materials proceedings

MDPI

Abstract

Effect of Durability on the Mechanical Properties of Geopolymers Made from By-Products from the Construction Industry †

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† Presented at the Materiais 2022, Marinha Grande, Portugal, 10–13 April 2022.

Keywords: durability; geopolymers; construction and demolition waste; chamotte; circular economy

The main objective of this research is to study the durability of a series of geopolymers obtained from the mixture of two industrial by-products used as a source of aluminosilicates: construction and demolition waste (CDW) and chamotte (CH). In previous studies, the optimal conditions of several variables such as the composition of geopolymeric mixtures, the type and concentration of the activating solution, and the curing conditions (time and temperature) were investigated. The chemical composition of both precursors determined by XRF indicates that they have high proportions of silica (higher than 50%), while the amount of alumina is lower: 20.1% in the CH precursor and 5.8% in the CDW residue. Five different mixtures of alkaline-activated binders were formed. The effect of incorporating increasing amounts of CH by-products (10–40 wt%) into CDW by-products has been studied. All of the mixtures were prepared under the same conditions: the alkaline activator was a mixture of 8 M NaOH (98% purity) with 50% Na_2SiO_3 (29.2% SiO_2, 8.9% Na_2O and 61.9% H_2O), a liquid solid ratio 0.45, and a particle size 100 µm. The mixtures were cured at room temperature. The results of this study yielded alkaline-activated materials with compressive strengths that increased when the CDW precursor was replaced by the CH precursor. These materials achieved a compressive strength of 15.2 MPa after 28 days of curing, which increased to 23.9 MPa when 40% CH was added to replace CDW. After 28 days of curing, these materials were subjected to durability tests in three different testing conditions: HCl 2%, NaCl 3.5%, and Na_2SO_4 4.4%.

For the durability study, the dry specimens were first weighed and then immersed in the solutions indicated above. The saturated specimens were weighed 24 hours after immersion and then every 7 days until they had been exposed to these media for 28 days. After each weighing period, with the exception of the first one (24 h), the solution was replaced with a new one, and the samples were immersed again until the next control period. On the 28th day of immersion, they were left to dry in ambient conditions, after which mechanical tests were carried out. The increase in the results is in accordance with a previous study. The compressive strength increased from 20.2 MPa with 100% CDW to 30 MPa with 40% CDW in 2% HCl, from 17.4 MPa to 25 MPa in 3.5% NaCl, and from 18 MPa to 26.5 MPa in 4.4% Na_2SO_4. Furthermore, the most favourable medium with the highest compressive strength was determined to be 2% HCl.

These results confirm that the manufacture of alkaline-activated materials using industrial construction by-products and demolition waste and chamotte as raw materials are very good alternatives to the use of traditional Portland cement (PC) in the construction sector,

Citation: García-Díaz, A.; Delgado-Plana, P.; Bueno-Rodríguez, J.S.; Pérez-Villarejo, L.; Eliche-Quesada, D. Effect of Durability on the Mechanical Properties of Geopolymers Made from By-Products from the Construction Industry. *Mater. Proc.* **2022**, *8*, 32. https://doi.org/10.3390/materproc2022008032

Academic Editors: Geoffrey Mitchell, Nuno Alves, Carla Moura and Joana Coutinho

Published: 23 May 2022

as, in addition to offering similar physical and mechanical properties, they present excellent resistance when in contact with different aggressive media. In this way, a new type of material that is less environmentally aggressive, as it requires less energy consumption than PC, is being introduced to the construction sector and will reduce greenhouse gas emissions into the atmosphere and avoid the extraction of new natural raw materials. In the same way, this also provides a new use for waste, resulting in a circular economy.

Author Contributions: Conceptualization, A.G.-D. and D.E.-Q.; methodology, A.G.-D. and P.D.-P.; validation, A.G.-D. and D.E.-Q.; formal analysis, A.G.-D.; investigation, A.G.-D.; resources, D.E.-Q.; data curation, A.G.-D.; writing—original draft preparation, A.G.-D.; writing—review and editing, A.G.-D., P.D.-P., J.S.B.-R., L.P.-V. and D.E.-Q.: visualization, A.G.-D. and P.D.-P.; supervision, D.E.-Q., L.P.-V. and J.S.B.-R.; project administration, D.E.-Q.; funding acquisition, D.E.-Q. All authors have read and agreed to the published version of the manuscript.

Funding: This work has been funded by the project GEOCIRCULA: Economía circular en la fabricación de nuevos composites geopoliméricos: hacia el objetivo de cero residuos (P1 8-RT-3504) Consejería de Economía, Conocimiento, Empresas y Universidad. Secretaría General de Universidades, Investigación y Tecnología/FEDER "Una manera de hacer Europa".

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Acknowledgments: The technical and human support provided by CICT of Universidad de Jaén (UJA, MINECO, Junta de Andalucía, FEDER) is gratefully acknowledged.

Conflicts of Interest: The authors declare no conflict of interest.