Durability of sandwich structures
Fatigue testing
and
Recent advances in fire strength modeling

Pascal Casari

Background


Bonduelle
59

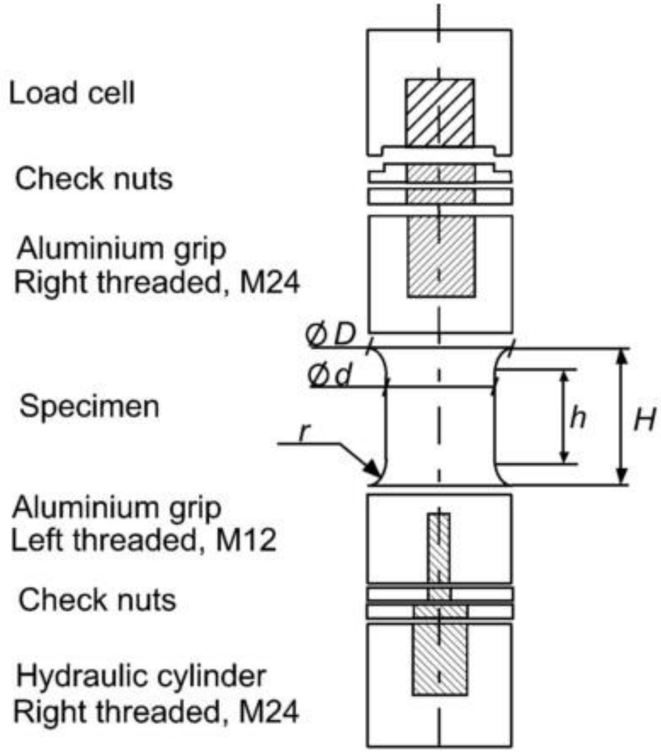

FRA 79
AREVA
AREVA


OMEGA
NESPRESSO
NESPRESSO
NEW ZEALAND
CAMPER
OMEGA

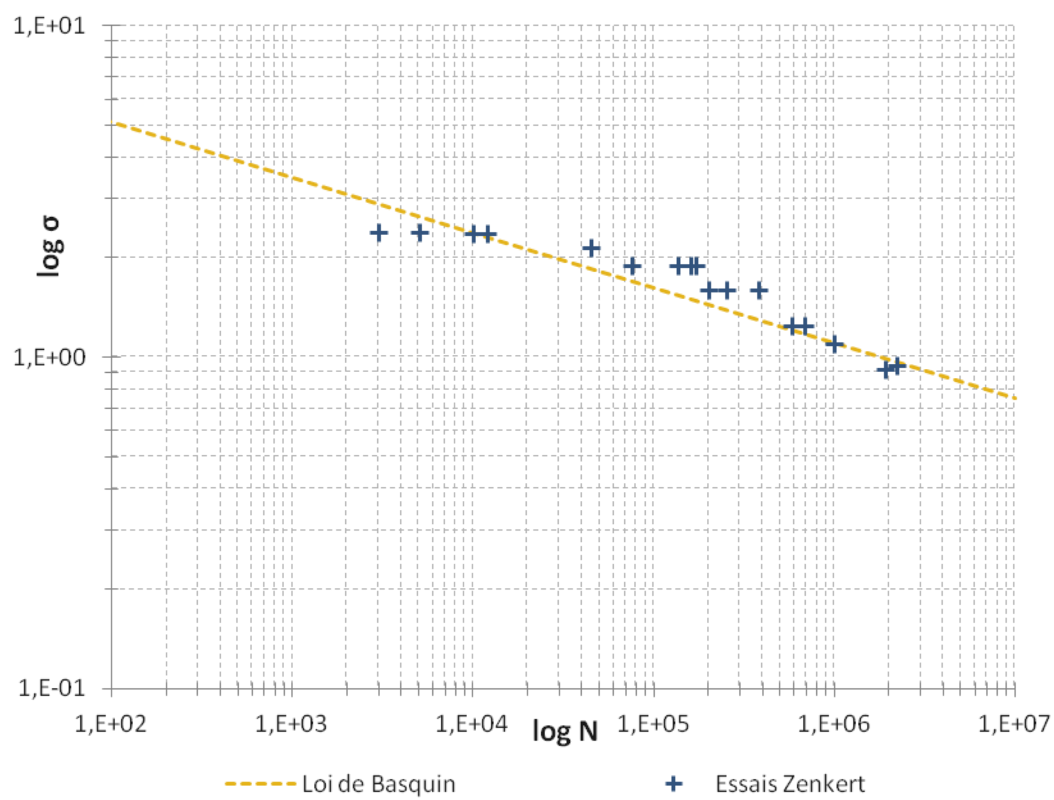

LUNA ROSSA
PRADA

Back to tensile fatigue on foam core
Raphael GERARD PhD

State of the art

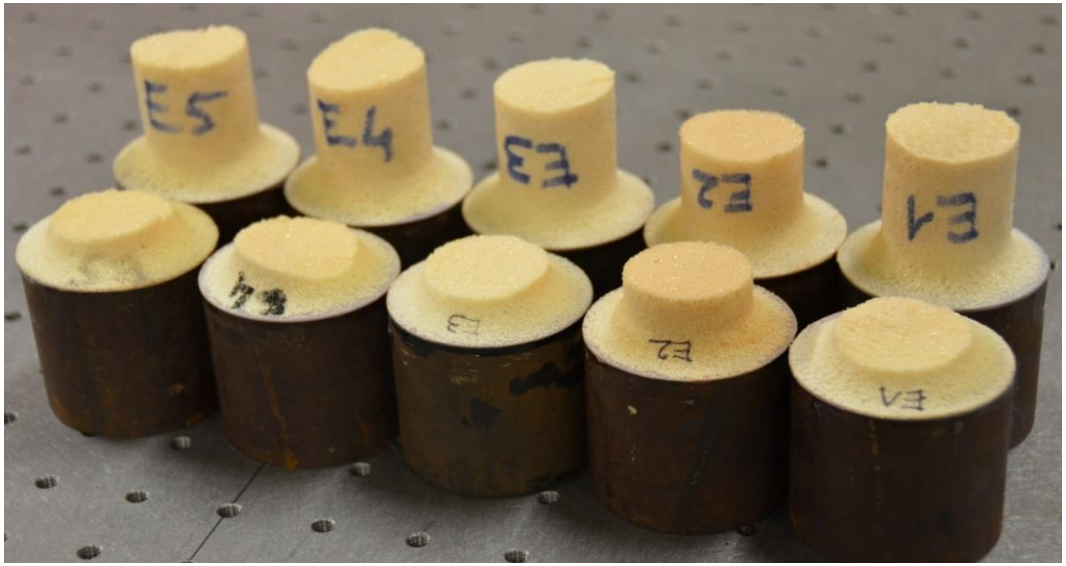


Zenkert, D., **Burman**

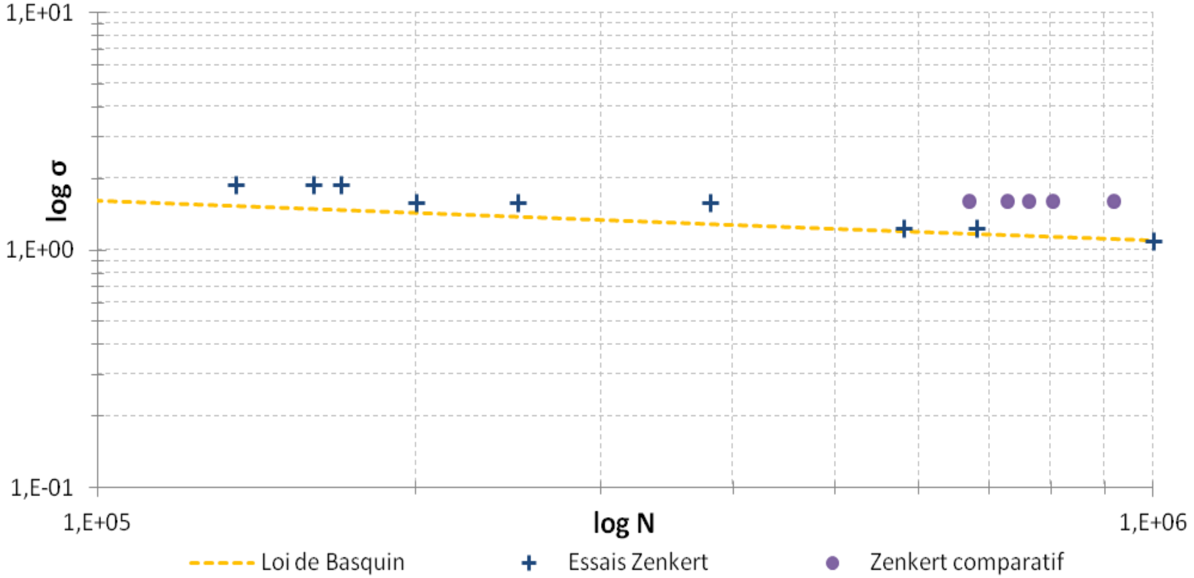


