Fibres as reinforcement of alkali-activated materials: comparative study

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Keywords: fibres, reinforcement, alkali-activated materials, circular economy.
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In last decades it has been published many papers about new materials developed, which are more eco-friendly. The target pursued by these materials is the partial or total replace of ordinary Portland cement. The scientific community has focused on developing improvements for alkali-activated cements, which are formed from a precursor rich in aluminosilicates and an alkaline activator [1]. These materials have developed good properties, although they depend on the material used. Some of these materials presenting shrinkage problems, as well as flexural strength problems [2]. For this reason, in recent years new researches related to reinforce alkali-activated materials have appeared. Some of this studies are focused on the use of fibres, which can be synthetic or natural origin [3, 4], to overcome these shortcomings.

In this work, different fibres both artificial and natural origin are compared. Natural fibres have been previously treated to improve their compatibility with the matrix. Synthetic fibres used have been polypropylene and fiberglass; while natural fibres were sisal, cellulose and olive pruning. The last one was used untreated and with six different treatments. Fibres without any treatment were immerse in a solution for 60 minutes, then were cleaned with water. Treatments used for olive pruning fibres were: 5% wt. NaOH (mercerization), 10% wt. Na_2SiO_3, 3% wt. $CaCl_2$, 6% wt. silane, hornification (dry-wet cycles), and a combination of mercerization and ultrasounds. The amount of fibres used in the matrix of alkali-activated material was the same for all binders: 1 % wt. This percentage was established in a previous work as the optimal percentage for precursors used.

Electric arc furnace slag (EAFS) and biomass bottom ash (BBA) were used as raw materials in the synthesis of the matrix of alkali-activated materials. EAFS was supplied by Siderúrgica Sevillana (Seville, Spain), with a maximum particle size of 5 mm, while BBA was delivered by Aldebarán Energía del Guadalquivir (Andújar, Jaén, Spain), with a heterogeneous particle size. Both materials were crushed in a ball mill and then they were sieved to a grain size of less than 0.1 mm. The activator used was a solution of KOH (8M) and K_2SiO_3, mixed at 50 % wt., and it was determined in a preceding study. A l/b (liquid/binder) ratio of 0.6 was used for all compositions. Precursors and fibres were mixed in a planetary mixer for 90 seconds. After that, activator solution were poured into a mixer and blended with precursors for another 90 seconds. Fresh pastes were sloped in two types of moulds: prismatic (60x10x10 mm) and cylindrical ones (55 mm diameter); afterwards moulds were put in a shaking table to remove bubbles. Later, moulds were placed in a climatic chamber at 20 ºC and 90 % relativity humidity until test day: 1, 7, 28 and 90 days of curing.

Table 1. Codes for binders

Code	Fibre	Code	Treatment
Control	-	UT	Untreatment
PP	Polipropylene	NS	10% Silicate
GF	Glass fibre	C	3% $CaCl_2$
Sis	Sisal	M	5% NaOH (Mercerization)
Cel	Celulose	Sil	6% Silane
O-	Olive pruning	H	Hornification
		MU	Mercerization + Ultrasound

The mechanical properties of these composites materials were studied, so flexural and compressive strength were conducted according to UNE-EN 1015–11:2000/A1:2007 [5], as well as their physical properties as bulk density and water absorption following UNE-EN 1015–10 [6], and thermal properties, thermal conductivity under the standard ISO 8302 [7].

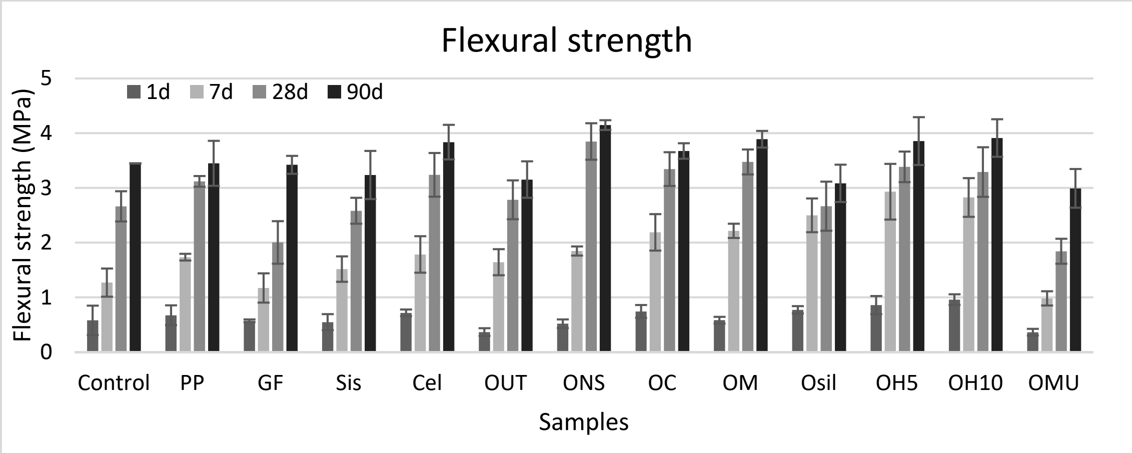

Figure 1. Flexural strength of binders at curing time.

Results show that fibres of natural origin give better flexural strength than rest of fibres. On the other hand, the compressive strength loss when fibres are added were lower using synthetic fibres. In all cases, the addition of fibres caused a deterioration in physical properties, as lower values of bulk density and an increment of porosity and water absorption. Thermal properties were also affected, with conductivity values decreasing when fibres were added. The best value of flexural strength was observed in composites using olive pruning fibres treated with 10 % wt. Na_2SiO_3. Thus, it is verified that fibres from natural sources can improve some properties of alkali-activated materials.

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Acknowledgements

This work has been funded by the project PID2020-115161RB-I00: "Applying the circular economy in the development of new low carbon footprint alkaline activated hydraulic binders for construction solutions" (CongActiva), MCIN/AEI/ 10.13039/501100011033 FEDER "A way of making Europe" and the project "Development and characterization of new geopolymeric composites based on waste from the olive industry. Towards a sustainable construction" (MAT2017-88097-R), FEDER/Ministry of Science, Innovation and Universities, State Research Agency. The authors thank Siderúrgica Sevillana company for supplying slags and Aldebarán Energía del Guadalquivir for supplying ashes. M.A. Gómez-Casero acknowledges support of MINECO (PRE2018-084073). Technical and human support provided by CICT of University of Jaén (UJA, MINECO, Junta de Andalucía, FEDER) is gratefully acknowledged.