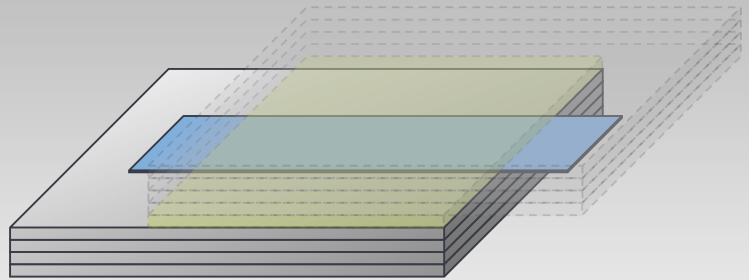
VALIDATION OF STATIC RESIDUAL STRENGTH ANALYSES OF FIBER COMPOSITE BONDED JOINTS

JoinDT – Joining with predictable Damage Tolerance



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DLR Institut für Systemleichtbau

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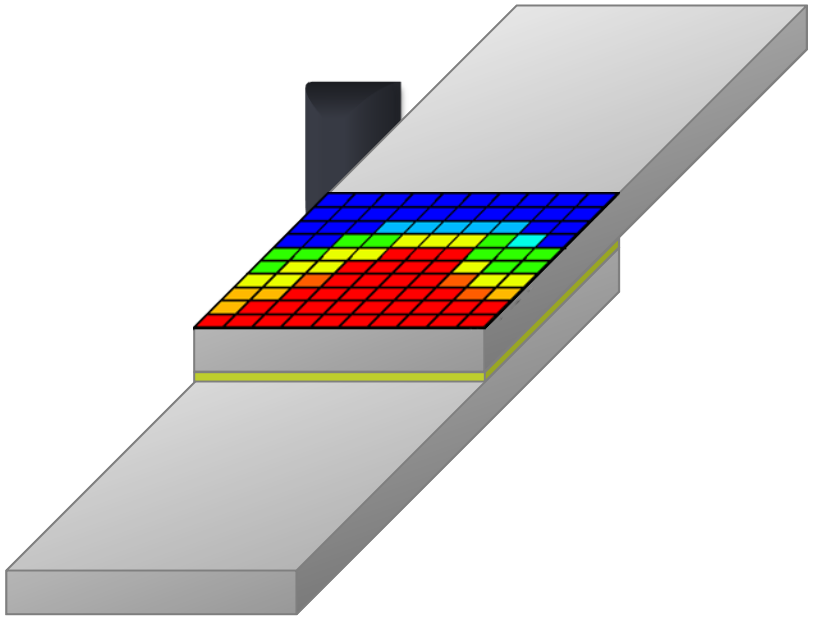
Introduction



Damage Toleranz Analysis:

- Impact Simulation
- Fatigue Simulation

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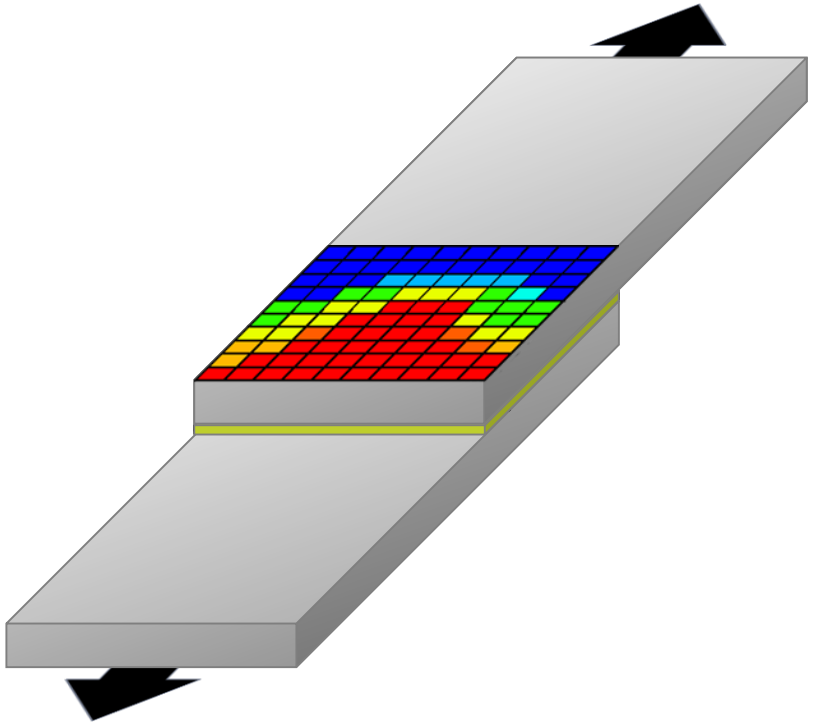
Introduction



Damage Toleranz Analysis:

- Impact Simulation
- Fatigue Simulation
- Residual Strength Simulation

No perfect predictions

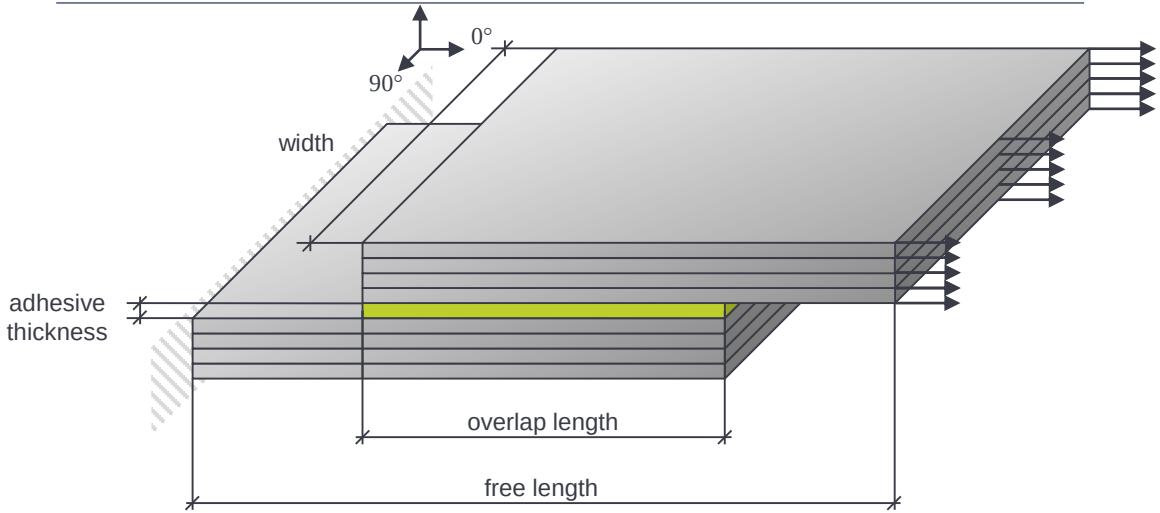
- Error propagation

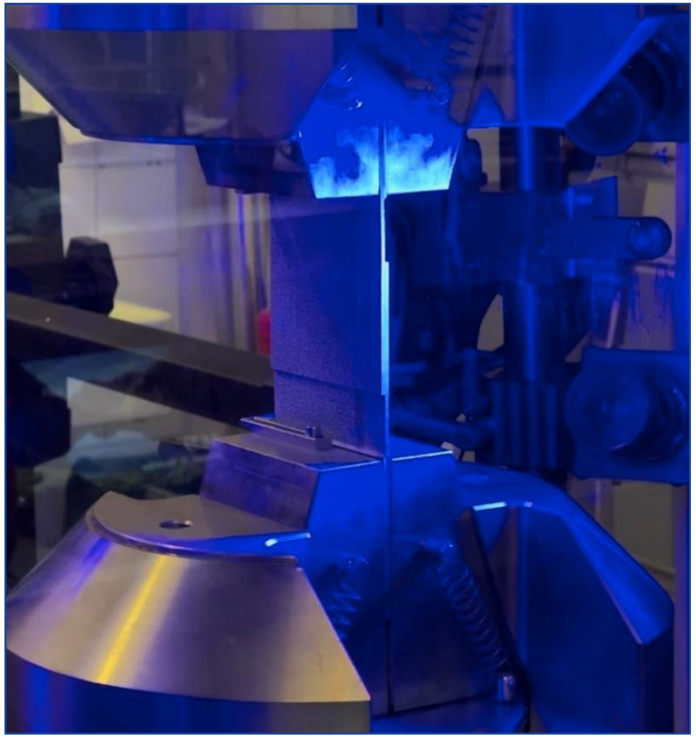
Independent and reproducible validation methods required

Experiments with artificial damage

Large single lap coupon tests

- Material: 8552-IM7 / EA9695
- Width: 100 mm
- Overlap length: 60 mm
- Free Length: 120 mm
- Layup: $[45,90,-45,0]_{2s}$
- Quasi static test: 2 mm / min





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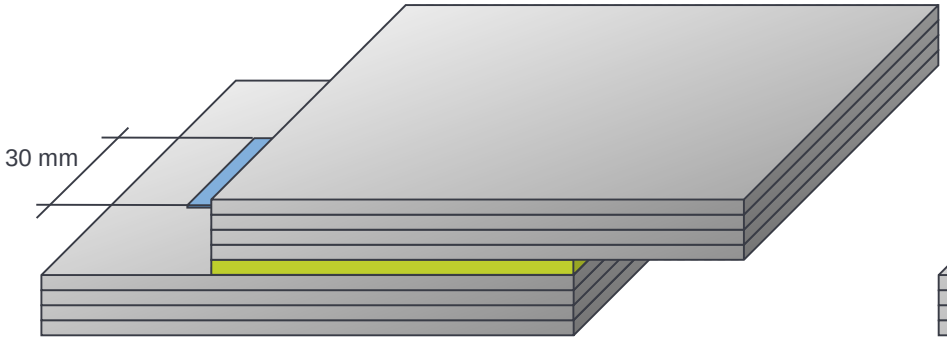
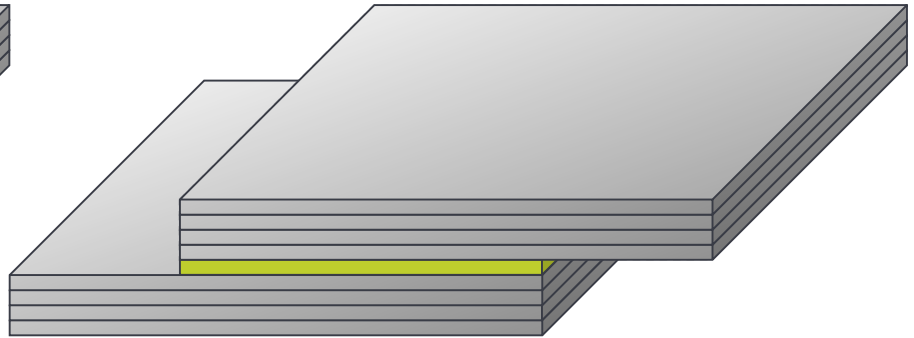
Experiments with artificial disbond and artificial interlaminar disbond