SN curve : Strength vs log N

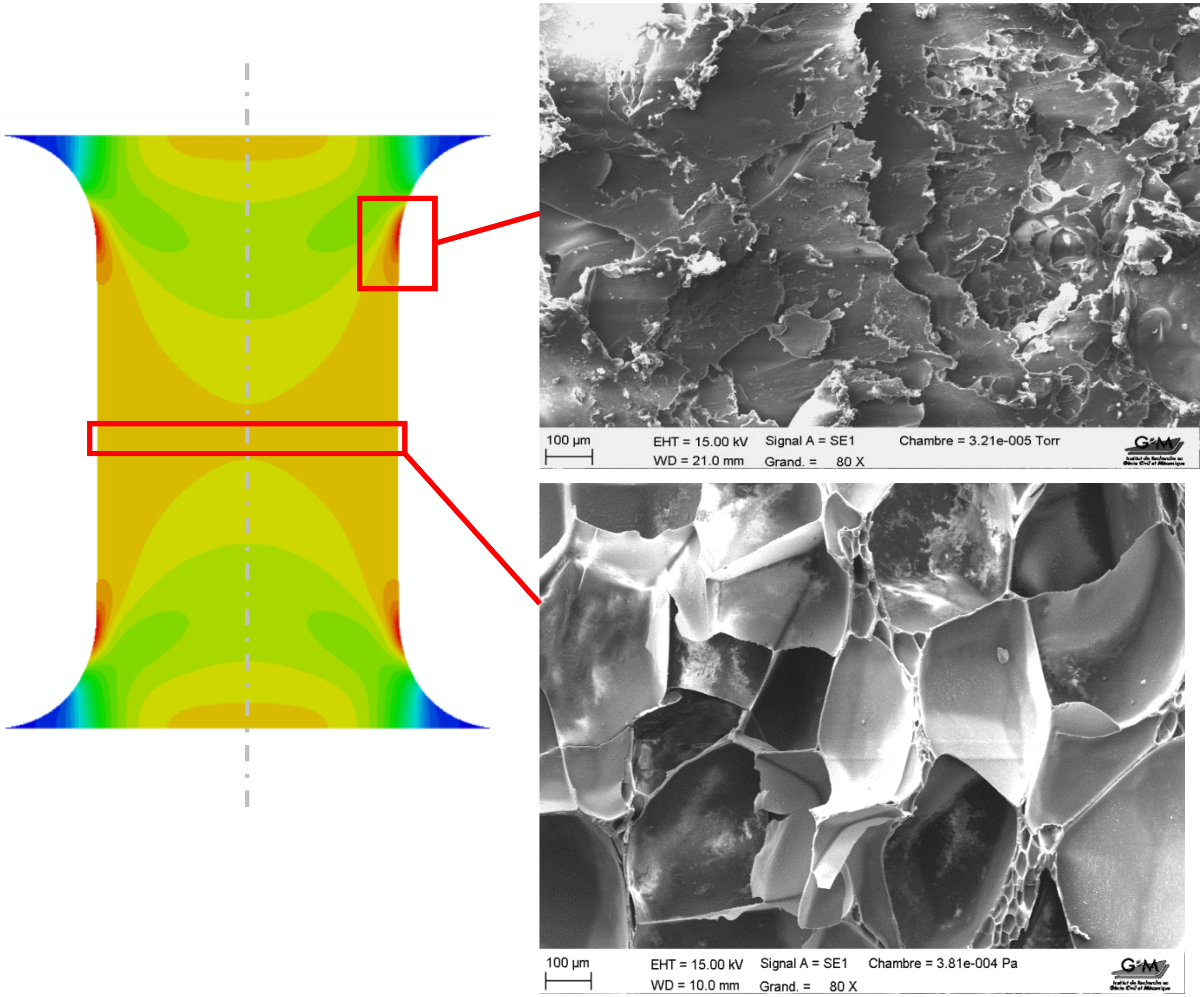
Repeating tests from the literature

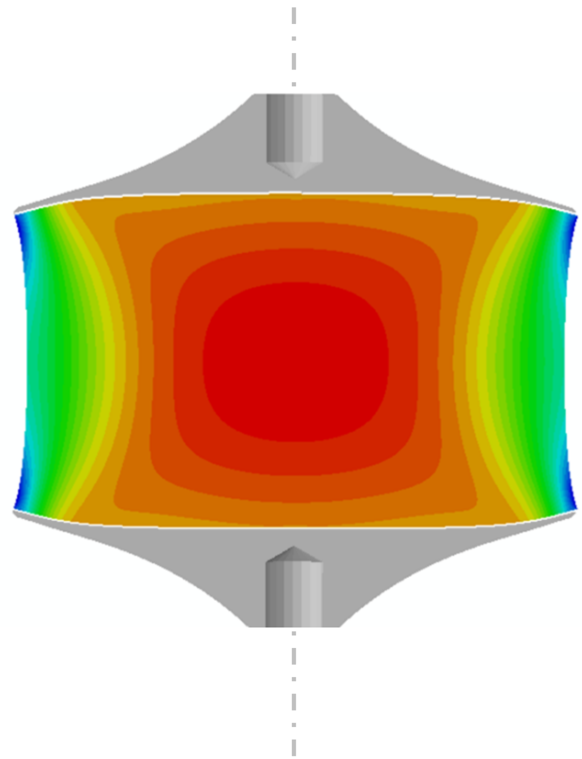


- Failure in the curved area



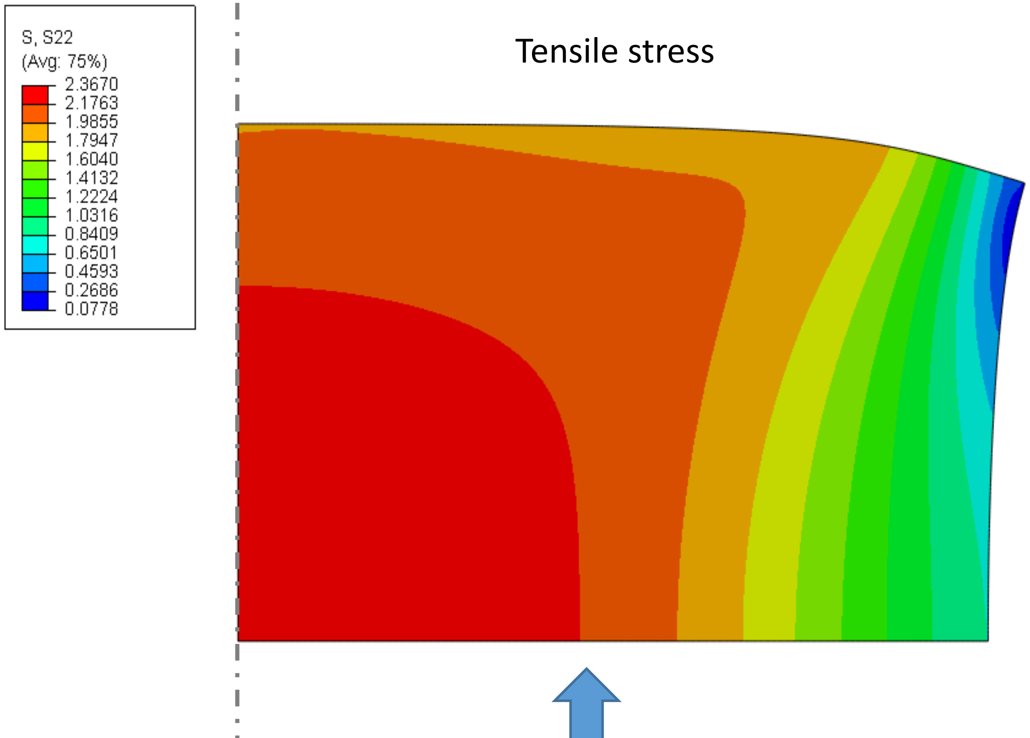
Design of a new test geometry



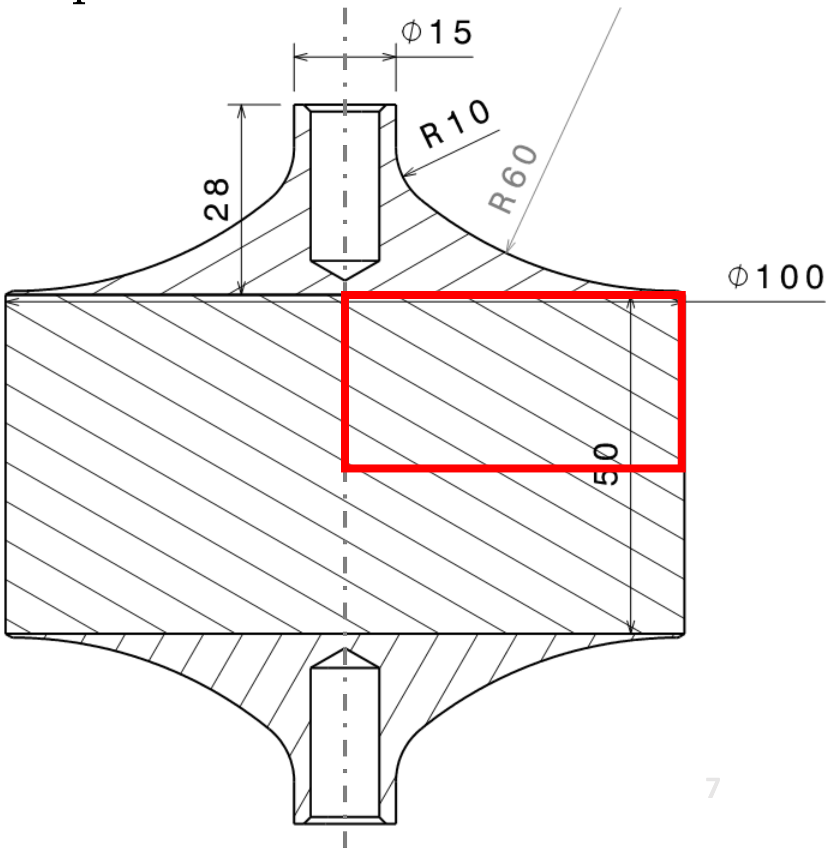


Objective : Limit edge effects

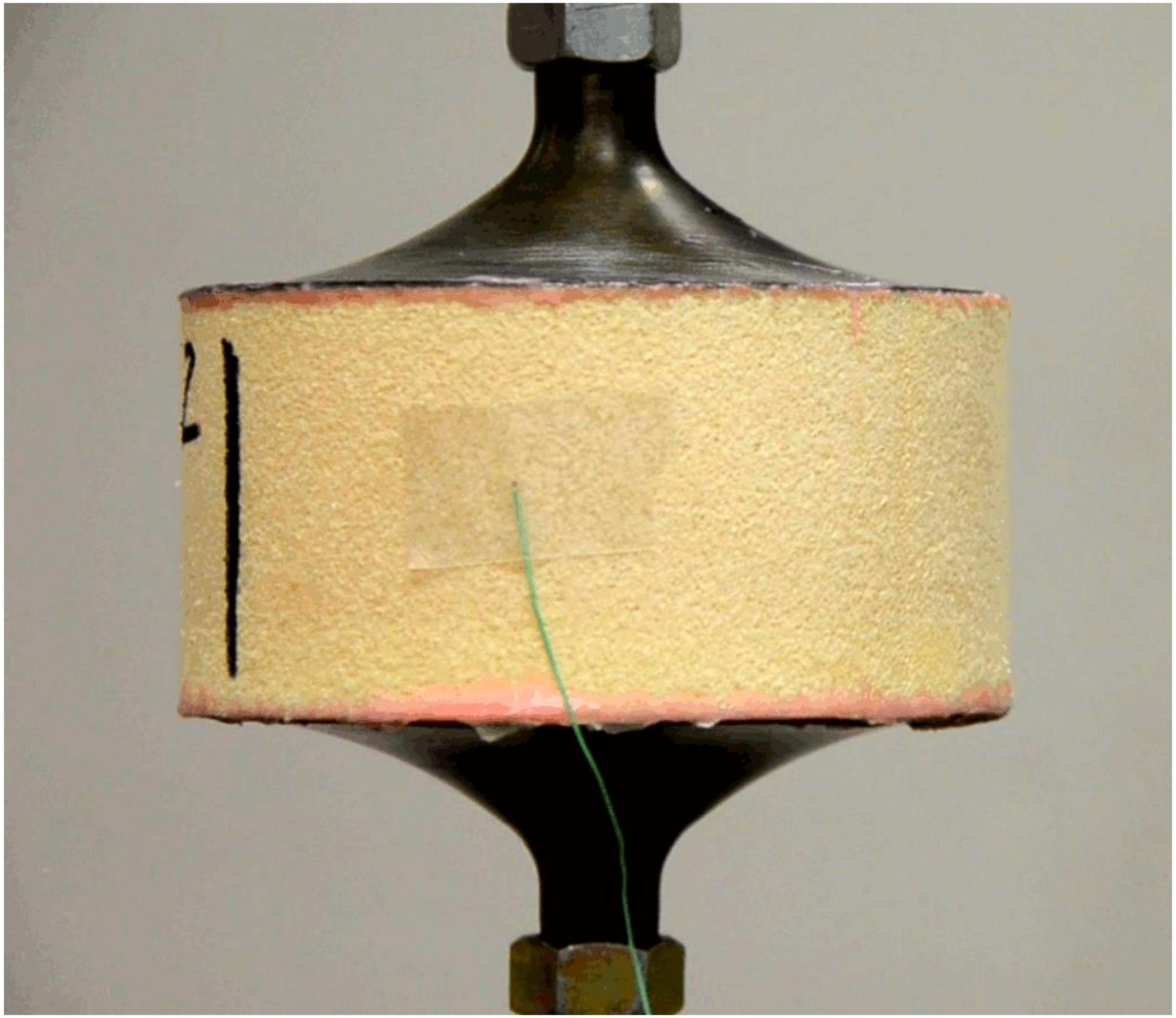
Design of a new test geometry



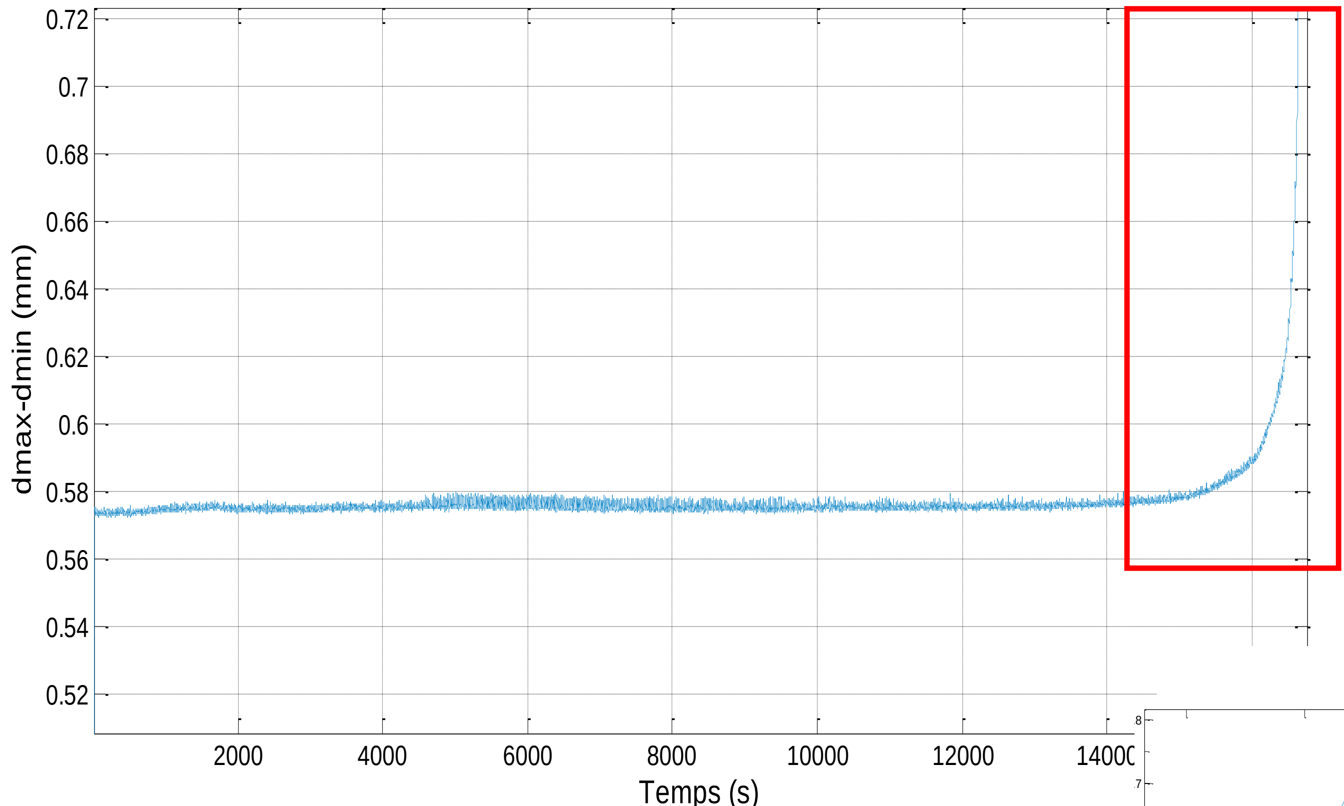
Clamps are deforming to ensure a maximum tensile stress in the middle of the specimen



