Head Impact on Windscreen - Modelling and Validation

13th LS-DYNA Forum 2014, Bamberg

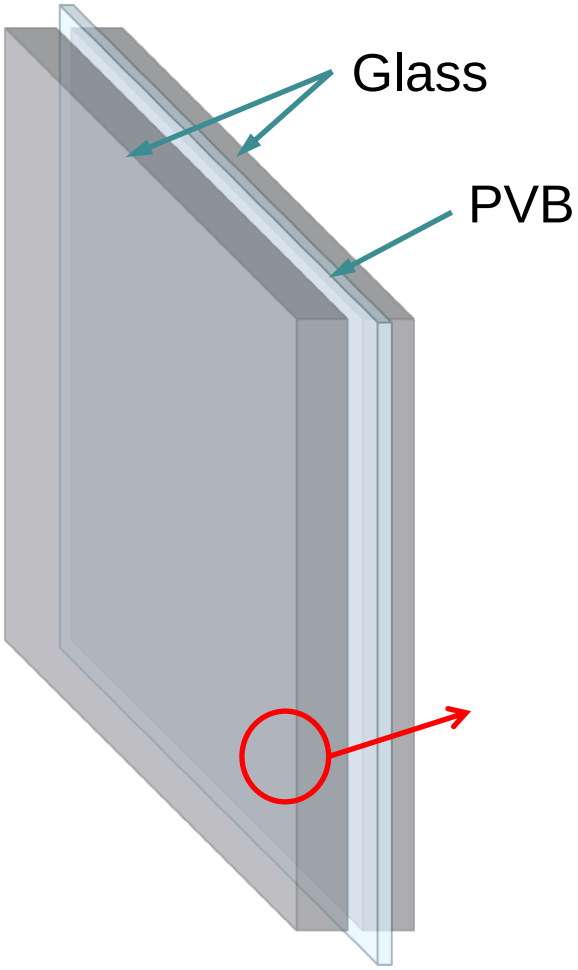
Christian Alter[1], Jens Schneider[2], Stefan Kolling[1]

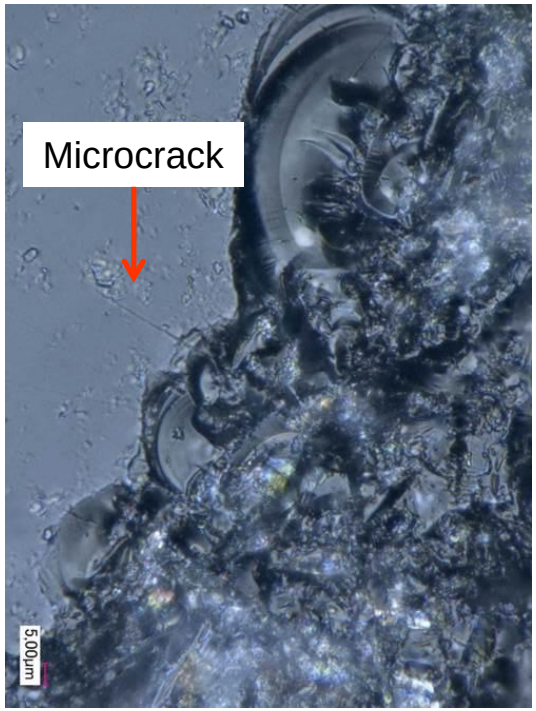
[1] Institute of Mechanics and Materials, THM Gießen

[2] Institute of Materials and Mechanics in Civil Engineering, TU Darmstadt

Overview

- Motivation
- Experimental setup
- Simulation
- Summary





Brittle material glass

Motivation

Motivation

- In case of an accident
  1. Pedestrian gets hit on his legs
  2. Rollover zone
  3. Head impact on windscreen or engine hood
- Safety requirements must be fulfilled (e.g. HIC*)
- To keep the developmental period short, exact simulations are needed
- Optimization of the simulation of laminated glass in respect of the initial failure and the post-breakage behavior

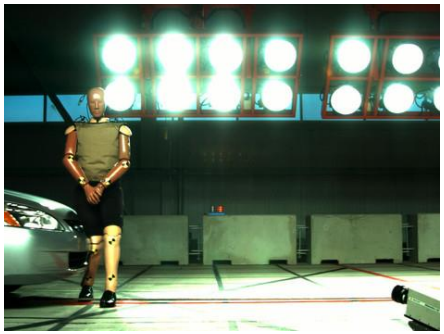


Photo: hondanews.com

*Head Injury Criterion: $HIC = max\left\{\left[\frac{1}{t_2-t_1}\int_{t_1}^{t_2} a_{res}dt\right]^{2.5}(t_2-t_1)\right\} \leq 1000$

