Buckling of Stiffened Variable Angle Tow Panels

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Zhangming Wu, Paul M. Weaver
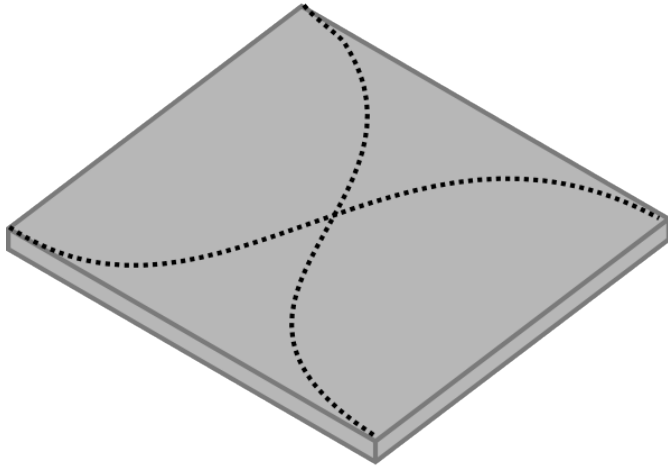
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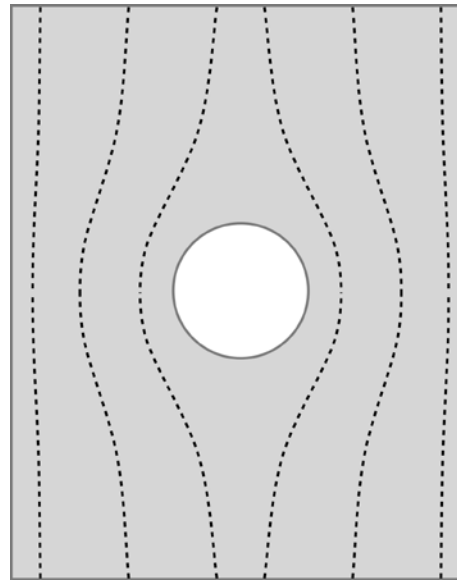15 April 2014

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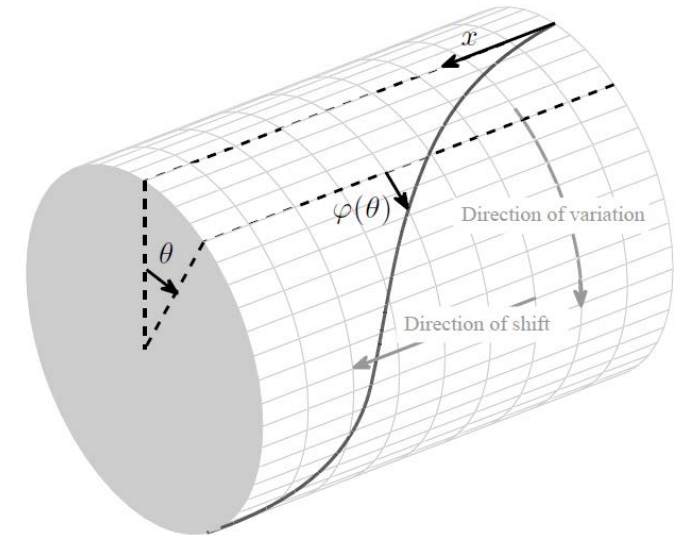
Variable Angle Tow Laminates

Buckling
performance

Discontinuities

Integrated
structures

Variable Angle Tow Laminates
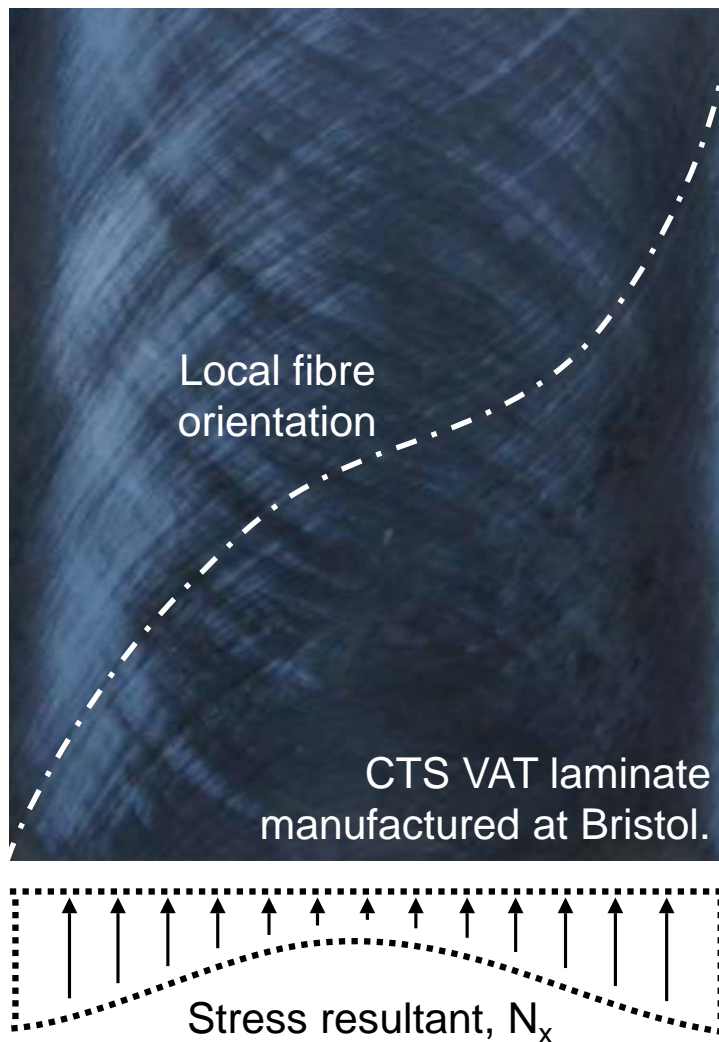
Local fibre orientation