Tension fatigue test

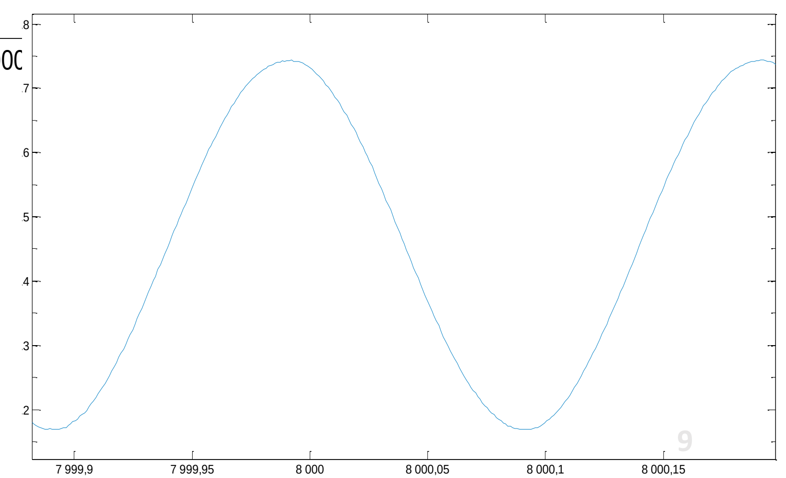


Tension fatigue test

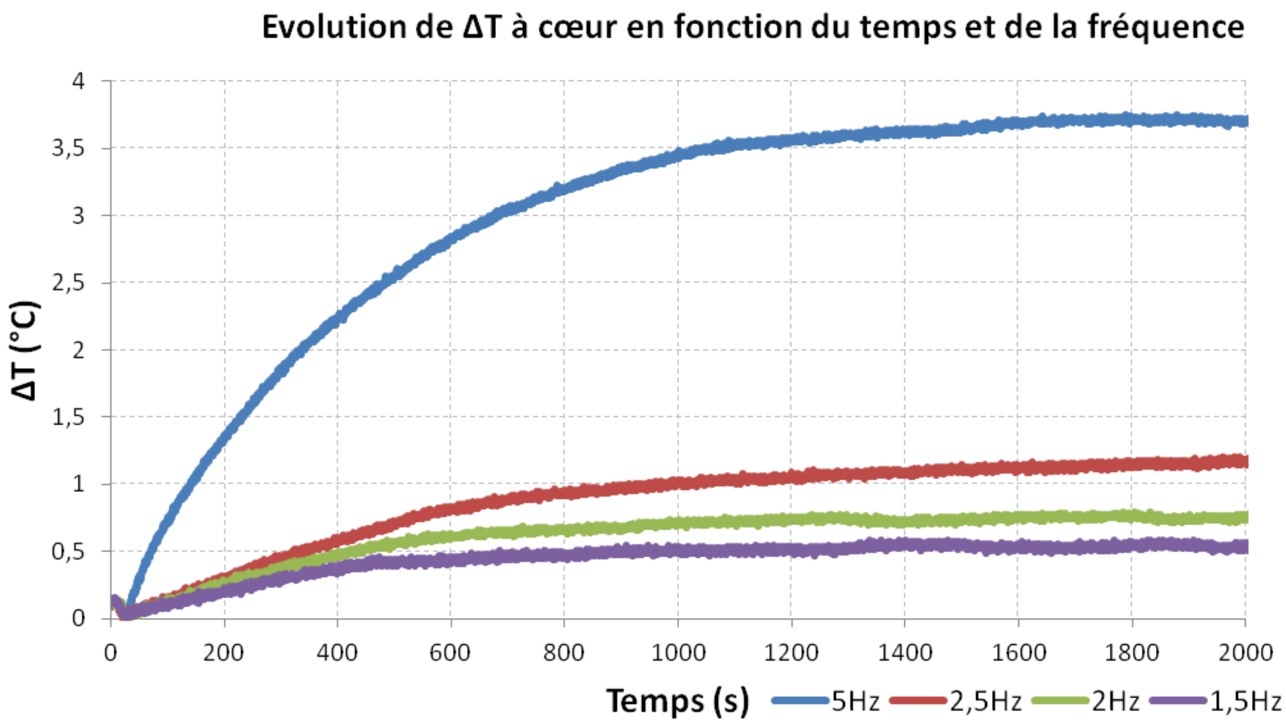


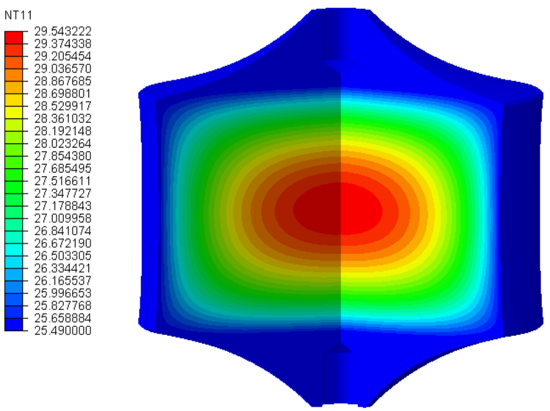
- Transient state
- Permanent state
- Towards failure

Displacement vs time



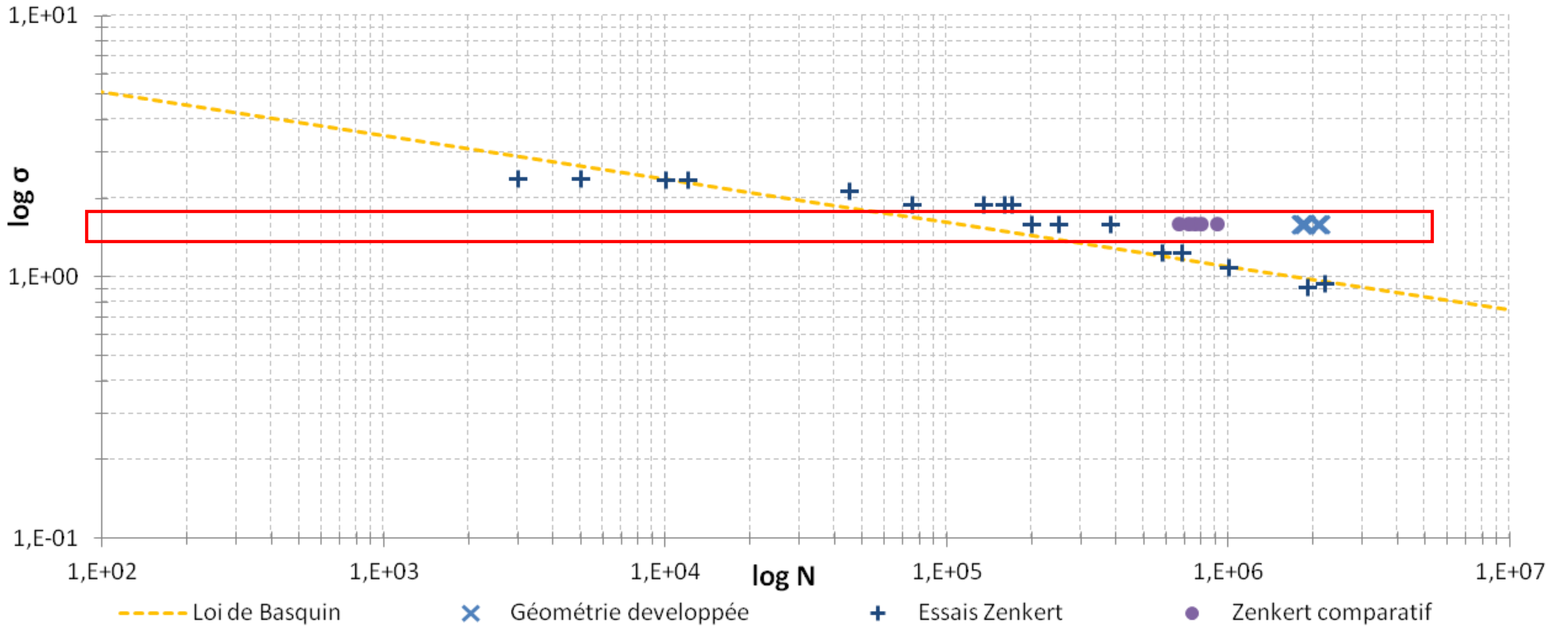
Self heating issues

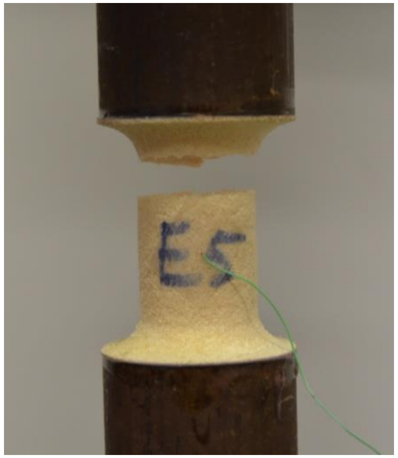


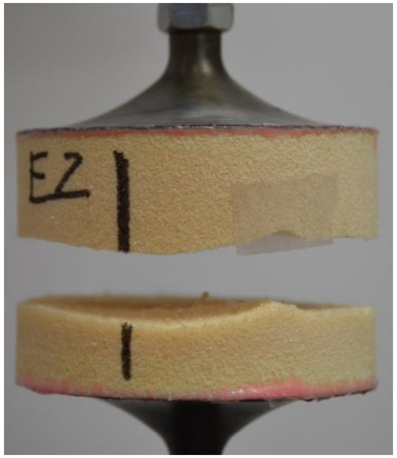


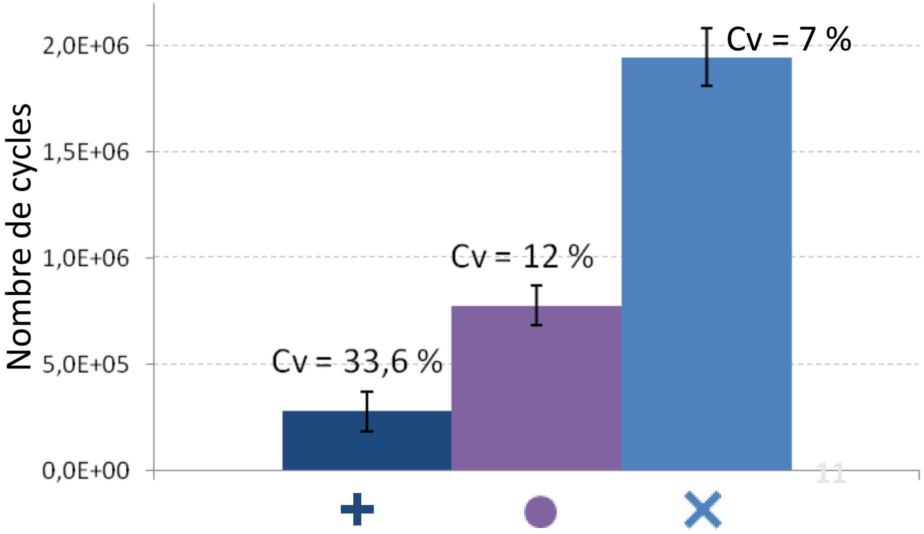
- Various frequencies
- Viscoelastic modeling with heating exchange

