# Geopolymer-based on biomass bottom ash with addition of different slags

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Keywords: geopolymer, bottom ash, steel slag, ferrosilicon slags, copper slags, sustainability.
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A research line of great interest worldwide can be found in the development of alternative materials to Portland cement. The manufacture of Portland cement involve high emissions of polluting gases into the atmosphere while these new materials could reduce the energy consume and landfill deposit. Nevertheless alternative material based on cement have been developed by the incorporation of chemically active additions, such as pozzolans or industrial by-product. Some industrial waste are slags and ashes (Imbabi et al., 2012). Although in recent years, researchers are focusing on alkaline activated materials, also known as geopolymers (Provis, 2018). These materials are based on a precursor material (natural minerals, waste or industrial by-product) and an alkaline activator (Torres-Carrasco et al., 2015). As activator several options have been used, but the more used are NaOH, KOH, $Na_2SiO_3$ and $K_2SiO_3$ (Provis, 2018).

The production of geopolymers reduces environmental impact, reducing $CO_2$ emissions by 85% (Nasvi et al., 2013). Due to these advantages, they help to combat climate change, becoming a future option in materials engineering. As precursors, multiple materials have been used, highlighting slag and fly ash as the most used. However, the use of bottom ash has not been studied as thoroughly (Santa et al., 2017).

This study compares the effect of adding different steel slags to geopolymers based on biomass bottom ash (BBA). Black steel slag (BSS), ferrosilicon slag (FSS) and cupper slag (CS) were used. For this, geopolymers were manufactured with 50% wt of each material. A control geopolymer using only bottom ash was used. As activating material a mixture of KOH and $K_2SiO_3$ was used with different molar ratio of $SiO_2$ to $K_2O$ (Ms). Ms modules used were those obtained from mixing different proportions 35-65, 50-50, 65-35, 75-25 (% wt $K_2SiO_3$ - % wt KOH). Raw materials were mixed in a planetary kneader and then the activator solution was inserted. Specimens of 10x10x60 mm were synthesized. The pastes were cured 24 hours in a climatic room at 20 °C at 90% of relative humidity, subsequently demoulded and cured at same condition during 1, 7 and 28 days.

Their physical properties, such as bulk density, apparent porosity and water absorption, mechanical properties, such as compressive strength, and thermal properties such ash thermal conductivity have been determined.

The results show that adding slag to geopolymer-based on bottom ash improved their properties. Each geopolymer found a different optimal Ms modulus. Although the most repeated was the Ms module 65 % wt $K_2SiO_3$ and 35 % wt KOH (Ms = 1.38). In fact the best geopolymer was using this Ms module with CS as precursor material. . Great mechanical strength and physical properties were obtained for pastes with slags as addition in geopolymer-based on biomass bottom ash.

**Acknowledgements**

This work has been funded by 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, Atlantic Copper company, Ferroatlántica (XEAL) company for supplying slags and Aldebarán Energía del Guadalquivir S.A. for supplying the biomass ash. M.A. Gómez-Casero acknowledges support of MINECO (PRE2018-084073). Technical and human support provided by CICT of Universidad de Jaén (UJA, MINECO, Junta de Andalucía, FEDER) is gratefully acknowledged.

**List of references**

Imbabi MS, Carrigan C, McKenna S. Trends and developments in green cement and concrete technology, International Journal of Sustainable Built Environment 1 (2012) 194-216.

Nasvi NC, Ranjith PG, Sanjayan J. The permeability of geopolymer at down-hole stress condition: Aplication for carbon dioxide sequestration wells. Appl. Energ. 102 (2013) 1391-1398.

Provis, J. L. (2018). Alkali-activated materials. Cement and Concrete Research, 114, 40-48.Santa, R. A. A. B., Soares, C., & Riella, H. G. (2017). Geopolymers obtained from bottom ash as source of aluminosilicate cured at room temperature. Construction and Building Materials, 157, 459-466

Torres-Carrasco, M., & Puertas, F. (2015). Waste glass in the geopolymer preparation. Mechanical and microstructural characterisation. Journal of cleaner production, 90, 397-408