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Validating Beam Modelling for Bend-Twist Coupled Wind Turbine Blades

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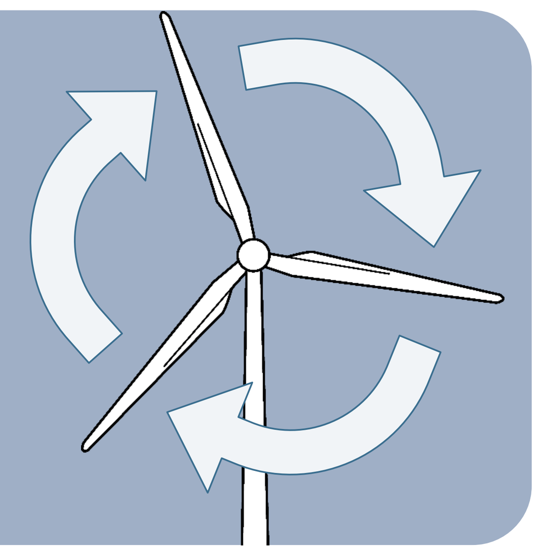
Over their operating lifespan wind turbines are subjected to harsh environmental conditions resulting in detrimental fatigue damage. The concept of bend-twist coupled (BTC) blades investigated in this work passively mitigates aerodynamic loads, effectively reducing fatigue and increasing wind turbine lifespan.



AIM

To provide data for validation of **cross-sectional stiffness coefficients** as used in beam models of BTC wind turbine concept blades, Figure 1. For this both higher fidelity models based on **shell finite elements** and **physical demonstrators** are being developed.

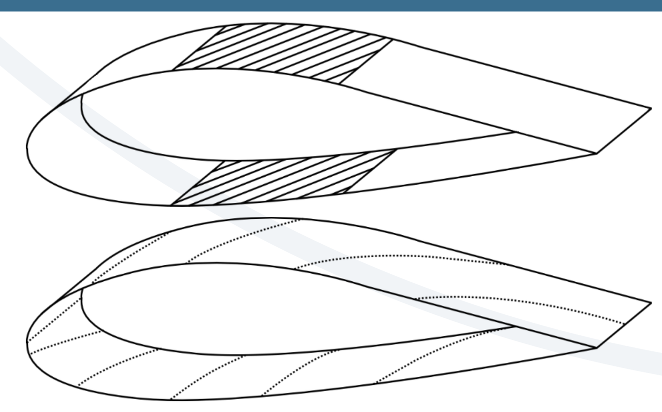


Figure 1 – Schematics of BTC concepts

MODELLING

The implementation of BTC involves the introduction of more compliant and non-standard composite stacking sequences with off-axis fibre angles. **Finite Element Analysis (FEA)** with **shell elements** is used to capture coupled deformations accurately.