CTS VAT laminate manufactured at Bristol.
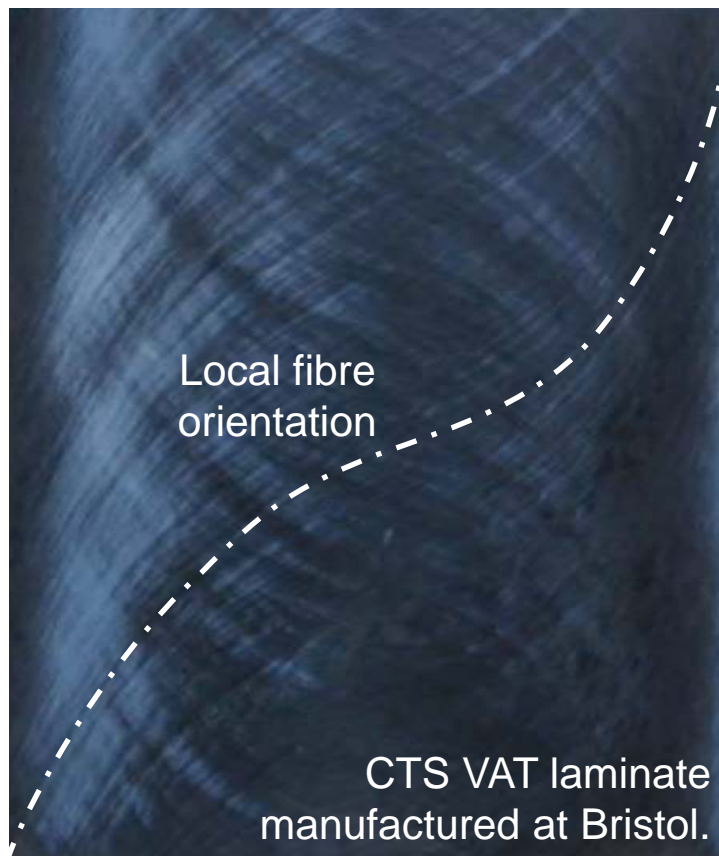
Stress resultant, N_x

Optimal VAT offers 80% higher buckling load than optimal straight fibre ($\pm 45°$)

$\Delta x/2$

$\pm 75°$

$0°$

$\Delta x/2$
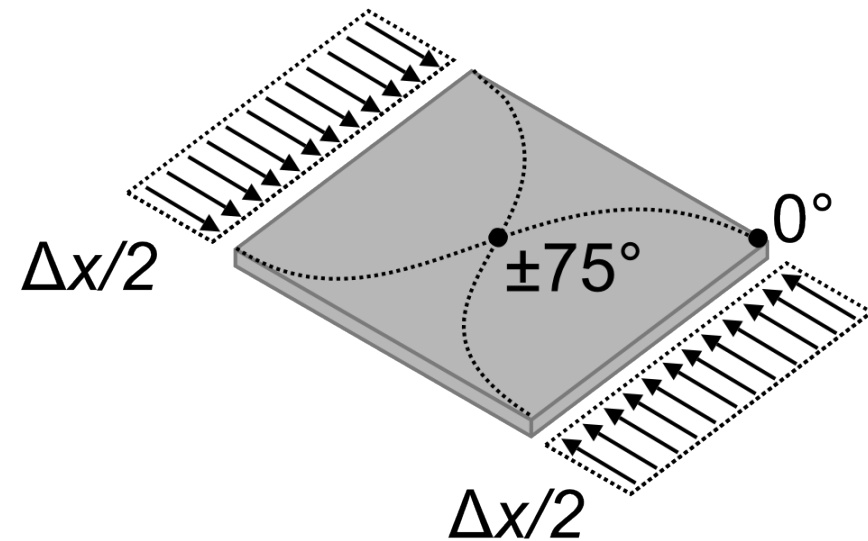
Gürdal, Tatting, Wu, Composites Part A, 2008.