Summary of tests results

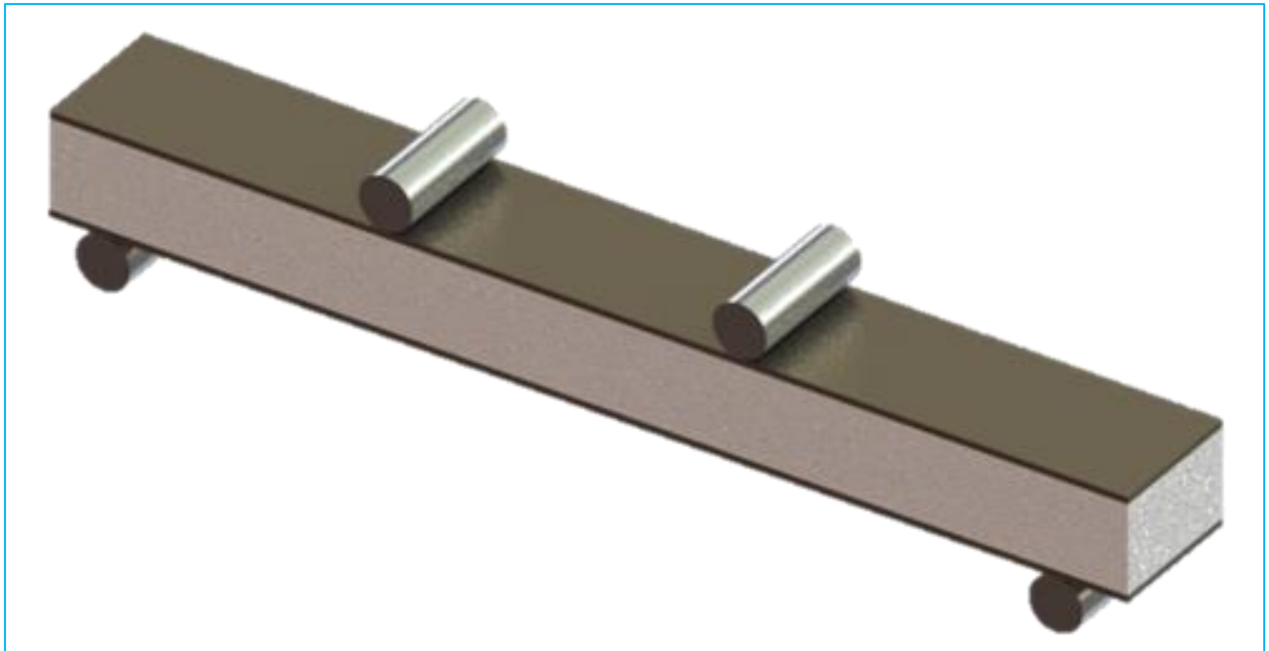


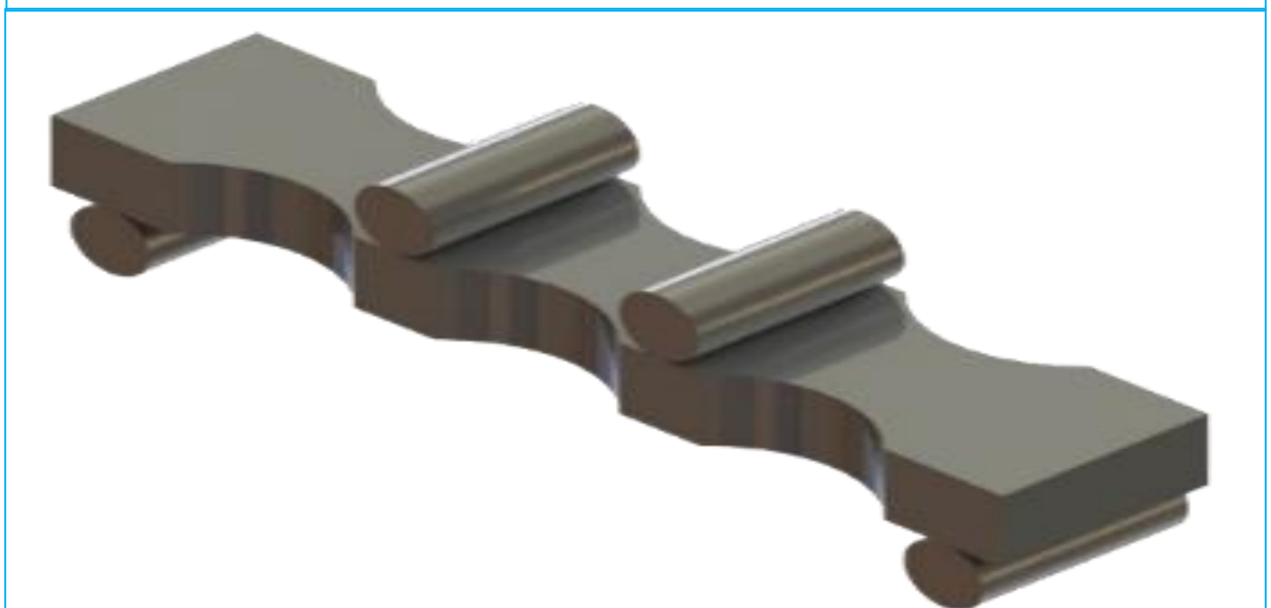


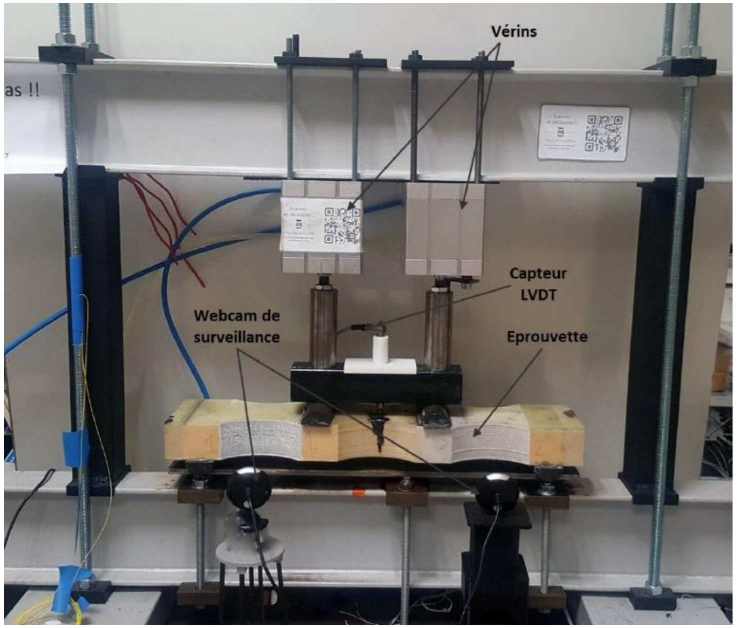


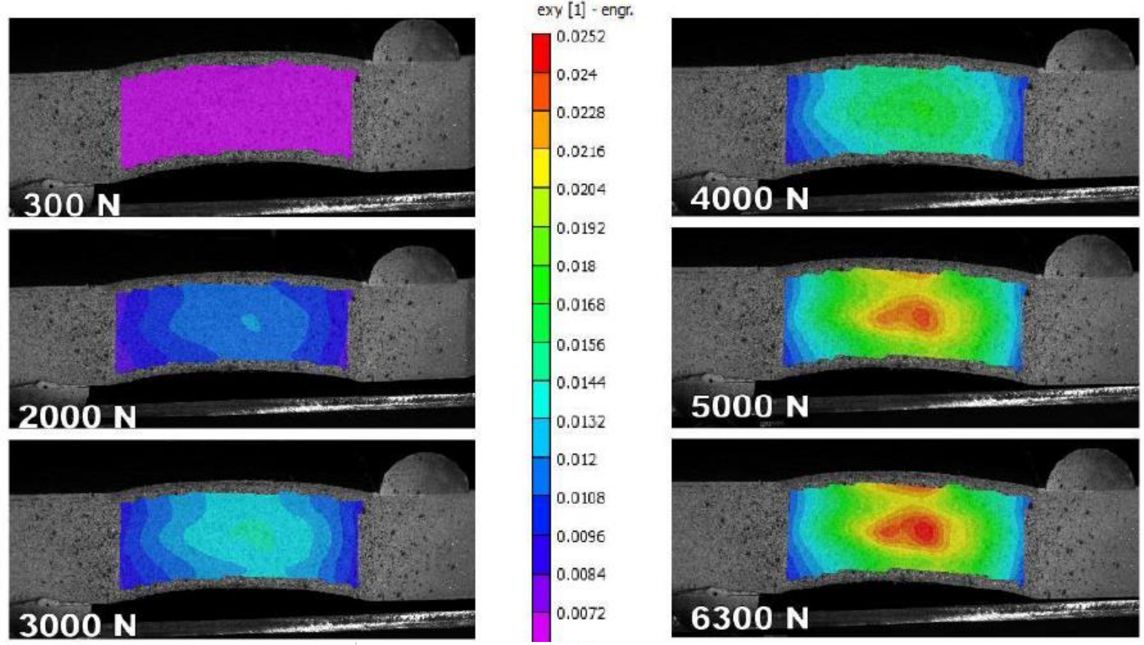


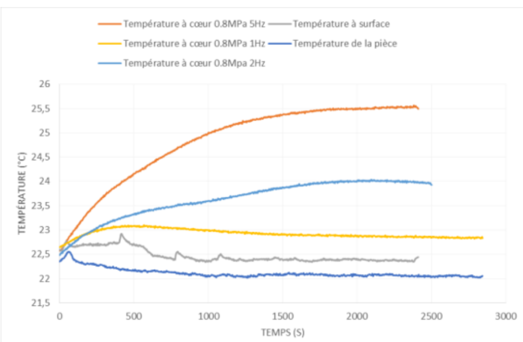
Bending fatigue on sandwich specimen
PVC foam core
PhD of Fahmi ALILA

