Karlsruhe Institute of Technology

Institute of Vehicle System Technology
Division Lightweight Engineering
Digitalization in Lightweight Design

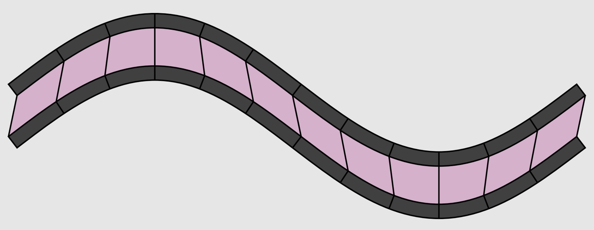
The influence of impact damage on the damping behavior of constrained layer damping laminates

Jackstadt, A.[a] | Kärger, L.[a] | Weidenmann, K.A.[b]

[a] Karlsruhe Institute of Technology (KIT), Institute for Vehicle Systems Technology, Rintheimer Querallee 2, Karlsruhe, 76131, Germany
[b] University of Augsburg, Institute of Materials Resource Management, Am Technologiezentrum 8, Augsburg, 86159, Germany

Motivation

Constrained layer damping (CLD)

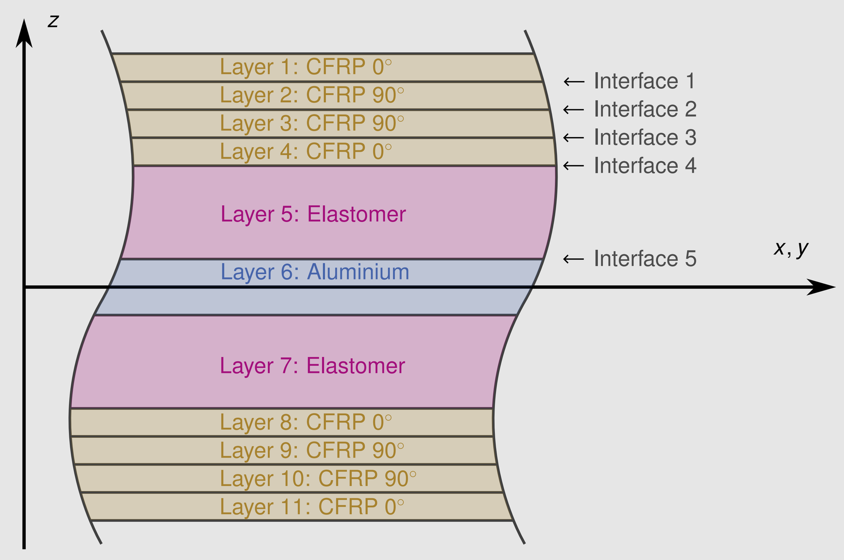


constraining layer: stiff material
constrained layer: highly compliant, viscoelastic material

- Lightweight structures are prone to vibrations
- Vibrations induce a bending deformation
- Shear bending leads to high deformations in the constrained layer
- High dissipation in the constrained viscoelastic layer results in vibration damping

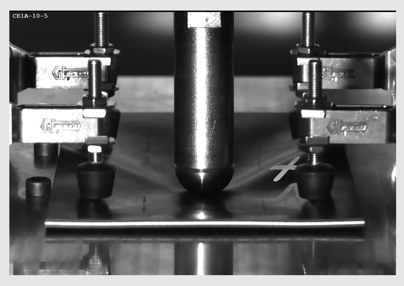
Material

Hybrid CFRP Elastomer Metal Laminate (HyCEML)



Experimental findings

Low-velocity impact



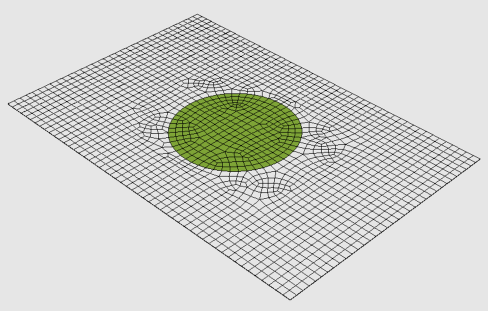
Low-velocity impact test on a hybrid laminate according to ASTM D7136.

