FLANDERS INNOVATION & ENTREPRENEURSHIP SIM
Clusters for Growth

GHENT UNIVERSITY

M3 Macro Model Mat

Investigating tensile rate-dependence in composite laminates using a hydraulic pulse test bench

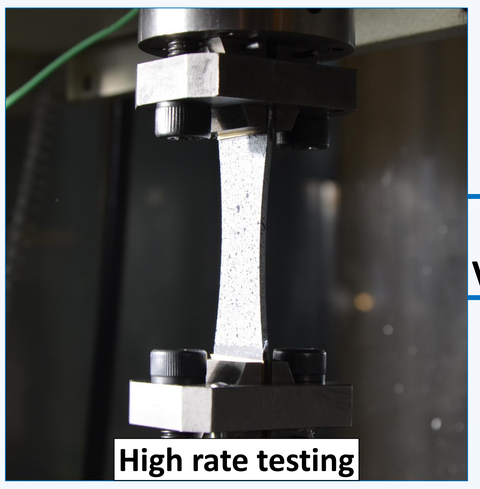
S.W.F. Spronk[a,b], F.A. Gilabert[a,b], R.D.B. Sevenois[a,b], D. Garoz[a,b], W. Van Paepegem[a]

[a] Department of Materials, Textiles and Chemical Engineering (MaTCh), Ghent University, Tech Lane Ghent Science Park - Campus A Technologiepark-Zwijnaarde 903, B-9052 Zwijnaarde, Belgium, siebe.spronk@ugent.be

[b] SIM vzw, Technologiepark Zwijnaarde 935, B-9052 Ghent, Belgium

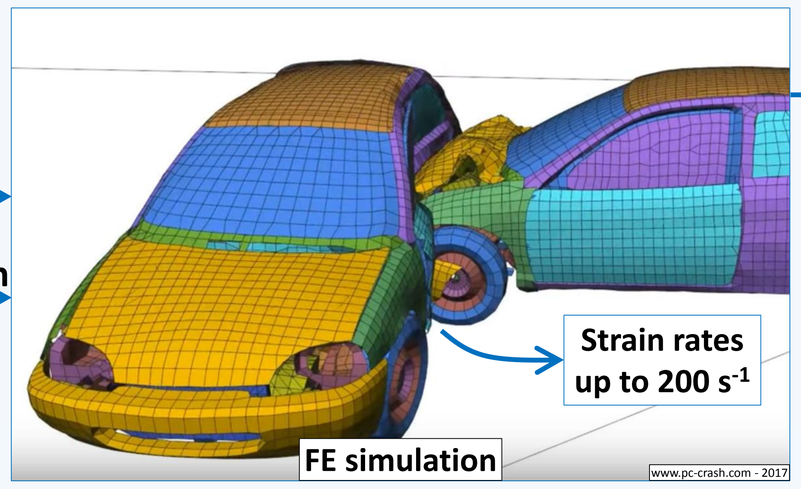
1. Motivation.

To meet the ever more stringent emission regulations, car manufacturers turn to composites to make lighter cars. Cost-effective manufacturing of structurally safe vehicles requires the use of FE-models to reduce testing: **accurate input test data at impact rates of strain** are needed.

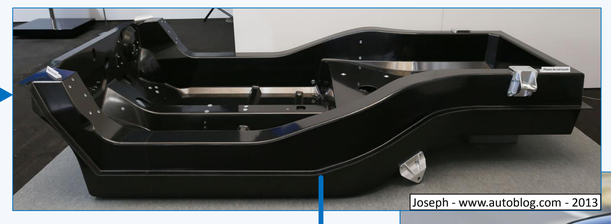


Input

Validation



Design



Far left: dynamic tensile specimen mounted in hydraulic pulse machine
Left: simulation of side-impact
Top: prototype CFRP chassis by Honda
Right: Honda CR-Z with CFRP chassis

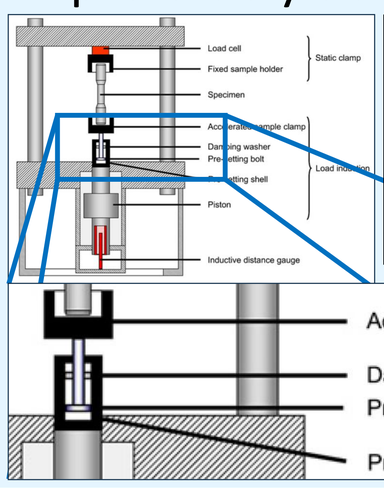
Composite car

2. Objective.

Obtain tensile properties of various composites from 10^{-4} to 10^{2} s^{-1} using a **single set-up**.