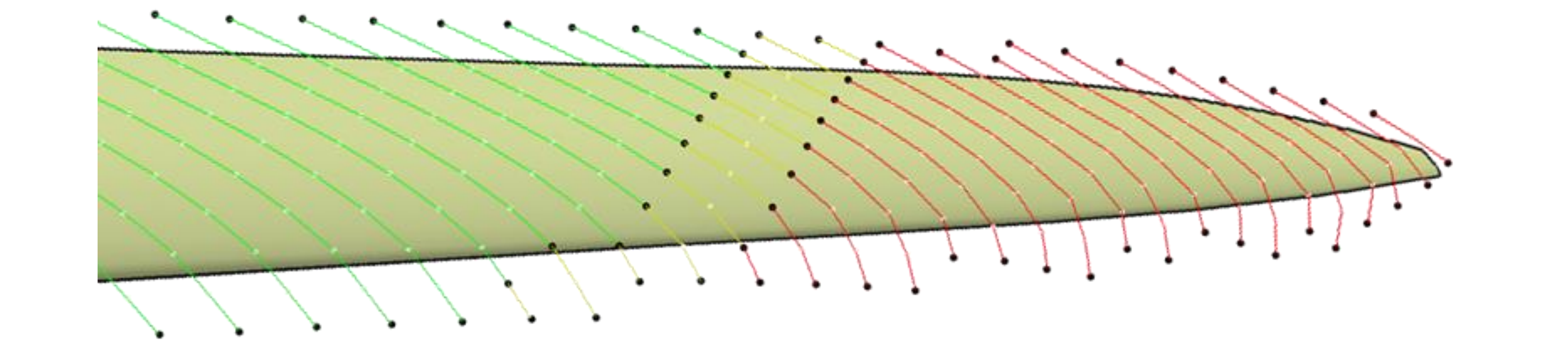


Figure 2 – Kinematic draping simulation results (red means >10° reorientation)

The geometry of blades results in significant **draping**, especially near the tip as seen in Figure 2. For blades with **unconventional laminates**, the performance was found to be affected strongly by draping effects, suggesting the need to consider these effects in the analysis early on.

DEMONSTRATOR

The first demonstrator design has been set to be a simple box cross-section. Using layers at **±20°** to the beam axis in the flanges as shown in Figure 3, the beam achieves roughly a **tip twist of 2.5°** when loaded by a **10% tip bending** deflection.

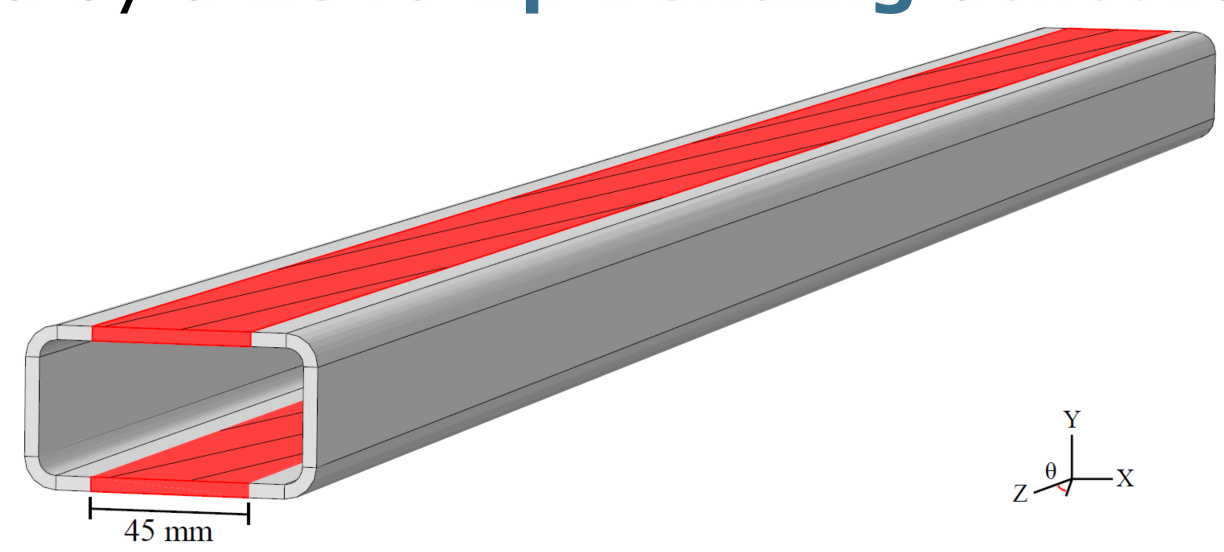


Figure 3 – Schematic of demonstrator highlighting flange regions in red

Refined solid element models show decent agreement with the proposed shell models.

Table 1 – Preliminary results of demonstrator forshell and solid element models

		Shell Model	Solid Model	% Diff.
1st Buckling Eigenvalue	[-]	2.84	2.66	-6.42
Static Tip Twist	[deg]	-2.43	-2.66	9.65
Max Strain Index	[-]	1.03	1.02	-1.40

NEXT

- Explore wider design spaces (incl. **internal geometry**) under **realistic loading**.
- Build and test **first BTC demonstrator** and develop testing and measuring techniques.
- Integrate manufacturing considerations (i.e. **draping**) more directly into analysis.

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