Low-velocity impact leads to

- Intra-ply damage in CFRP layers
- Delaminations
- Permanent laminate deformation

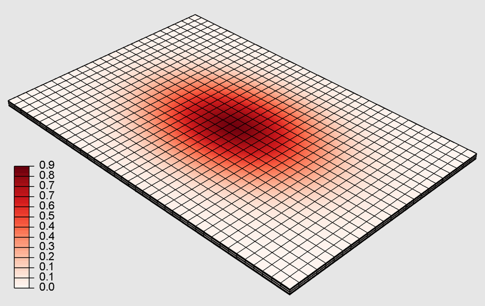
of varying extent, depending on impact energy.

Model: delaminations



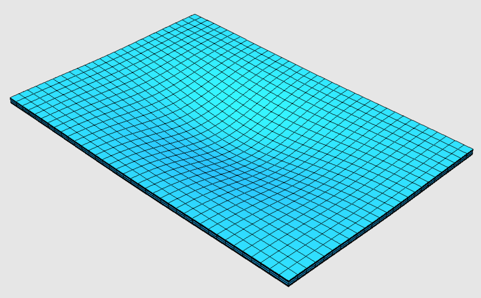
Finite element mesh in a partially delaminated interface. Delaminated area shown in green.

Model: intra-ply damage



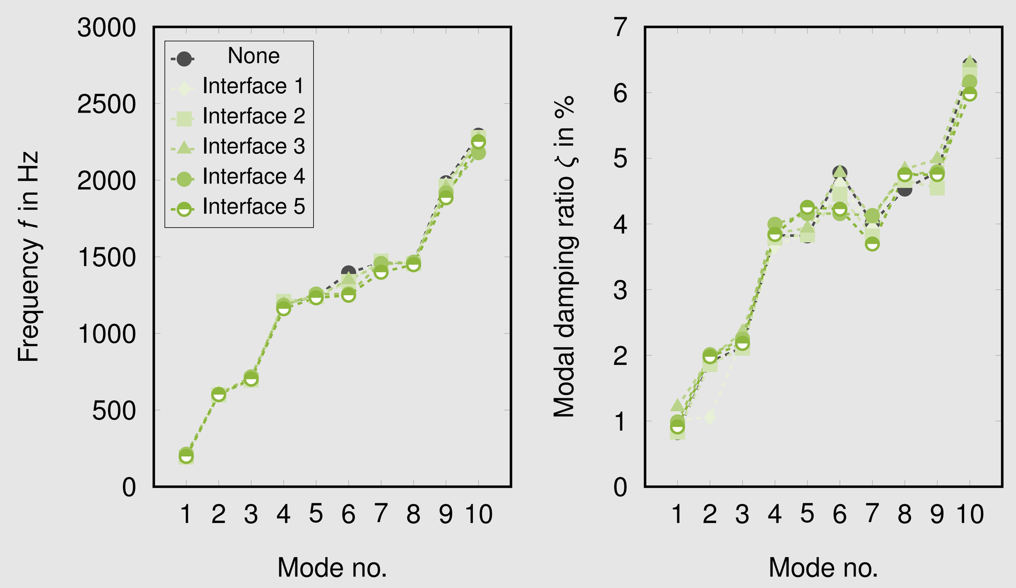
Finite element model showing the assumed distribution of Hashin type fiber damage parameter d_f.

