The Influence of Twist on the Mechanical Properties of Braided Composites

CIMComp
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Project Background:

Previous research has shown that adding twist to fibres during rewinding has fibre processability benefits during braiding.
Limited data exists on the effect of twist on mechanical performance of braided structures.
State-of-the-art braiding simulation capabilities are built of generalised yarn assumptions - Improving the quality of prediction methods for braided composites is essential for increasing industrial application.

Methodology:

Preforms were manufactured using the 192-carrier braider at the NCC with 12K HTS45 fibres supplied by Teijin rewound with 0 twists per metre (Tpm) and 7 Tpm. Braid angle was 45°.

Figure 1. 192-carrier braider at the NCC

Preforms of three layers were produced. These were removed from the mandrel without cutting and flattened to create a six layer preform. Visible increase in fibre damage was seen during braiding with the 0 Tpm - shown by the higher filamentisation and matt fibre appearance (see Figure 2 and Figure 3). A reduction in process interruptions was seen with 7 Tpm fibres due to reduced fibre snagging and breakages.

Figure 2. 0 Tpm braid

Figure 3. 7 Tpm braid

The braid preforms were vacuum infused using EPIKOTE RIMR 135 Resin and RIMR 137 Hardener. Coupons were cut in the 0/90° fibre direction and tensile tested in accordance with standard ISO 527-4, (30 samples of each level of twist).

Results and Discussion:

Stress-Strain Behaviour:

Failure strength (first occurrence of fibre failure) is higher for 0 Tpm. The variability of 0 Tpm is much greater, Table 1.

Additional Twist, Tpm	Failure strength (MPa)	Standard Deviation	Young's Modulus (GPa)
0	673	98	55
7	531	42	56

Table 1: Failure Strength Data

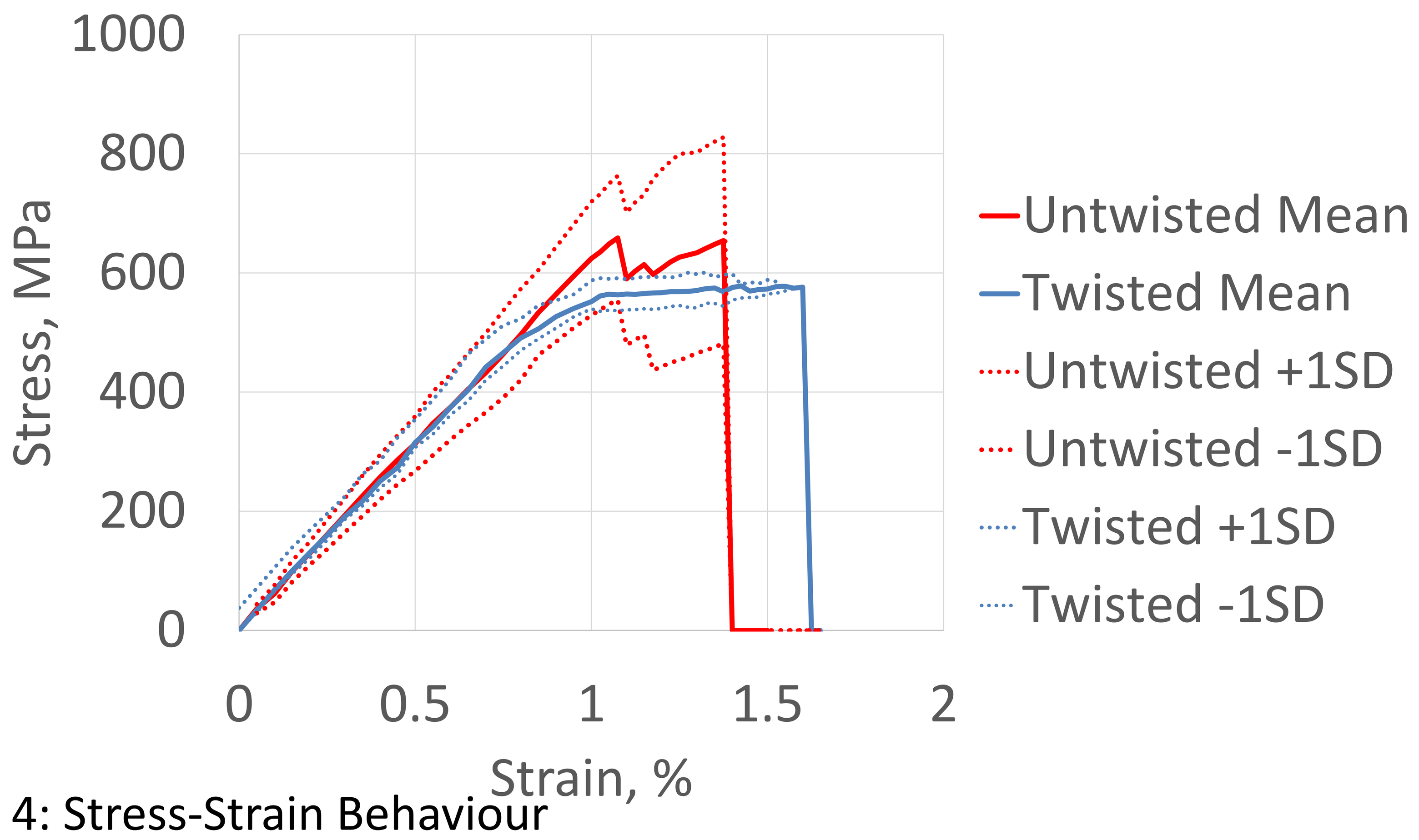

Figure 4: Stress-Strain Behaviour

Figure 4 shows mean values of stress-strain curves with upper and lower bounds representing +/-1 standard deviation.
Untwisted coupons showed a brittle failure at a higher stress value (mean of 673 MPa) as all fibres fail simultaneously. Twisted coupons showed a initial failure at a lower stress (mean of 531MPa) with a more progressive failure at higher strain levels, absorbing greater level of strain energy. Using an A-basis allowable, the lower bound for 0 Tpm is lower (374MPa) than the equivalent for 7 Tpm (402MPa). No significant difference was noted for other mechanical properties.