Artificial disbond



Artificial interlaminar damage

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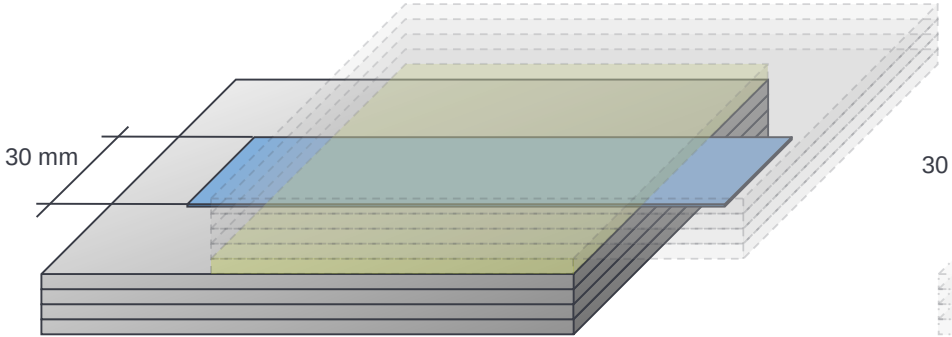
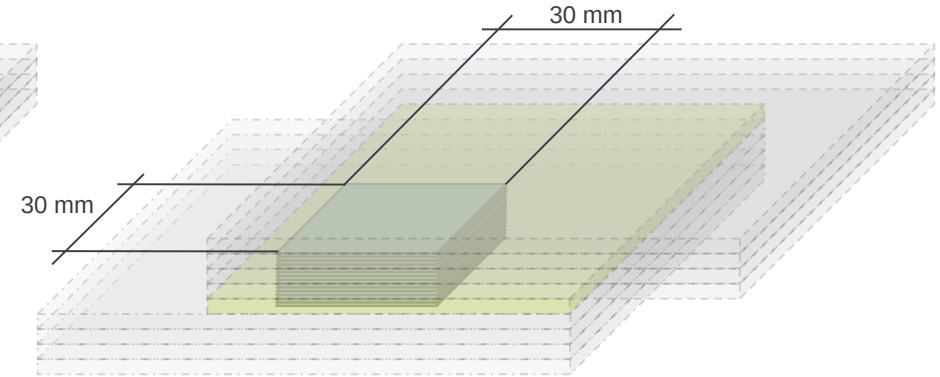
Experiments with artificial disbond and artificial interlaminar damage



Artificial disbond



Artificial interlaminar damage

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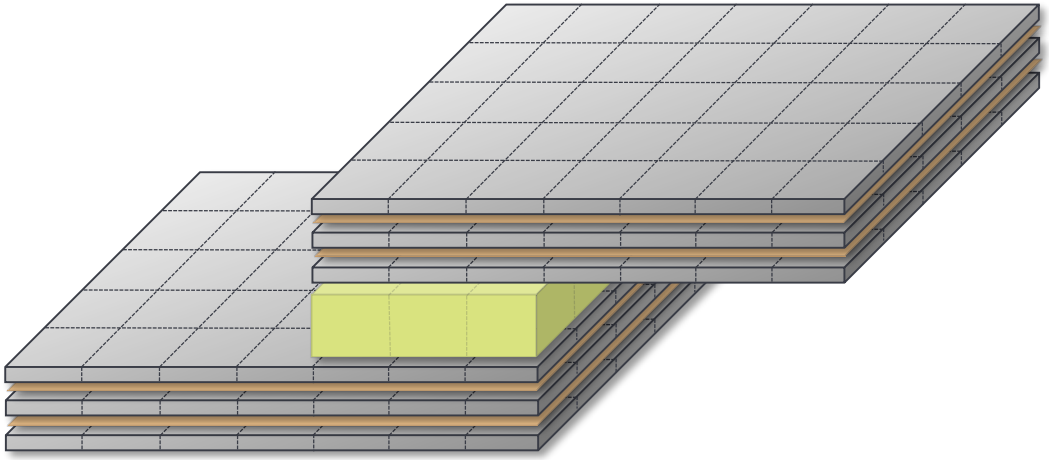
Numerical approach



Intralaminar modeling

- Layer-wise approach
- Continuum Shells (SC8R)
- User-defined material model in Abaqus / Explicit (VUMAT)
  - Considering plasticity of matrix
  - Cuntzes Failure Mode Concept

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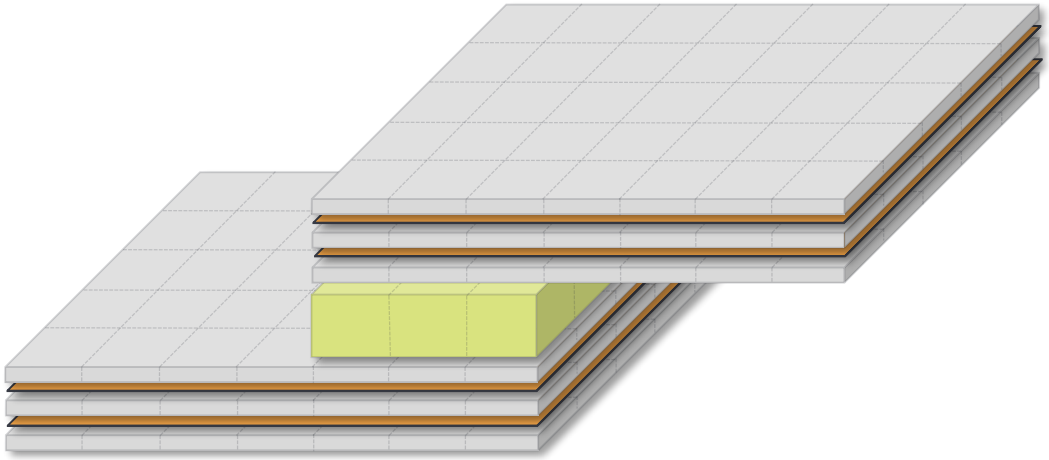
Numerical approach



