Experimental validation of bend-twist coupling stiffness predictions

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Overview

• Introduction

• Numerical Work:
  • Demonstrator Design
  • Model Comparison

• Experimental Work:
  • Build & Testing
  • Results

• Conclusions and Future Work
Introduction

• Literature
  • Bend-Twist Coupling has demonstrated advantages,
  • Modelling techniques disagree on performance [1,2].

• Industry
  • Design remain unchanged, pending validation.
Numerical Work: Demonstrator Design

• 5 demonstrators:

• BECAS, VABS, and 3D FEM shows:
  • 100% agreement between BECAS and VABS
  • Primary stiffness coefficients \( S_{44}, S_{66} \) within 1%
  • Coupling stiffness coefficients \( S_{46} \) within 2.5%
  • Strong dependence on input handling
Numerical Work: Model Comparison

• Numerical Studies:
  • Looking into handling of features as suggested by Saravia et al. [4].

<table>
<thead>
<tr>
<th>Terms</th>
<th>Inner corner</th>
<th>Simplified</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{44}$</td>
<td>326.92E-6</td>
<td>325.30E-6</td>
</tr>
<tr>
<td>$S_{66}$</td>
<td>433.46E-6</td>
<td>432.07E-6</td>
</tr>
<tr>
<td>$S_{46}$</td>
<td>-75.32E-6</td>
<td>-78.91E-6</td>
</tr>
</tbody>
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• Tweaking lay-up in corner, differences can be reduced to under 2%
Experimental Work: Build & Testing

• Built at the NCC out of 913 E glass

• Tested at University of Bristol:
  • Using calibrated inclinometers
  • Repeated load cycles
  • Manual displacement loading
Experimental Work: Results

- Initial testing of first two beams:
  - Results repeatable and match well,
  - Material appears less stiff than modelled,
  - Awaiting material characterization for final validation.

![Graph showing experimental results compared to models.](image.png)
Conclusions

• Initial numerical studies show good correlation, but:
  • High sensitivity to model generation/inputs,
  • Some sensitivity to model simplifications,
  • Potentially higher sensitivity to manufacturing tolerances.

• Demonstrators built and being tested.
Future Work

- Complete testing campaign:
  - Confirm material properties
  - Validate model predictions

- Run extended numerical studies:
  - Further calibration of modelling techniques
  - Assessing sensitivity of stiffness coefficients:
    - To modelling simplifications,
    - Manufacturing tolerances.
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Questions?

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References:

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