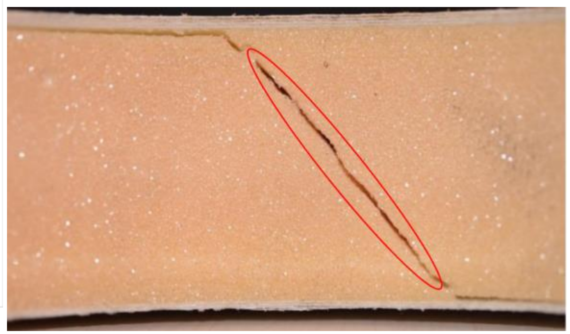


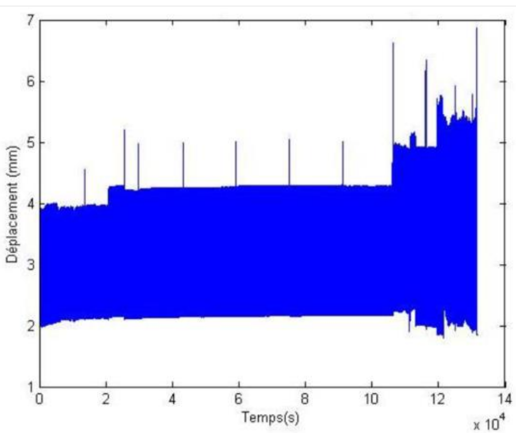


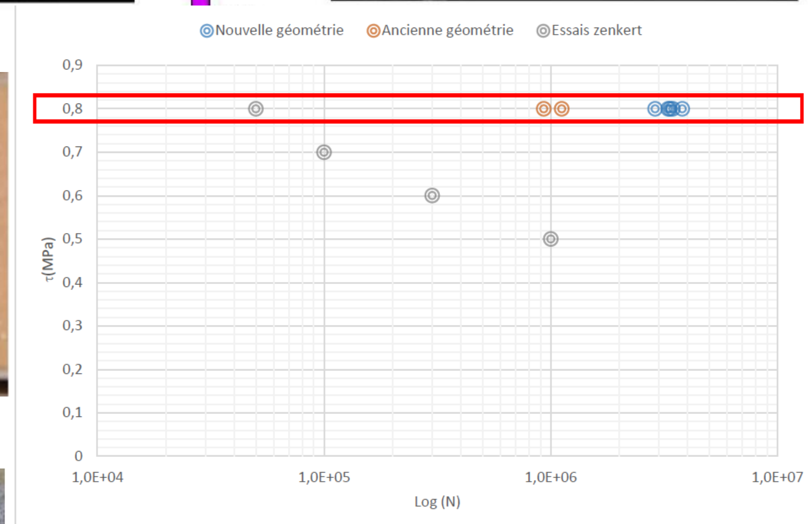










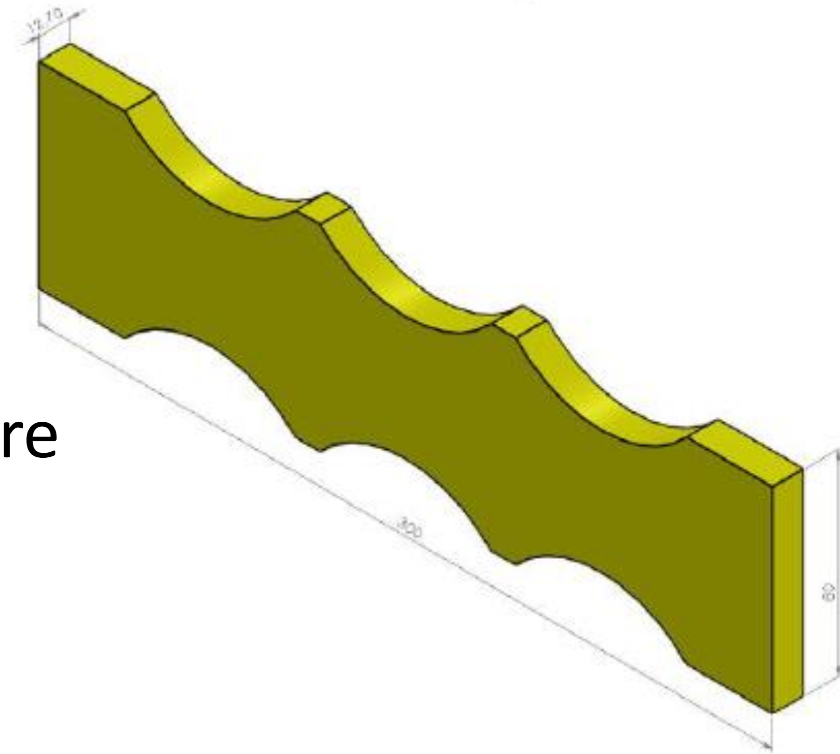


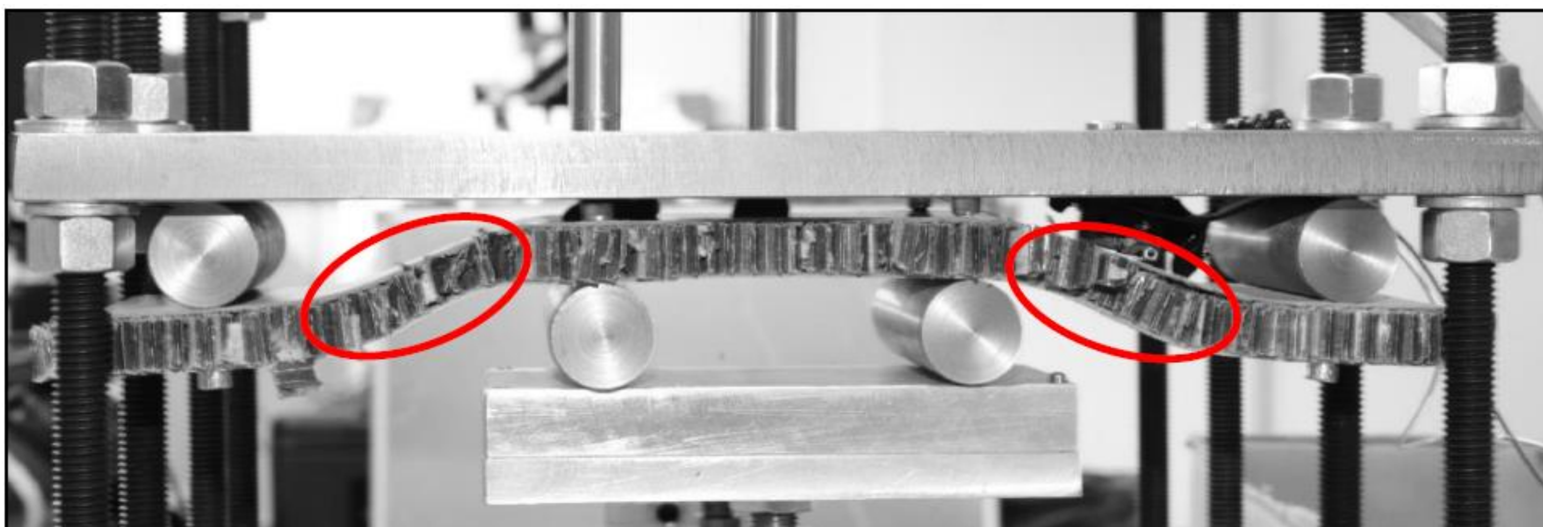
Lifetime from 1 to 3 Million cycles
Scatter reduced from 9 to 6%

Bending on sandwich specimen
Honeycomb core 48 kg/m^3
Fatigue

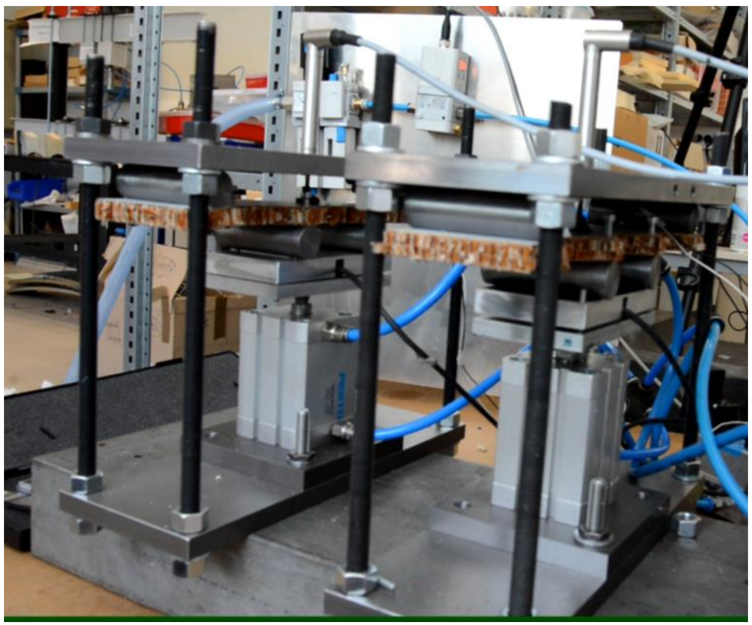
New geometry

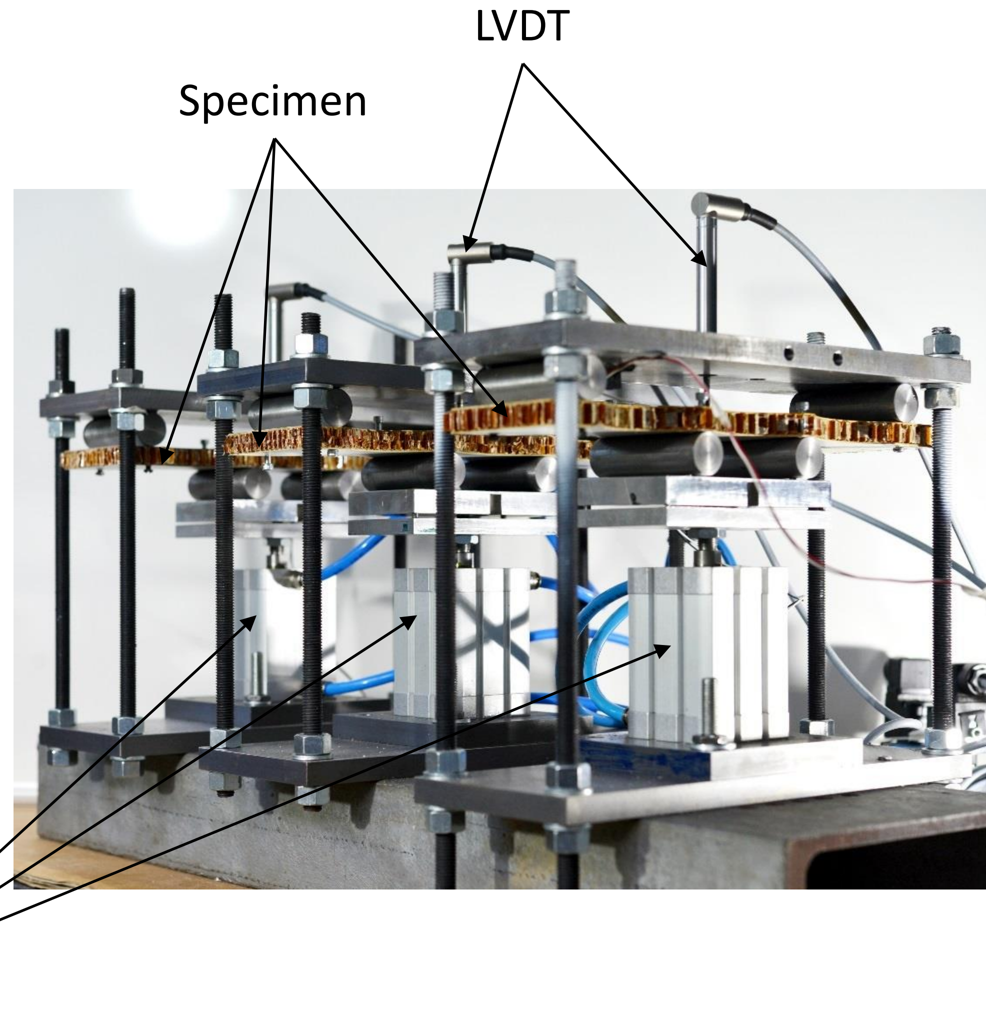
More surface for supports
Possible to design with narrowed specimen in the pure moment area or in the shear area or both



