# Measuring and Predicting Composite Impact Damage

**Siebe Spronk**[a,b], Francisco Gilabert[a,b], Wim Van Paepegem[a], Joris Degrieck[a]

[a] Department of Materials Science and Engineering, Ghent University, Technologiepark 903, B-9052 Zwijnaarde, Belgium, siebe.spronk@ugent.be

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

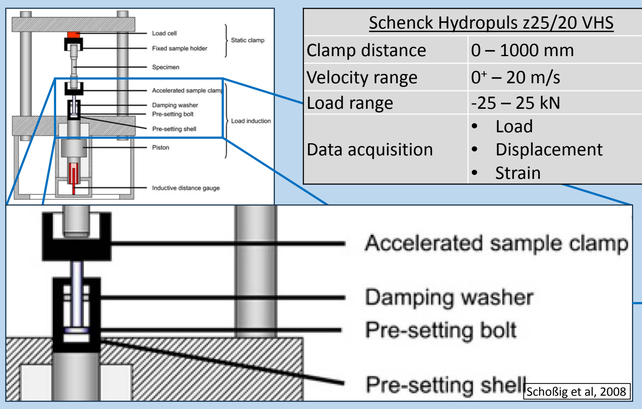
**Goal:** efficient and accurate predictive model for impact damage in laminated composites

**Method** Large-scale test programme for 1: material characterisation 2: model validation
Efficient phenomenological 3-stage multi-scale model
Virtual testing to complement experiments to obtain material parameters

Input and validation

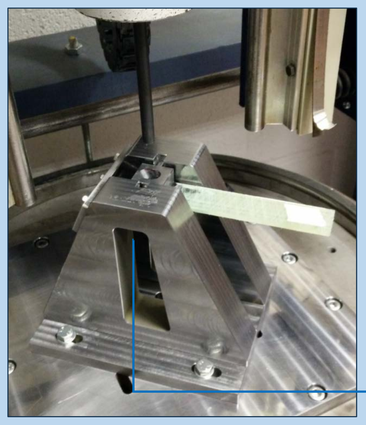
## Experimental

### **Dynamic tension:** hydraulic actuation to 20 m/s

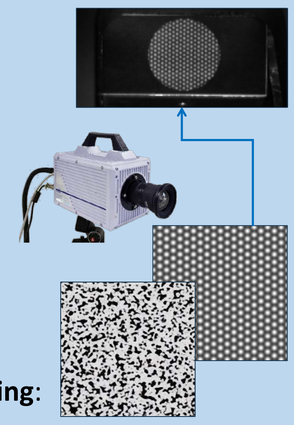



| Schenck Hydropuls z25/20 VHS | |
|---|---|
| Clamp distance | 0 – 1000 mm |
| Velocity range | $0^+$ – 20 m/s |
| Load range | -25 – 25 kN |
| Data acquisition | • Load<br>• Displacement<br>• Strain |

### **Dynamic delamination** with drop-weight tower

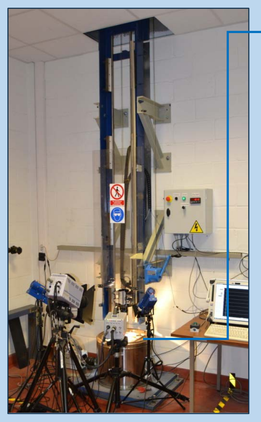


| In-house developed delamination setup | |
|---|---|
| For use in | Drop-weight tower |
| Leg separation | 0 – 100 mm |
| Data acquisition | • Load<br>• Lower arm:<br>▪ Position<br>▪ Velocity<br>▪ Acceleration |

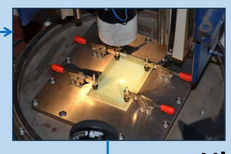


**DIC** and **pattern following**:

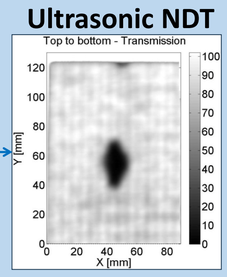
### **Drop-weight impact** and measuring damage



| In-house developed drop-weight tower | |
|---|---|
| Drop height | 10 – 3000 mm |
| Drop mass | 6.5 – 10 kg |
| Velocity range | 0.4 – 7.0 m/s |
| Energy range | 0.6 – 250 J |
| Peak force | 22 kN |
| Data acquisition | • Load<br>• Displacement<br>• Acceleration<br>• Strain |