Variable Angle Tow Laminates

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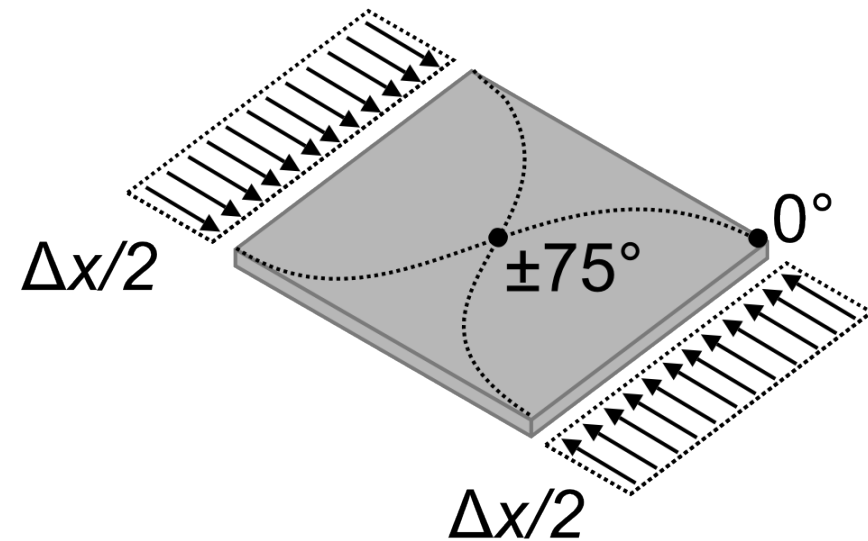
Gürdal, Tatting, Wu, Composites Part A, 2008.

Most studies limited to simple geometries and boundary conditions

Stiffened Panels

Wing skin (top cover)