Model: permanent deformation

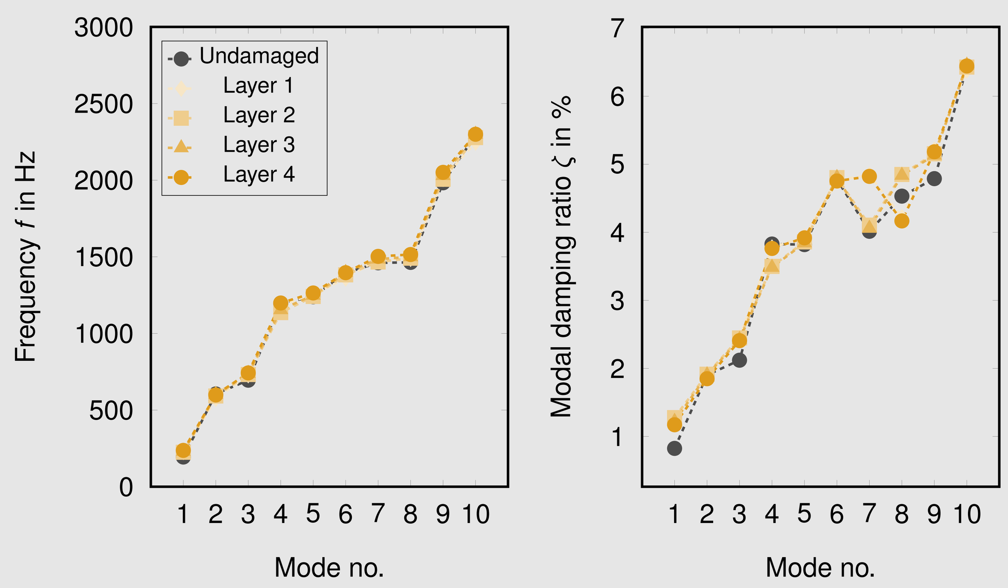


Predeformed, stress-free finite element model depicting the permanent deformation caused by an impact event.

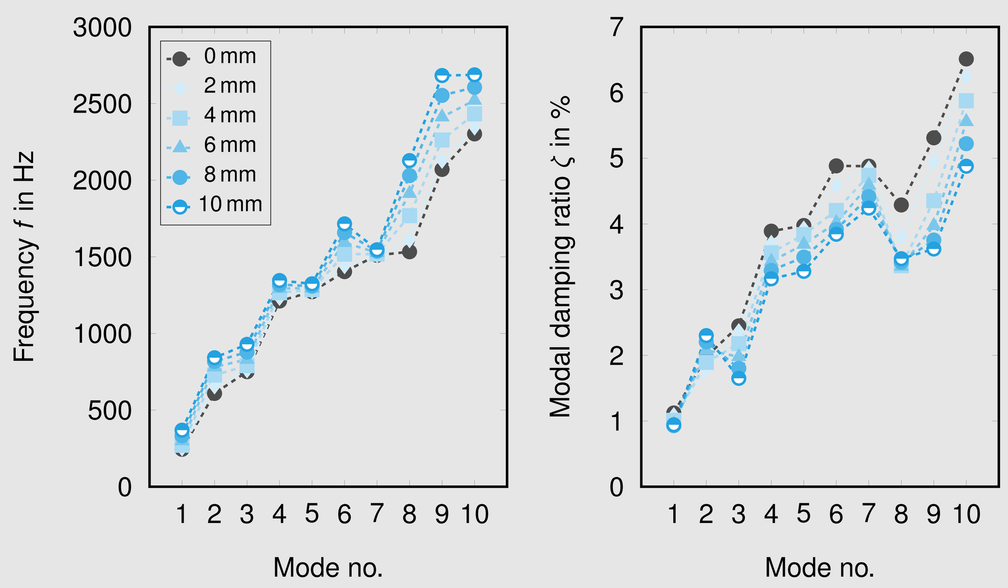
Results: Free vibration after impact



Natural frequencies and modal damping ratios of HyCEML plates with delaminations occurring in different interfaces.



Natural frequencies and modal damping ratios of HyCEML plates with Hashin type intra-ply damage occurring in different CFRP layers.



Natural frequencies and modal damping ratios of HyCEML plates with different levels of predeformation. The predeformation is given as the maximum indentation depth.

Conclusions

- Low-velocity impact results in delaminations, intra-ply damage to CFRP layers and permanent deformation
- Natural frequencies and modal damping ratios largely unaffected by delaminations and intra-ply damage
- Permanent deformation is the leading cause of change in natural frequencies and modal damping ratios
- CLD is a highly damage-tolerant intrinsic damping mechanism for lightweight design

Outlook

- Combinations of different types of damage
- Forced vibration
- Varying laminate configurations and materials

Contact
Alexander Jackstadt, M.Sc.
alexander.jackstadt@kit.edu
www.fast.kit.edu/english/lbt

Acknowledgments
This work was kindly funded by the German Research Foundation (DFG) within the priority program SPP1897. Furthermore we thank Gummiwerk KRAIBURG GmbH & Co. KG for supplying the elastomer material.

FAST Institute of Vehicle System Technology