Lateral Torsional Buckling resistance of Pultruded FRP beams by testing

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“Pultrusion”

The Pultrusion line (Courtesy of Fiberline)

Mat

Roving

Reinforcement

Resin injection

Heating and curing

Pulling devices

Saw

Ventilation

Orthotropic Material

Wide Flange Beam

$E_L$

$E_T$
WHAT IS LATERAL TORSIONAL BUCKLING (LTB)?

Laterally unrestrained simply supported FRP beam

Later deflection

Twist rotation

Unload, initial geometry ➔ Flexural equilibrium ➔ Instability failure with LTB mode

WHY STUDY LTB?

(1) LTB is an important global instability failure mode in design.
(2) LTB is well understood in STEEL, not Pultruded FRP.
(3) Need more comprehensive data to validate design formulae.
DESIGN OF LOADING FIXTURE

(1) The points of application remain unchanged relative to cross sections.
(2) Their lines of action move parallel to the undeflected positions.

THEORETICAL ASSUMPTIONS

EXPERIMENTAL DESIGN
4 SPECIMENS:

5 SPANS: 1828 mm to 4064mm

LOAD APPLICATION:

OR

DEAD WEIGHT

TENSION JACK
CONDUCTED:

- 114 Tests
- 4 sections
- 5 Spans
- Two BCs
- Three vertical load positions

Inclinometer to measure $\phi$

Load cell to measure $P$

FRP beam

Simply supported ends

Load, $P$
- **Two BCs**

- **Three vertical load positions**
How to decide the onset of buckling?

- **Sudden failure,** $P_{cr,e} = \text{Peak load}$
- **Gradual failure,** $P_{cr,e}=?$
\[ P_{\text{cr,e}} = \frac{1}{\text{Gradient}} \]
Experimental results vs Theoretical predictions

$E_L = 28 \text{Gpa}, \ G_{LT} = 3 \text{GPa} \ (\text{design manual})$

$E_L = 32 \text{Gpa}, \ G_{LT} = 4.5 \text{GPa} \ (\text{actual measured})$

END BOUNDARY CONDITION 1
$E_L = 28 \text{ Gpa}, \ G_{LT} = 3 \text{ GPa} \ (\text{design manual})$

$E_L = 32 \text{ Gpa}, \ G_{LT} = 4.5 \text{ GPa} \ (\text{actual measured})$

**END BOUNDARY CONDITION 2**
Concluding Remarks

1. Test rig was able to satisfy the theoretical requirement of loading and displacement conditions.

2. Comparison showed that the closed-form equation may be suitable after modification and calibration for inclusion in a design standard.

3. The modification should take into account the influence of the orthotropic elastic constants, initial geometric imperfections, shear deformation any resistance reduction due to local-global-distortional buckling interaction.
Thank you for your attention

Any questions?