CERIS : Civil Engineering Research and Innovation for Sustainability

Development of bio-based CFRP laminates for strengthening civil engineering structures

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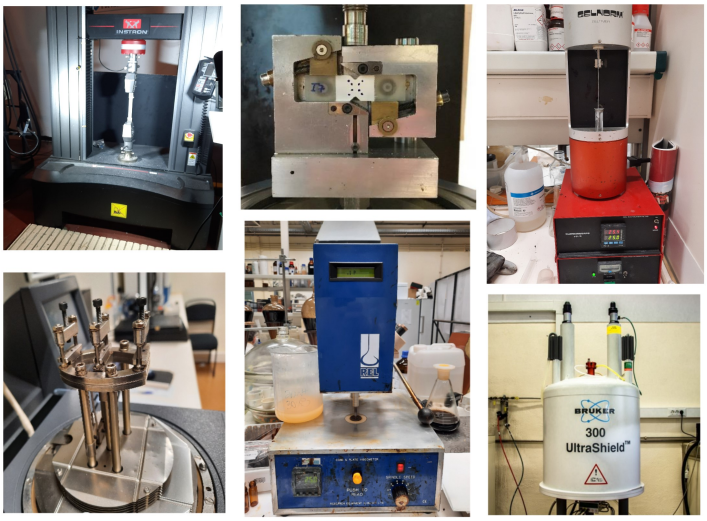
Summary

The ongoing PhD thesis aims to address the civil engineering sustainability challenge applying a bio-based polymeric resin system, able to replace current petroleum-derived resins, and use it in the development of Pultruded Carbon Fibre Reinforced Polymer (CFRP) laminates for structural strengthening. In particular, the bio-based CFRP should provide comparable mechanical and structural performance to existing conventional CFRP laminates produced with vinyl ester or epoxy resins, with more competitive price, better fire properties and superior environmental sustainability. CFRP laminates are now often used in the structural strengthening of civil engineering infrastructure, such as bridges and buildings. They have a typical fibre volume of 70% and their resin matrix is usually made of petrochemical-based vinyl ester or epoxy resins. In this context, there is an opportunity to improve the sustainability of CFRP laminates by using resins obtained from bio-based materials, the so-called bio-resins, provided that they present similar performance to conventional polymeric resins. The most promising path for the development of bio-composites for structural applications is the synthesis of polymers from renewable raw materials, such as vegetable oils or biomass.

Lignocellulosic biomass is an abundant renewable resource, composed mainly of cellulose, hemicellulose, and lignin. Phenolic compounds from biomass can be incorporated in the polymeric chain at a competitive cost, increasing the bio-content, improving fire performance and, consequently, the sustainability and performance of resins and composites in which they are incorporated. The thesis experimental campaing will provide insights about the potential use of the new bio CFRP laminates. In particular, the thermal and mechanical characterization tests of the laminates will allow determining their glass transition temperature, the stiffness and strength properties under compression, tension, and in-plane shear. After the material characterization based on small-scale tests, intermediate- and full-scale tests will allow evaluating respectively (i) the adhesion between the bio-phenolic laminate and concrete specimen, based on double-lap tensile tests and pull off tests, and (ii) the flexural behaviour of reinforced concrete beams strengthened in flexure, based on four-point bending tests. As an innovation contribuition, it is expected that the new bio-laminates will have a favourable structural response, namely in comparison with their petrochemically-based conventional counterparts, being a cheaper and more environmentally friendly solution for the civil engineering industry.

Keywords:

Construction, sustainability, bio-polymers, composites, CFRP laminates, strengthening.



Small scale tets for bio-resin development.