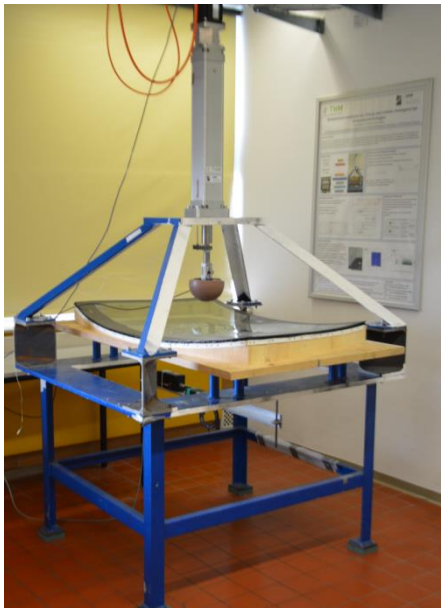
Regulation (EC) No 78/2009

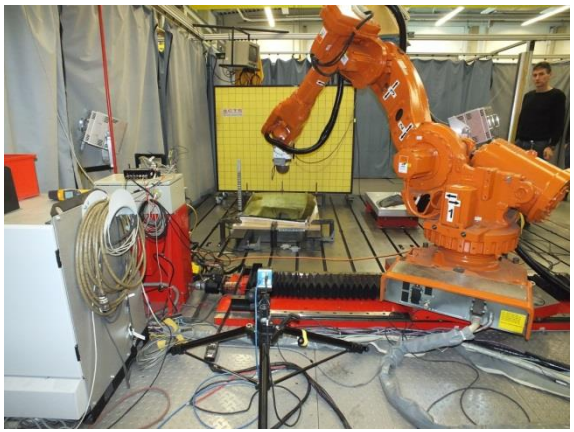
Experimental setup

Experimental setup

IMM
Institute of Mechanics and Materials

- Different tests have been done
  - Quasi static: electric cylinder (0.365m/s) or pneumatic cylinder (<10m/s)
  - Dynamic: free-flying impactor (10m/s)
- Four hemispherical bearings or clued on a wooden frame
- Windscreens tested in concave and convex direction

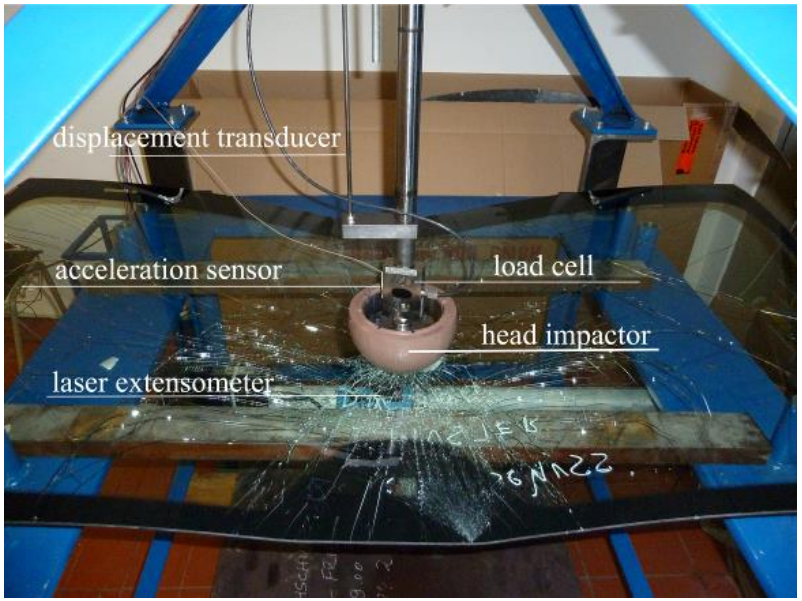


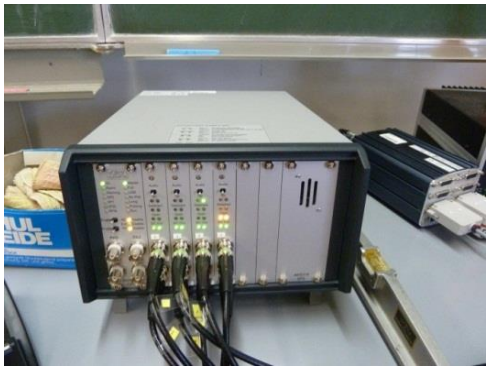


Experimental setup

IMM
Institute of Mechanics and Materials

- Data measurement (qs.):
  - Displacement transducer
  - Acceleration sensor
  - Laser extensometer
  - Load cell
  - Acoustic emission system
  - High speed camera
  - *3D measurement*
- Data measurement (dyn.)*:*
  - Transversal Acceleration
  - High speed camera

