

# The effect of natural fibres on geopolymers made using Mt. Etna volcanic ash as precursor

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## Introduction

In the last years the awareness of environmental issues has led to the development of eco-friendly materials that could combine high performance products with the possibility of the re-use of waste materials in both construction and restoration field [1].

Alkali activated materials have favourable properties such as low curing temperature, recyclability, low cost of the precursors, thermal stability and low density, making them a valid alternative to traditional OPC. Despite these excellent qualities their brittle behaviour imposes constraints in structural design. To enhance the strength of the geopolymer matrix, both organic and synthetic fibres were added to the binders to improve mechanical properties [2].

This research, funded by the PNR "Advanced Green Materials for Cultural Heritage" project aims to develop natural fibre-reinforced geopolymers for retrofitting seismic areas.

## Materials

Geopolymers were prepared using formulations taken from literature [1]. The employed precursors are volcanic ash and metakaolin while the alkaline solution used was made of sodium hydroxide and sodium silicate. Then, organic prickly pear and palm tree fibres were selected and added in two different lengths: 10 mm (short) and 40/60 mm (long). Short fibres were added to the volcanic ash-based geopolymeric matrix by using a mechanical mixer while a sandwich-like disposition was chosen for the long fibres. The samples (2x2x8 cm) were cured at room temperature for 28 days.



## Methods

Flexural and compressive strength tests were carried out in order to compare the mechanical behaviour of the samples with and without fibres. Moreover Scanning Electron Microscope (SEM) was used to evaluate the adhesion of the fibres to the geopolymeric matrix.



## Results

### Mechanical tests

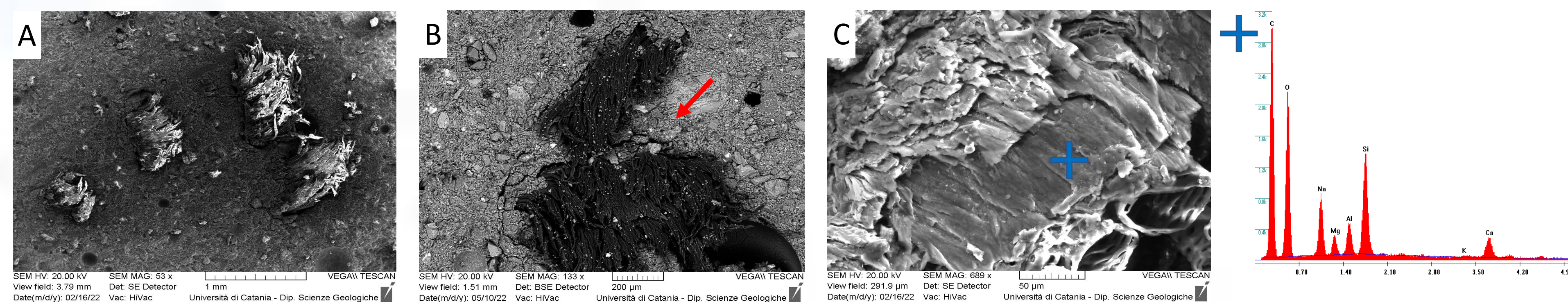
Sample	Flexural Strength [MPa]	Standard Deviation
Prickly pear (short)	5,63	0,38
Prickly pear (long)	5,06	0,60
Palm tree (short)	7,59	0,72
Palm tree (long)	12,63	3,06
Without fibres	8	----

The addition of long palm fibres to the geopolymeric matrix led to an increase in flexural strength resistance if compared with samples without fibres. Otherwise prickly pear fibres negatively affected the flexural strength of the samples.

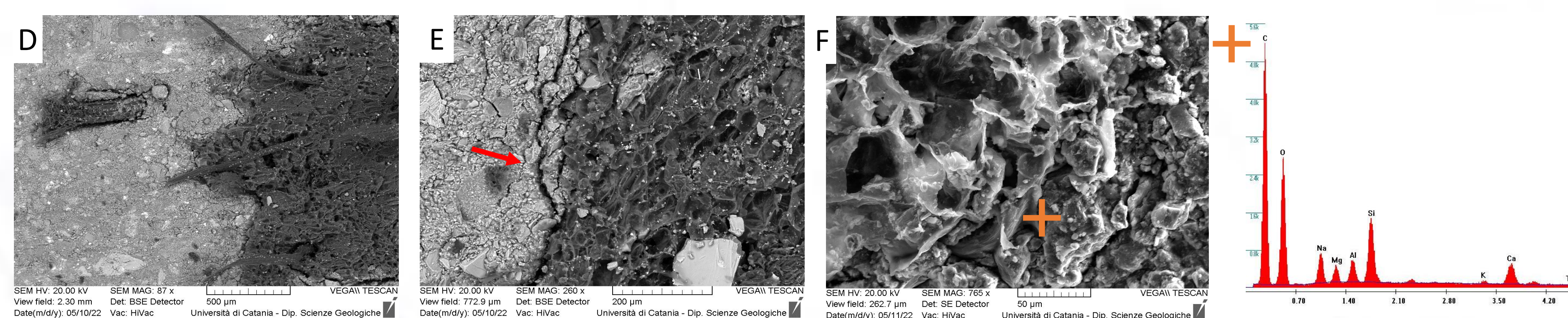
Sample	Compressive Strength [MPa]	Standard Deviation
Prickly pear (short)	22,86	5,19
Prickly pear (long)	25,44	2,68
Palm tree (short)	24,09	3,21
Palm tree (long)	23,50	5,74
Without fibres	45	----

The addition of fibres brought to a drop in compressive strength resistance of about 50% if compared to geopolymer without fibres. This drop is due to the interruption of the geopolymeric structure caused by the fibres which imply a decrease in strength.

### Scanning Electron Microscope



SEM images of samples made with prickly pear fibres (A-C). Image A shows the fibres perfectly wrapped by the matrix. Image B revealed the presence of a fracture near the transition zone between the fibre and the geopolymeric matrix. The fractures could be due to a bad adhesion of the fibres or to the cutting process during the samples preparation. Image C shows the geopolymeric matrix on the top and the fibre on the bottom of the picture.



SEM images of samples made with palm tree fibres (D-F). Image D shows a transition zone between palm tree fibres and the geopolymeric matrix. At that magnification the fibres seem to have an acceptable adhesion to the matrix. Image E, which is a magnification of image D, reports the existence of a fracture located in the geopolymeric matrix. The nature of these fractures is still under study. Image F, instead, shows a detail of the fibre and the related spectrum.

## Conclusion

Two types of organic fibres in different length were used to reinforce Mt. Etna volcanic ash-based geopolymers. Preliminary tests have shown that the addition of fibres enhances the flexural properties, reduces the brittle fracture and the shrinkage of the system. Otherwise, the results achieved by the compressive strength tests revealed a significant reduction in resistance due to the presence of the fibres. These first results are promising and further analysis are still in progress.

## References

- [1] Barone, G., Caggiani, M. C., Coccato, A., Finocchiaro, C., Fugazzotto, M., Lanzafame, G., ... & Mazzoleni, P. (2020). Geopolymer production for conservation-restoration using Sicilian raw materials: feasibility studies. IOP Conf. Ser.: Mat. Sci. & Eng. 777, 012001.  
[2] Aydın, S., & Baradan, B. (2013). The effect of fiber properties on high performance alkali-activated slag/silica fume mortars. Composites Part B: Eng. 45, 63-69.