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Interlaminar modelling

- cohesive zone modelling
- cohesive contacts or zero-thickness cohesive elements between individual plies

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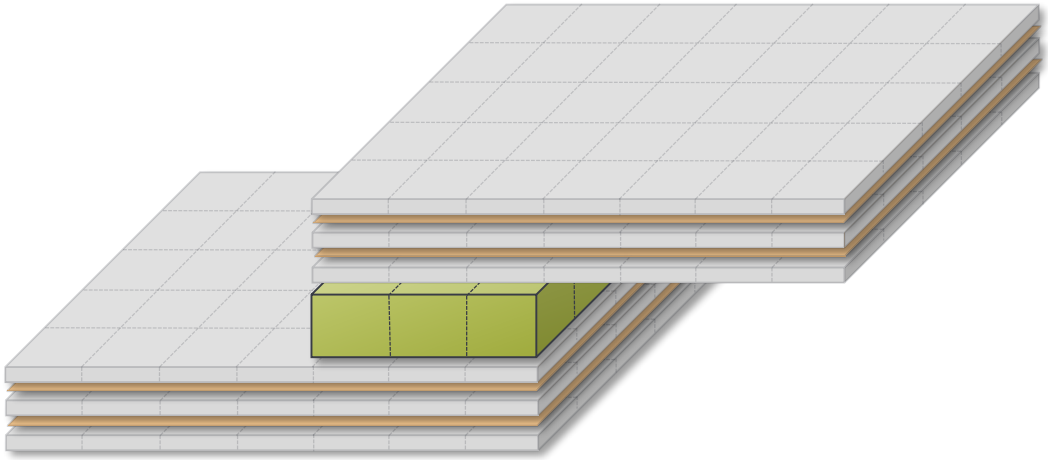
Numerical approach



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Adhesive modelling

- cohesive elements to replace adhesive layer

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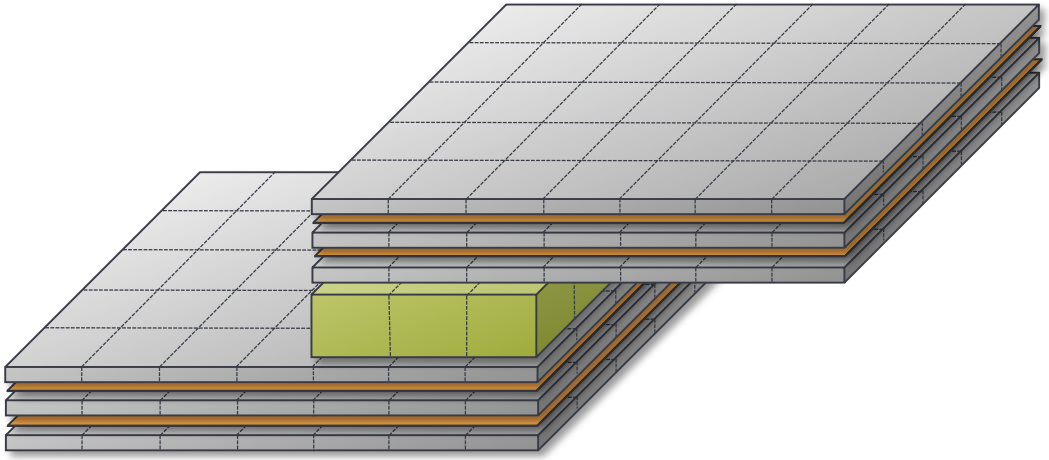
Numerical approach



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Interlaminar modelling

- cohesive zone modelling
- cohesive contacts or zero-thickness cohesive elements between individual plies

