Generic modelling of adhesively bonded structures

prof. dr. Stijn Debruyne, EAE

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Introduction & problem statement

Evolution to multi material construction & combination of ≠ joining techniques
Introduction & problem statement

Adhesive bonding becomes increasingly popular/important!

However…

• Assessment and optimization of structural performance and reliability is complex,
• lifetime and durability estimation becomes more prominent, while product development cycles shorten.
• This is sometimes contradictory to circular design and production!

Increasing need for adequate and efficient numerical modelling!
Introduction & problem statement

Detailed (FE) modelling

• High degree of precision,
• Suitable for geometric optimization of bonds,
• Computationally expensive!

Concept modelling

• Lower degree of precision,
• Suitable for overall structural optimization,
• Computationally efficient!

How can concept models be enriched and improved?
How to obtain good-quality input data for any model type in an efficient way?
Smart strategy for model complexity reduction?
The Jointtool project framework

• Jointtool is a 5-year research project in cooperation with Flemish industry, with 8 leading manufacturing companies involved,
• Cooperation of Flanders Make and KU Leuven, involving 3 PhD research tracks,

Project goals:

• Develop methods to improve and enrich concept models for discrete (bolt, rivet) and adhesive joints,
• Validate through specific cases (Tenneco, Bosal, CNHi…)
Different modelling scales

Load translation? Suitable lab-scale tests?
Applicational relevance? Environmental loads?

Interaction!
# Concept models

## JOINT CONCEPT MODELS

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## Simulation

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Concept models: known example
Concept models: known example

FEM + Joint concept model

Joint concept model

Beam element

Rigid body element
Concept models: bonding example

- Substrates modelled as 2D or 3D structures
- Adhesive bulk modelled as 3D
- Adhesive interfaces modelled with CZ

Can be computationally efficient and yet very accurate!
Concept models: bonding example

Valid & efficient input data? (substrates, test conditions…)

Extraction of stress, strain and fracture toughness characteristics
Methodologies to provide model input

• Process of obtaining relevant model input data always very cumbersome,

• Not only mechanical loading is important! Effects of moisture, UV, temperature… Relation with modelling?

• Methods to make this process more efficient are most welcome!

  - Experimental: combined environmental testing
  - Numerical: virtual testing & virtual sensing
Methodologies to provide model input

Experimental, combining:

• Mechanical loading: static & dynamic. Dual actuators allow mode I and II loading (and mixed).

• Environmental loading (UV, RH, T)

- Increased relevance, accuracy and speed of testing!
- Extraction of time-evolving joint characteristics,
- See presentation of S. Fevery (AB19 76)
Methodologies to provide model input

Numerical:

- Virtual testing: dedicated FEM based simulations, for complex stress/strain states.
- Virtual sensing:

  1D representation

  State estimation in the time domain, based on model order reduction!

  Allows a quick, yet accurate, estimation of elastic parameters!
Conclusions and prospects

• Generic or concept models are very complementary to detailed FE models,
• The more generic the model gets, the more ‘abstract’ model input data becomes,

Translation between different levels of modelling is necessary! Virtual testing plays an important role here…

• Numerical techniques like virtual sensing can speed up parameter estimation. Currently these are elaborated for 2D and 3D structures and joints,
• Concept models can be enriched with time-dependent input data on strength and elasticity. This is currently done for moisture uptake and temperature effects on epoxy adhesives.
Thank you!

Stijn.debruyne@kuleuven.be
zeno.poupeye@kuleuven.be
hendrik.devriendt@kuleuven.be
bert.pluymers@kuleuven.be
isabel.vandeweyenberg@flandersmake.be
paola.campestrini@flandersmake.be

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