FALLING WEIGHT IMPACT PROPERTIES OF E-GLASS/JUTE HYBRID LAMINATES AND NON-LINEARITY OF THEIR BEHAVIOUR

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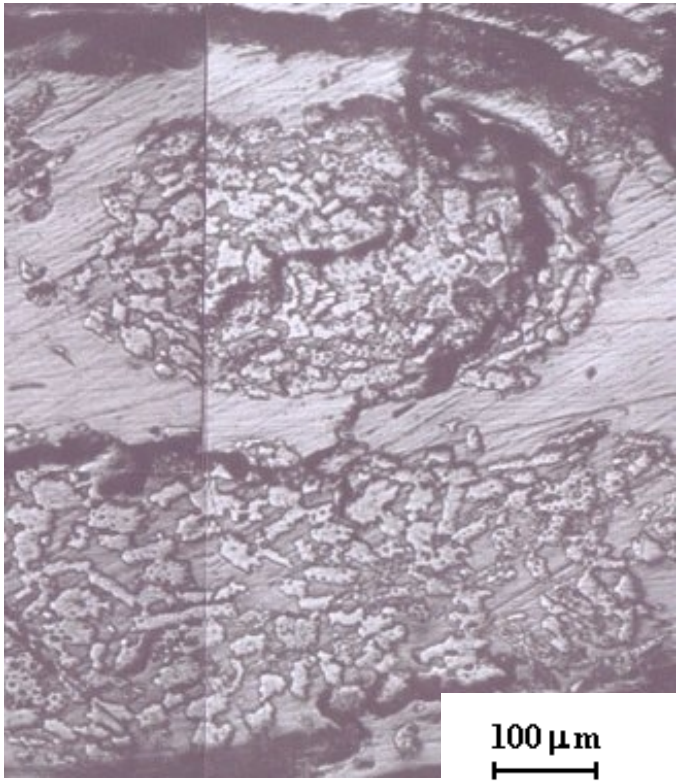
HYBRID PLANT/GLASS FIBRE LAMINATES AS STRUCTURAL MATERIALS

- Sufficient impact damage resistance with better LCA profile and reduced weight
- Glass fibre composite skin provides impact resistance, whilst plant fibre composite core provides damage dissipation

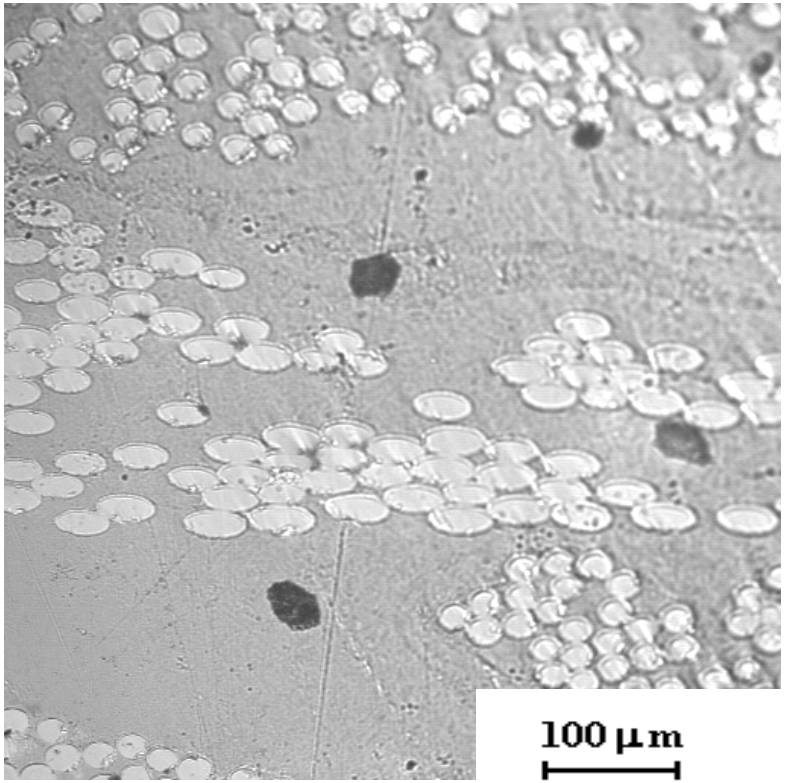
Limits:

- Limited knowledge of the effect of hybridisation on the mechanical properties of the material (rule-of-mixtures? More complex rules?)
- Scarce exploration of post-impact residual properties

COMPARED MICROSTRUCTURES



Jute/polyester



E-glass/polypropylene

Plant fibre composites:

- Irregular geometries of fibre bundles, often with internal fractures
- Criticality of fibre-matrix compatibility

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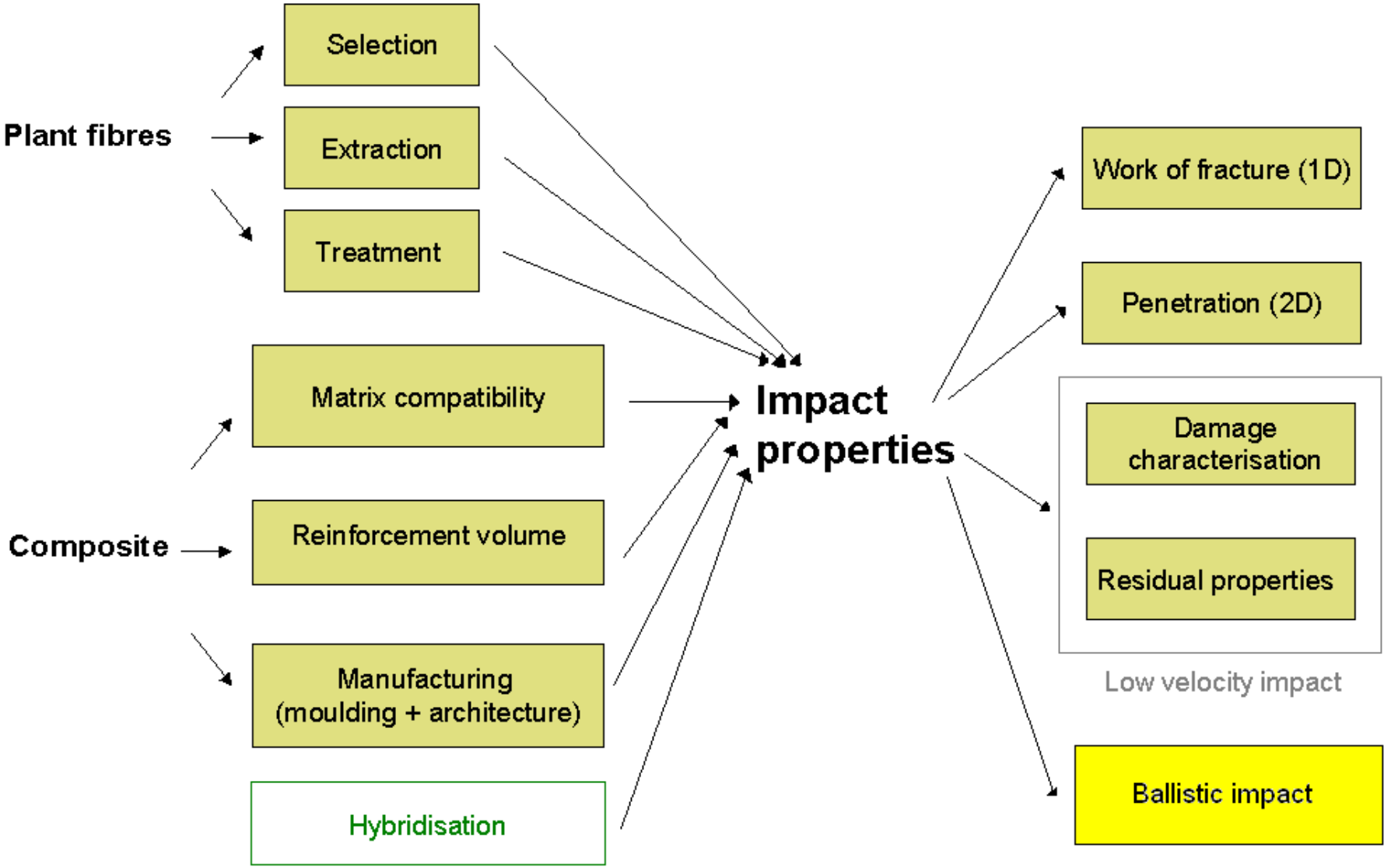
ASSETS OF PLANT FIBRE COMPOSITES FOR ENGINEERING STRUCTURES

