HiPerDuCT Programme Grant

Final report: Microbraided ropes

This study presents the manufacture and mechanical characterisation of hybrid microbraids made by braiding UHMwPE fibres over a unidirectional core of carbon fibres, and their direct use as the reinforcing phase within polymer composites. The main aim of this work is to investigate composite materials able to undergo large deformations, nevertheless having stiffness and energy absorption capabilities at least similar or better with respect "conventional" fibre reinforced polymer composites made of the same materials (1,2).

The manufacture of 2D hybrid microbraid was performed using a Herzog RU2/16-80 vertical braiding machine as shown in Figure 1. The braider was set to interlace eight DyneemaRSK75 yarns in a diamond fashion over a unidirectional core of carbon fibres (ToraycaR T300). Microbraids having different braid angle α were manufactured by changing the cogwheel ratio on the braiding machine.

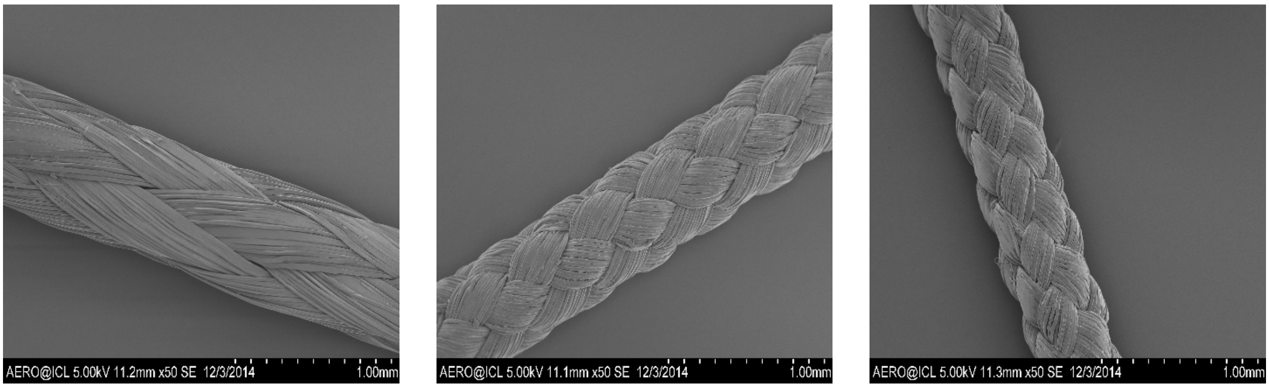

Figure 1: Hybrid microbraids: (a) HMB1 α=14° (b) HMB2 α=33°; (c) HMB3 α=39°.

Quasi-static tensile tests on yarns and dry microbraids were performed at room temperature using an Instron 5969 universal testing machine equipped with a 50 kN load cell. In order to prevent fibre damage and a possible premature failure of the carbon filaments, rubber tabs were glued on the specimen ends using Araldite 2011.

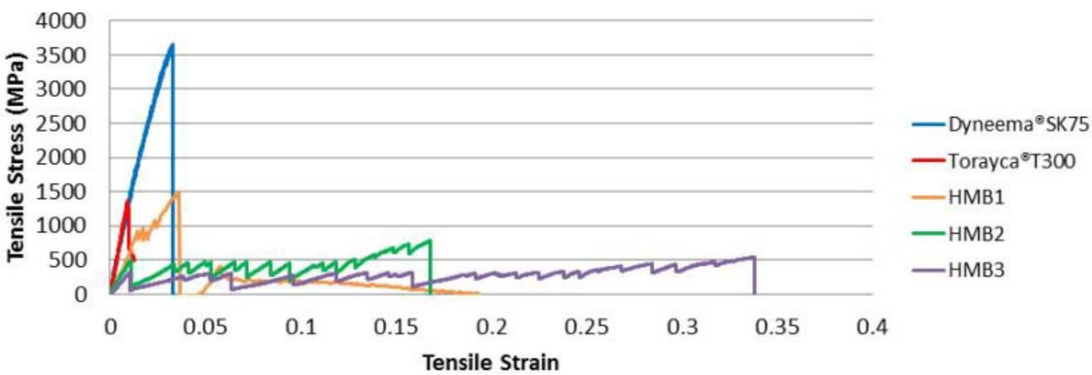

Figure 2: Tensile stress vs. tensile strain of the investigated yarns and microbraids.

The mechanical behaviour of core-filled microbraid has three distinctive regions:
In Region 1, the tensile behaviour of the hybrid microbraids was mainly governed by the unidirectional core fibres and, to a lesser extent, by the bias fibres. The UD core eliminated the initial long plateau commonly seen when tensile testing coreless braids. The tensile stress increased in a linear fashion with increasing the load. The Young's modulus E_i and the strength at the first failure of the carbon fibres σ_{ic} decreased with increasing braid angle. When the strain reached the strain to failure of the carbon fibres, failure of the inner core occurred. The bias fibres not only contained the failed carbon fibres in the core of the braid, but also carried the load after failure of the core.
In Region 2, a series of peaks in the tensile stress was observed. As the bias fibres tended to scissor to the loading direction, the diameter of the microbraid reduced, squeezing and containing the failed core. The load was taken by the bias fibres and transferred to the inner fibres via friction. Although fractured, the carbon core was able to absorb the load until a subsequent failure occurred.
In Region 3, the bias fibres reached the jamming point and the tensile stress increased until a final catastrophic failure occurred. Even in this region it is possible to identify further ruptures of the carbon fibres in the core.

References

1. Del Rosso S, Iannucci L, Curtis PT. Experimental investigation of the mechanical properties of dry microbraids and microbraid reinforced polymer composites. Composite Structures. 2015 Jul 1;125:509-19.
2. Del Rosso S, Iannucci L, Curtis PT, Robinson P. Hybrid UHMwPE/Carbon microbraids for ductile composites in ECCM17 - 17th European Conference on Composite Materials; 2016 26-30th June 2016; Munich, Germany