USE OF MICRO-CT TO STUDY THE EFFECT OF VOIDING AND FIBRE MISALIGNMENT ON KINK-BAND FORMATION

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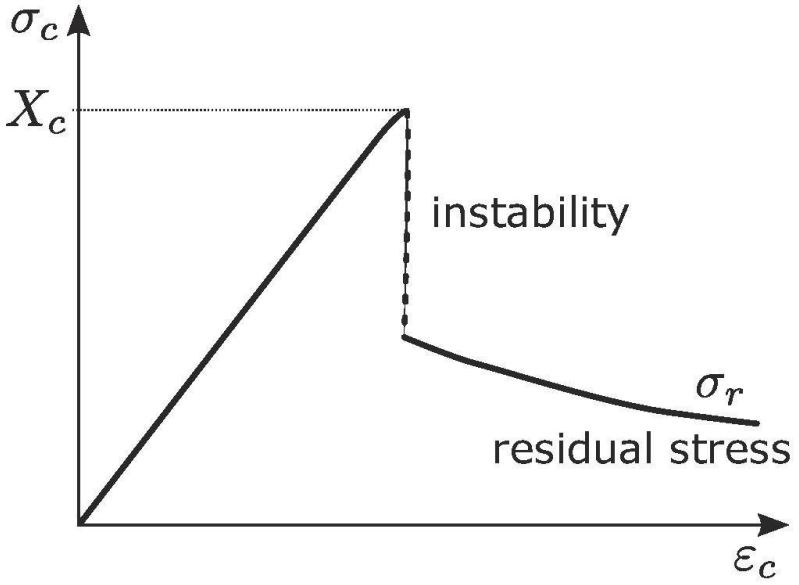
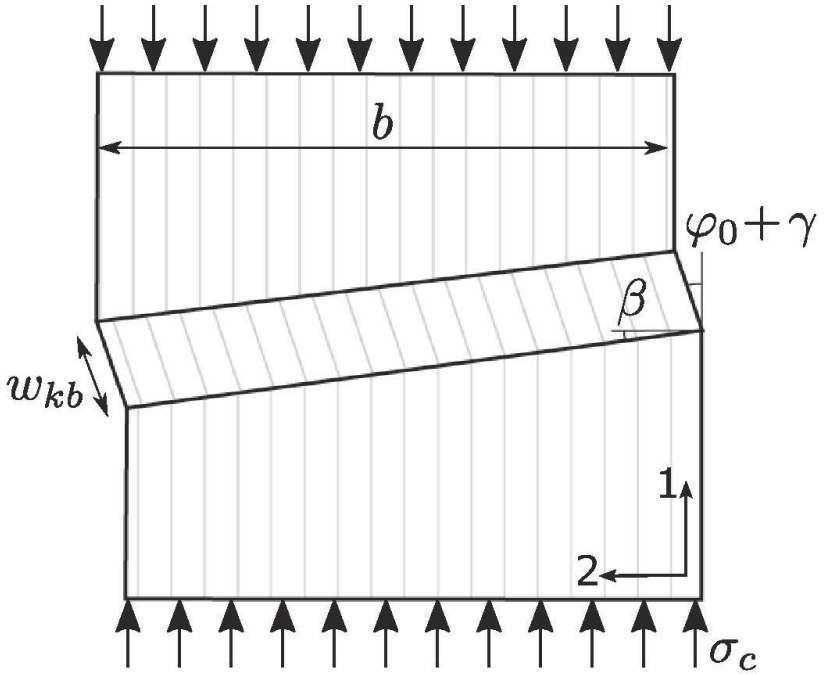
Introduction – Compressive failure

Fibre kinking



(a) Characteristic constitutive response of fiber kinking theory



(b) Schematic idealization of a kink band

Bergan, A et al. (2020)

