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T. Morgado, N. Silvestre, J.R. Correia

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SIMULATION OF FIRE RESISTANCE BEHAVIOUR OF PULTRUDED GFRP BEAMS - PART II: STRESS ANALYSIS AND FAILURE CRITERIA

T. Morgado[a], N. Silvestre[b], J.R. Correia[a]*

[a] CERIS, Instituto Superior Técnico, Universidade de Lisboa.

[b] IDMEC, Instituto Superior Técnico, Universidade de Lisboa.

Av. Rovisco Pais, 1, 1049-001 Lisboa, Portugal.

* corresponding author – email: joao.ramoa.correia@tecnico.ulisboa.pt

Abstract: This two-part paper presents a numerical study on the fire resistance behaviour of pultruded GFRP profiles with square tubular cross-section simultaneously subjected to four-point bending and the standard fire of ISO 834. The first part [1] presented the numerical models and results focused on the most relevant *kinematic* issues (deflections and strains), while this second part (present paper) reports numerical results associated to the *static* issues, particularly the evolution of stress distributions and failure initiation with fire exposure time[i]. The paper first presents and discusses the evolution of stress distributions in both longitudinal and transversal directions of an unprotected GFRP beam under one-side fire exposure (reference beam). Next, the influence of using a fire protection system and exposing the beams to fire in three sides is assessed by comparison with the case of reference beam. Additionally, the Tsai-Hill failure (initiation) criterion was used to identify the zones (sections and points) of GFRP beams that are most sensitive to failure due to high temperatures. The numerical results obtained show that (i) longitudinal stresses across the section become highly nonlinear as a result of temperature increase; (ii) shear stress diagram is severely affected by fire exposure in three sides; (iii) transversal stresses are negligible compared to the longitudinal and shear ones; and (iv) the collapse of beams (considering Tsai-Hill failure analysis) occurs due to top flange and web (top part) failure, which generally agrees with experimental observations.

Keywords: Glass fibre reinforced polymer (GFRP); Fire behaviour; Numerical study; Stress analysis; Tsai-Hill failure criterion.

1. INTRODUCTION

The structural use of glass fibre reinforced polymer (GFRP) composites for civil engineering applications is being increasingly considered as an alternative to traditional materials (such as reinforced concrete, steel and timber) in order to fulfil increasing performance requirements and guarantee longer service lives with lower maintenance [2, 3].

The design of GFRP structures is usually governed by deformation requirements and deflection limits. Therefore, *kinematic* issues, such as those dealt with in the previous part [1], play a crucial role not only in normal service conditions, but also in accidental events, such as fire. Fire action deteriorates the stiffness (elastic properties) and also the resistance (strength properties) of GFRP

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[i] Again, the classical binomial relation of mechanics (constitutive law related by two variables, *kinematic* and *static*, through a material property) is recovered: *kinematics* refers to displacements, rotations and deformations while *statics* denotes forces, moments and stresses.