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Thermal and structural response of pultruded GFRP profiles under fire exposure

PhD student
Tiago Miguel Rodrigues Morgado

PhD program
Civil Engineering (IST, University of Lisbon)

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

Co-supervisors
Fernando Branco (CERIS, IST, University of Lisbon) and Nuno Silvestre (IDMEC, IST, University of Lisbon)

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Summary

With the advent of high-strength materials, high-strength Concrete Filled Steel Tubes (CFST) GFRP profiles have great potential for civil engineering applications, presenting some advantages (lightness, strength and durability) and some drawbacks (cost, low elastic moduli and poor fire behaviour. With the purpose of investigating the viability of the structural use of pultruded GFRP profiles in the construction industry, this PhD thesis aimed at obtaining a better understanding of thermal/structural responses of GFRP profiles exposed to fire.

In a first stage, experimental/analytical studies were carried out in order to characterize compressive/shear behaviour of GFRP material at elevated temperatures (~20-180 °C). The results obtained showed that (i) compressive strength is severely affected (reduction of 87% at 180 °C); (ii) shear strength is noticeably affected (reduction of 88% at 180 °C); and (iii) shear modulus is significantly affected (reductions of 80% at 140 °C).

In a second stage, fire resistance tests were performed on pultruded GFRP beams/columns. For one-side fire exposure, the fire resistance of beams was increased from 36 min (unprotected) to 83/120 min (with passive/active fire protection); the fire endurance of columns was increased from 16 min (unprotected) to 51/120 min (with passive/active fire protection). For three-side fire exposure, the fire resistance of the unprotected beams and columns was remarkably reduced (about 80% and 50%, respectively). As expected, the fire endurance of beams/columns was reduced by the load level increase.

In a third stage, numerical models were developed for simulating thermal response (2D/3D finite volume models), in which the results obtained were in agreement with the experimental ones. Also, numerical models were developed for simulating the mechanical behaviour of GFRP beams/columns (3D finite element models), providing interesting insights about deformations, stresses and failure modes. In addition, analytical models were also developed to simulate the mechanical response of GFRP beams exposed to fire, which provided results in close agreement with those obtained from numerical/experimental studies.

Keywords

Glass fibre reinforced polymer (GFRP), pultruded GFRP profiles; fire behaviour, GFRP beams and columns, fire protection systems, thermal and mechanical responses, experimental tests, numerical and analytical studies.

Fire resistance tests performed on GFRP tubular beams.