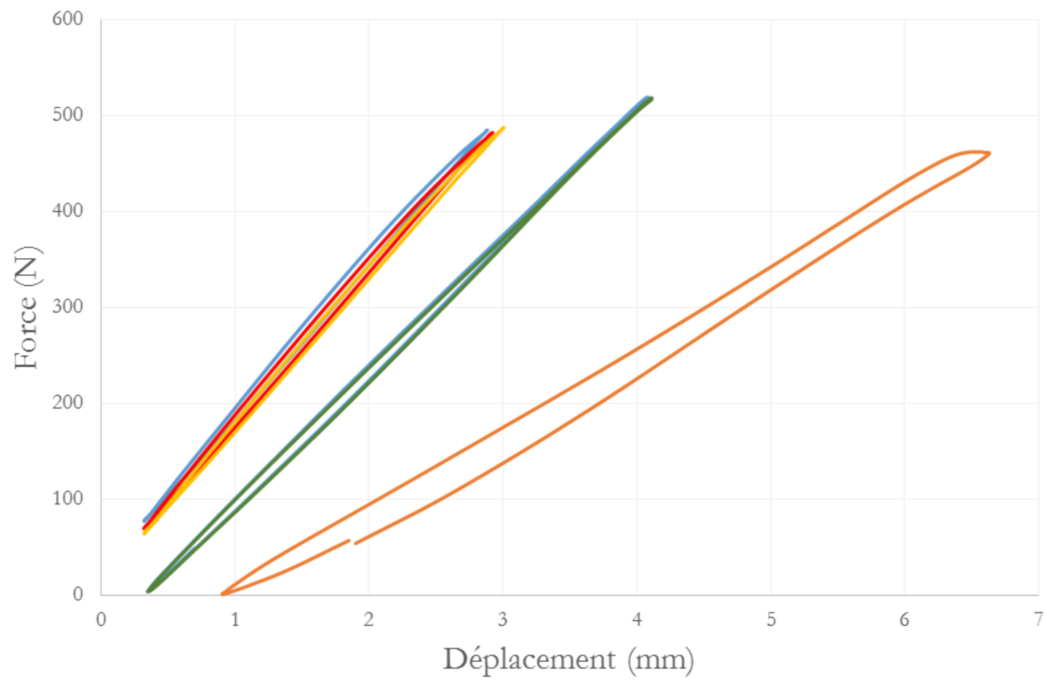


Pneumatic test rigs

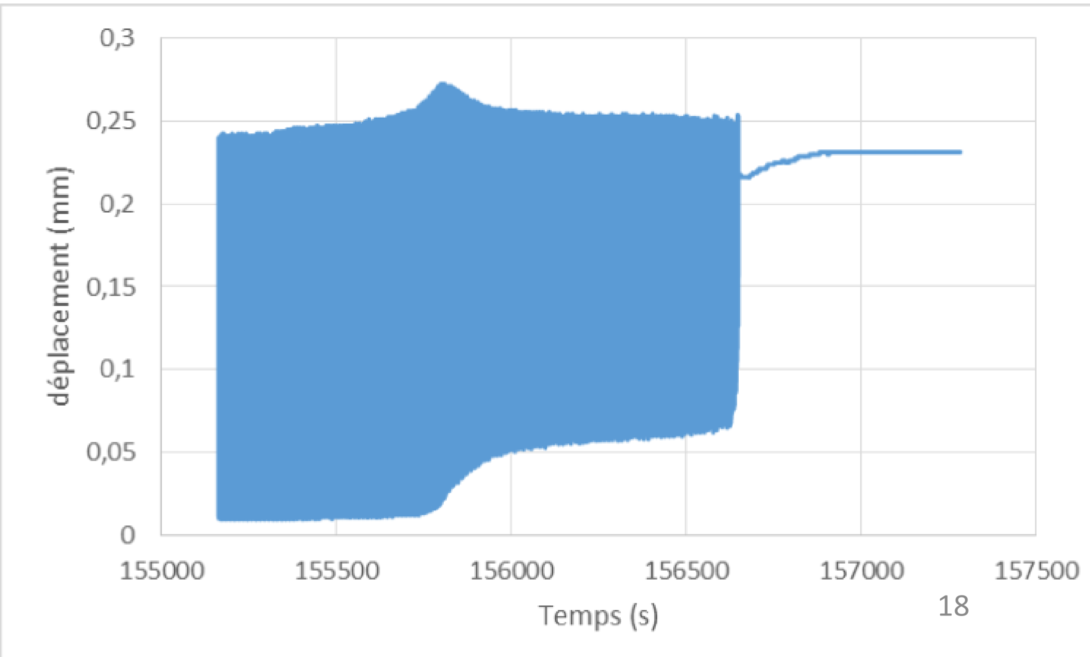




Variation of stiffness and permanent displacement with fatigue

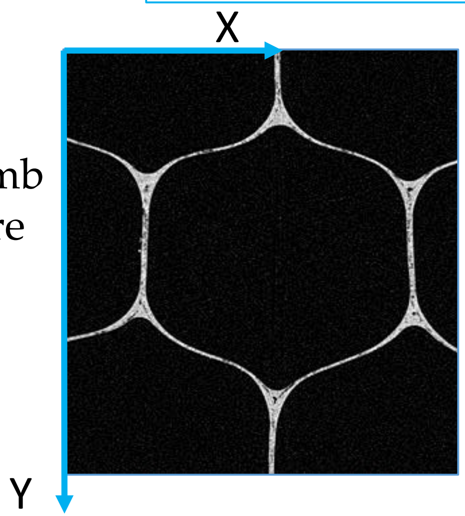


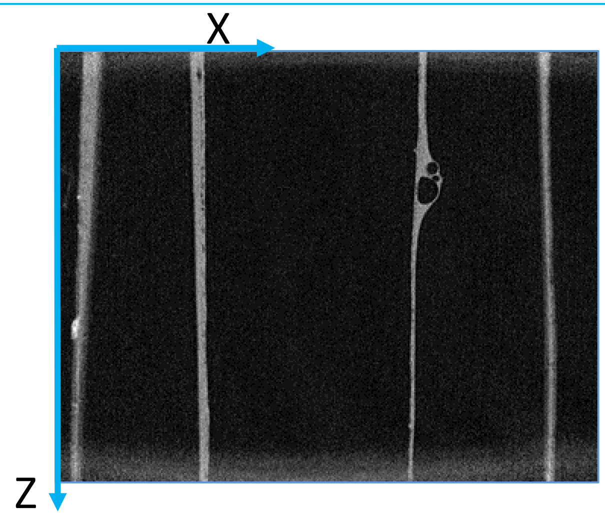
It takes approx. 1000 cycles to reach catastrophic failure



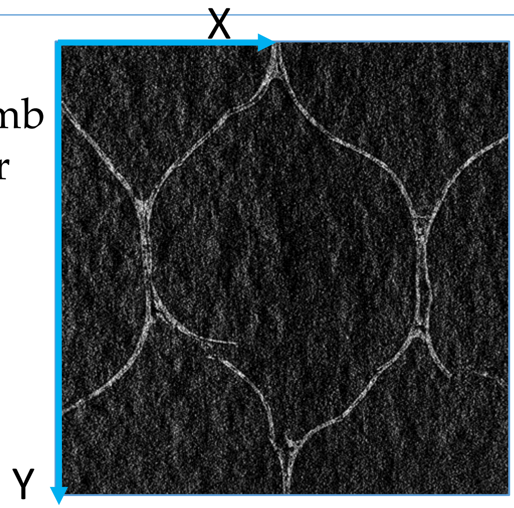
Tomography analysis
Core shear failure analysis

