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PRESTRESSED NSM-FRP LAMINATES – ASSESSING THE CREEP BEHAVIOUR OF THE BONDING AGENT

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KEYWORDS
Structural adhesives; Creep; Theoretical models; Analytical models; Standards.

ABSTRACT

This study is part of a research project that aims to develop a new strategy to apply prestressed Carbon Fibre Reinforced Polymer (CFRP) laminates according to the Near Surface Mounted (NSM) technique for the flexural strengthening of Reinforced Concrete (RC) elements. This paper includes a short description covering the following main aspects: theoretical models used to simulate the creep behaviour and experimental tests for evaluating tensile creep in the adhesives to be used with the prestressed NSM-FRP technique.

INTRODUCTION

Bibliographic research concerning prestressed NSM reinforcement shows that little work has been conducted in this scope. Most of the analysed authors (Wight et al. 2001; Nordin and Täljsten 2006; Gaafar and El-Hacha 2008) recognize that prestress presents benefits of extreme significance, namely: the closure or reduction of the width of existing cracks and retardation of the appearance of new fissures, resulting in benefits in terms of structural integrity and concrete durability.

However, in the prestress technology, two main phenomena cause time-dependent prestress losses: creep/shrinkage of the substrate and relaxation of the prestressing material. When compared to ordinary steel strands, CFRP elements exhibit lower prestress losses (Sayed-Ahmed and Shrive 1998; Lopez Anido and Naike 2000), but the adhesive substrate can contribute to significant losses. The creep of the bonding agent is, therefore, the most relevant long-term effect to be taken into account in the long term effectiveness of this strengthening technique. The creep intensity is known to depend on the applied stress level and environmental exposure conditions (temperature and humidity).

THEORETICAL MODELS

The behaviour of viscoelastic materials is usually modelled using rheological models that replicate the elastic and viscous components of the material's behaviour (Brinson and Brinson, 2008). In Figure 1, the most common rheological curves are presented. Additional information can be found elsewhere (Costa and Barros, 2011).

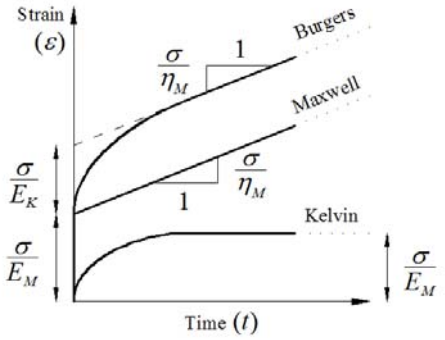

Figure 1: Strain evolution under constant stress

EXPERIMENTAL TESTS

Creep tests were performed in the selected material following, as much as possible, the existent standard (ISO 899-1:2003). The aspect of the creep apparatus can be observed in Figure 2. The results obtained were later parameterized according the most appropriate theoretical model. The experimental curve obtained clearly shows that Burgers model is the most appropriate to describe the behaviour of the material under analysis, as can be observed by comparing Figures 1 and 3. The equation that describes Burgers model is also presented in Equation (1) and the values of the parameters determined in this particular case are included in Table 1.

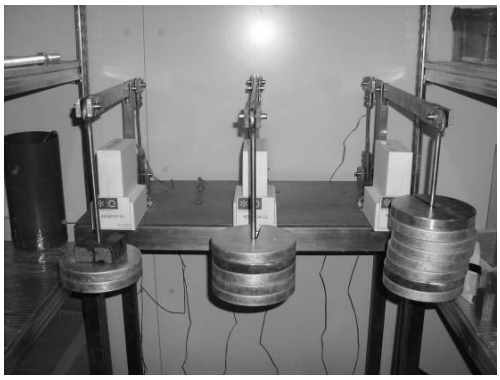

Figure 2: Creep test apparatus

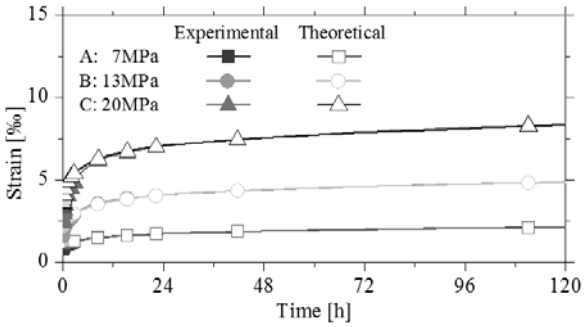

Figure 3: Average strain evolution on the specimens

$$\varepsilon(t) = \frac{\sigma}{E_M} + \frac{\sigma}{\eta_M} t + \frac{\sigma}{E_K}\left(1 - e^{-\frac{E_K}{\eta_K} t}\right) \qquad (1)$$

Table 1: Burgers equation parameters (E_M =5.91 GPa)

Specimen	σ	η_M	E_K	η_K
	[MPa]	[GPa·h]	[GPa]	[GPa·h]
A	7	2958	9.99	184
B	13	2660	6.38	73
C	20	2370	5.02	52

CONCLUSIONS

In this paper, the most noteworthy classic rheological models were presented, as well as the experimental tensile creep characterization of the structural adhesive to be used in conjunction with the prestressed NSM-FRP technique. The results obtained demonstrate that the theoretical model is adequate to describe the material's behaviour and that the parameters strongly depend strongly on the applied level stress.

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