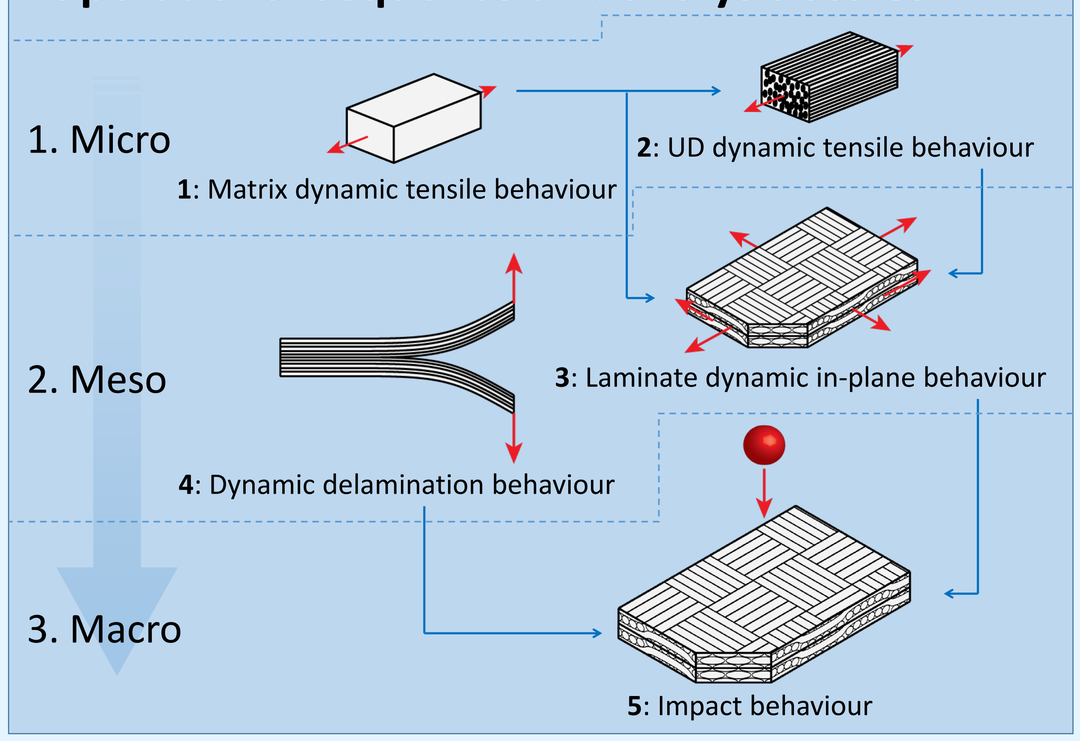


**Ultrasonic NDT**



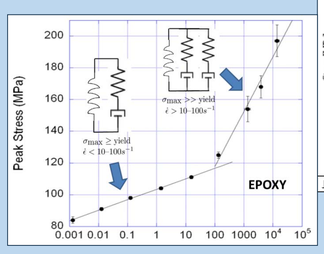

## Numerical

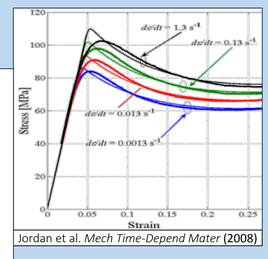
### **Operational sequence** and **analysis scales**




### **First results:** response subject to rate effects

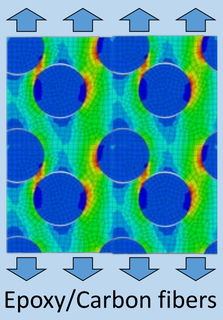
1. Pure matrix:
   - Design: **physical model**
   - Method: explicit FE analysis, with 3D user material
   - Two materials studied:
     - Thermoset: **epoxy**
     - Thermoplastic: **PA-6** (nylon)




Jordan et al. *Mech Time-Depend Mater* (2008)

2. Fiber assembly in a strain-rate dependent matrix:
   - Components: matrix + fibers + interface
   - Periodic boundary conditions
   - Loads: longitudinal, transversal, shear
   - Method: explicit FE analysis with solid 3D elements
   - Two fibre types studied:
     - **Carbon** fibres
     - **Glass** fibres



Epoxy/Carbon fibers

Prediction

**Conclusions** Tracking lower delaminating arm delivers useful force and displacement values
Explicit periodic 3D analysis with debonding conceivable but CPU intensive

**Future tasks** Removing inertia effects from dynamic results
Minimising test programme needed as model input

## Acknowledgement

The work leading to this poster has been funded by the SBO project “M3Strength”, which fits in the MacroModelMat (M3) research program funded by SIM (Strategic Initiative Materials in Flanders) and IWT (Flemish government agency for Innovation by Science and Technology).