Adhesive modelling

- cohesive elements to replace adhesive layer

Artificial damage modelling

- Neglect contact in defined areas

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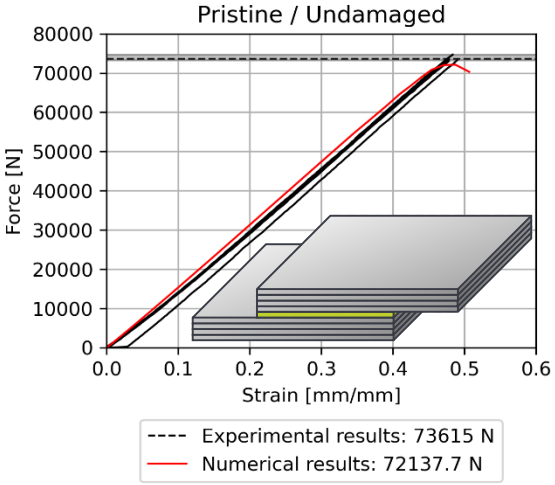
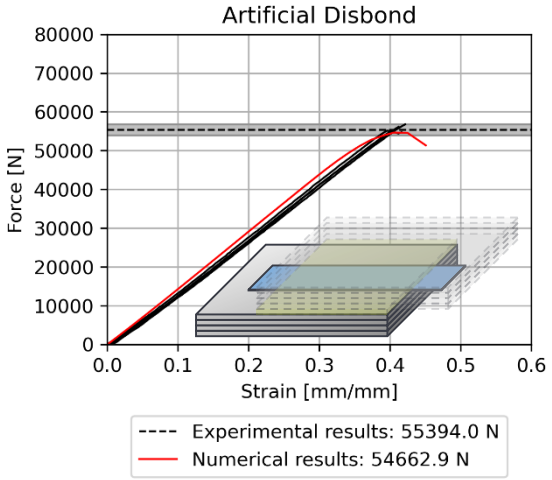
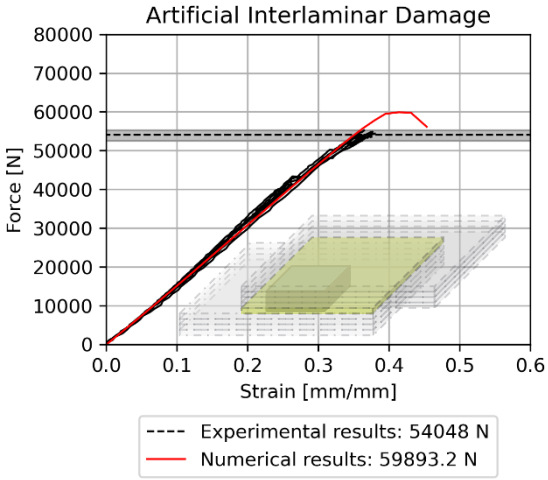
Comparison of numerical results and experiments







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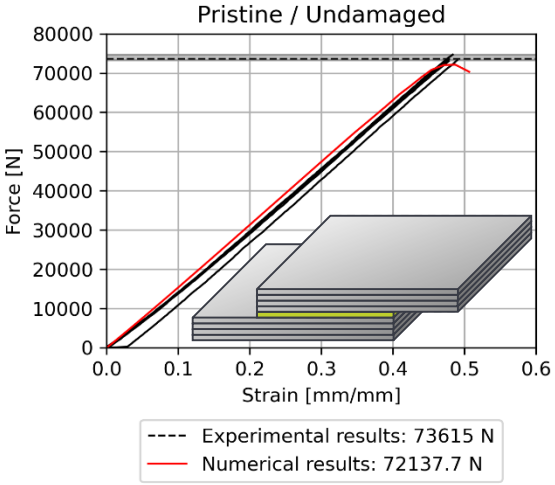
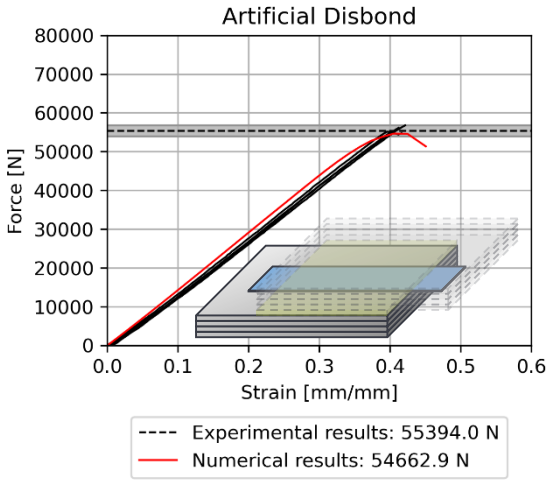
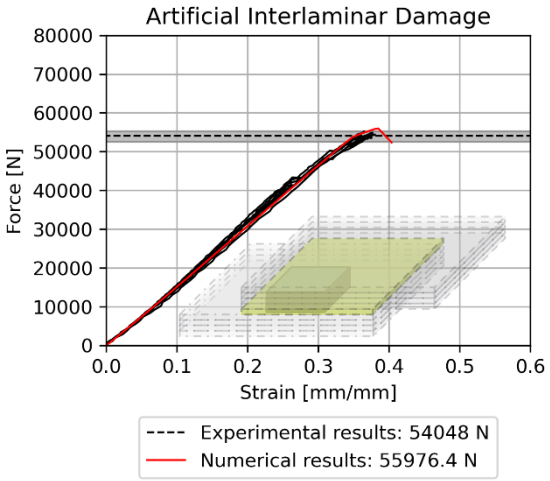
Comparison of numerical results and experiments







Stiffnesses and strengths of experiments and simulations agree well.