- Low weight of fibres
  (density around 0.8-1.6 compared to 2.5 of glass fibres)
- Glass-plant fibres hybrid composites manufacturing
- Coupling with biodegradable matrices (e.g., starch-sorbitol or polylactic acid) to obtain a fully sustainable composite

IMPACT PROPERTIES: SYSTEM OF INTEREST



EXPERIMENTAL

- Laminates (E-glass fibre reinforced, jute fibre reinforced, hybrids) manufactured by RTM process, using polyester resin, and with 60% global wt. reinforcement content.

- All laminates had a ten layers stacking structure: in particular, the hybrid laminates included four layers of E-glass reinforced laminate on each side, with two layers of jute fibre reinforced laminate sandwiched between them.

- One group of specimens was not impacted, other three were impacted at energies of 5, 10 and 15 Joules, and the last one was impacted to penetration always using a hemispherical impactor tip (diameter 12.7 mm).

- Tensile specimens of dimensions 200x25 mm have been impacted and then subjected to post-impact tensile tests.

- Delamination areas have been obtained by sectioning the samples and characterising damage through optical microscopy (maximum magnification x60).

POST-IMPACT TENSILE TESTS

Impact energy (J)	GFRC	JFRC	Hybrid	Hybrid theoretical
0	270±15	60±8	206±9.5	186
5	276±20	36±5.5	192±8	180
10	273±27	38±4	148±7.5	179
15	228±30	37.5±6.5	132±9	152