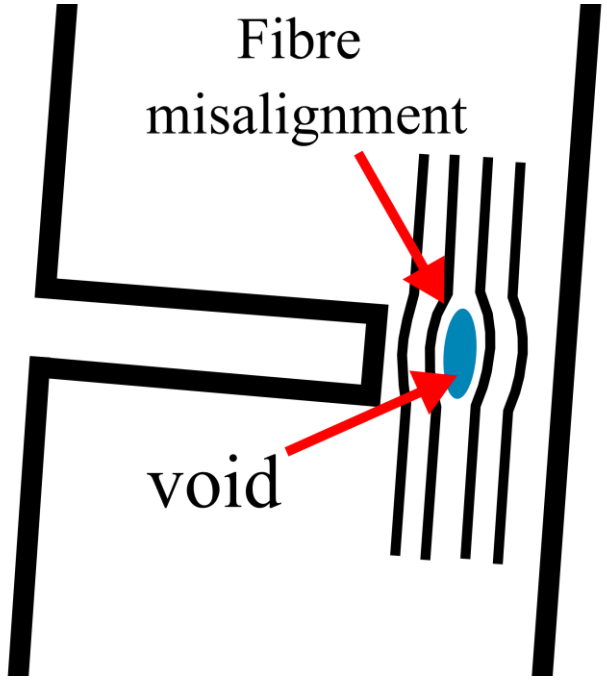
Introduction – Imperfection

Fibre waviness/misalignment

+

Existing of voids

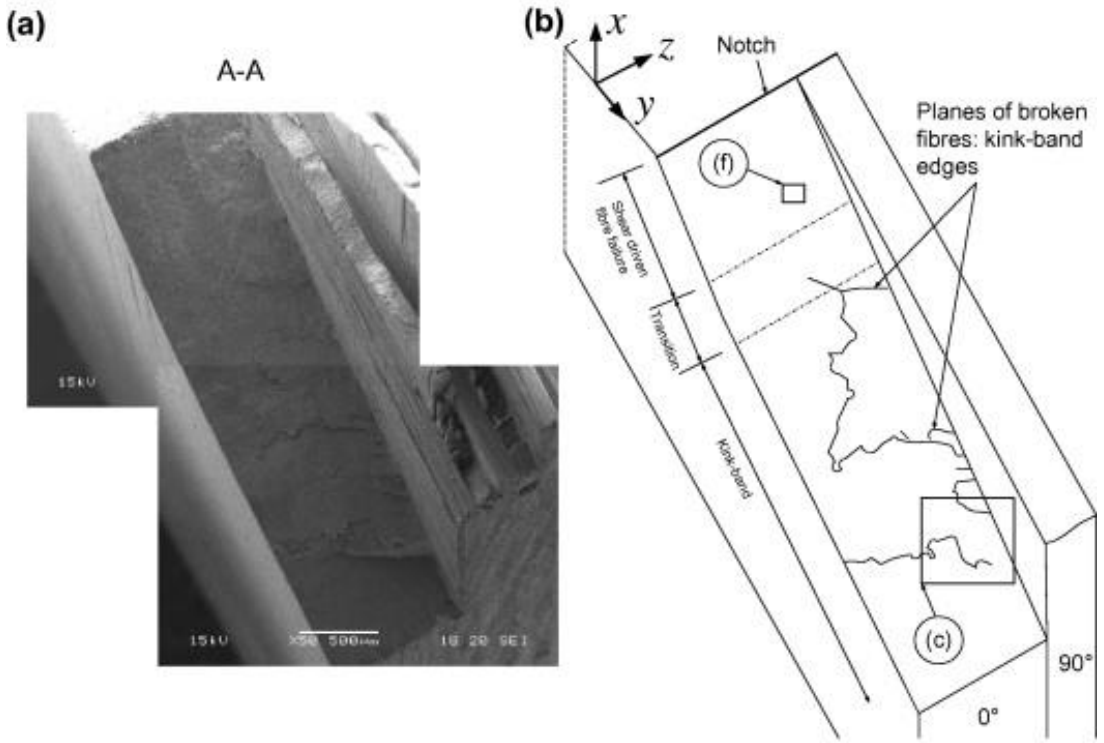
Micro-buckling of fibre

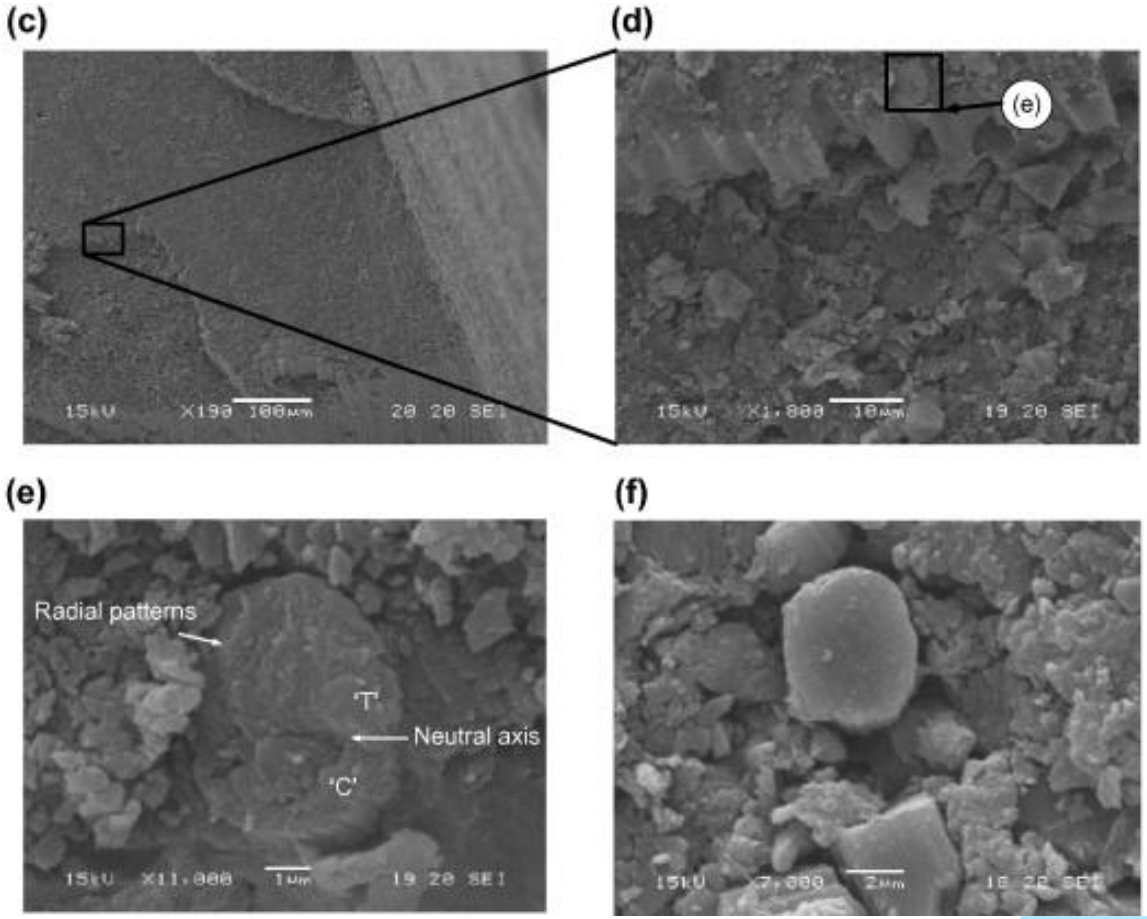


Introduction – Research gaps

Post-mortem analysis

- SEM/TEM/FIB





Gutkin, R et al. (2010)

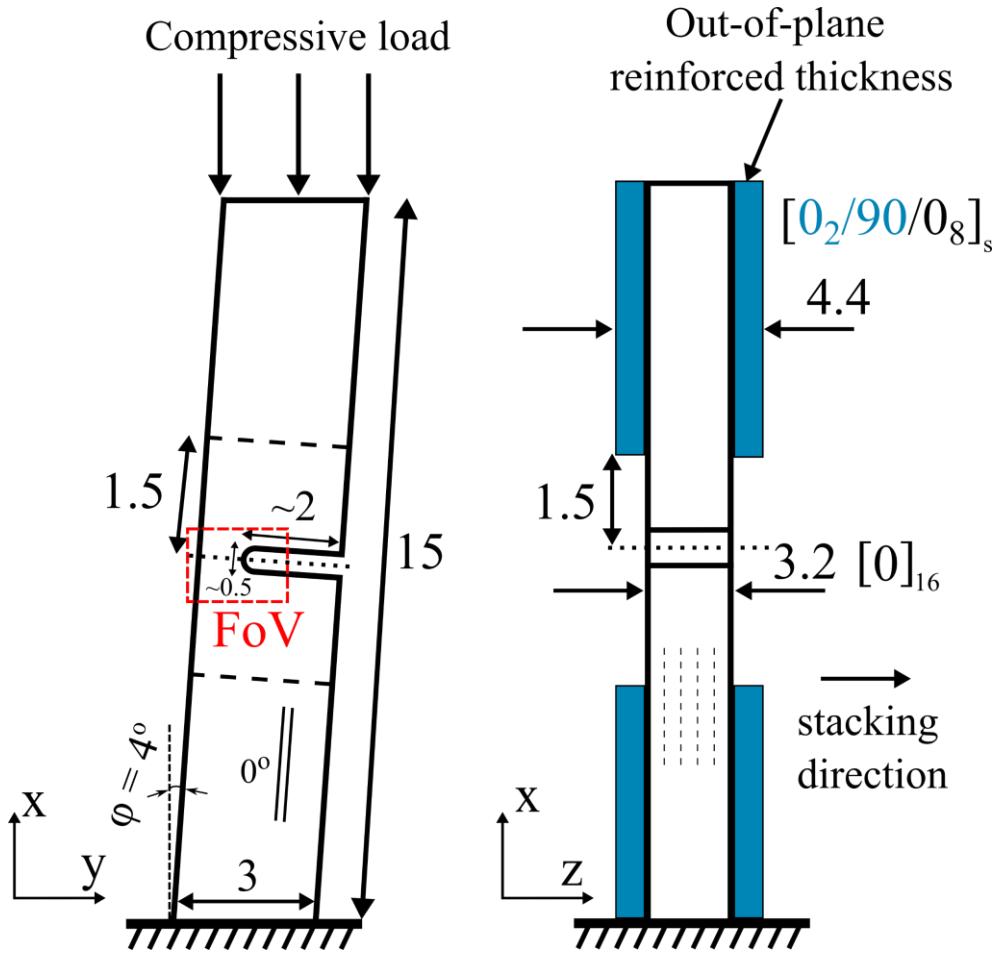
Experiment – Sample geometry

Offset geometry
- Addition shear loading - More stable failure
- No addition device
- Geometry symmetry

