



FIRE BEHAVIOUR OF BIOBASED TEXTILE REINFORCED CEMENT COMPOSITES

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Abstract

Our research group has recently developed a composite laminate reinforced with flax fibre nonwoven fabrics with a flexural strength of around 30 MPa and a toughness of around 13 kJ/m², owing to the combination of a strong fibre-matrix bonding and the use of entangled fibres. The mechanical performance of the cement composites developed fulfils the requirements for applications in panels for ventilated façades, but the fire behaviour was not been yet studied. Hence, this work focuses on the analysis of the performance of these composites at high temperatures. For this purpose, flax nonwoven reinforced calcium aluminate cement (CAC) composites with variable metakaolin content (from 10 to 40%) have been prepared and characterized. In order to evaluate the effect of temperature on the mechanical properties, the different samples were exposed to temperatures of 250 °C, 450 °C and 950 °C, and were further subjected to bending tests. As a main conclusion, the presence of natural fibres do not seem to worsen the fire behaviour of the CAC/metakaolin composites.

Keywords:

Fire behaviour; Flax fabrics; Cement based composites; Façade panels

1 INTRODUCTION

A ventilated façade is a construction system for the enclosure of a building. It consists of a ventilated air chamber between an external cladding and the wall of the building. The main advantage of ventilated façades is their good thermal performance. The continuous thermal insulation minimizes thermal bridges, and the air chamber allows natural ventilation. However, in case of fire the chimney effect of the air chamber will contribute to the fire propagation [Giraldo 2013]. Therefore, ventilated façades must incorporate some measures, such as fire barriers, to avoid fire spread. In this context, the use of non-combustible materials is another strategy to improve the fire performance of the façade.

Composite materials of cement matrix and natural fibre reinforcements are a good alternative for the external panels of ventilated façades, since they are lightweight and have good mechanical properties [Claramunt 2016a]. Nonetheless, durability of vegetal reinforced cements is a widely known problem [Almeida, 2013; Santos, 2015; Wei, 2015], mainly because of the alkaline environment resulting in the degradation of the cellulosic fibres. Thus, one of the strategies to avoid this is the substitution in the matrix of Portland cements by calcium aluminate cements [Claramunt 2018]. Although the mechanical performance of these cement

composites has been assessed in a previous work, the requirements for applications in panels for ventilated façades, the fire behaviour of these materials has not been studied yet. Hence, this work focuses on the analysis of the performance of these composites at high temperatures.

2 MATERIALS AND METHODS

2.1 Materials

The calcium aluminate cement (CAC) used as matrix was provided by Grupo Cementos Molins (Barcelona, Spain), and the metakaolin (MK) by Arcillas Refractarias S.A. (Gijón, Spain). Flax fibers of a length of 60 mm, from Fibers Reserche Development of the Technopole de l'Aube en Champagne (France), were used for the production of the nonwoven reinforcing fabrics under the methodology defined in previous works [Ventura, 2014]. This nonwoven presents 2 mm of thickness and 275 g/m² of areal weight.

2.2 Dosage and sample preparation

Panels of 300x300 mm² and 10 mm thickness were produced. For the matrices, pastes of CAC with MK contents between 0 and 40 wt. % were prepared with a water/cement ratio of 2. Samples were obtained by a laminate technique with 5 layers of nonwoven fabric

soaked in the cement matrix, which were subjected to two vacuum-assisted steps for water extraction and a 24-h compression step under 3.3 MPa. This process has been detailed in previous works [Claramunt 2014; Claramunt 2016b]. The samples references correspond to the MK content in the matrix: 0MK, 10MK, 20MK, 30MK and 40MK.

2.3 Testing methodology

The panels were then cut to the required dimensions. Three specimens of 150x45 mm² were exposed to high temperatures according to conditions given in Tab. 1.

Tab. 1. Definition of the heat exposure procedure.

T_{\max} (°C)	Heating time (min)	Exposure time at T_{\max} (min)	T_{\min} (°C)	Cooling time (min)
250	60	60	25	120
450	110	60	25	120
950	240	60	25	120

Then, the samples were mechanically tested in the original state and after the heat exposures, performing a 3-point bending test according to the UNE-EN 196-1:2018 standard.

3 RESULTS

The values of the average maximum strength of the samples exposed to different temperatures is presented in Tab. 2.

Results reveal that when increasing the MK content, the strength of the material is reduced. This reduction is around the 30%.

4 CONCLUSIONS

The materials presented in this work revealed good mechanical properties even after exposures of 60 min to 250 °C. Hence, composite materials with CAC matrix and reinforcement of nonwoven fabric from (flax) natural fibres present a good and sustainable alternative for application as external panels in ventilated façades.

5 ACKNOWLEDGMENTS

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Tab. 2: Bending strength values depending on the MK content and the temperature of exposure. Values in brackets are the standard deviation of the samples.

T_{\max} (°C)	Bending strength (MPa)				
	0MK	10MK	20MK	30MK	40MK
20 [ORIGINAL]	13.45 (1.76)	12.06 (0.16)	11.44 (0.95)	10.86 (0.10)	9.68 (1.41)
250	11.31 (0.25)	10.72 (1.89)	9.45 (0.93)	8.55 (6.80)	7.48 (1.44)
450	3.76 (1.35)	2.94 (0.46)	2.08 (0.57)	1.98 (0.95)	0.72 (1.42)
950	1.58 (0.61)	1.49 (0.93)	1.60 (0.54)	1.33 (0.86)	0.04 (1.41)