Rib

Spar

Spar

Rib

Local buckling
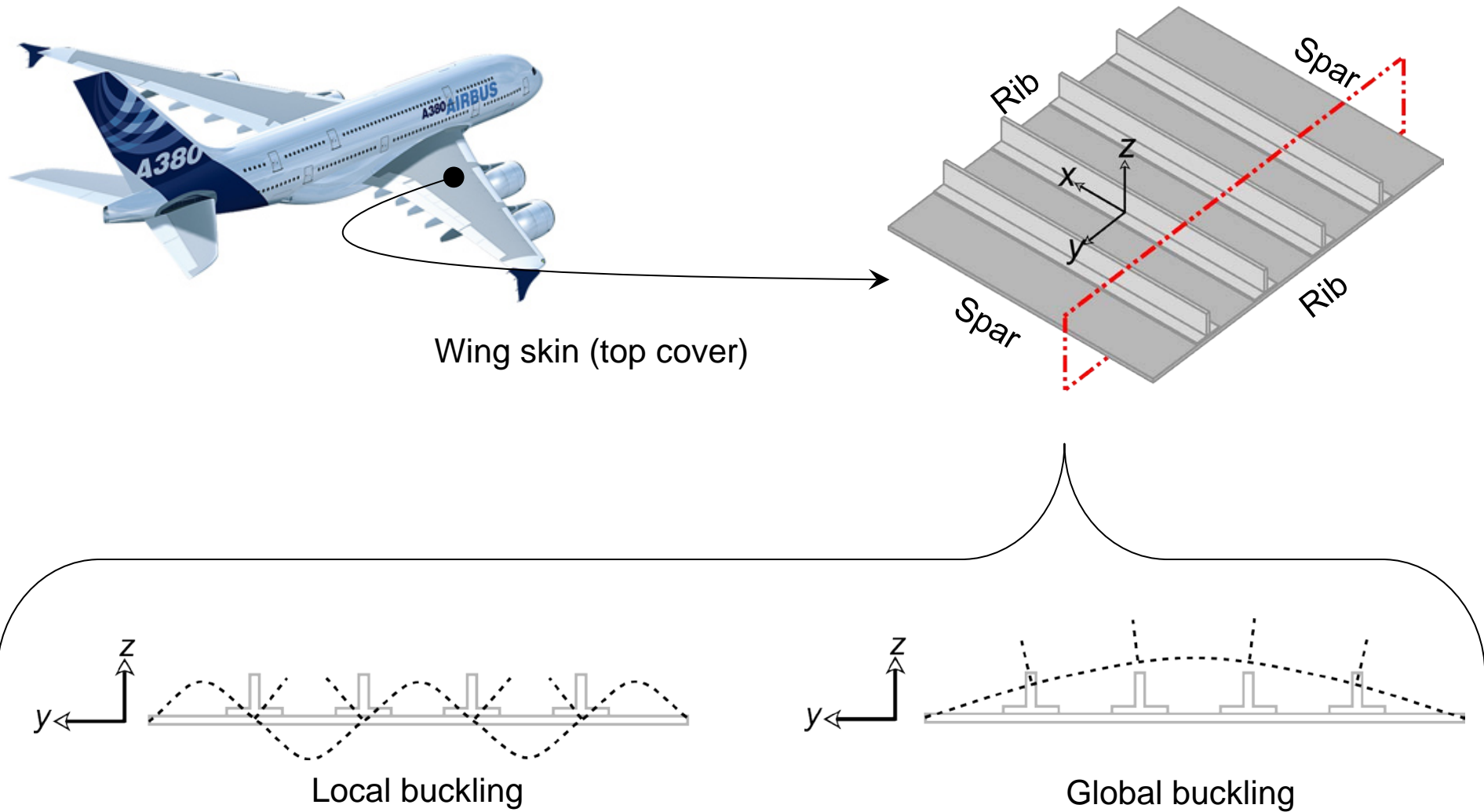
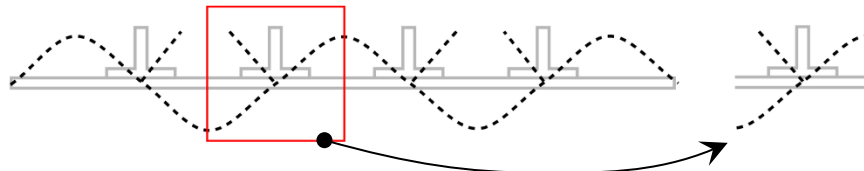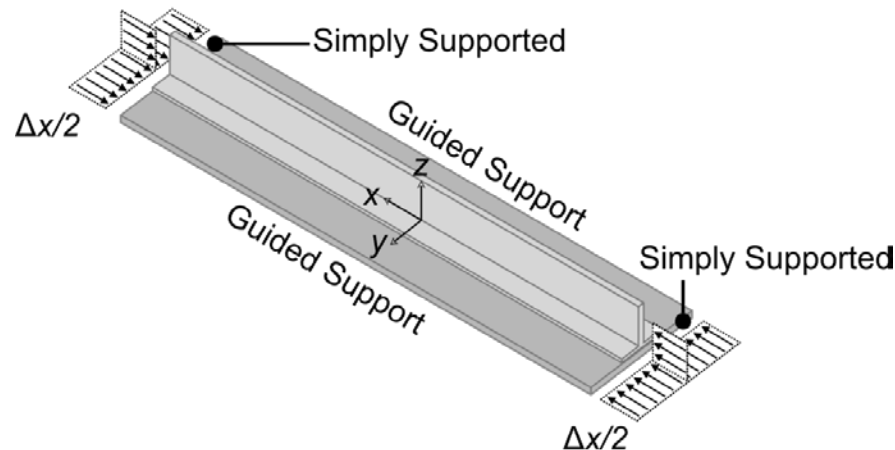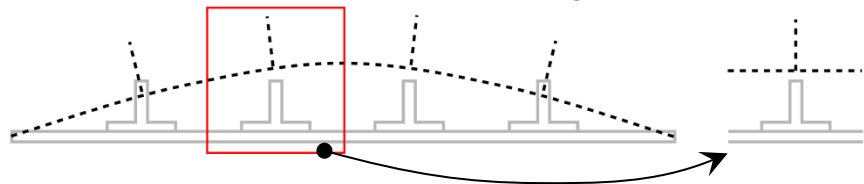Global buckling