Manufacturing conditions
- Standard pressure – baseline
- Low pressure – defect sample

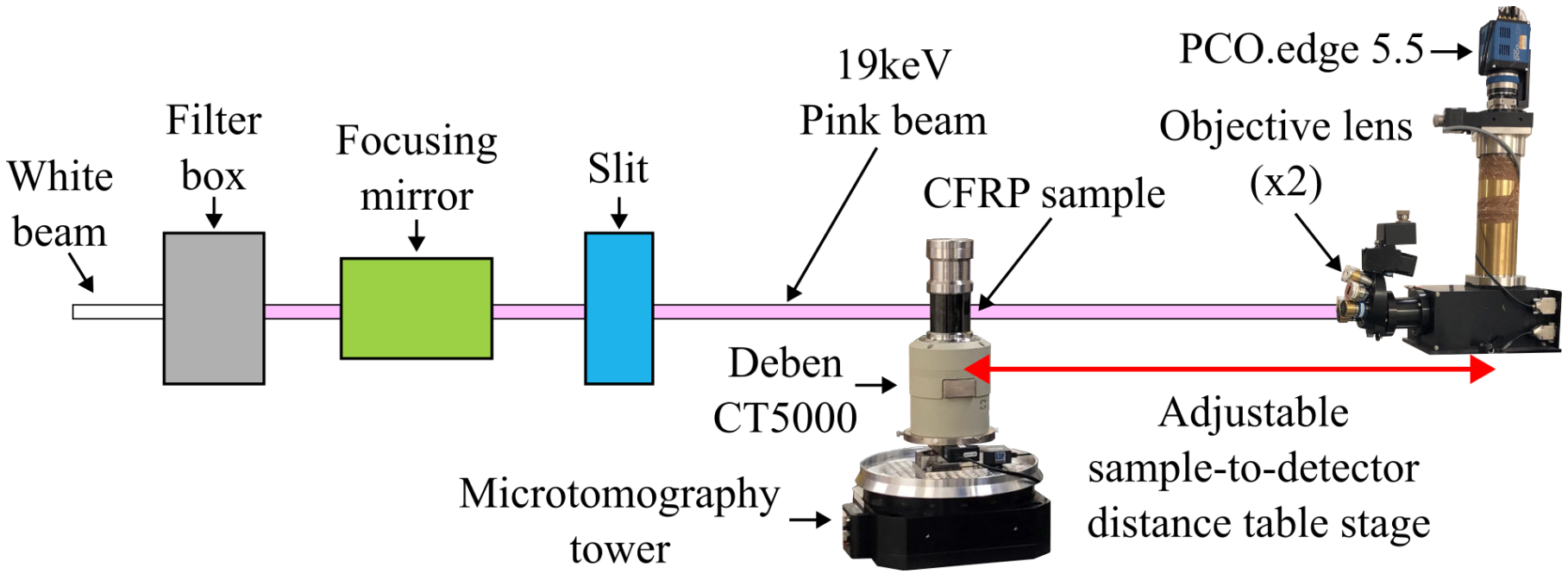
Notch
- Localised damage area

Addition plies
- Prevent out-of-plane buckling



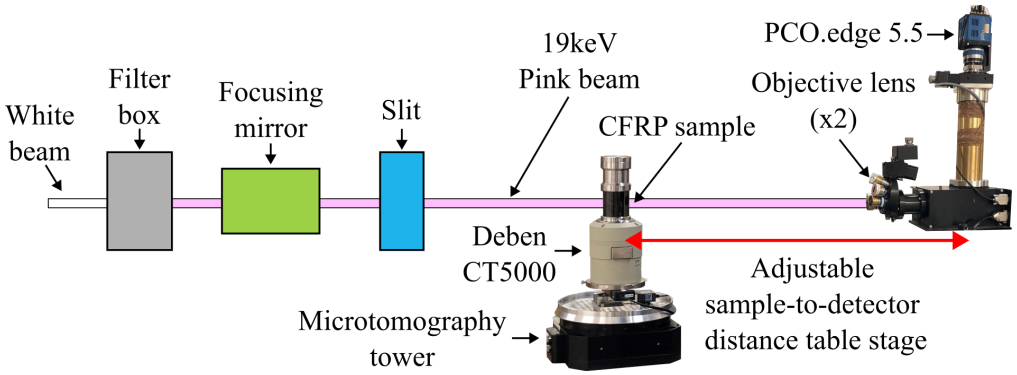
Schematic of offset angle compressive testing adopted from Pimenta et al. (2009)