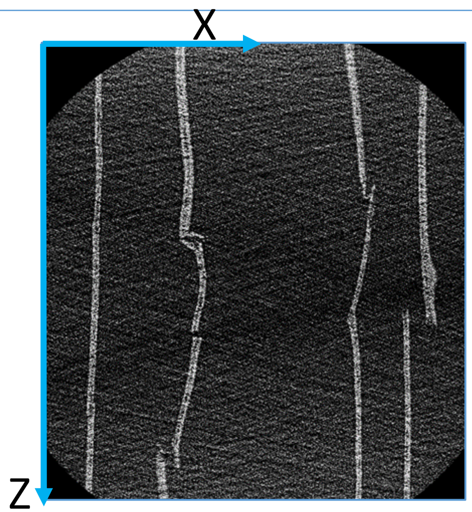
Honeycomb cell before failure

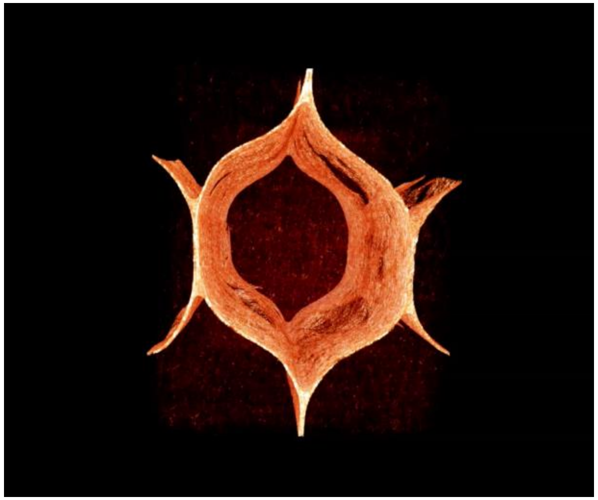




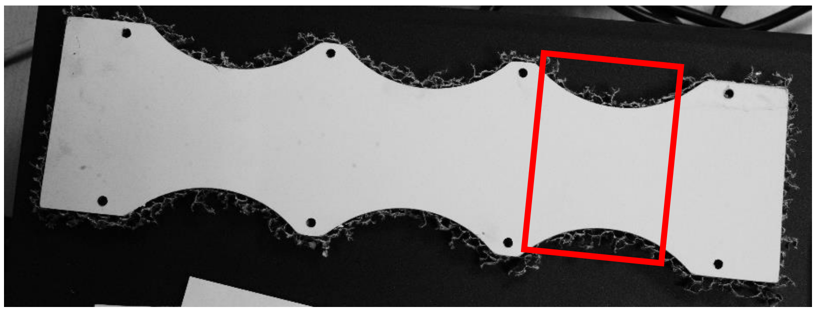
Honeycomb cell after failure

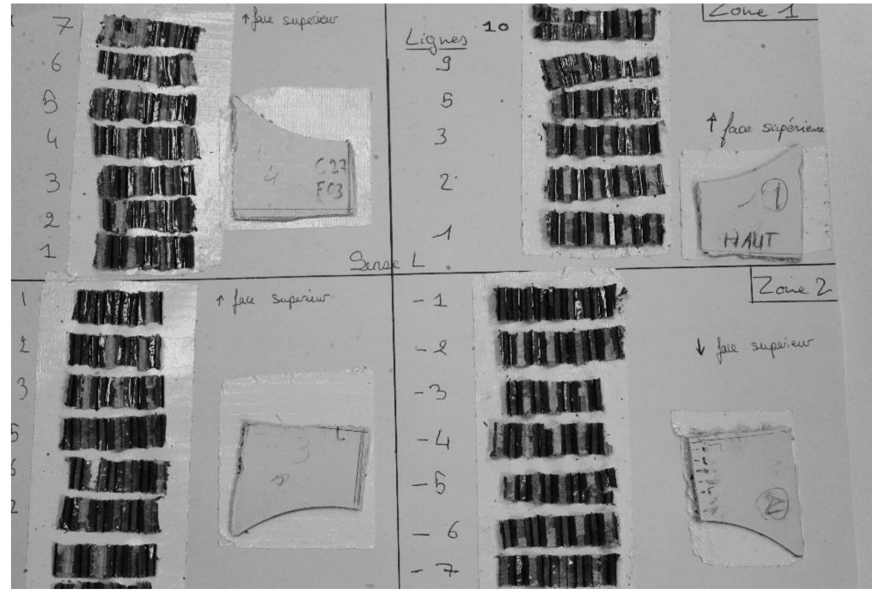


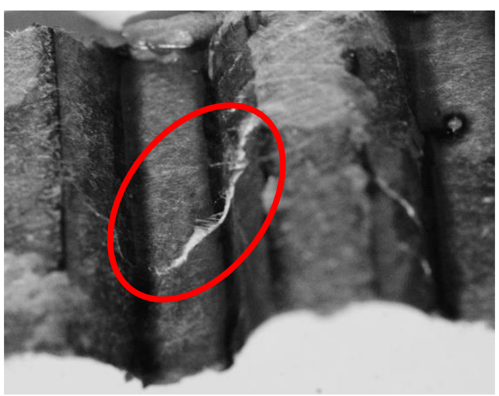




Failure mode analysis



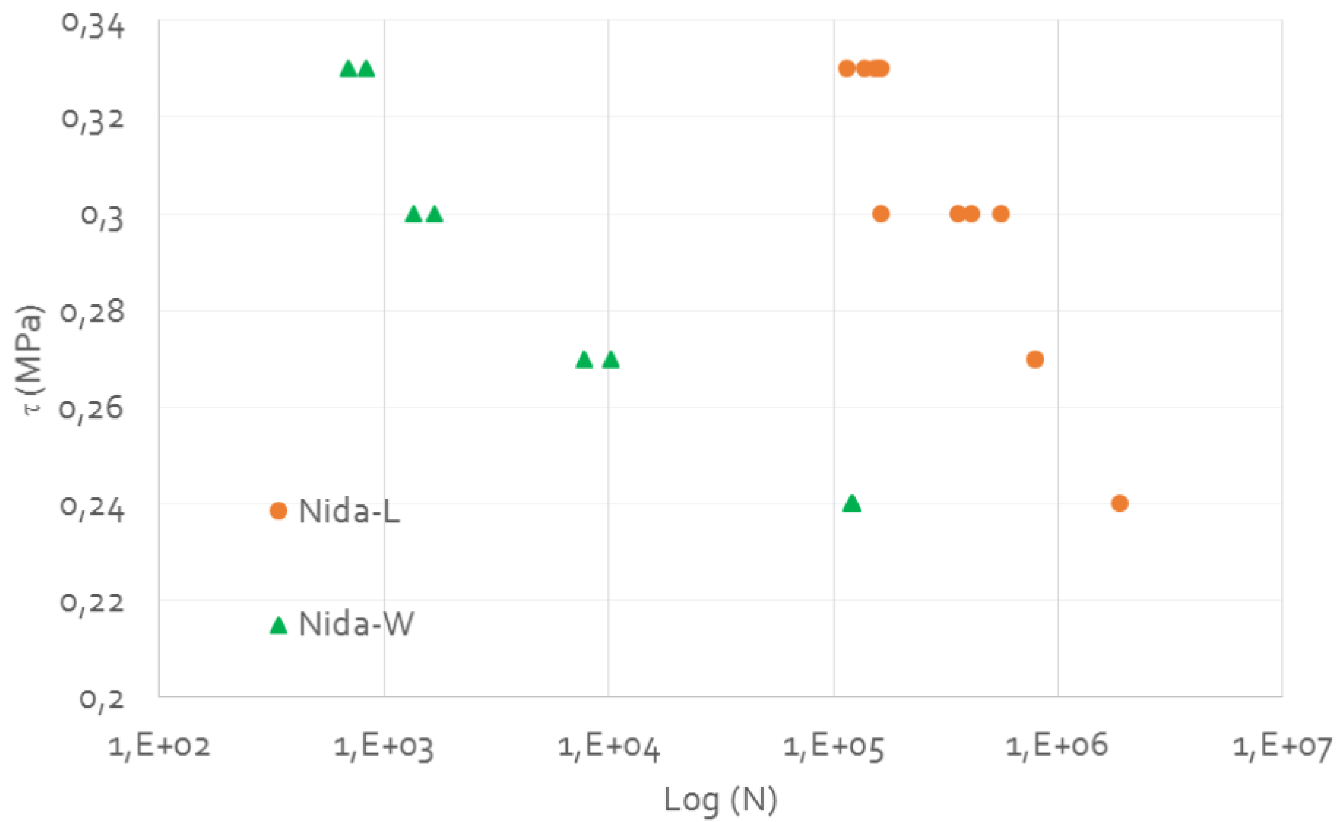




Failure mostly at 45° in the single wall cell's

Fatigue results

R = 0,1
f= 2Hz



Shear strength :
L Direction : 1,21 MPa
W Direction : 0,69 MPa

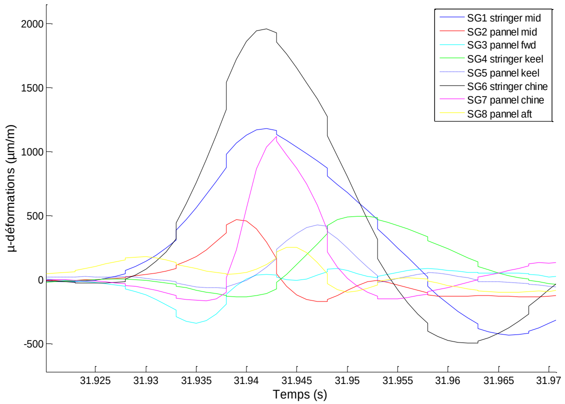
Conclusions

Various test standards have been re-visited

- Significant lifetime increased
- New failure modes

Next

Torsion test to replace ASTM C 273
Fatigue with real load spectra



Fire strength modeling
PhD of Georgio RIZK

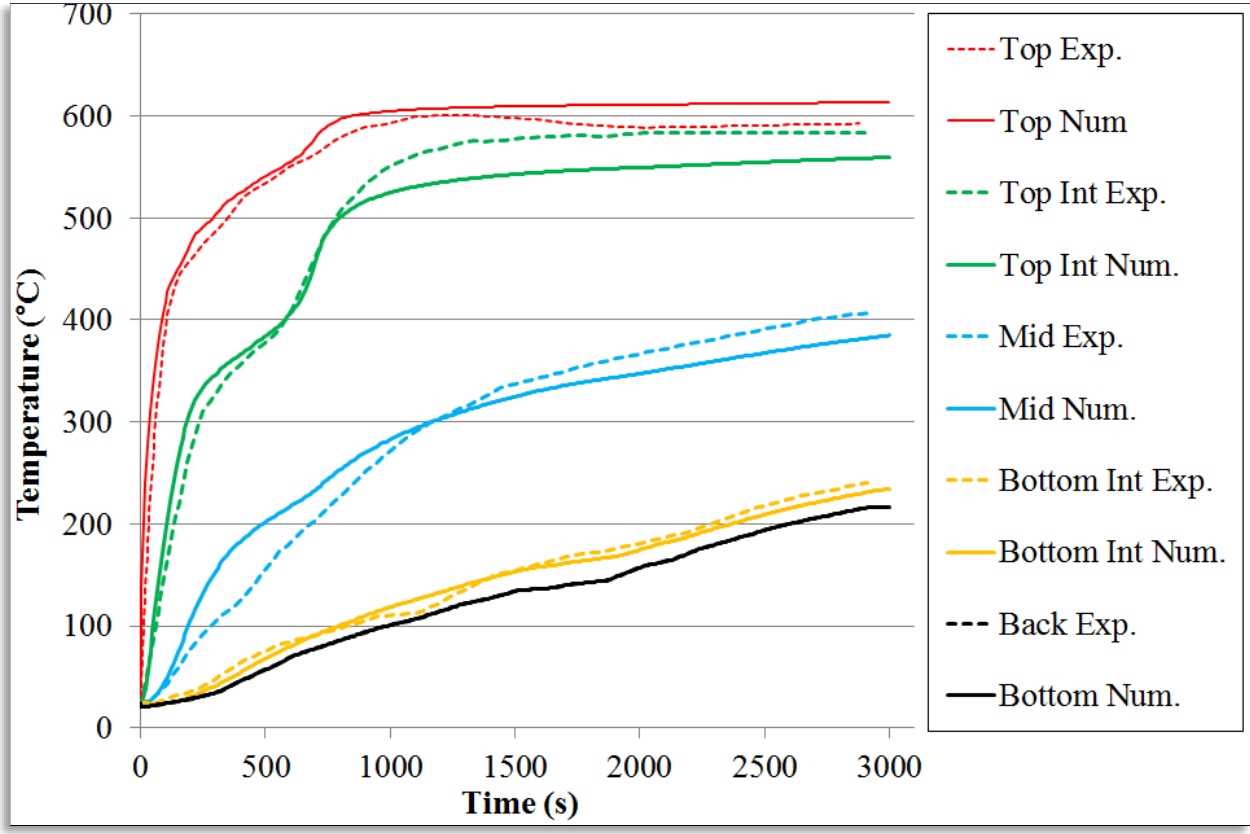
Thermal modeling - Gibson & al.

$$\rho C_p \frac{dT}{dt} = \frac{d}{dx}\left[k_x \frac{dT}{dx}\right] - \dot{m}_g C_{pg} \frac{dT}{dx} - \frac{d\rho}{dt}\left(Q_p + H_c - H_g\right)$$

$$\frac{d\rho}{dt} = -\rho_0 \left[\frac{\rho - \rho_\infty}{\rho_0}\right]^n A.\,exp\left(\frac{-E_a}{RT}\right)$$

Implemented in ABAQUS - UMATHT

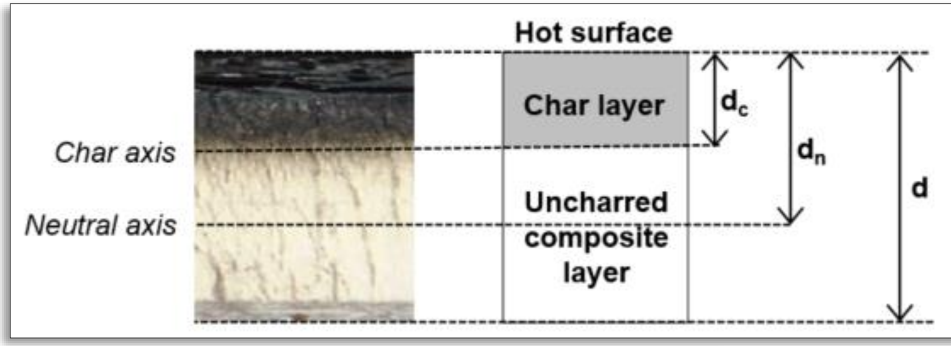
Fire testing and temperature measurements