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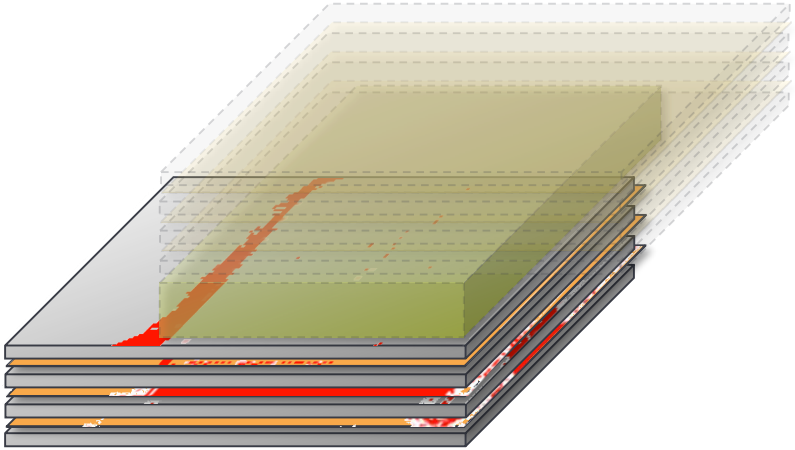
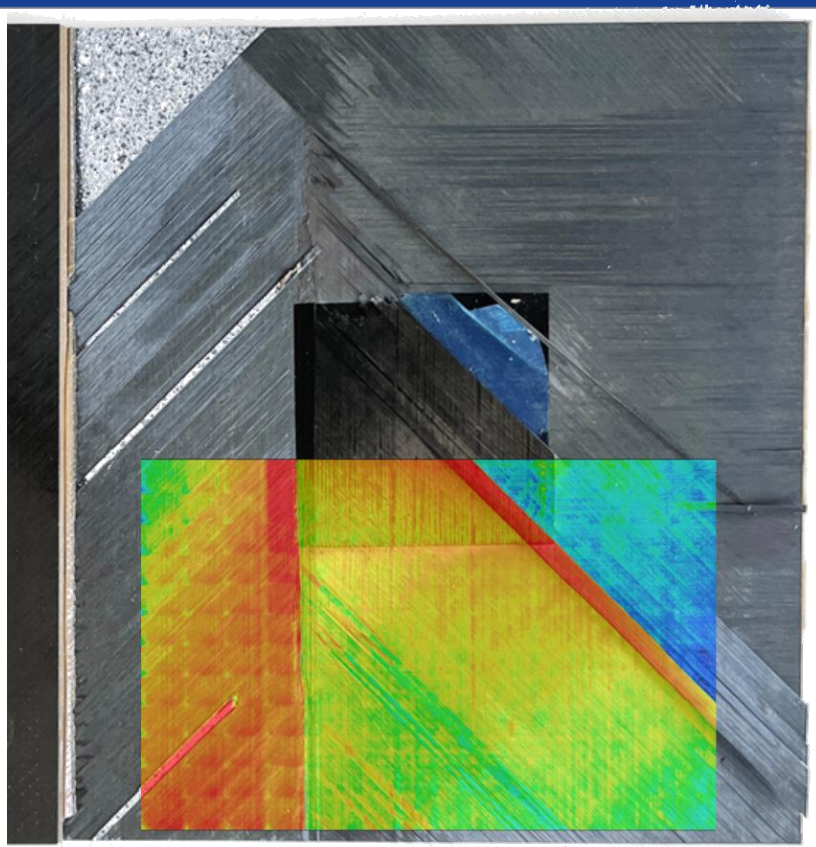
Comparison of Failure Patterns – Artificial Interlaminar Damage





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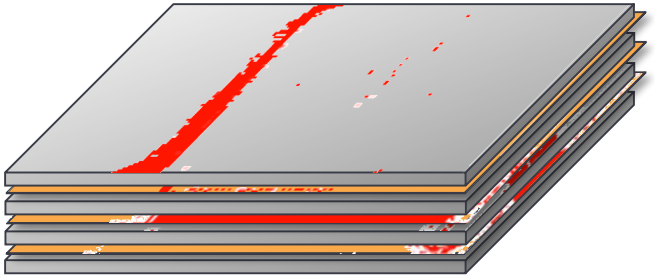
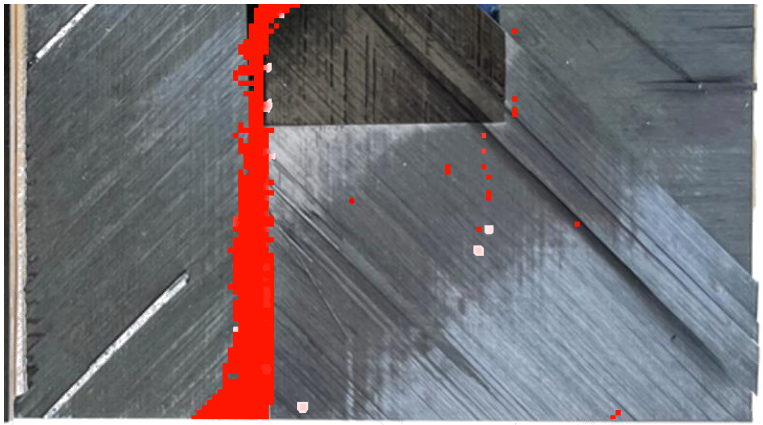
First Composite Layer

