FIRE PROTECTION SYSTEMS FOR REINFORCED CONCRETE BEAMS STRENGTHENED WITH CFRP LAMINATES

João P. Firmo*, João R. Correia*, Paulo França* and S. Cabral-Fonseca†

* Instituto Superior Técnico – IST/ICIST, Universidade Técnica de Lisboa
Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal
e-mail: firmologo@gmail.com, web page: http://www.civil.ist.utl.pt
† Laboratório Nacional de Engenharia Civil (LNEC)
Av. do Brasil 101, 1700-066 Lisboa, Portugal
e-mail: sbravo@lnec.pt, web page: http://www.lnec.pt

Key words: Reinforced Concrete, Carbon Fiber Reinforced Polymer (CFRP) Strengthening Systems, Fire, Protection.

Summary: This paper presents results of experimental and numerical investigations on the fire behaviour of reinforced concrete (RC) beams strengthened with carbon fibre reinforced polymer (CFRP) laminates. Experiments included fire resistance tests on loaded CFRP-strengthened RC beams, both unprotected and protected with different fire protection systems, simultaneously submitted to the thermal exposure of ISO834. Numerical investigations comprised the development of thermochemical FE models in order to simulate the thermal response of all beams tested.

1 INTRODUCTION

While fibre reinforced polymer (FRP) materials are being increasingly used in civil engineering applications, new design issues and challenges are inevitably encountered [1]. Among these issues, there are legitimate concerns regarding the performance of FRP materials when exposed to fire, especially in building applications. In fact, it is well established that the strength, stiffness and bond properties of FRPs are severely deteriorated at moderately elevated temperatures, namely when the glass transition temperature (Tg) of the resins is approached, typically in the range of 60-120ºC. Furthermore, when exposed to temperatures of about 300-500ºC, the organic matrix of FRPs decomposes, releasing heat, smoke, soot and toxic volatiles. This paper presents experimental and numerical investigations [2] on the fire behaviour of reinforced concrete (RC) beams strengthened with CFRP laminates – the main objective was to study the viability of their use in floors of building and to assess the efficacy of different fire protection systems.

2 EXPERIMENTAL INVESTIGATIONS

Dynamic mechanical analyses and differential scanning calorimetry and thermogravimetric measurements were first performed in the CFRP material, in the epoxy adhesive and also in the fire protection materials (calcium silicate (CS) boards and vermiculite/perlite (VP) cement based
mortars, with thicknesses of 25 mm and 40 mm) in order to determine their thermo-physical and thermo-mechanical properties. Subsequently, fire resistance tests were conducted on an intermediate scale oven to investigate the behaviour of loaded RC and CFRP-strengthened RC beams in a fire situation (unprotected and protected), simulated by the ISO 834 time-temperature curve (Fig. 1). These tests allowed to investigate (i) the feasibility of applying the investigated fire protection materials to CFRP-strengthened RC beams; (ii) the thermal response of the beams when exposed to fire; (iii) the mechanical response and failure modes of the beams under a simulated fire (Fig. 2); and (iv) the fire resistance of the beams with the different fire protection systems, allowing to define the field of application of each investigated solution, according to standards’ requirements.

4 NUMERICAL INVESTIGATIONS

Two-dimensional finite element thermochemical models of all tested beams were developed, using commercial package Ansys, in order to simulate the variation of material properties and determine the evolution of the temperature fields.

5 CONCLUSIONS

The fire endurance of CFRP-strengthened RC beams can be considerably extended provided that appropriate fire protection systems are used. The thermochemical FE models developed were able to reproduce the thermal response of the beams tested with fairly good accuracy.

REFERENCES