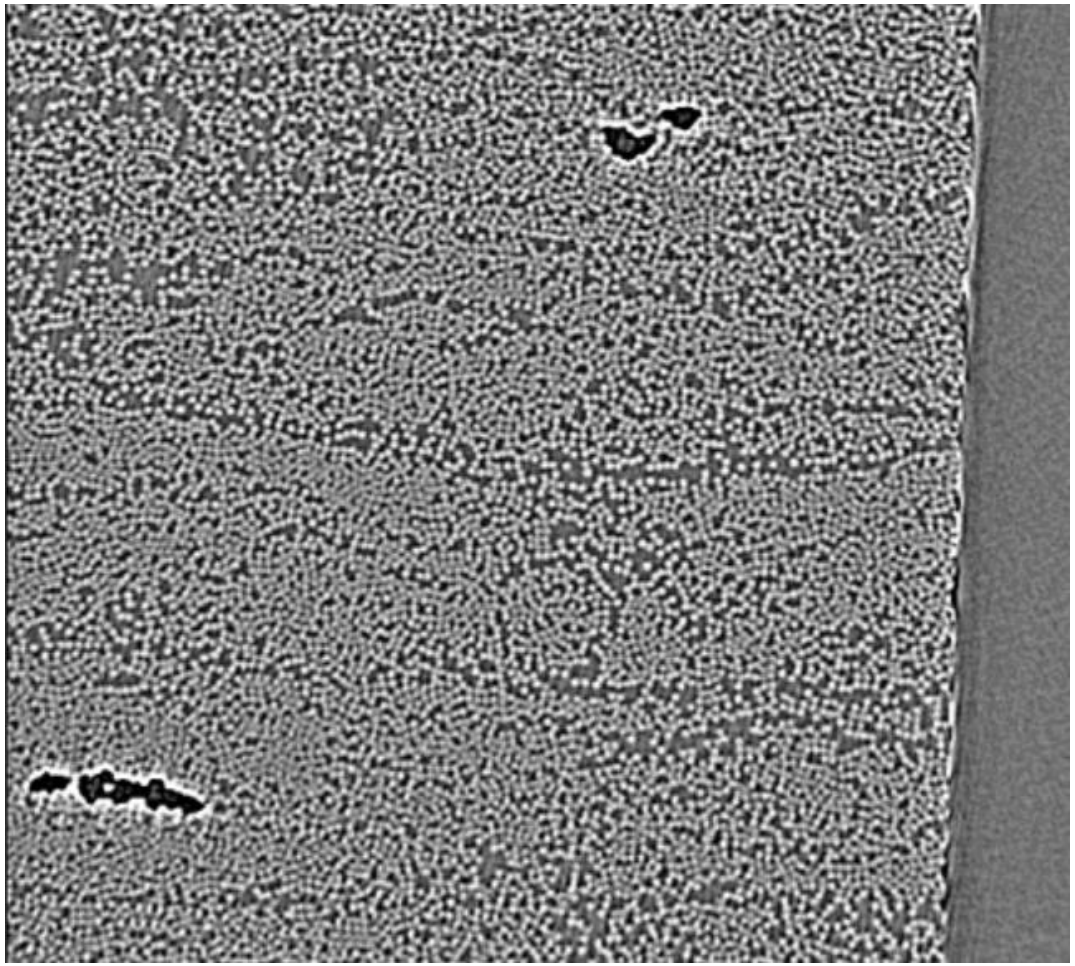
Experiment – Synchrotron setup



Experiment – Synchrotron setup

Phase contrast enhancement in CFRPs





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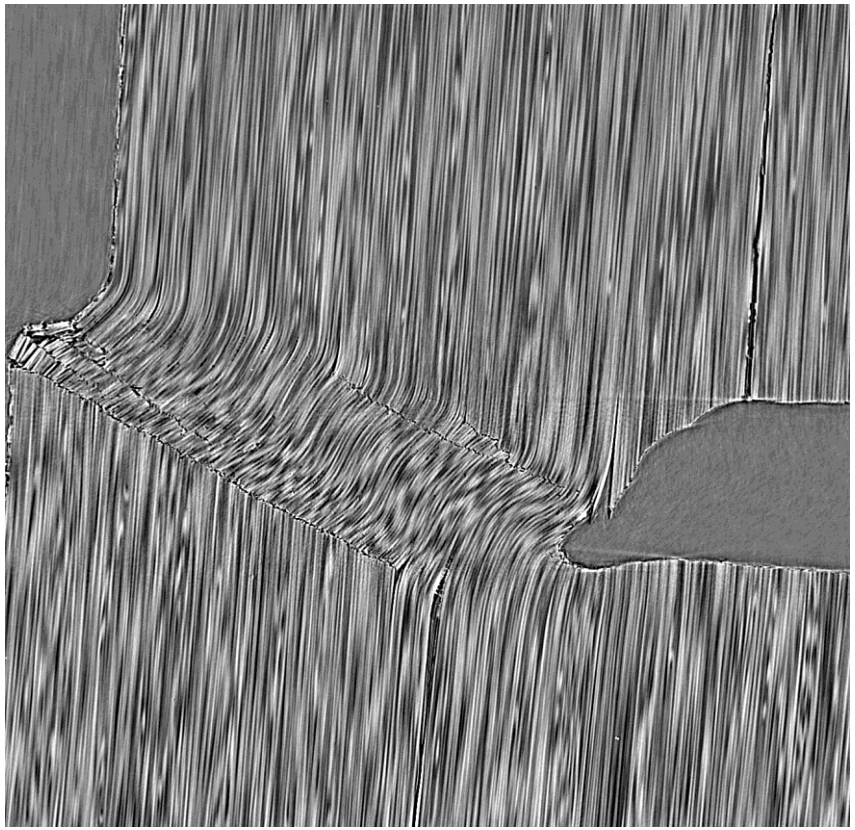
Results – CT images

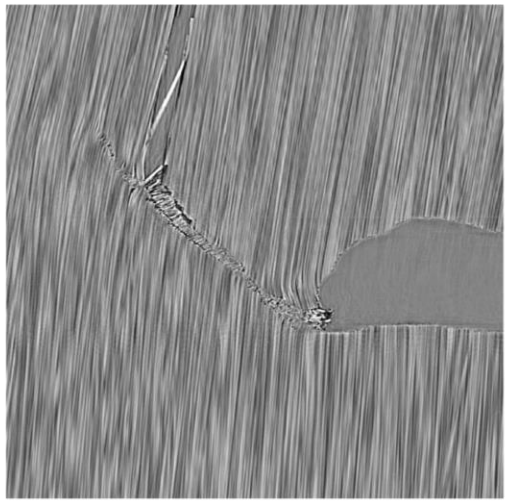
Baseline sample



Defect sample

Image Processing

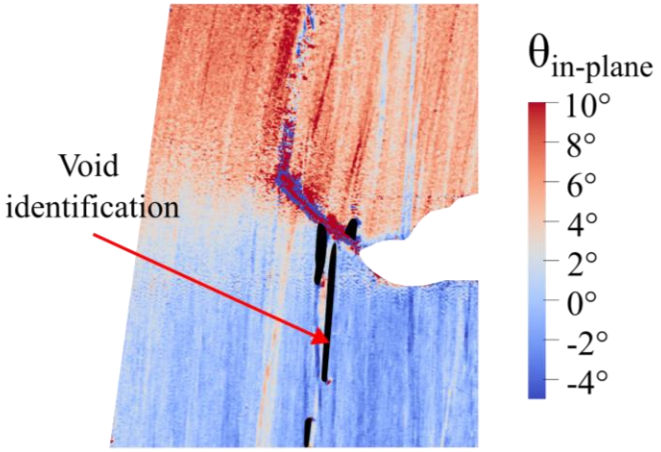
Synchrotron
µCT of UD CFRPs with a notch