3. Method.

- **Hydraulic pulse test bench**: the only option to cover the full range of rates of interest
- A **slack rod** allows unloaded actuator speed-up
- Both **digital image correlation** and **strain gauges**
- A **piezoelectric** force sensor measures load
- Most challenging: the most brittle material at the highest speed of 15 ms^{-1}, this test lasts **20 µs**
- A minimum frequency of 25 kHz to be detected preferably above 250k samples/s



Schenck Hydropuls z25/20 VHS	
Clamp distance	0 – 1000 mm
Velocity range	0^{+} – 20 m/s
Load range	-25 – 25 kN
Measurement	• Load (piezoelectric cell) • Displacement • Strain (Vishay 2100)
Data acquisition	HBM Gen5i oscilloscope

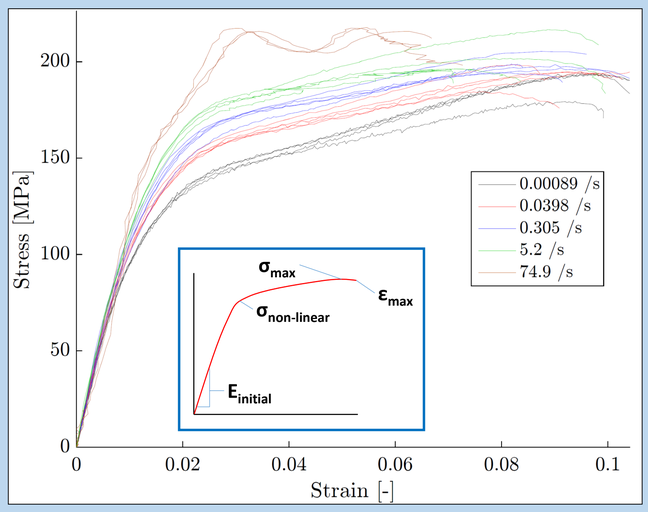
4. Materials. Two automotive composites.

- Carbon/epoxy (Mitsubishi Rayon & Honda R&D)
- Glass/PA-6 (Ten Cate Advanced Composites)

5. Results. Clear rate-dependency for #(±45):

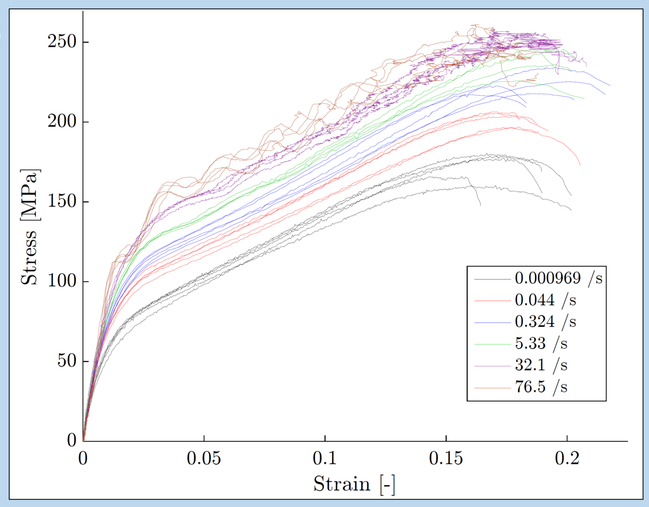
Carbon/epoxy plain weave
$[\#(\pm45)]_{4s}$ – thickness = 1.8 mm
Dogbone, L_{gauge} = 50 mm

Increasing rate:
- $\sigma_{non\text{-}linear}$: ↗
- σ_{max}: –
- ε_{max}: –
- $E_{initial}$: –



Glass/polyamide-6 twill weave
$[\#(\pm45)]_{2s}$ – thickness = 2.0 mm
Dogbone, L_{gauge} = 50 mm

Increasing rate:
- $\sigma_{non\text{-}linear}$: ↗
- σ_{max}: ↗
- ε_{max}: –
- $E_{initial}$: –



Conclusions: Single hydraulic pulse machine suitable for tension in the range from 10^{-4} to 10^{2} s^{-1}
Discovered rate-dependence of thermoset- and thermoplastic-based composites
Highest achieved rate creates stress oscillations (inertia effects under research)

Improvements: Load cell optimization: reduction of inertia effect
Specimen optimization: increase of maximum rate

Acknowledgement

The work leading to this poster is funded by the SBO project “M3Strength”, which fits in the MacroModelMat (M3) program funded by SIM (Strategic Initiative Materials in Flanders) and VLAIO (Flemish government agency for Innovation and Entrepeneurship).

SIEMENS SABCA LIMBURG N.V. HONDA Honda R&D Co., Ltd. LAZER SPORT 3d weaving MITSUBISHI RAYON CO., LTD.