The Goal

Blade stiffened variable angle tow panel
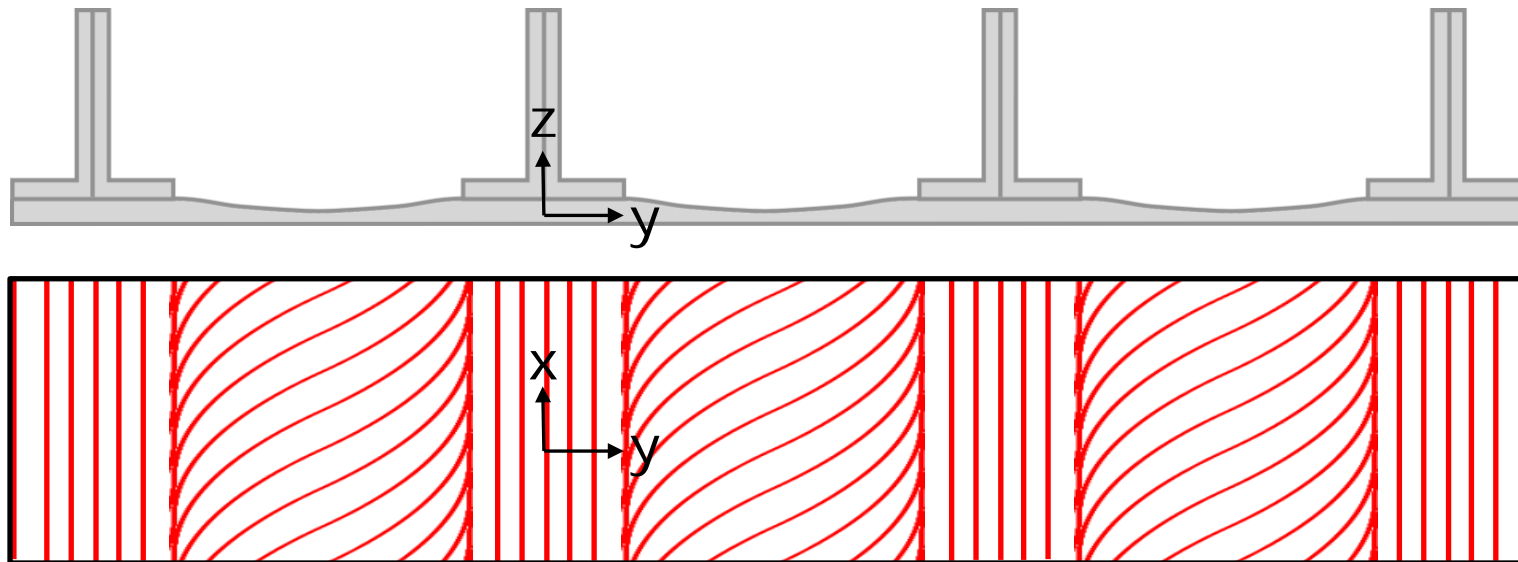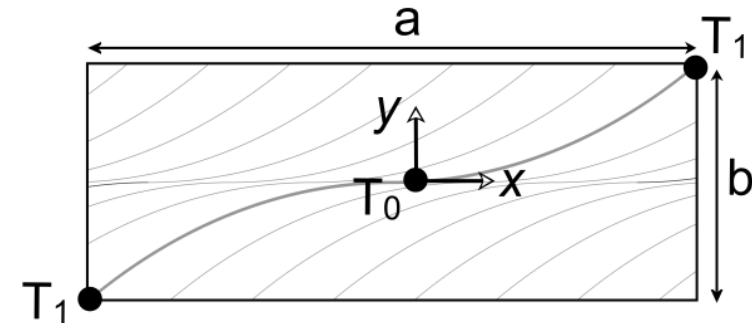
Analysis Overview