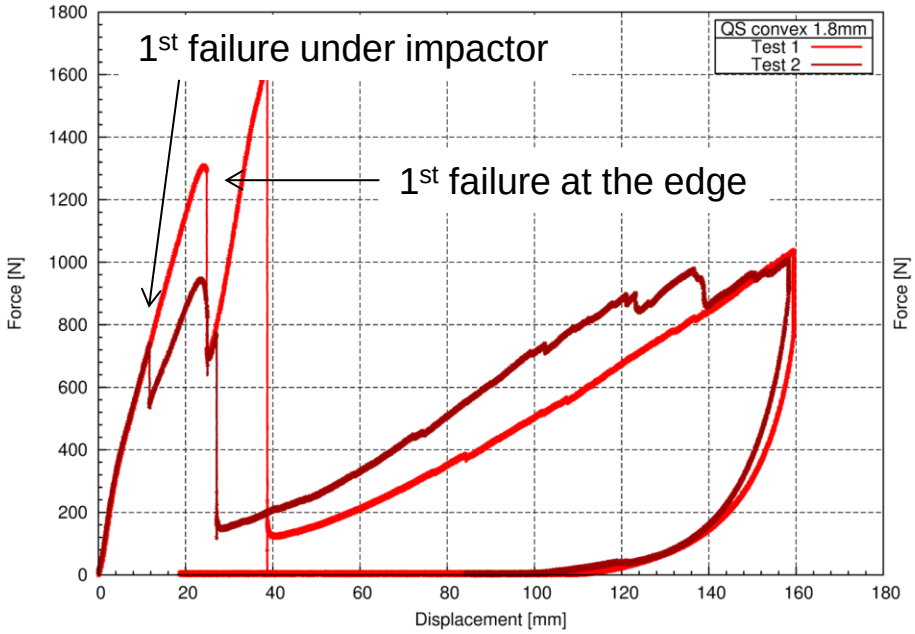


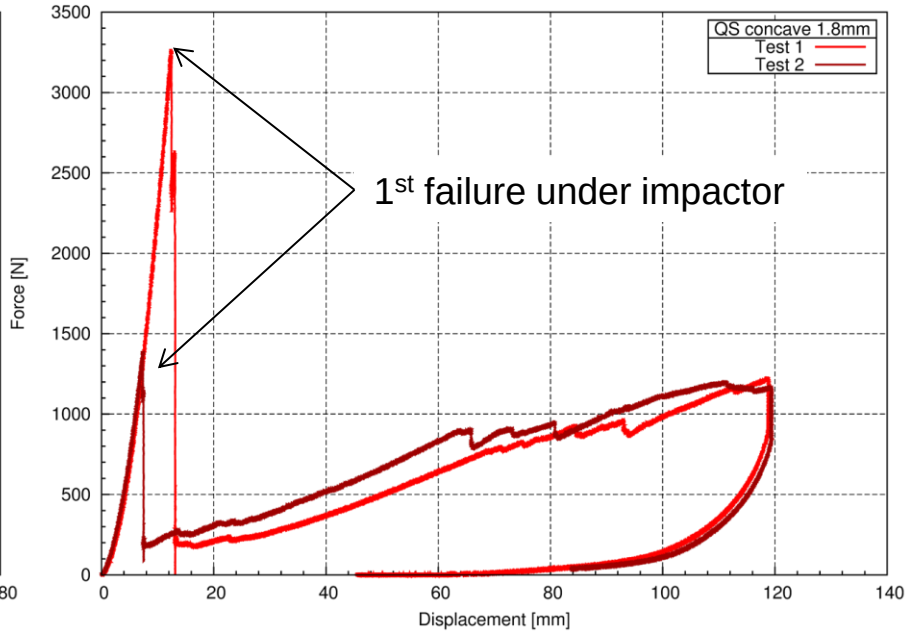


Experimental setup

IMM
Institute of Mechanics and Materials

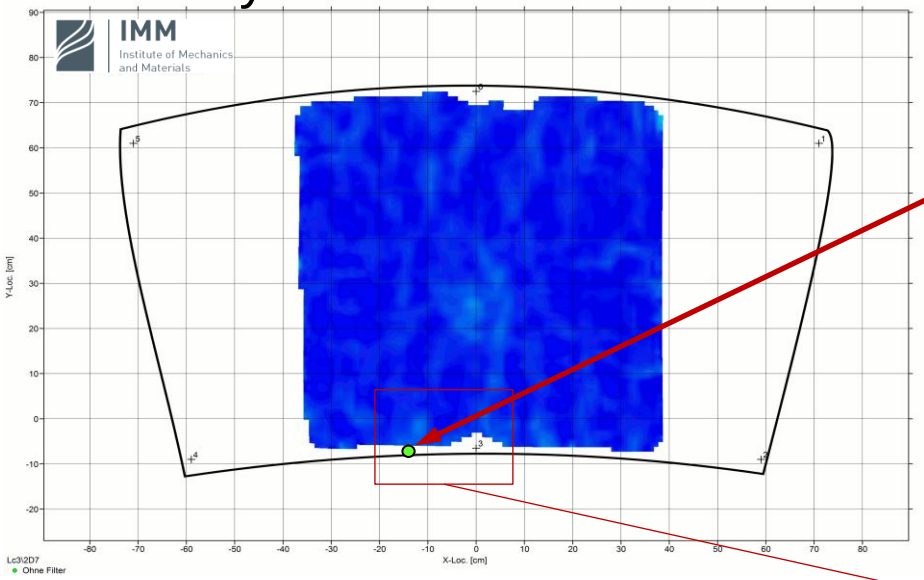
- Quasi-static test, windscreens in convex and concave direction
  - Repeatable elastic behavior until failure
  - High statistical scattering of the strength of glass
  - Different positions of the initial failure