Kink-band formation
in the presence of micro defects

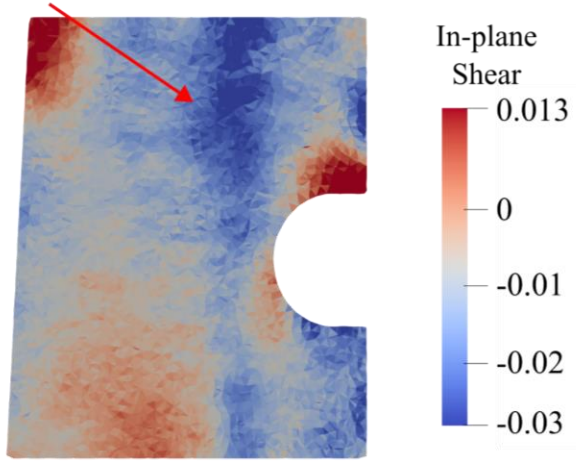
Image processing

Fibre misalignment orientation analysis



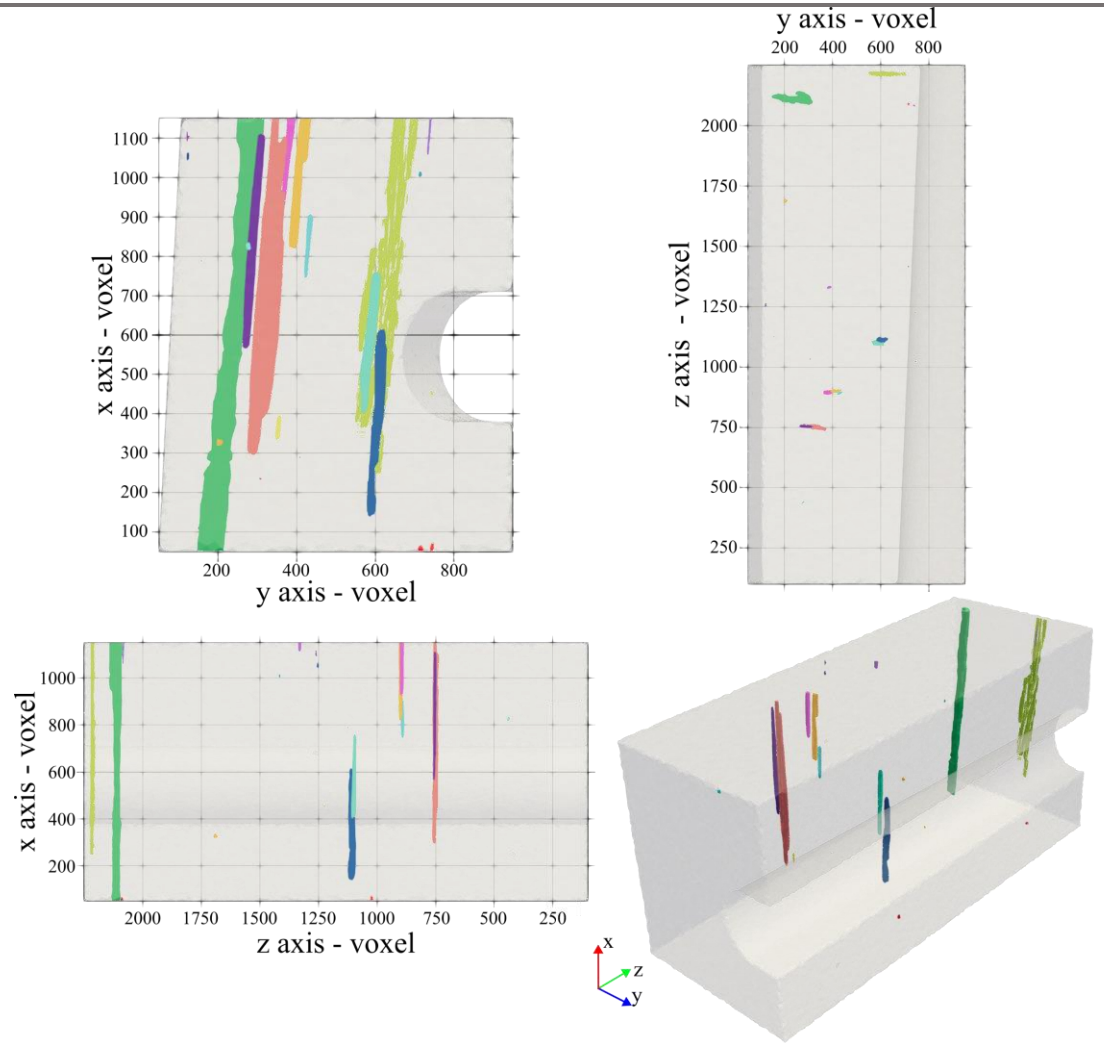
Fibre angle after failure

Localised strain field analysis



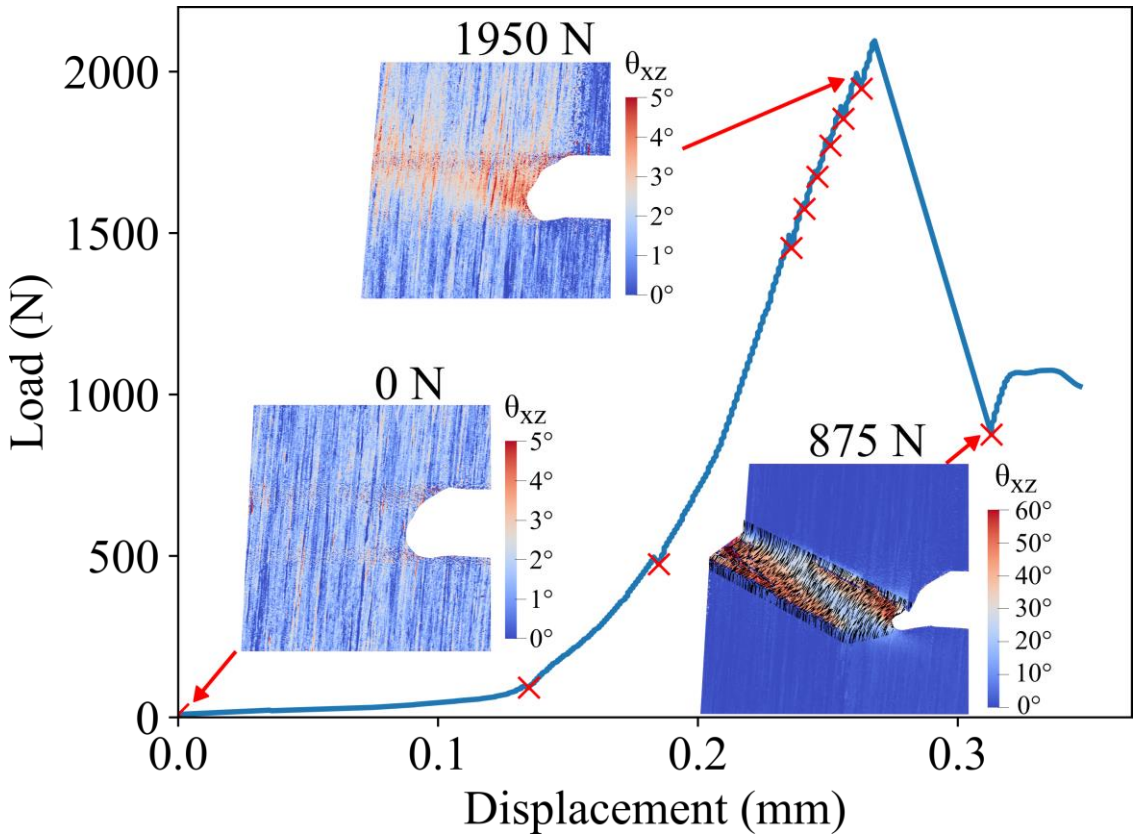
Digital volume correlation
before failure