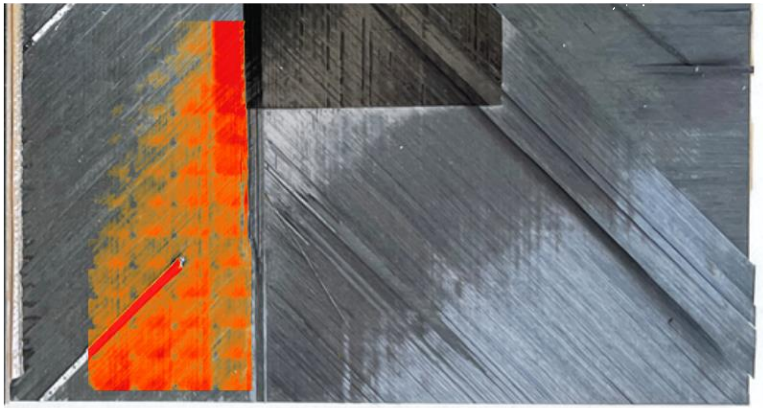
Interfibre failure



Damage in Simulation



Height measurement



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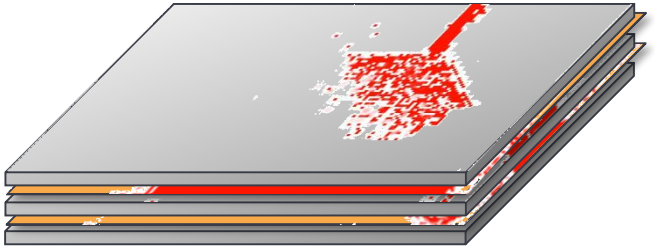
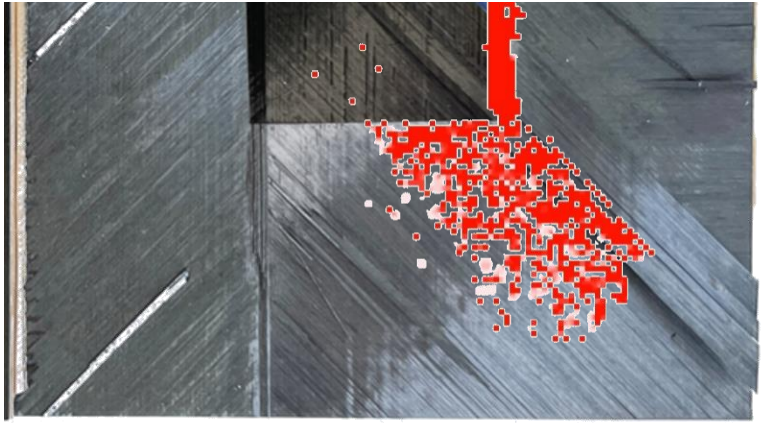
Second Composite Layer

Interfibre failure



Simulation



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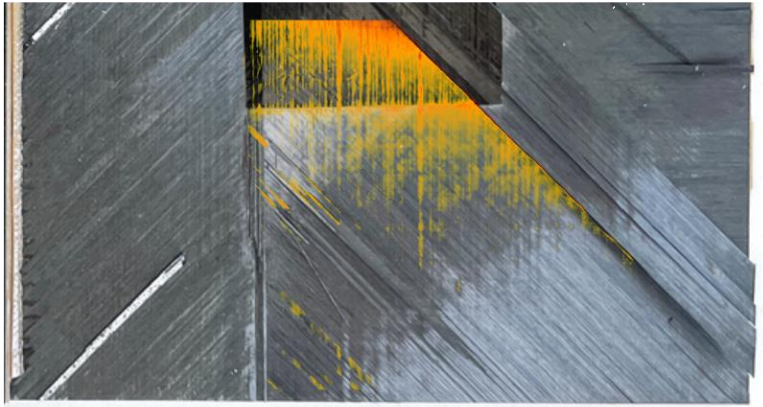

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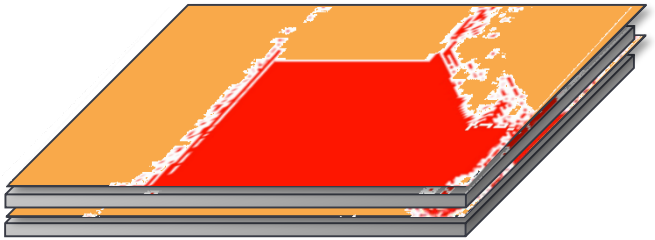
Second Interlaminar Layer

Interlaminar failure



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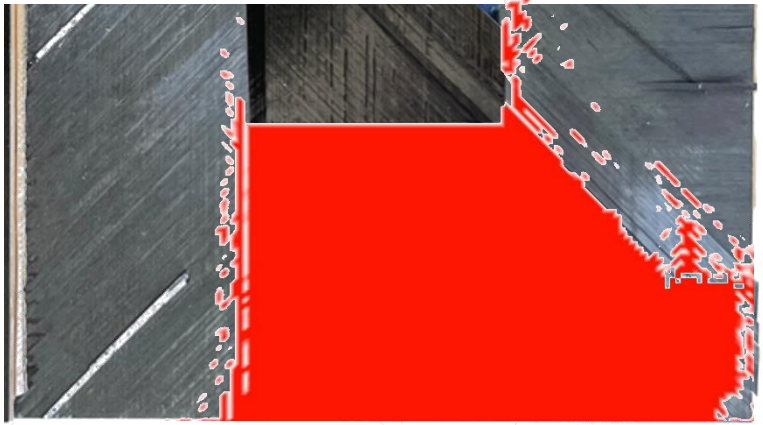

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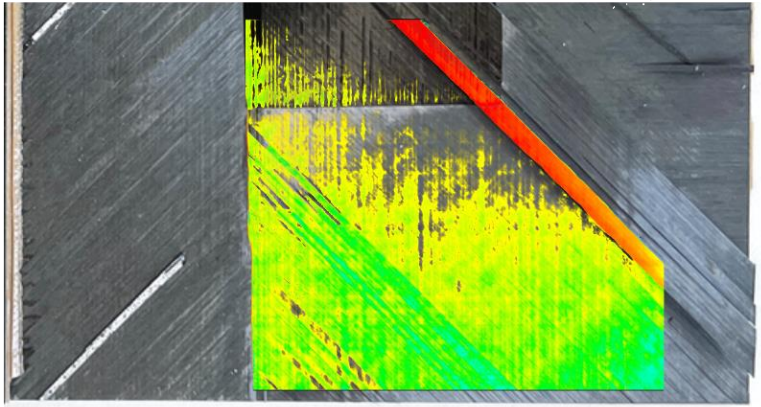