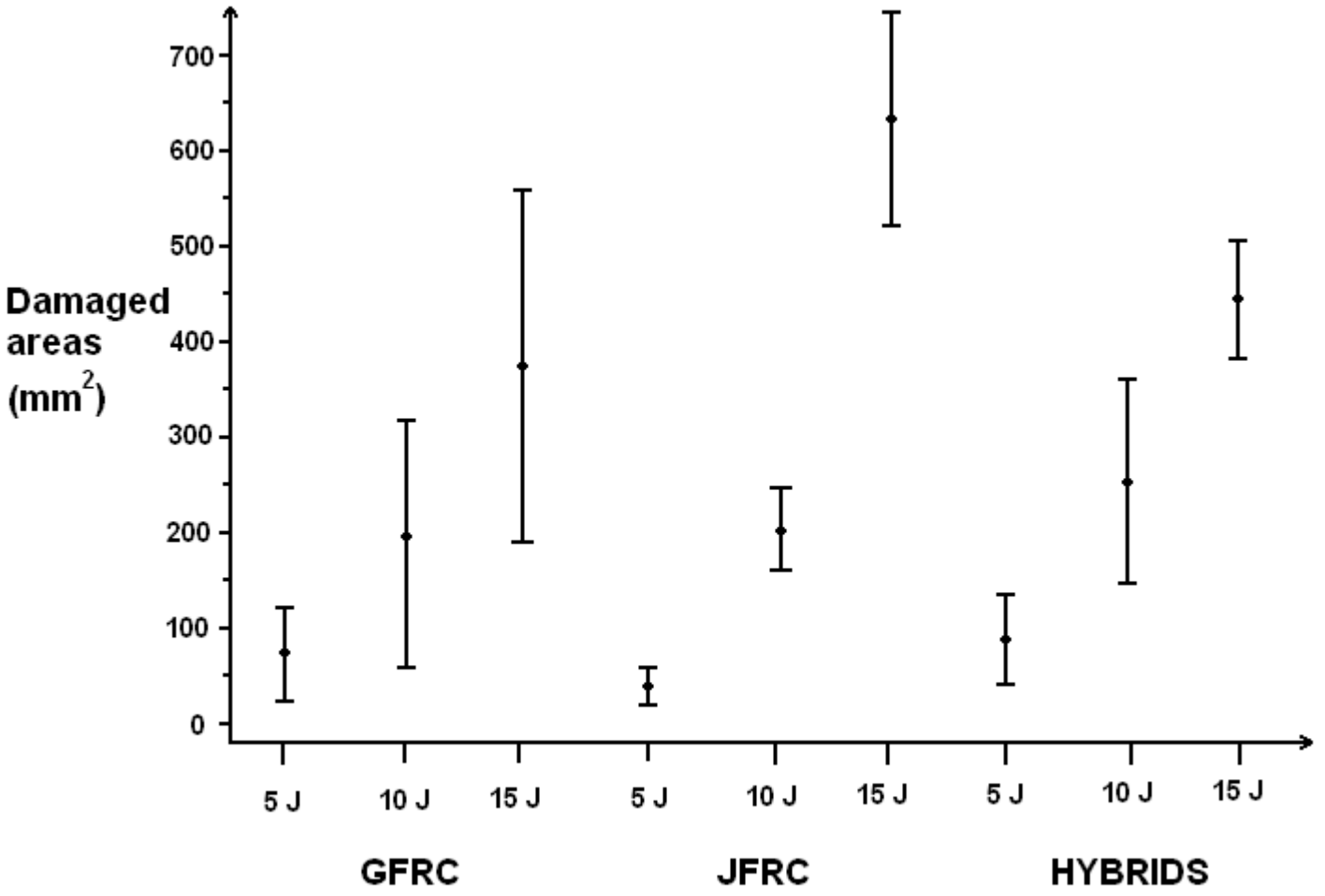
TENSILE STRENGTH (MPa)

Impact energy (J)	GFRC	JFRC	Hybrid	Hybrid theoretical
0	14.7±0.8	5.6±0.3	10.5±0.8	11.1
5	14.5±0.6	5.7±0.2	8.4±0.7	11.0
10	14.2±0.9	5.5±0.3	7.6±0.5	10.7
15	12.3±0.5	5.3±0.5	7.1±0.7	9.5

TENSILE MODULUS (MPa)

Theoretical results were obtained supposing the hybrid laminates
would behave as prescribed in the rule of mixtures
(weighed average of components)

DELAMINATED AREAS



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MAIN RESULTS

- On jute fibre reinforced laminates (JFRC) it is the effect of impact itself that generates the higher reduction in strength and stiffness, while E-glass fibre reinforced laminates showed no substantial properties degradation at 5 and 10 Joules.
- The comparison of the theoretical and the experimental results on the hybrids show that hybridisation can yield positive results in terms of strength, at least for non-impacted and 5 J impacted laminates, while the degradation appears quite considerable for higher impact energies and overall for the stiffness results.
- Delamination areas (albeit scattered) indicate that in hybrid laminates, impact damage and reduction in strength and especially in stiffness appear to be more easily related. Also, jute fibre reinforced laminates appear to be substantially damaged at 15 Joules (close to their penetration energy), while hybrids appear to be less damaged.

CONCLUSIONS

- In general, hybridisation appears to be an interesting concept for obtaining composites with sufficient impact resistance, but more biodegradable and having a reduced weight.
- The relation between delaminated areas and post-impact properties was studied, although with limited emphasis for as concerns local properties and difficulty of damage characterisation in jute fibre reinforced composites.
- In the future, a more complete study would allow e.g., a possible modelling of the post-impact behaviour and establishing reasonable safety coefficients for using hybrid laminates in applications requiring impact resistance, such as in the automotive sector.