Results – Void segmentation

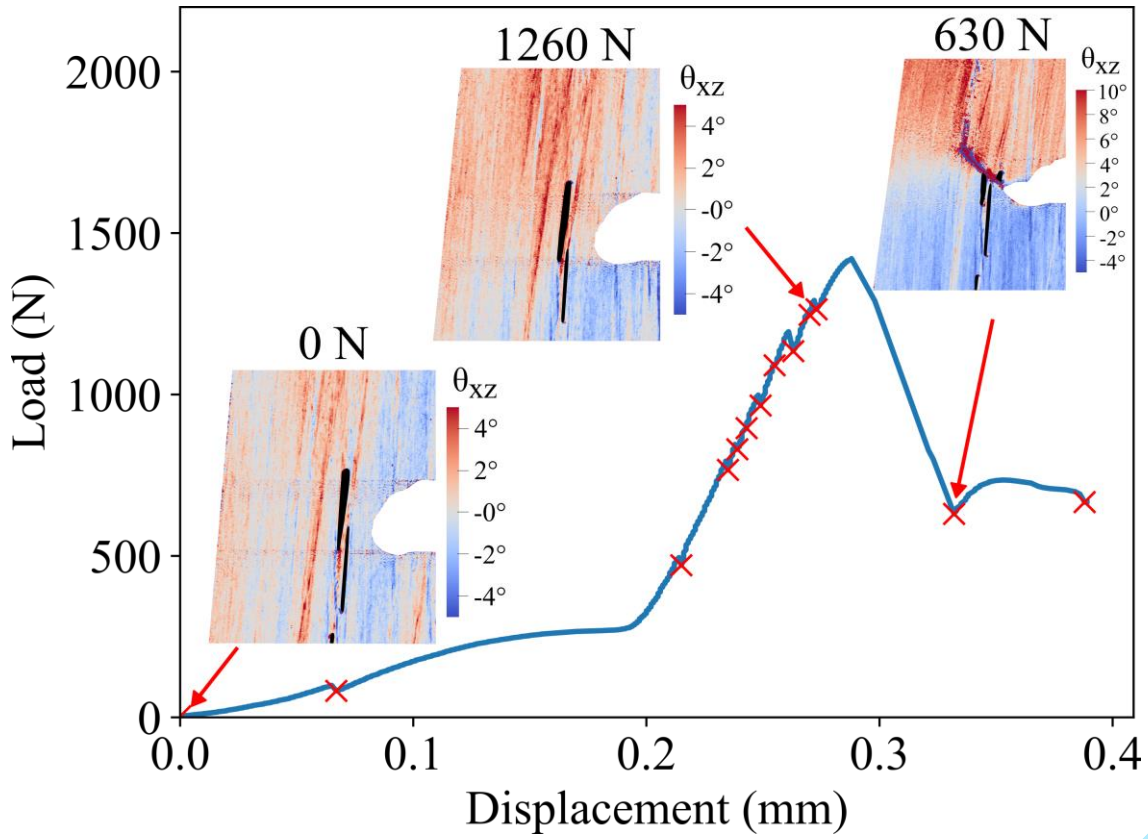


Results – Fibre orientation development

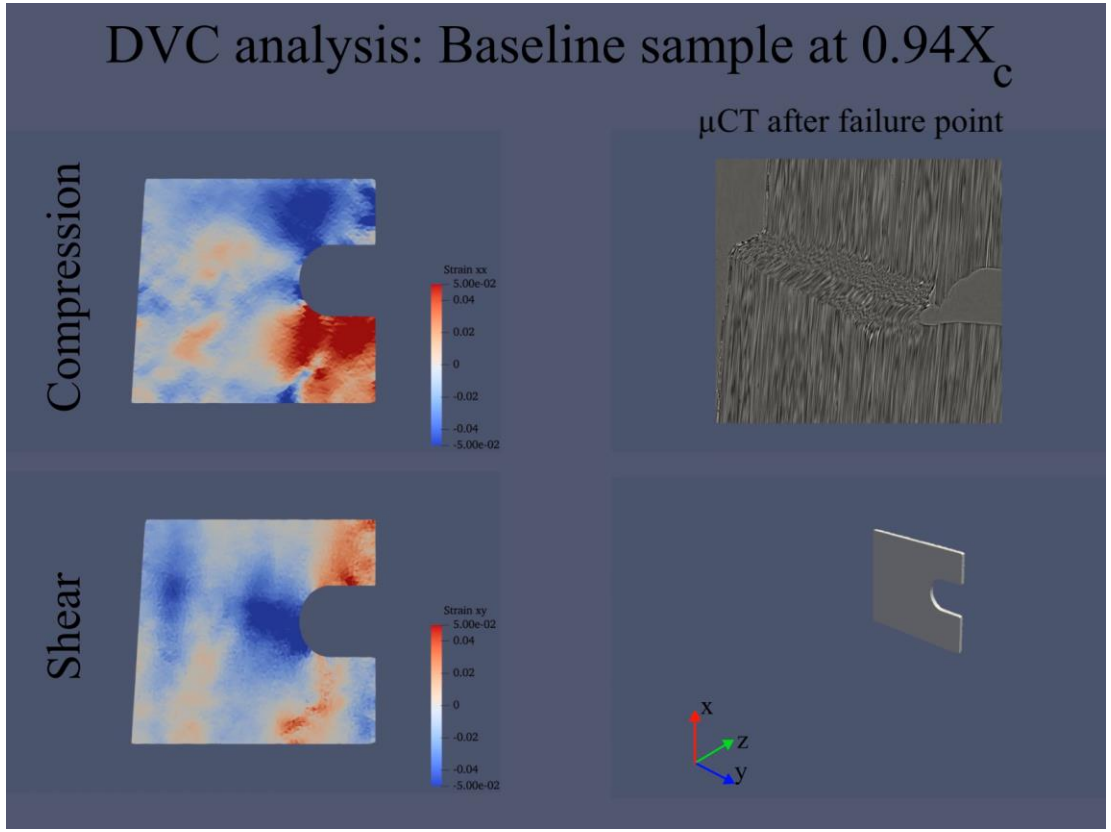
Baseline

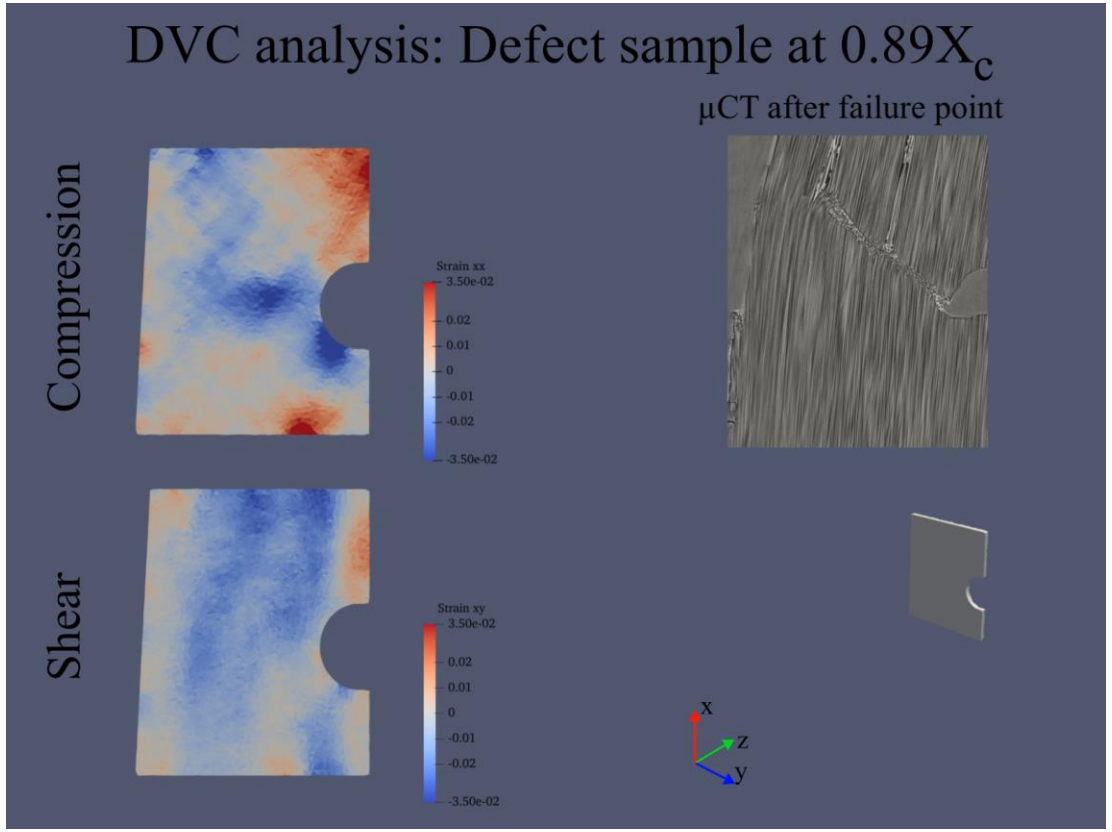


Defect



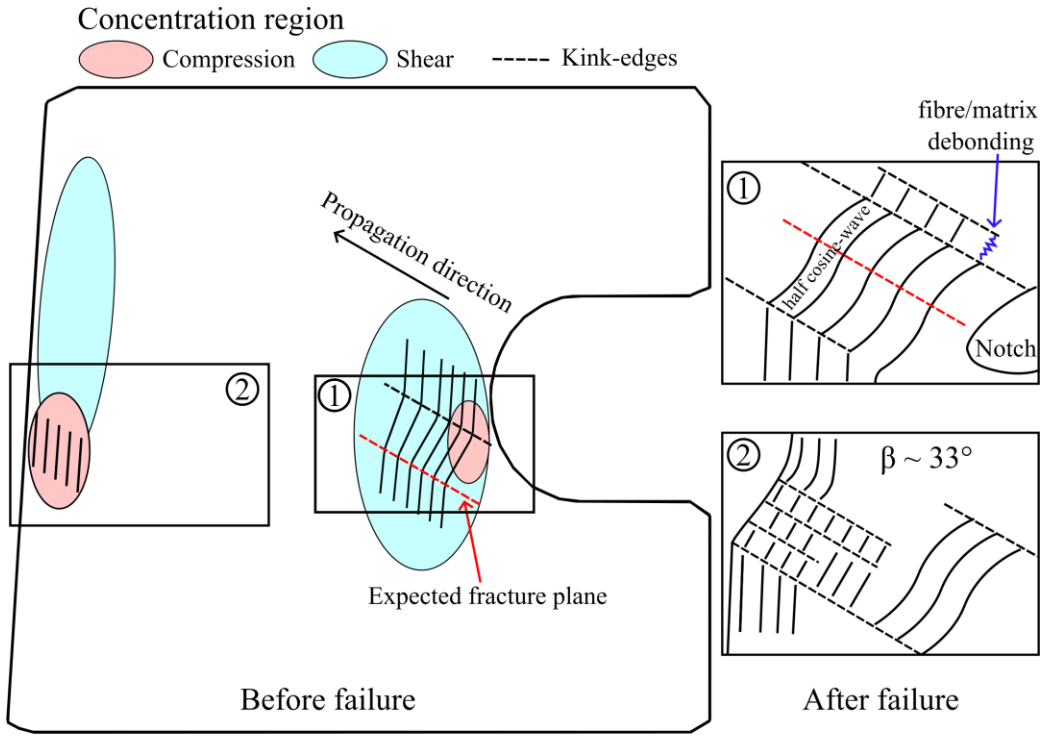
Results – Digital Volume Correlation



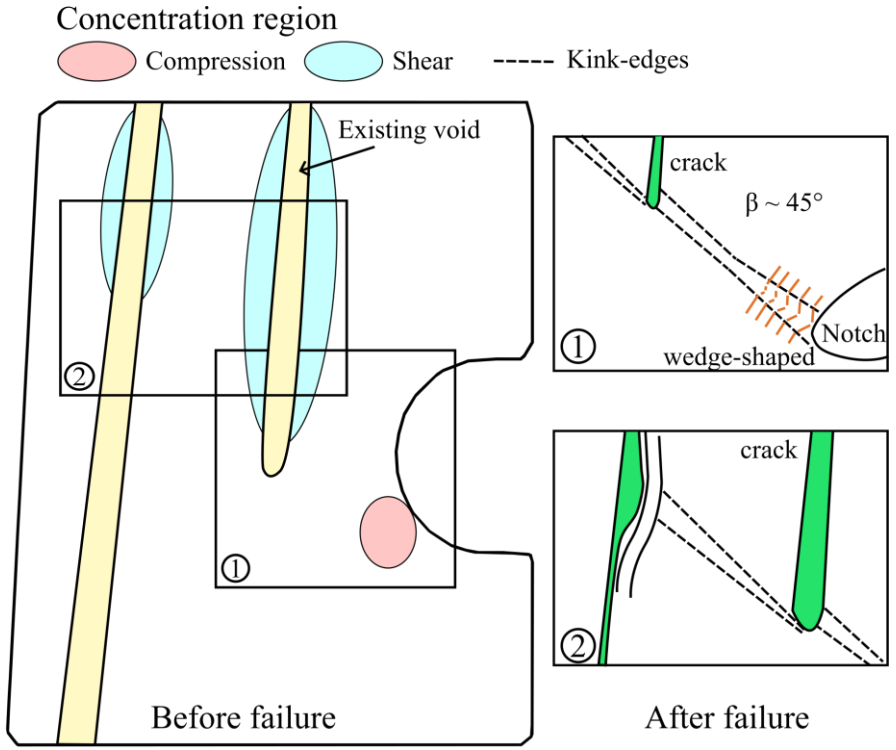


Results – Summaries

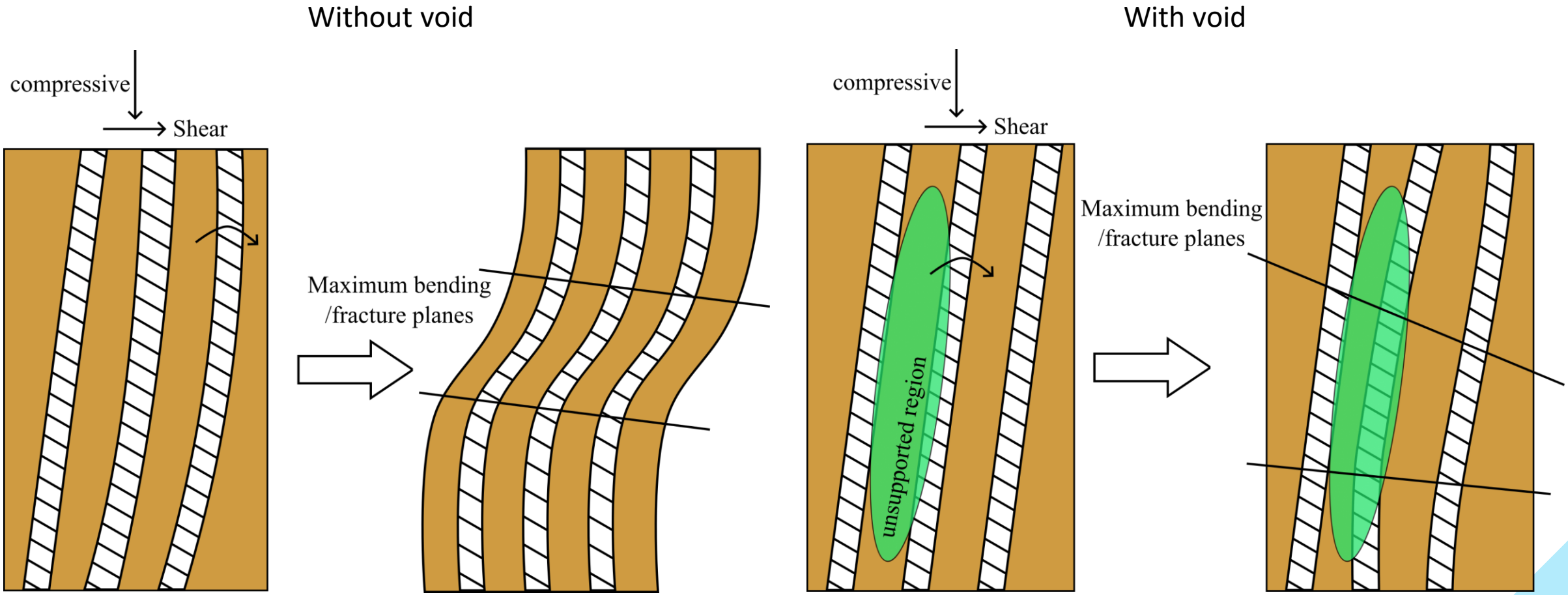
Baseline sample



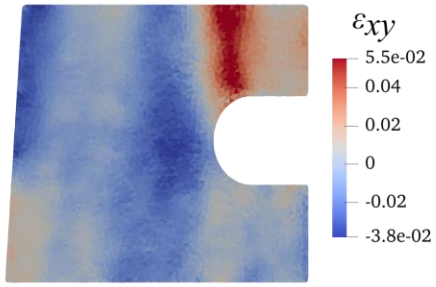
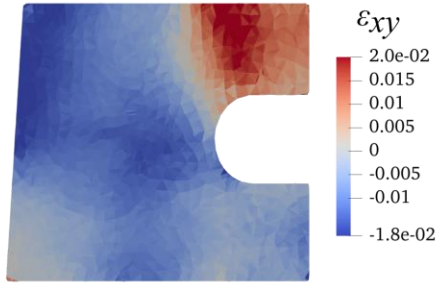
