Thermo-Mechanical Structural Modeling of GFRP Profiles Subjected to Fire

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ABSTRACT

The use of polymer composites (FRP) have been increasing in an exponential fashion since they were introduced in the market in the 1960's. Their use is directly connected to many engineering fields, with applications ranging from aerospace, naval, automation and structural engineering problems. This growth is expected to continue as this materials penetrate even deeper in established markets such as construction and rail [1]. The success of FRP composites is mainly attributed by their outstanding mechanical properties, outperforming traditional materials like steel and aluminum alloys in many aspects. Some key advantages worth mentioning are their low density, high stiffness and excellent corrosion resistance.

The major drawback of FRP composites is related to their poor fire performance. When exposed to high temperatures, their polymer organic matrix decomposes releasing heat, smoke, soot and toxic volatile. This decomposition can decrease mechanical properties significantly compromising the structural integrity of their applications in fire events [1]. Understanding the fire response of such materials is of key importance to further expand their application in many engineering problems.

The main objective of this work is to develop and implement a model which is capable of predicting the thermal and structural behaviour of GFRP (where "G" stands for glass) profiles subjected to fire. The results provided by the model will be used to create project guidelines (currently non-existent) for GFRP structural components that take into account fire safety issues.

It is agreed in the literature that the thermal part of the problem can be solved independently from the mechanical part [2]. Considering this, the work will be divided into 3 main parts. The first part will concern the thermal part of the problem. For this, the existing models, consisting in a coupling between and thermal conduction equation together with a Arrhenius decomposition equation [3], are being reproduced and expanded to 2-dimensions. After this, a new modeling strategy will be applied with the use of phase-fields to track the decomposition front in place of the Arrhenius equation.

On the second part, the temperature profiles and decomposition degree obtained from the thermal model will be used to characterize the mechanical problem. This model will also use large strain shell models, which is a significant improvement when compared to the literature (simple bar models). All the results obtained will be compared and validated with in-house experimental data.

Finally, using the results obtained in the thermal and mechanical models, the third part of the problem will focus on the creation of project guidelines for structural application of GFRP profiles that take into account fire safety issues. This guidelines will mostly be inspired in the already existing ones made for wood materials, which present a similar response to fire events.

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