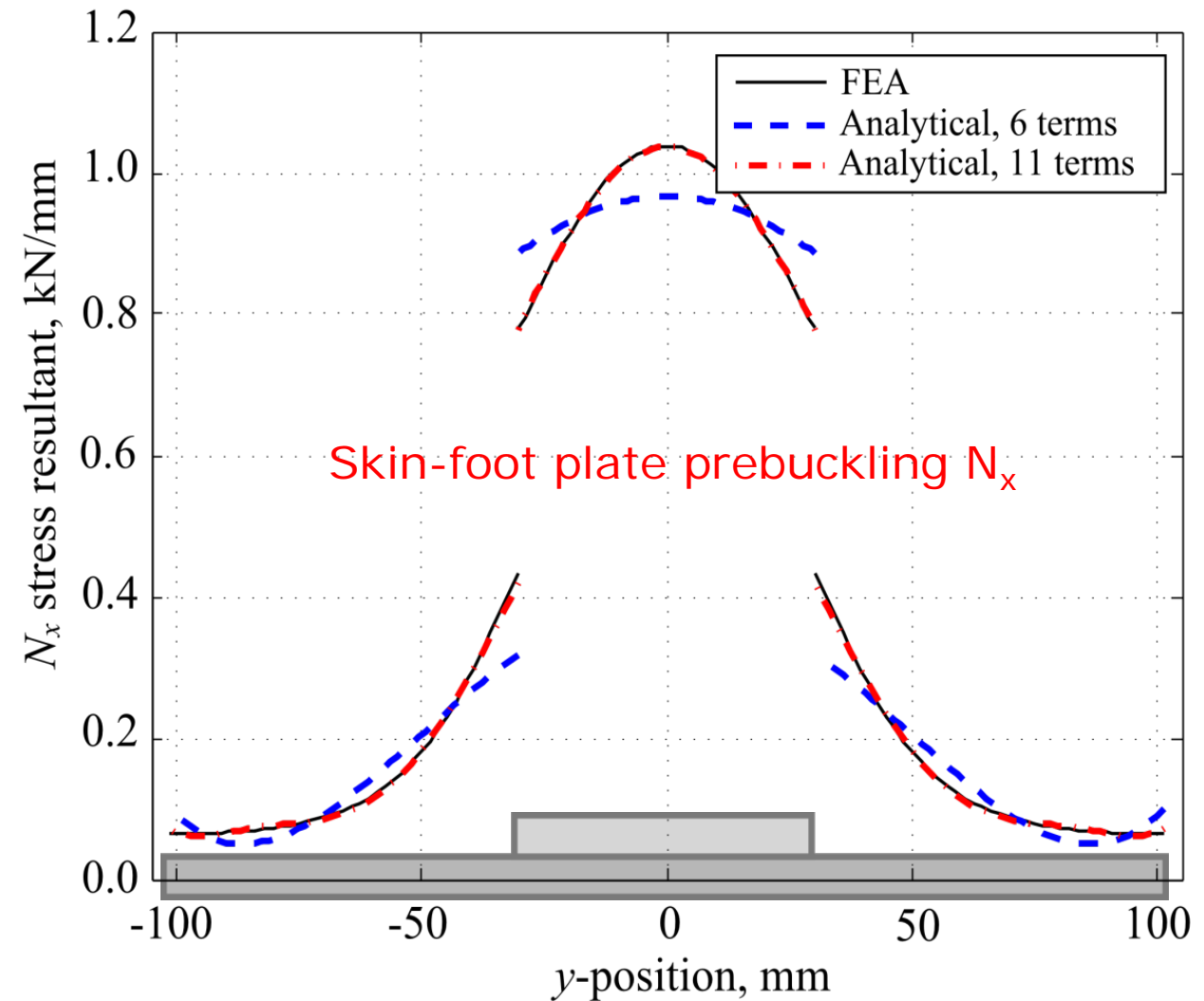Representative Section

Local buckling

Global buckling

Simply Supported
Guided Support
Guided Support
Simply Supported
$\Delta x/2$
$\Delta x/2$
z
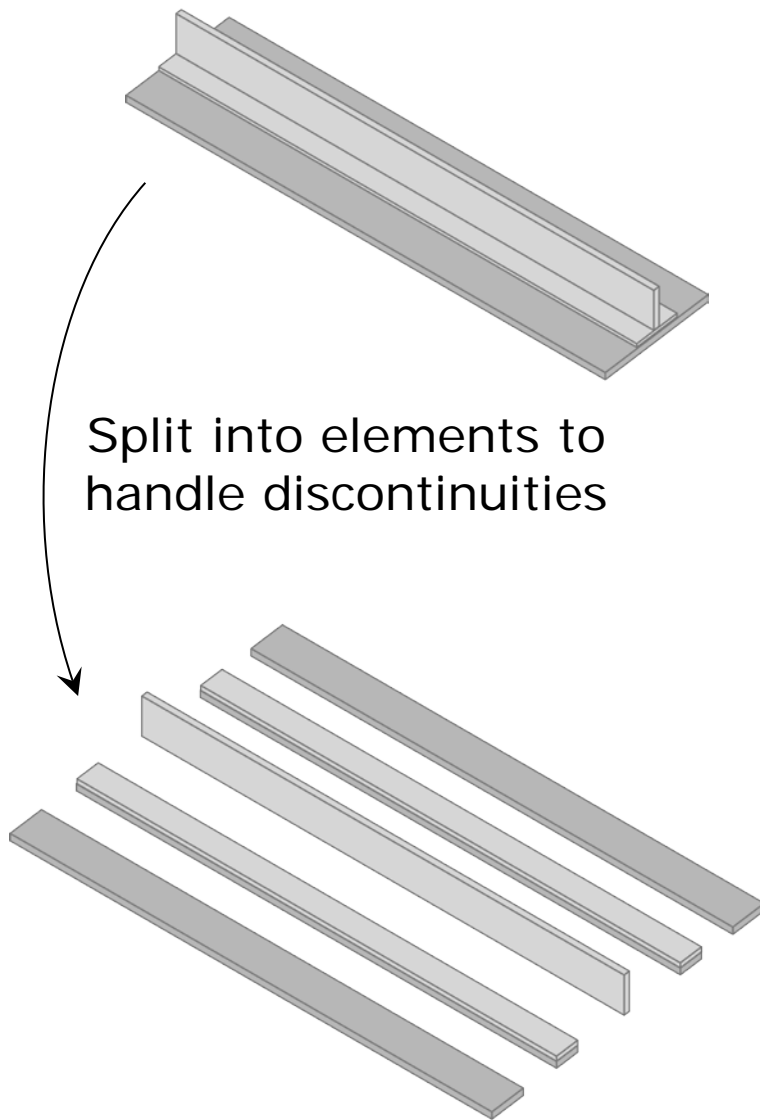x
y

- Rayleigh-Ritz energy method:

  1. Energy expression.

  2. Assume series form of solution.

  3. Minimise energy with respect to unknown coefficients.

  4. Solve system of equations.

a
T_1
y
T_0
x
b
T_1

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Prebuckling Analysis

Split into elements to handle discontinuities
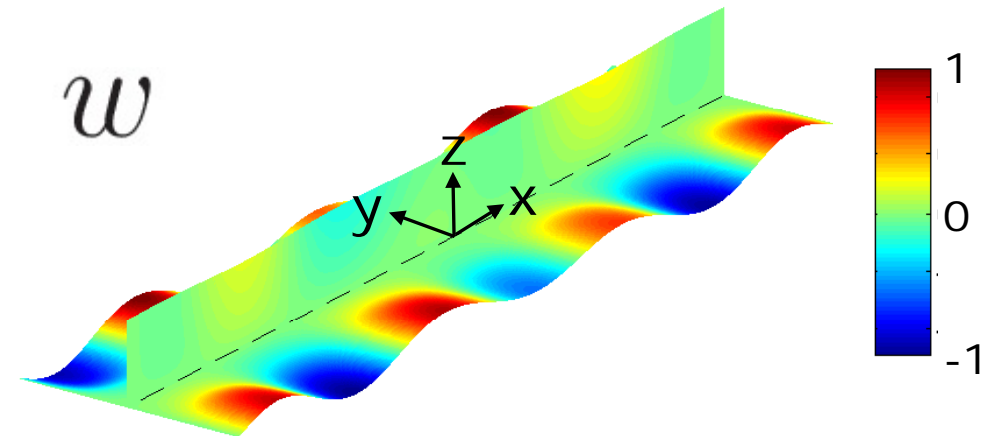
Skin-foot plate prebuckling N_x

Buckling Analysis

- Raleigh-Ritz on total potential energy.

- Four main considerations:
  1. Thick laminates.
  2. B-matrix terms.
  3. Skin-stiffener interaction.
  4. Discontinuous stiffness terms.

- Buckling results:
  – Captures curvature discontinuities.
  – Good agreement with FEA.
    - < 2% local.
    - < 7% global.
  – Computationally efficient.

Results (practical high loading cases):

Local buckling
<2% error (from FEA)

w

Discontinuous curvature, κ_y
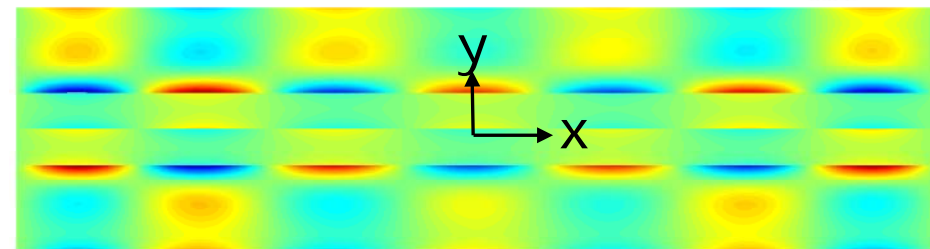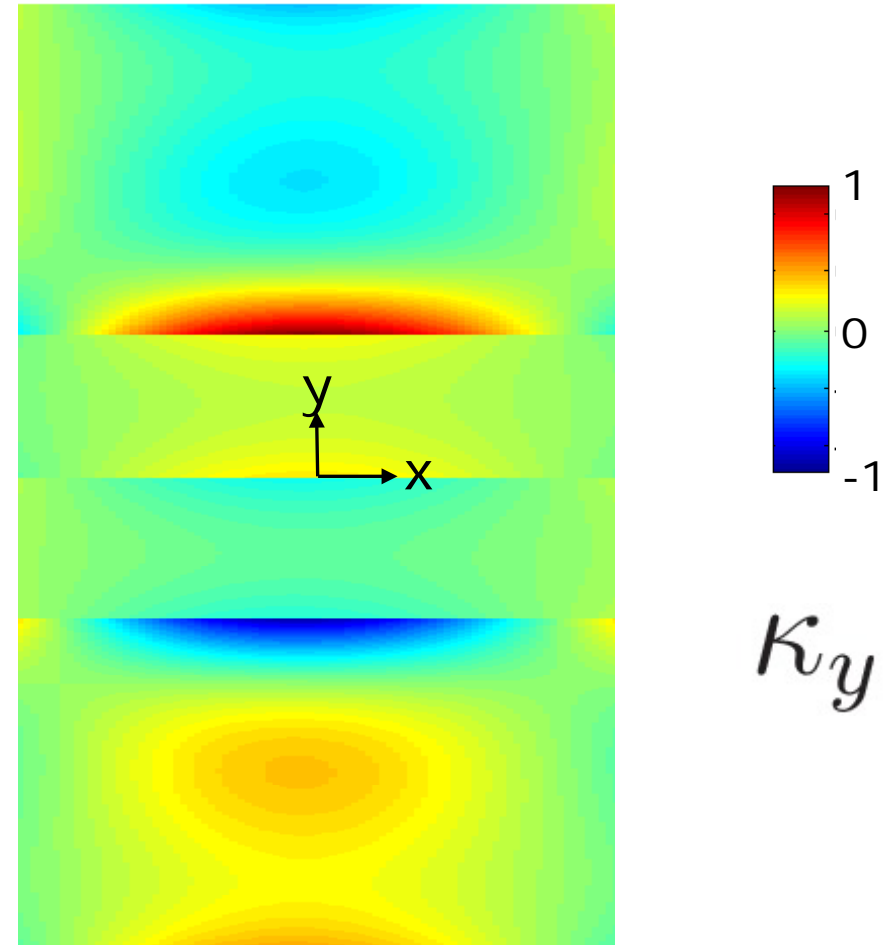
Buckling Analysis