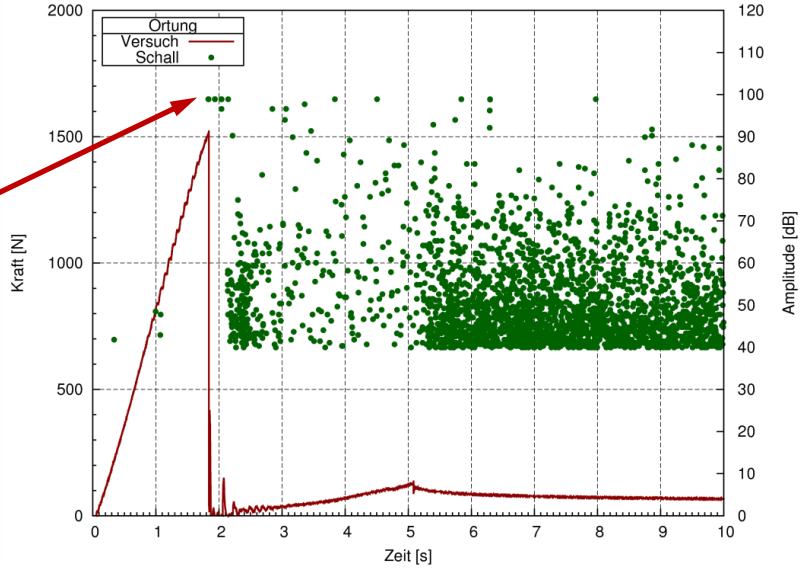


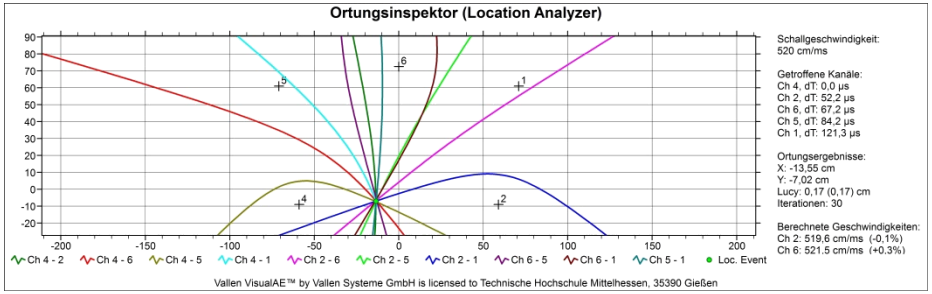


Experimental setup

- Comparison of the 3D measurement and the acoustic emission analysis

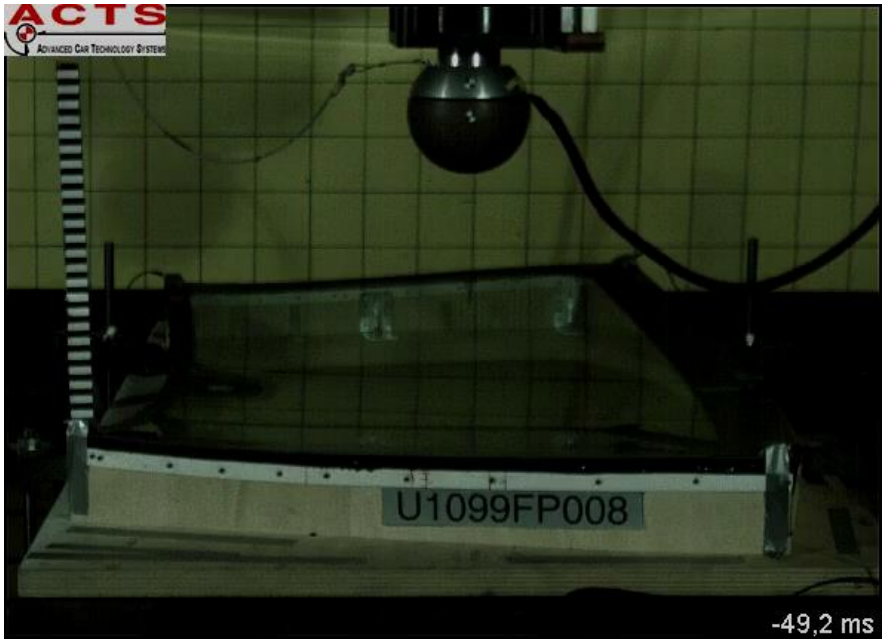


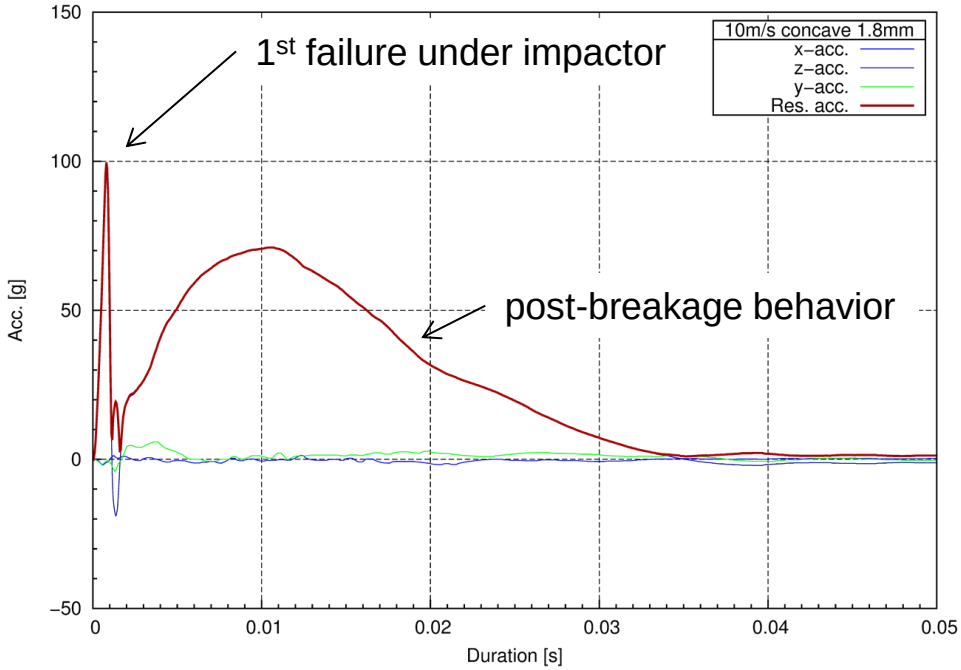




Experimental setup

- Dynamic test, windscreens in concave direction, 1.8mm glass
  - Initial failure under impactor