Mode of Failure:

Figure 5 shows the brittle failure of 0 Tpm braid coupons compared to the extensive delamination observed in the 7 Tpm braids. More 0 Tpm coupons fail laterally (90º), 28 from 30 samples, compared to the 22/30 of the 7 Tpm samples.

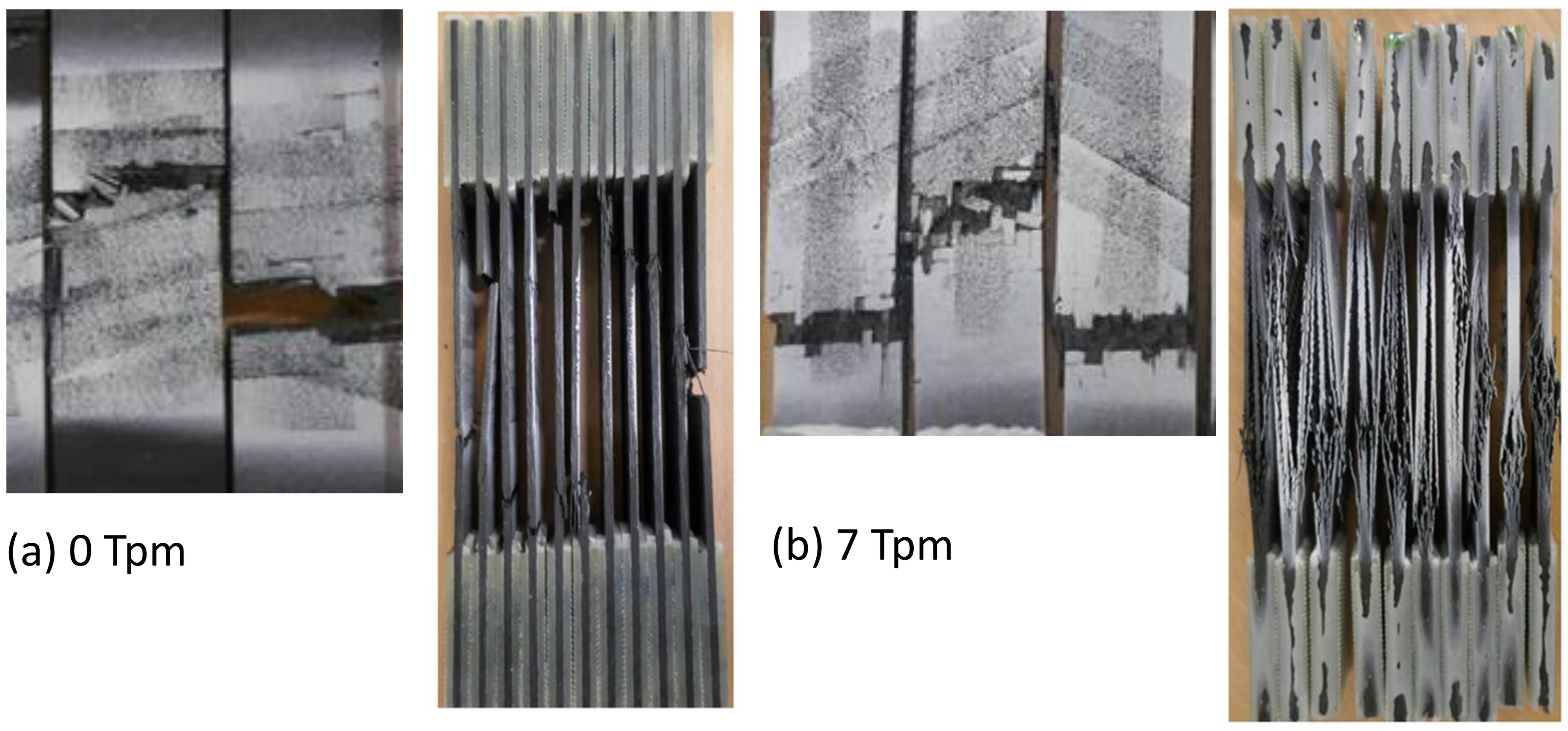

Figure 5. Post-failure coupons: showing greater levels of delamination in 7 Tpm.

Conclusions:

- Visible improvement was seen in fibre processibility during braiding for twisted fibre tows. More fibre damage was seen in the 0 Tpm braids.
- Average failure strength was higher for 0 Tpm braids, however the variability was much greater than the 7 Tpm braids.
- Due to the higher variability the A-basis allowable for the untwisted coupons was lower than the twisted coupons.
- Untwisted 0 Tpm fibres exhibited a more brittle failure.
- Extensive delamination was seen in the failed 7 Tpm twisted coupons.

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