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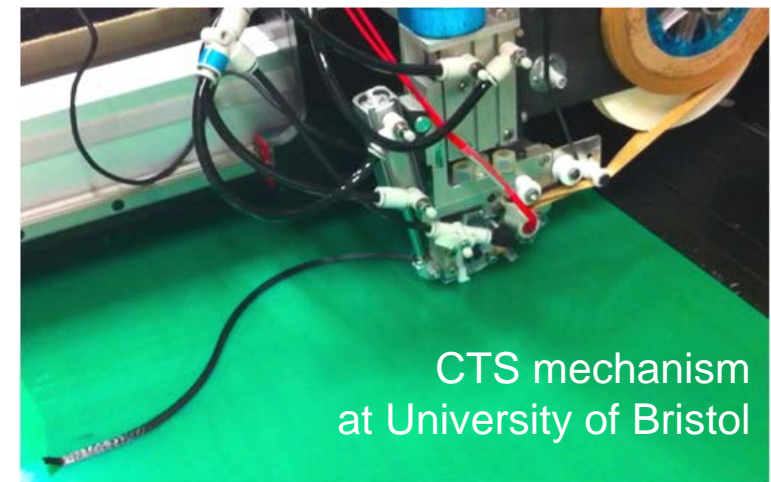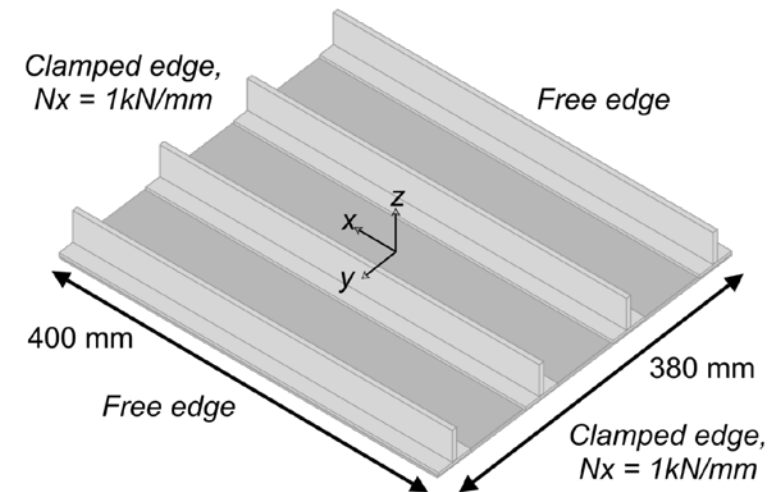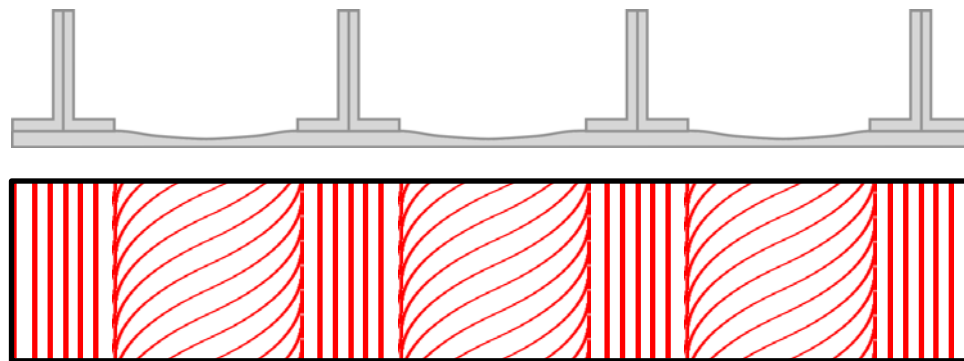   - Computationally efficient.

Results (practical high loading cases):

κ_y

Future Work: Demonstrator

- Stiffened VAT panel demonstrator:

  1. **Design** and **Optimise** for buckling performance with developed analytical methods.

  2. **Manufacture** with Continuous Tow Shearing method.

  3. **Test** both VAT and straight fibre panels.

Clamped edge, Nx = 1kN/mm
Free edge
400 mm
Free edge
380 mm
Clamped edge, Nx = 1kN/mm

CTS mechanism at University of Bristol

Thank You

Acknowledgement:

Questions