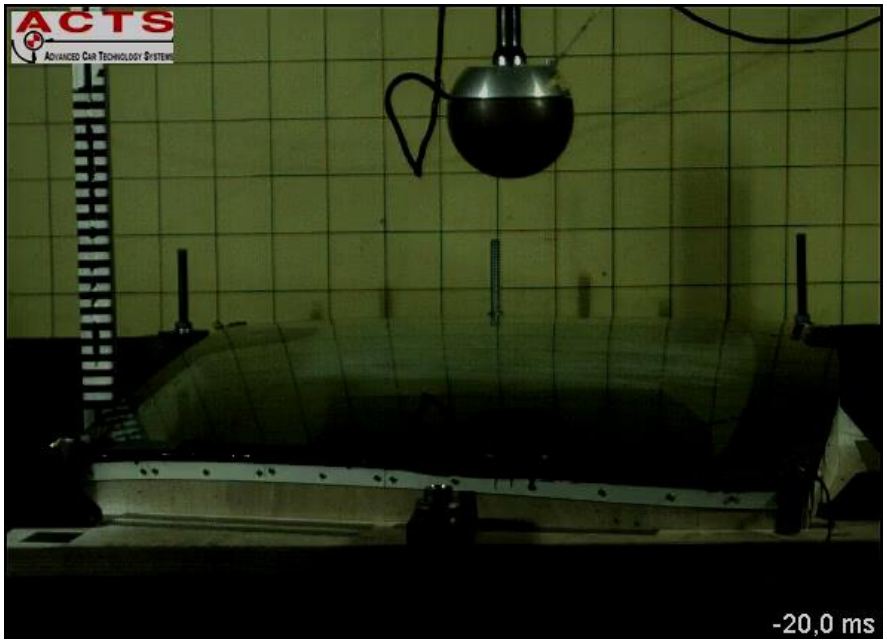


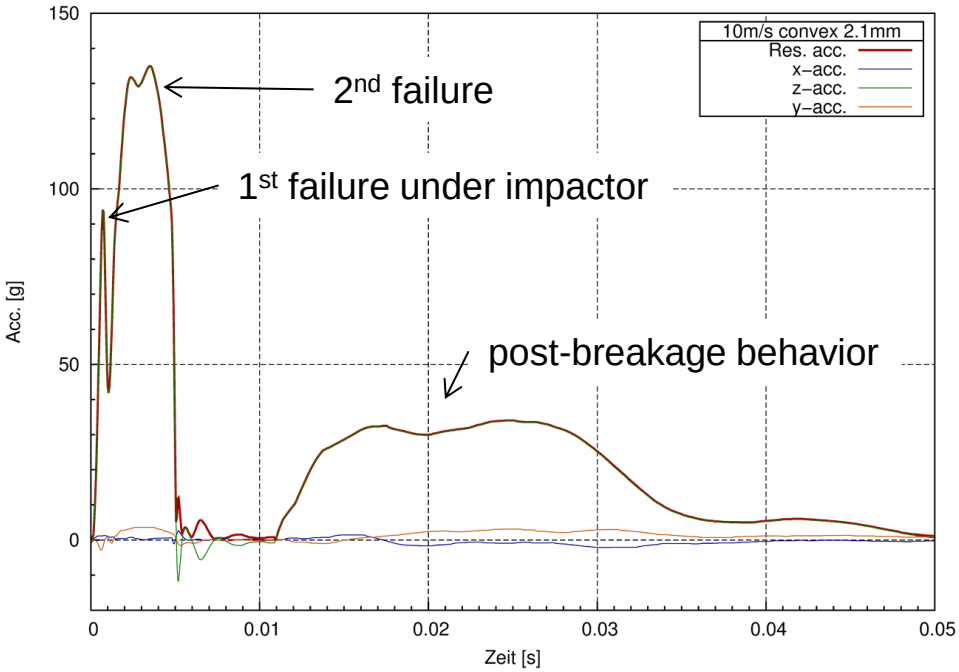


Experimental setup

IMM Institute of Mechanics and Materials

- Dynamic test, windscreens in convex direction, 2.1mm glass
  - Initial failure under impactor

