CERIS : Civil Engineering Research and Innovation for Sustainability

Fracture and web-crippling behavior of pultruded GFRP profiles at elevated temperature

PhD student
Yuyi Ye

PhD program
Civil Engineering (IST, University of Lisbon)

Supervisor
João Ramôa Correia (CERIS, IST, University of Lisbon)

Co-supervisors
Nuno Silvestre (IDMEC, IST, University of Lisbon) and José Gonilha (CERIS, IST, University of Lisbon)

Period
2022-2026

Funding
China Scholarship Council (CSC) (No. 202108440197)

Summary

Pultruded fiber-reinforced polymer (FRP) profiles are known to present significant sensitivity to high temperatures, exhibiting considerable reduction of their mechanical properties. To ensure the reliable design of pultruded FRP structures during their service life, the influence of elevated temperatures on their mechanical and fracture behavior must be understood and characterized; in fact, elevated temperatures affect the resistance of FRP structures, which can be governed by localized failure modes that are difficult to evaluate. In particular, web-crippling of FRP profiles has been a challenging issue in structural design due to the anisotropy and relatively low elastic moduli of these materials. In this context, this project aims to investigate, both experimentally and numerically, the fracture and web-crippling behavior of pultruded glass FRP (GFRP) profiles at elevated temperature.

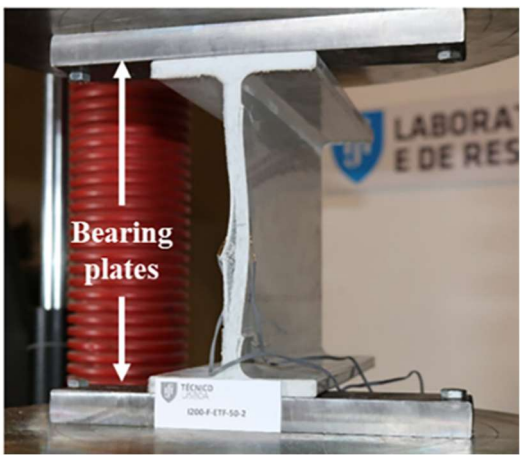
From the experimental campaigns to be developed, the following results are expected: (i) characterization of the tensile and compressive fracture behavior of pultruded GFRP profiles at elevated temperature; (ii) in-depth understanding of the mixed mode fracture behavior (i.e., Mode I and II) of pultruded GFRP profiles at both ambient and elevated temperatures and development of a failure criterion for mixed-mode fracture; (iii) in-depth understanding of web-crippling behavior of pultruded GFRP profiles under different loading conditions at both ambient and elevated temperatures, including failure modes, stiffness, resistance and stress distribution.

In addition, numerical simulation will be performed using a commercial finite element (FE) package ABAQUS, from which the following outputs are expected: (i) validation of experimental results with advanced non-linear FE models and development of an analytical model for the temperature-dependent fracture toughness; (ii) development of numerical models incorporating temperature-dependent fracture toughness parameters determined from fracture tests (or the analytical model) (i.e., fracture toughness-based models) to simulate the web-crippling behavior of pultruded GFRP profiles at both ambient and elevated temperatures, with varying loading conditions, bearing lengths and section geometries. Finally, based on an analytical study supported by experimental and numerical results, reliable formulae based on the direct strength method (DSM) will be developed for the design of web crippling of pultruded GFRP profiles over a wide temperature range.

Keywords

Pultruded glass fibre reinforced polymer (GFRP) profiles, fracture toughness, web crippling, elevated temperature, Direct strength method (DSM).

Fracture tests setup.



Web-crippling tests setup.