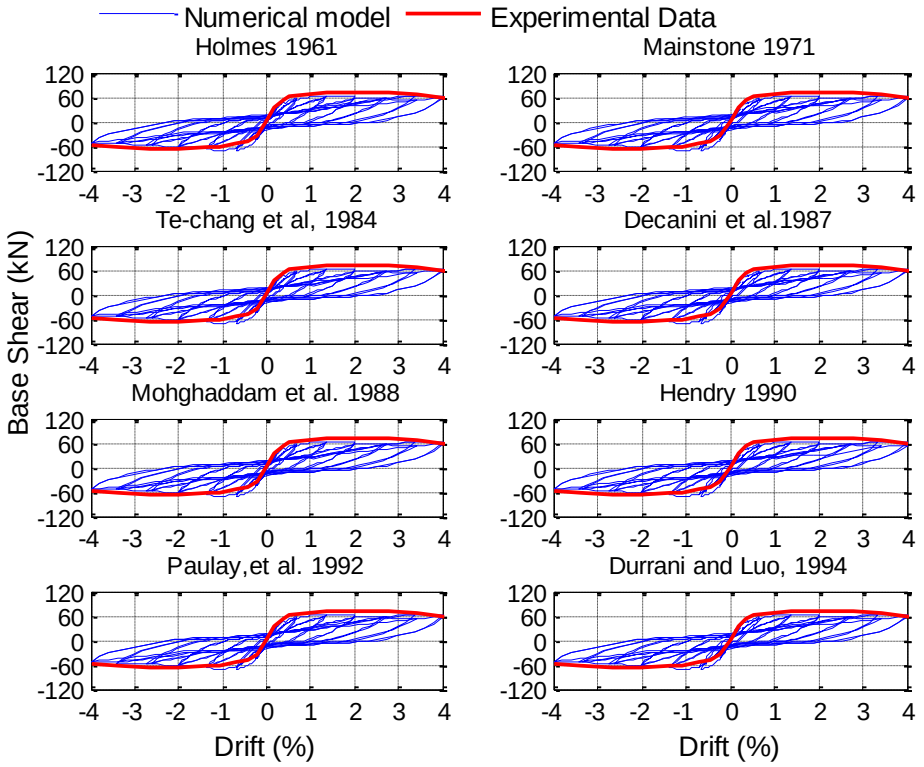
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Micro-modelling approach as a proxy for the experimental data

- The micro-modelling approach is as an effective tool to simulate the behaviour masonry-infilled RC structures when experimental data is not available.
- Based on predefined and checked detailed micro-models, the structural parameters of the strut were calibrated again.

❖ Fully infilled specimens
- specimen M2
- specimen S

❖ Partially infilled specimens
- specimen DO2
- specimen DX1
- specimen WO2
- specimen WX1



Conclusions

- The structural behaviour of the infill panel in masonry-infilled RC structures can be presented by a single strut model.
- Calibration of the strut model parameters based on the strength approach is more realistic when compared with the stiffness approach
- The experimentally-based calibration of the strut model parameters minimizes the error in structural response when compared to strength or stiffness approaches (which may lead to very large errors).
- The use of a micro-modelling approach as a proxy to the experimental data to calibrate the strut parameters is able to represent the real behaviour of the infill panel with a reasonable errors (the error of the estimated initial stiffness and maximum force is less than 20%).