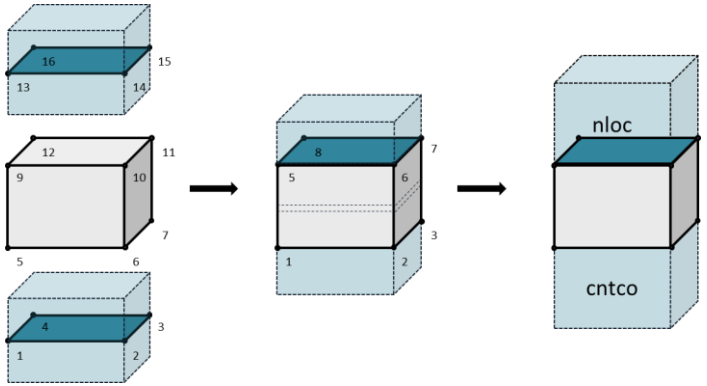


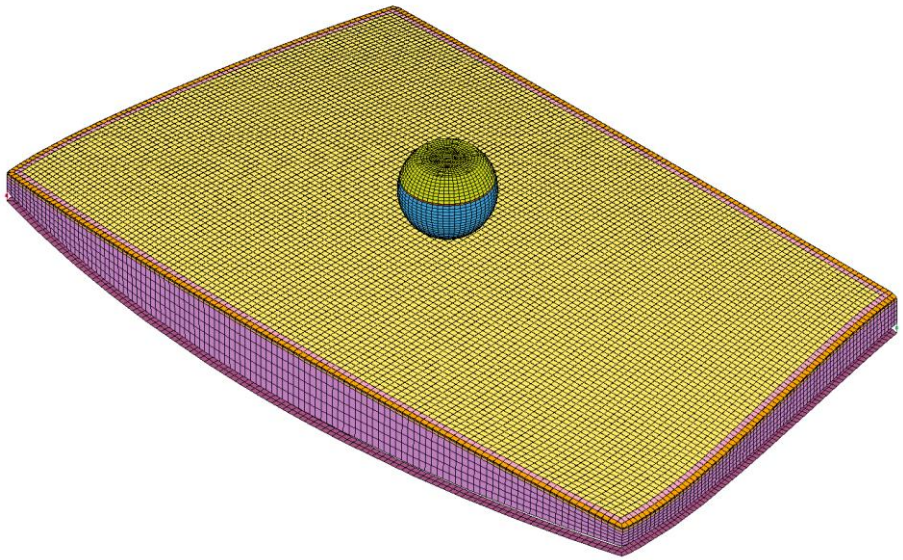


Simulation

Simulation

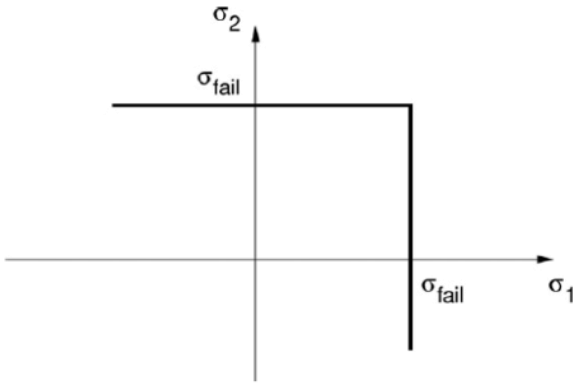
- Impactor provided by Lasso Ingenieurgesellschaft mbH
- Usage of a shell – solid – shell model is preferred
- Different strengths for edge and surface
- *CONTACT_TIED_SHELL_EDGE_TO_SURFACE_BEAM_OFFSET for adhesive bonding

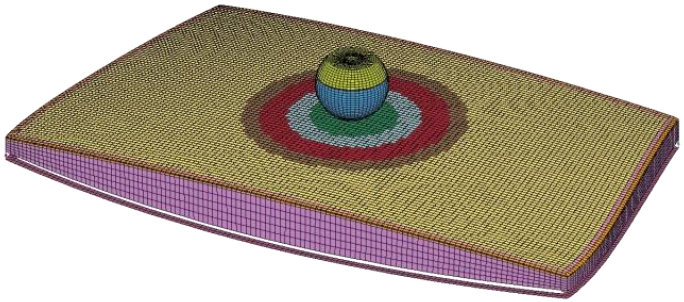




Simulation

- Linear-elastic behavior for glass until Failure
- Hyperelastic material behavior *MAT_BLATZ-KO_RUBBER (qs.) / *MAT_SIMPLIFIED_RUBBER (dyn.) for PVB
- Failure criteria for glass:
  - Classical failure criterion (major stress/strain)
  - Non-local failure criterion implemented in *MAT_ADD_EROSION (ENGCRT,DARCRT,SIGP1)