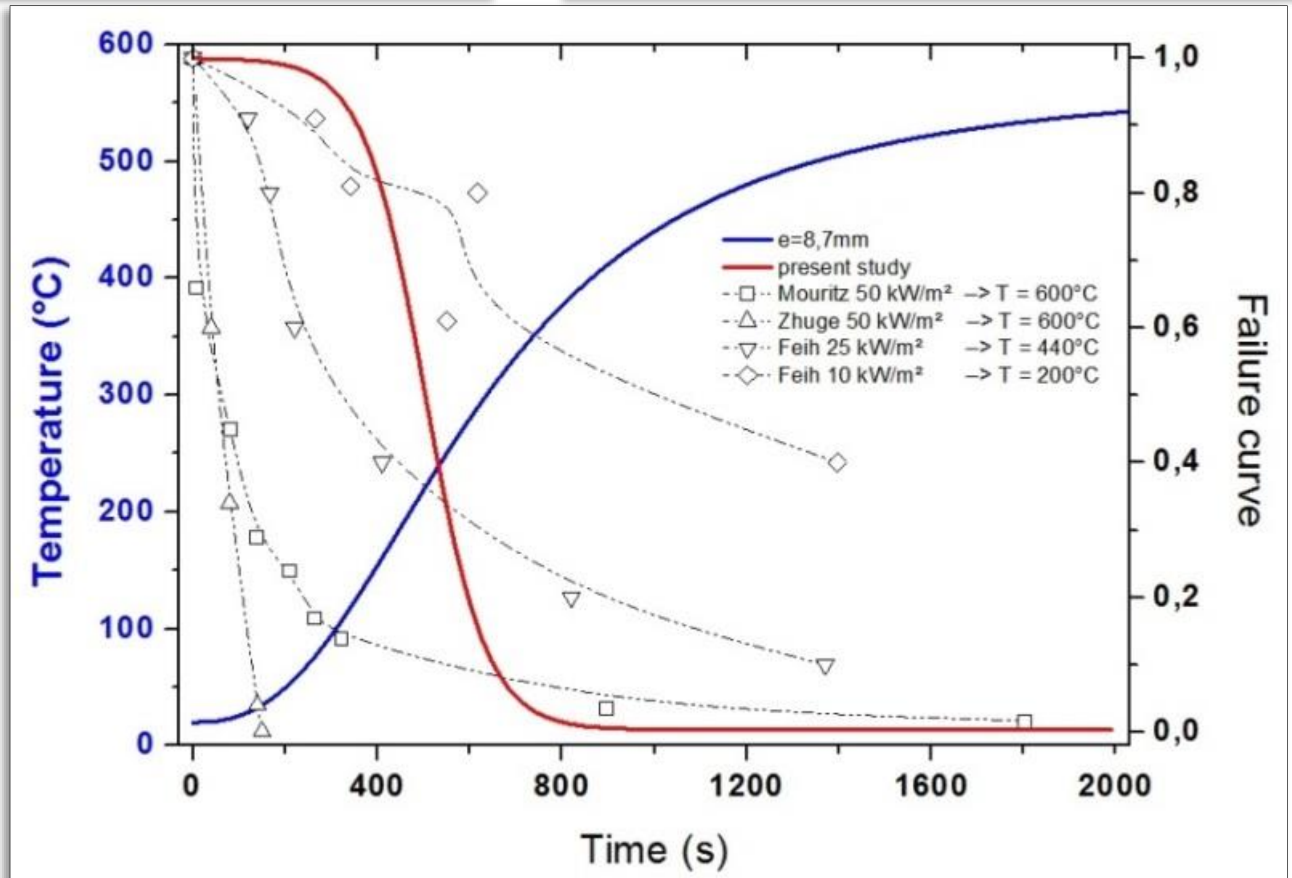


ISO 5660

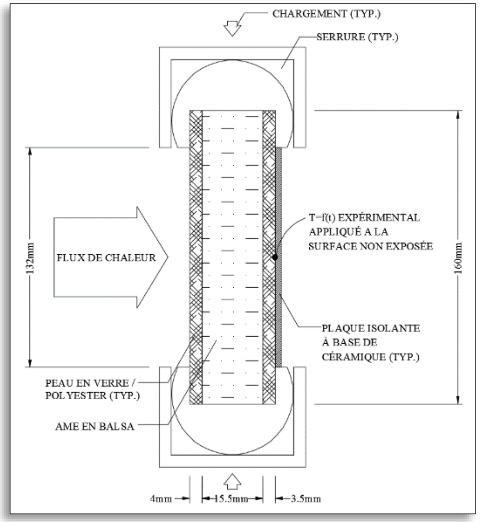
Model/experimental comparison

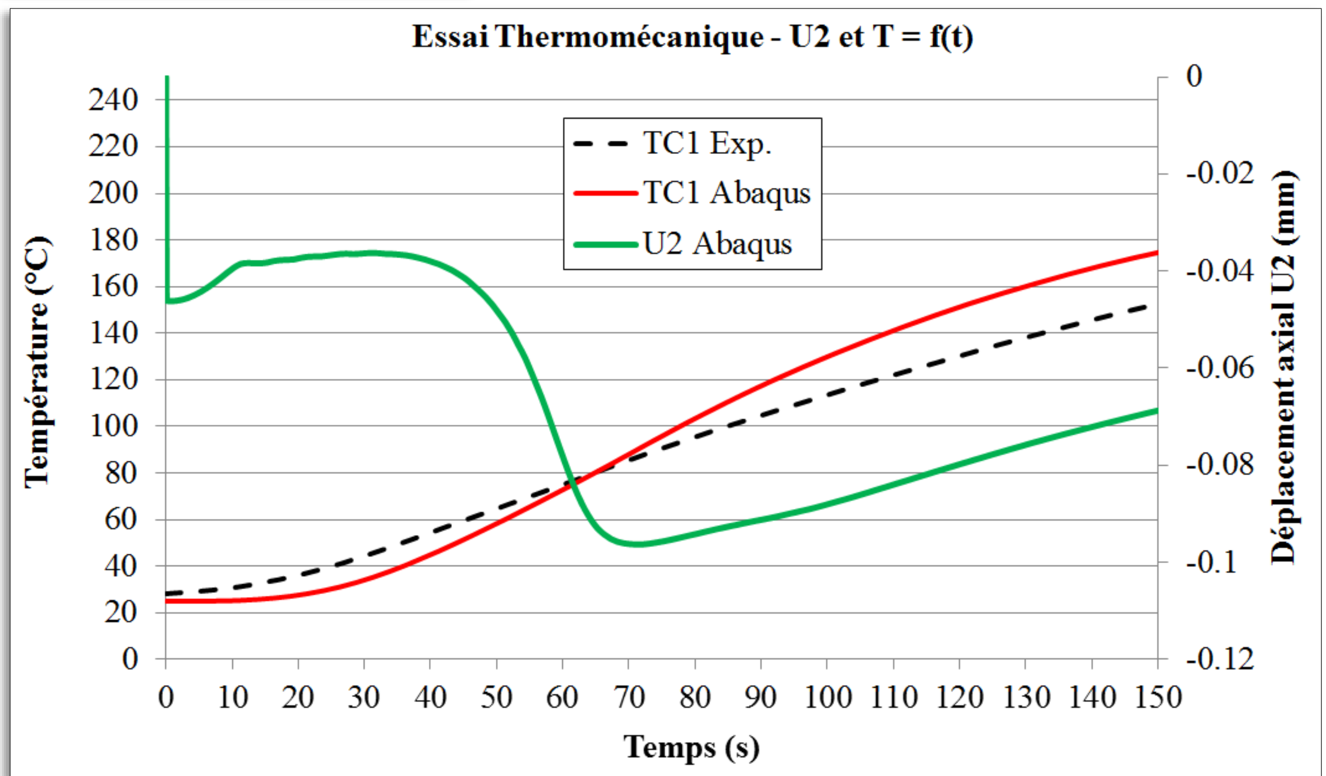
Bending stiffness post-fire



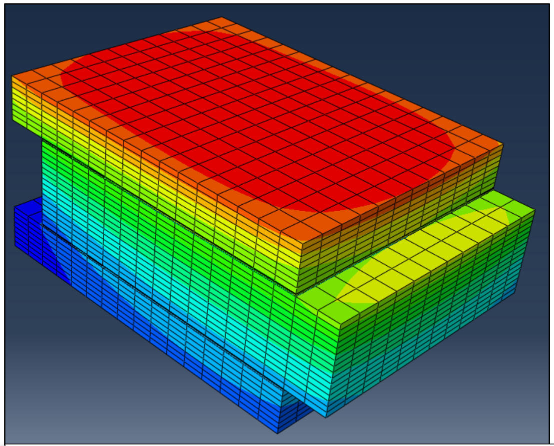


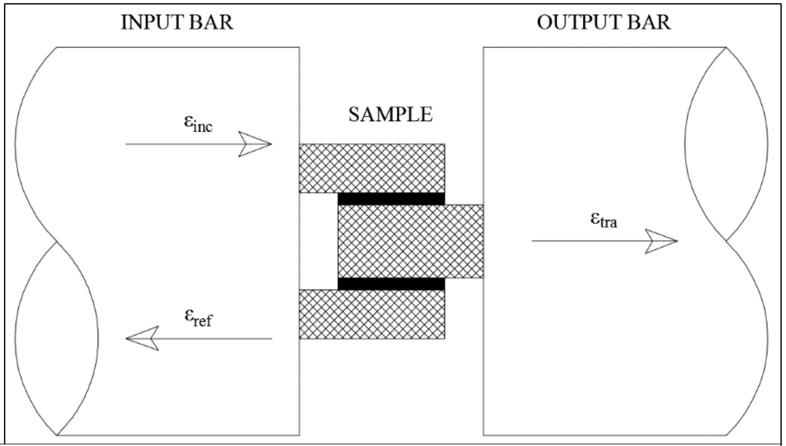
Compression under fire

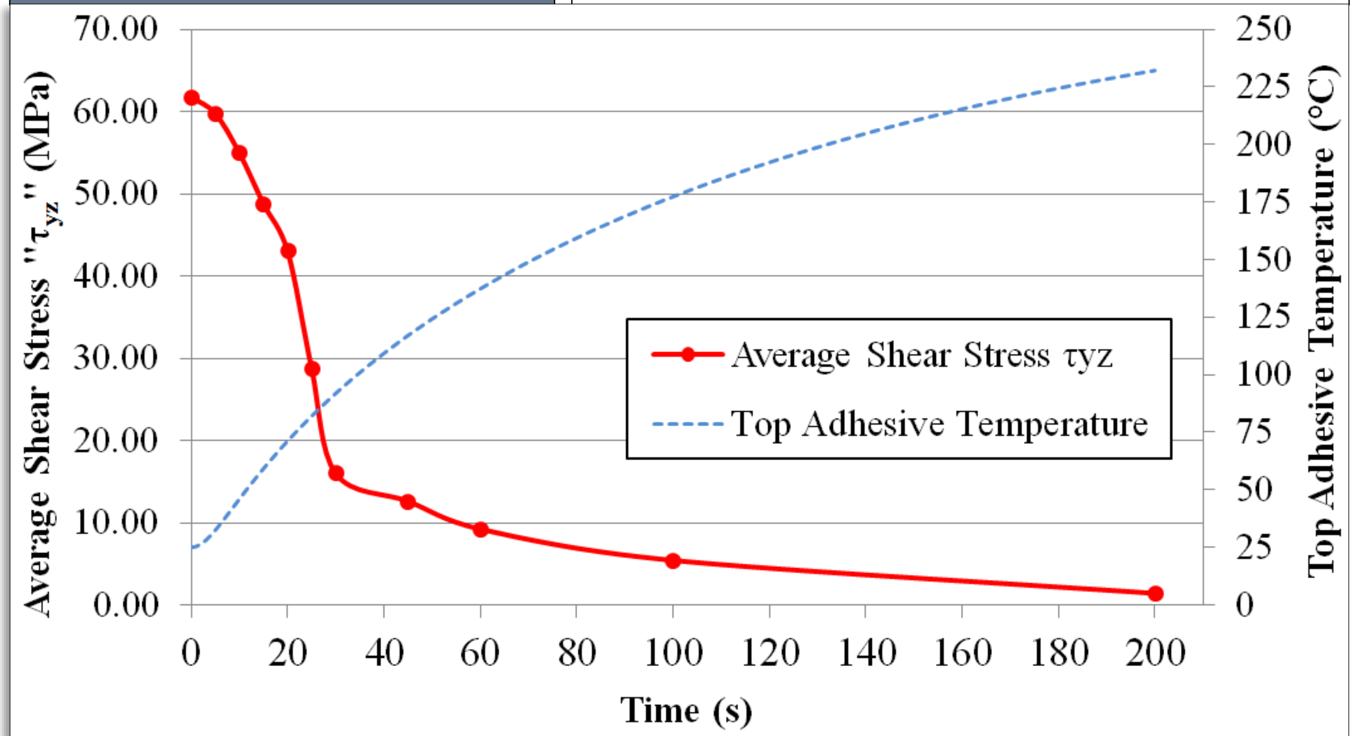




Application to bonded assemblies







- Relevant ABAQUS model and results
- Consistent temperature field prediction
- Failure prediction of a bonded assembly
- Need to characterize many properties

Any question ?