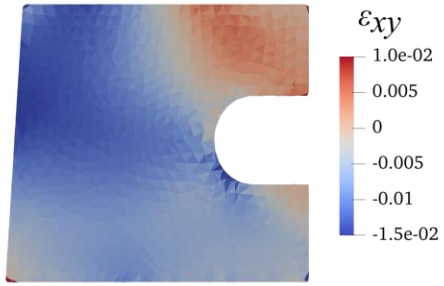
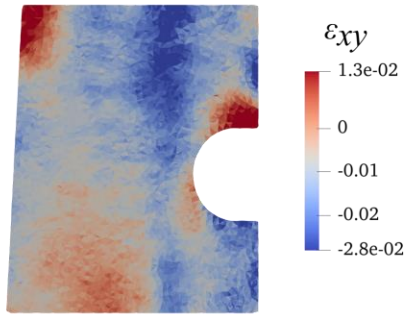
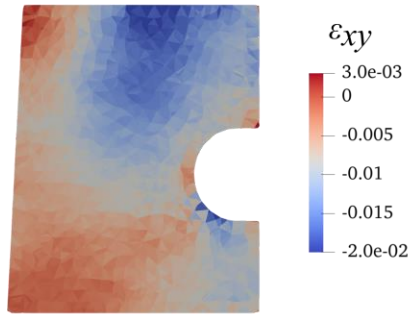
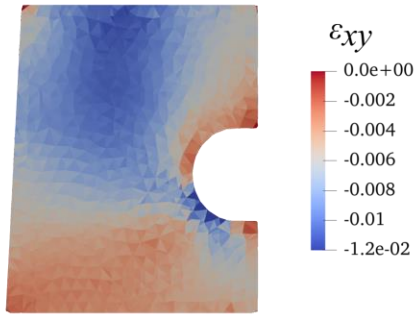
Defect sample



Results – Summaries



Results – DVC sensitivity analysis

	Small regularisation (localised deformation) l_{mesh}: 32, l_{reg}: 64	Medium regularisation (intermediate deformation) l_{mesh}: 64, l_{reg}: 128	Large regularisation (global deformation) l_{mesh}: 64, l_{reg}: 256
Pristine			
Porous			

Conclusion

- Synchrotron µCT with enhanced phase contrast
  - Reveals individual fibres (random speckle pattern)
  - Fibre misalignment orientation
  - 3D strain field mapping with a global approach DVC
- Detailed characterisation of CFRP damage mechanisms
  - Combined shear and compressive shear → Bending →kink-band formation
  - Unsupported region (e.g. void, matrix cracking) → fibre lose instability
- ‘Real’ boundary condition and geometry effects for future FE simulation

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