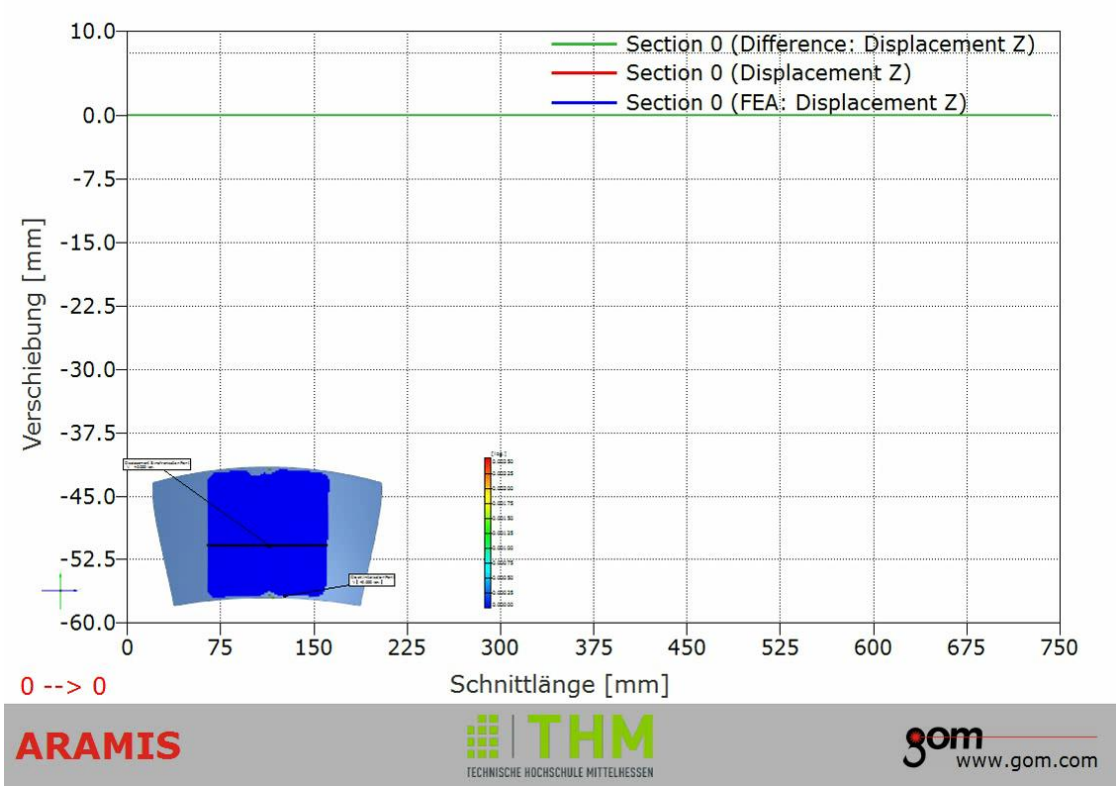




T. Pyttel, H. Liebertz, J. Cai: Failure criterion for laminated glass under impact loading and its application in finite element simulation, International Journal of Impact Engineering

Simulation

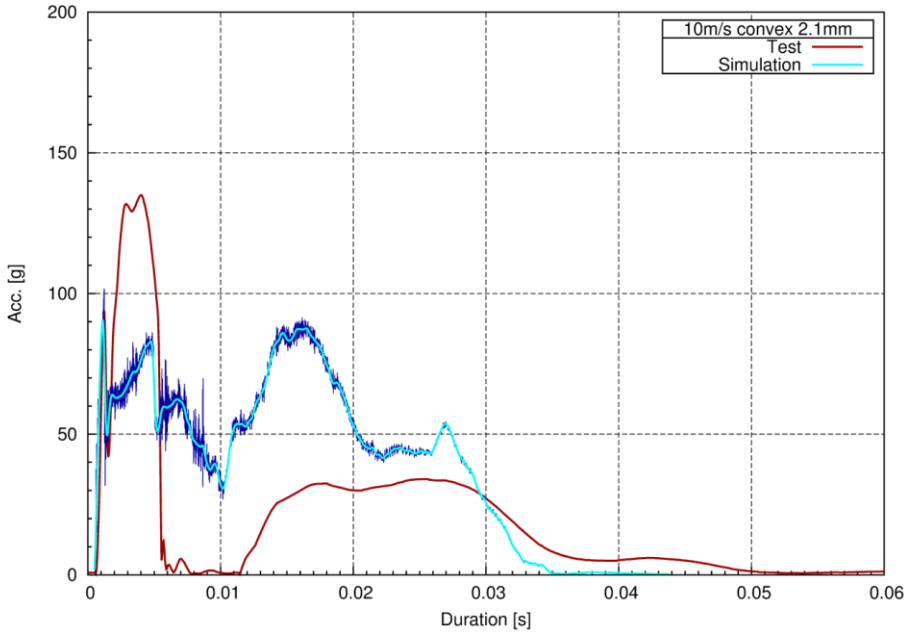
- Validation of the elastic behavior
  - Test and simulation are in good agreement until failure

