



François VILLETTE
 Thèse, 2017 – 2020
 3SR Lab (Jean-François BLOCH,
 Frédéric DUFOUR, Sabine ROLLAND,
 Julien BAROTH)

Endommagement de milieux hétérogènes : Le Papier en tant que matériau modèle

Damage in heterogeneous media: paper as a model material

Context

Issues

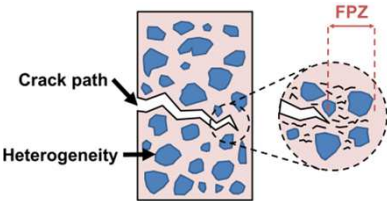


Malpasset dam breakage

- Civil engineering : strength of concrete (*photo*).
- Geotechnical: rock failure.
- Defects in wood structures.
- Damage in paper.

Problematic

Understanding of damage in quasi-brittle materials: microcracks localized into the neighbourhood of crack tip, so-called Fracture Process Zone (FPZ).



Numerical models involve internal length.

Which characteristic length is relevant ?

Why paper as model material?



Microstructure of Kraft paper

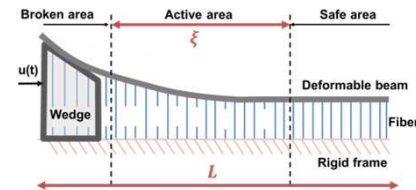
- Well-controlled process of the heterogeneities formation.
- Structure easily identifiable at both mesoscale (*photo*) and microscale.
- Damageable visible during experiments.

Method

1. Numerical simulation : ZIP model

Influence of material heterogeneities on crack propagation statistics using a Fiber Bundle Model: the so-called ZIP Model.

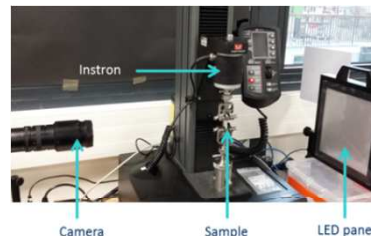
- Taking into account of a spatial correlation between fibers strength mimics microstructure.
- Analysis of breaking events distribution during cracking process.



Representation of ZIP model

2. Experiments

Characterisation of paper at macro- and mesoscale :



Experimental setup

- Tensile and fracture (mode I) tests.
- Tomography of microstructure.
- Optical tracking of cracks and FPZ.

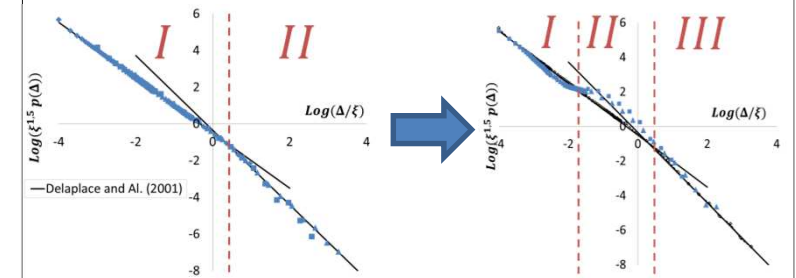
3. Finite Element Method

Numerical simulation with Finite Element Method (FEM) on *Cast3m* taking into account results from experiments and ZIP model.

Results

ZIP results

Distribution of breaking events



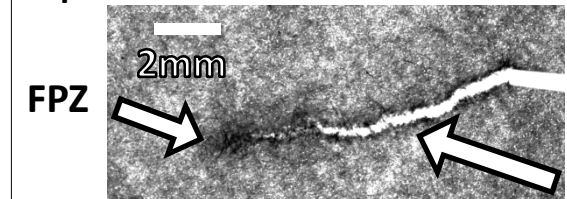
Existing code without microstructure size

After addition of microstructure size

- Appearance of a transitional regime *II* by taking into account the microstructure of material.
- Transitional regime depends on the microstructure size and imposed shape of stress field.

Highlight the role of the size of microstructure during crack propagation

Experimental results



FPZ

Crack path

Fractured paper sample

- Ability to see both FPZ and microstructure of material on paper samples.