engineering proceedings

Abstract

Development of Geopolymer Binders with Mixed Construction and Demolition Waste-Based Materials †

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† Presented at the 1st International Online Conference on Infrastructures, 7–9 June 2022; Available online: https://ioci2022.sciforum.net/.

Abstract: As a consequence of the ever-increasing urban population and continuous development of industrialization and economies of the countries around the world, the construction and demolition industry has gained eye-catching popularity, although it is also considered one of the largest producers of solid wastes globally. In an effort to counteract the negative effects of the growing construction and demolition waste (CDW) issue, the current study focuses on the utilization of mixed CDW-based materials such as hollow brick (HB), red clay brick (RCB), roof tile (RT), glass (G) and concrete (C) in the production of geopolymer binders. These materials were acquired from demolished residential buildings in an urban transformation area and then subjected to an identical two-step crushing–milling procedure to reach sufficient fineness for geopolymerization. In the first stage of the study, these materials were used singly in the production of geopolymer binders to analyse the effects of material characteristics (e.g., fineness, chemical composition and crystalline nature) on the geopolymerization performance. Thereafter, these materials were used altogether in a quinary mixture to produce geopolymer binders with the purpose of better simulating the real-life conditions where CDWs are obtained altogether and are time-/energy-consuming to separate. In order to characterize the performance of different CDW-based materials, several mixture designs were made using sodium hydroxide (NaOH) as the alkali activator. After applying thermal curing to the geopolymer pastes, compressive strength tests were performed in addition to microstructural analyses. The results showed that compressive strength values of up to 55 MPa could successfully be achieved depending on the mixture proportions. While RT was found to be the most effective material in terms of the mechanical performance of CDW-based geopolymer binders, G and C exhibited poor performances due to relatively coarse particle size distribution and an inadequate chemical composition of SiO_2 and Al_2O_3, which is a necessity for effective geopolymerization. In-depth microstructural analyses identified that geopolymer pastes with higher compressive strengths had denser and more homogeneous microstructures. The main reaction products of the geopolymer binders were mostly sodium aluminosilicate hydrate (N-A-S-H) gels with zeolite-like structures, as well as some calcium aluminosilicate hydrate (C-A-S-H) gels that arose from the use of C with a high CaO content. Our results prove that CDW-based materials can successfully be used in the production of geopolymers, and can be regarded as promising alternatives to traditional systems based on Portland cement.

Keywords: construction and demolition waste (CDW); geopolymer; compressive strength; microstructure

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Citation: Yildirim, G.; Ashour, A.; Ozcelikci, E.; Gunal, M.F.; Ozel, B.F. Development of Geopolymer Binders with Mixed Construction and Demolition Waste-Based Materials. *Eng. Proc.* **2022**, *17*, 4. https://doi.org/10.3390/engproc2022017004

Academic Editor: Frank Dehn

Published: 2 May 2022

Author Contributions: Conceptualization, G.Y. and A.A.; methodology, G.Y. and A.A.; software, G.Y.; validation, G.Y. and A.A.; formal analysis, G.Y. and A.A.; investigation, G.Y., E.O., M.F.G. and B.F.O.; resources, G.Y. and A.A.; data curation, G.Y., E.O., M.F.G. and B.F.O.; writing—original draft preparation, G.Y., E.O., M.F.G. and B.F.O.; writing—review and editing, G.Y. and A.A.; visualization, E.O.; supervision, A.A.; project administration, G.Y. and A.A.; funding acquisition, G.Y. and A.A. All authors have read and agreed to the published version of the manuscript.

Funding: This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No [894100].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ongoing research and will be made available upon full publishment of the results.

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