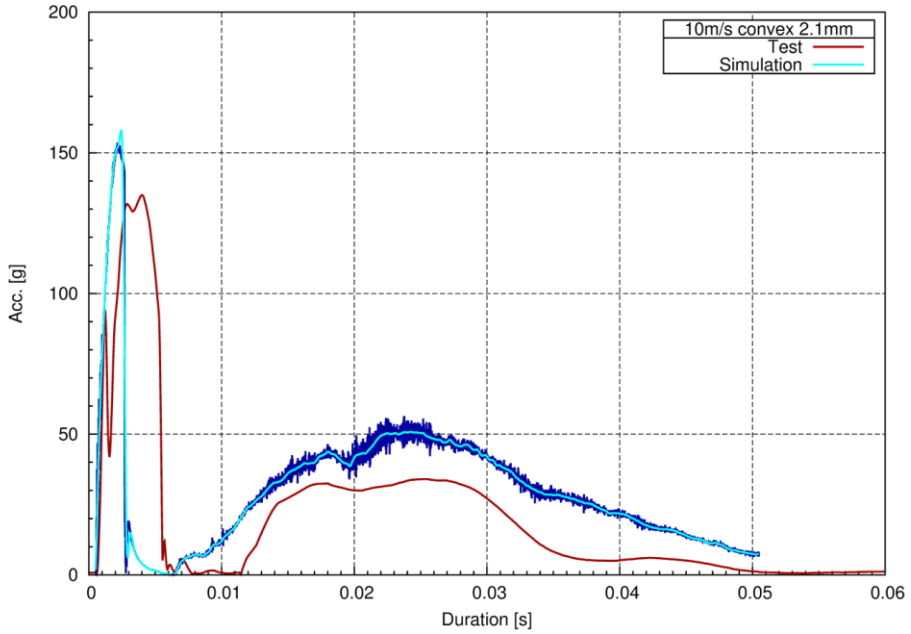


Displacement along horizontal line

Simulation

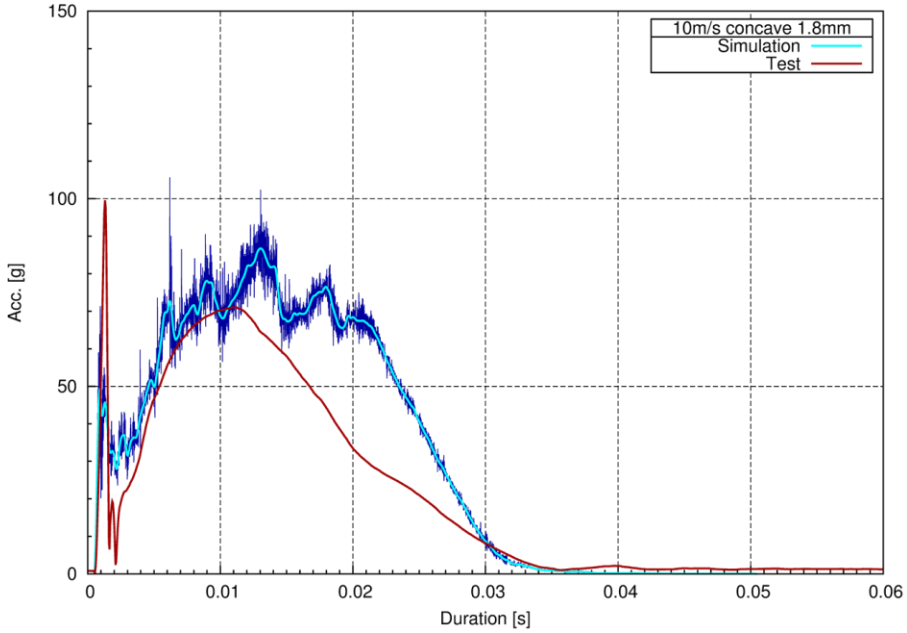
- Dynamic test in convex direction:
  - Necessary to adjust the failure criterion in the simulation
  - Classical failure criterion is not in good agreement after initial failure
  - Better results with the non-local criterion

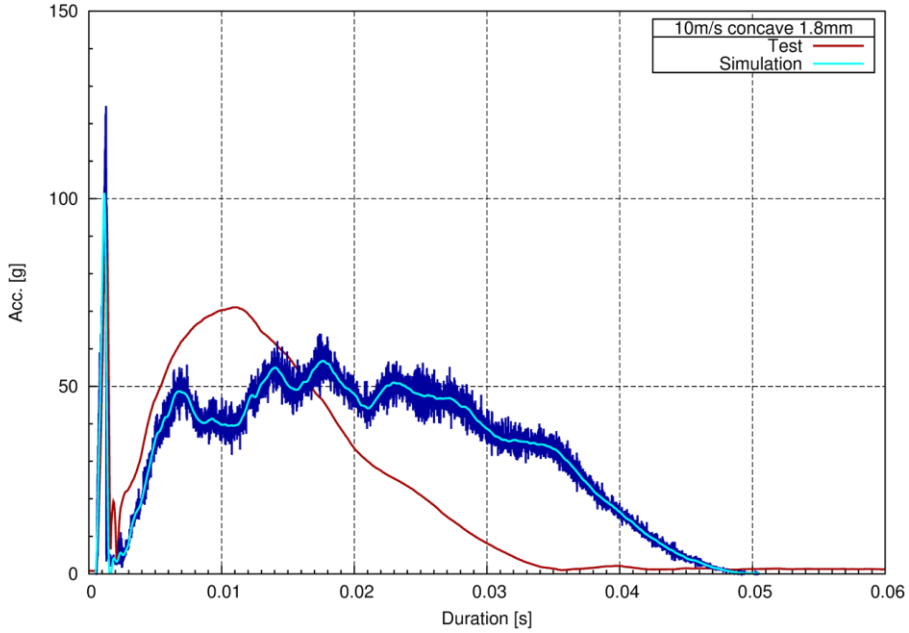




Simulation

- Dynamic test in concave direction:
  - Necessary to adjust the failure criterion in the simulation
  - Classical failure criterion not in good agreement after initial failure
  - Better results with the non-local criterion





Summary

Summary

- Quasi static and dynamic head impact tests
- High statistical scattering of the strength of glass

- Modelling technique for laminate glass
- Validation of the elastic behavior
- No appropriate failure criterion available at the moment

ALLIANZ INDUSTRIE FORSCHUNG

FAT | Forschungsvereinigung Automobiltechnik

Thank you for your attention!