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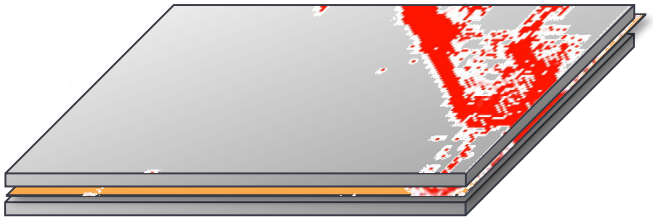
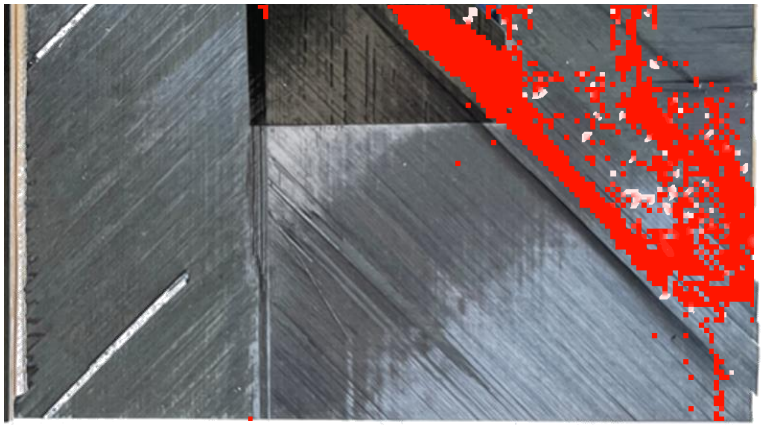
Third Compossite Layer

Interfibre failure



Simulation



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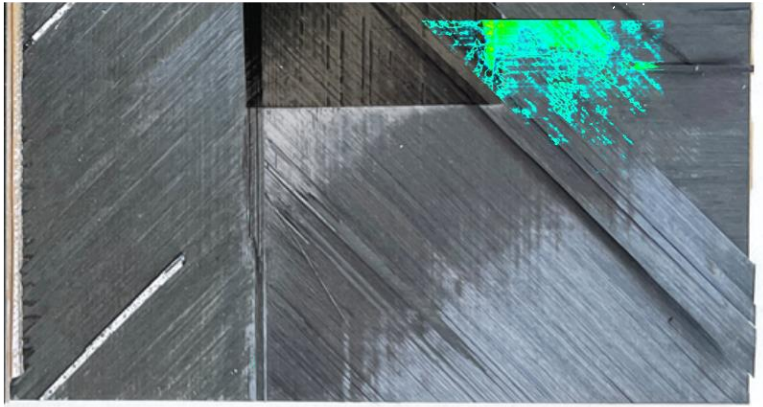

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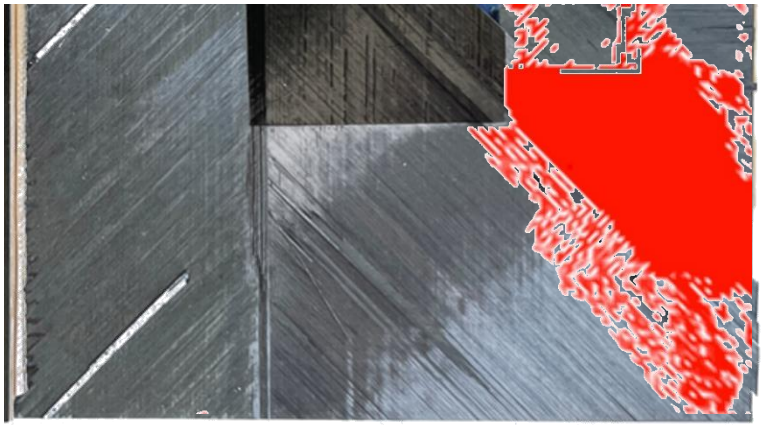
Third Interlaminar Layer

Interlaminar failure

Simulation



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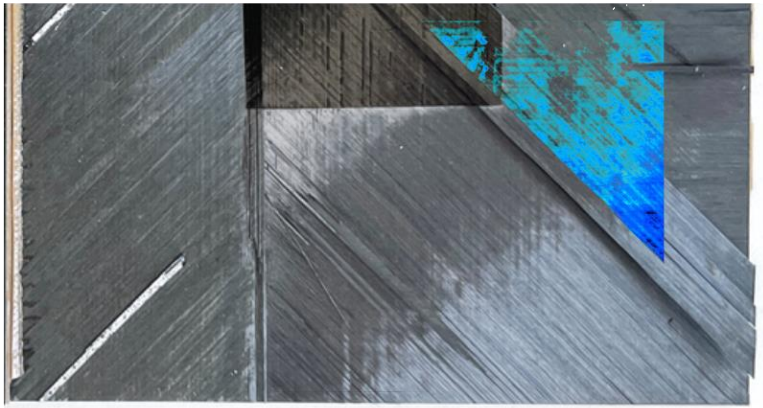

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Summary

- Suitable test specimens with a reproducible pre-damage were presented

- Artificial damage leads to significant strength reduction and reproducible failure patterns

- Two of the key failure mechanisms in bonded fiber composite components can
  - be validated using simple modeling strategies
  - be predicted almost perfectly with more complex modeling of the geometry change due to inserted release films

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Thanks!

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