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T. Morgado, N. Silvestre, J.R. Correia, F.A. Branco, T. Keller

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NUMERICAL MODELLING OF THE THERMAL RESPONSE OF PULTRUDED GFRP TUBULAR PROFILES SUBJECTED TO FIRE

T. Morgado\textsuperscript{a}, N. Silvestre\textsuperscript{b*}, J.R. Correia\textsuperscript{a}, F.A. Branco\textsuperscript{a}, T. Keller\textsuperscript{c}

\textsuperscript{a} CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal.
\textsuperscript{b} IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal.
\textsuperscript{c} Composite Construction Laboratory (CCLab), École Polytechnique Fédérale de Lausanne, BP 2225, Station 16, CH-1015 Lausanne, Switzerland.

* corresponding author – email: nsilvestre@ist.ulisboa.pt

Abstract: This paper presents a numerical study about the thermal behaviour of pultruded GFRP profiles with square tubular cross-section exposed to fire. Two-dimensional and three-dimensional numerical models of previous fire tests of GFRP profiles were developed using the commercial software ANSYS Fluent 14.5. The efficacy of using different fire protection systems (passive and active) and the influence of the number of sides exposed to fire (one or three) in the thermal response of the GFRP profiles was studied. The models developed consider the heat exchanges by means of conduction, internal radiation and convection of the air and/or water enclosed in the cavity of the GFRP tubular profiles. A general good agreement was obtained between numerical temperatures and test data. The results obtained highlight (i) the relative efficiency of the different fire protection systems and (ii) the remarkable influence of exposing GFRP profiles to fire in three sides, and (iii) show the importance of the heat exchanges due to internal radiation and convection inside the cavity of the GFRP cross-section in this type of thermal simulations. The thermal models were further validated through the simulation of previous fire resistance experiments on multicellular slab panels.

Keywords: Glass fibre reinforced polymer (GFRP); pultruded profiles; fire behaviour; thermal response; numerical modelling; computational fluid dynamics (CFD).

1. INTRODUCTION

Pultruded glass fibre reinforced polymer (GFRP) profiles are being increasingly used for civil engineering applications, in both new construction and structural rehabilitation, being connected by means of bolting or bonding [1, 2]. When compared to traditional materials, such as reinforced concrete and steel, the main advantages of GFRP profiles are lightness, high strength, ease of installation, good thermal and electro-magnetic insulation properties, durability and reduced maintenance [3]. On the other hand, the widespread acceptance of GFRP profiles is being hampered by their initial costs, relatively low stiffness and concerns about the behaviour at elevated temperature and under fire exposure [4].

These well-founded concerns, which are particularly acute for building applications, are due to the poor fire reaction and fire resistance behaviour of fibre reinforced polymer (FRP) materials in general [5-11], and of pultruded GFRP profiles in particular [4, 12]. Moreover, the available guidelines do not provide any specific procedures for the fire design of GFRP profiles. The development of such guidance depends on obtaining a better understanding of the thermal and
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