Michał Łach, Agnieszka Przybek, Kinga Setlak, Patrycja Bazan, Maria Hebdowska-Krupa
Structure and Environment 2024, vol. 16, (3), pp. 134-140, Article number: el 012
https://doi.org/10.30540/sae-2024-012

Structure and Environment
ISSN 2081-1500
e-ISSN 2657-6902
https://content.sciendo.com/sae
https://sae.tu.kielce.pl

sciendo

Kielce University of Technology

DOI: 10.30540/sae-2024-012

RESISTANCE OF LOW-EMISSION GEOPOLYMER BINDERS WITH FIBERS TO AGGRESSIVE EXTERNAL FACTORS

ODPORNOŚĆ NISKOEMISYJNYCH SPOIW GEOPOLIMEROWYCH Z WŁÓKNAMI NA DZIAŁANIE AGRESYWNYCH CZYNNIKÓW ZEWNĘTRZNYCH

Michał Łach*, Agnieszka Przybek, Kinga Setlak, Patrycja Bazan, Maria Hebdowska-Krupa
Cracow University of Technology, Poland

Abstract

Materials called geopolymers are considered an alternative to common hydraulic binders, but they have certain limitations in many applications due to their brittleness. The use of fibers to reinforce geopolymers can bring the expected results by increasing their compressive strength. This paper presents the results of accelerated durability tests of geopolymers based on coal shale and fly ash reinforced with natural fibers (1% by mass). The results of testing the resistance of such composites to UV radiation, variable temperature cycles and the results of the thermal conductivity coefficient are presented.

Keywords: geopolymer, natural fiber, composite, aging test; thermal resistance, UV resistance

Streszczenie

Materiały zwane geopolimerami uznawane są za alternatywę dla powszechnych spoiw hydraulicznych jednak posiadają one pewne ograniczenia w wielu zastosowaniach ze względu na ich kruchość. Zastosowanie włókien do zbrojenia geopolimerów może przynieść oczekiwane rezultaty zwiększając ich wytrzymałość na zginanie. W niniejszej pracy zaprezentowano wyniki przyspieszonych badań trwałości geopolimerów na bazie łupków węglowych i popiołu lotnego wzmocnionych włóknami naturalnymi (1% mas.). Przedstawiono wyniki badań odporności takich kompozytów na działanie promieniowania UV, zmiennych cykli temperaturowych oraz przedstawiono wyniki badań współczynnika przewodzenia ciepła.

Słowa kluczowe: geopolimery, włókna naturalne, kompozyty, badania starzeniowe, odporność termiczna, odporność UV

REFERENCES

[1] Davidovits J.: *30 Years of Successes and Failures in Geopolymer Applications*. Market Trends and Potential Breakthroughs. In Proceedings of the Geopolymer 2002 Conference, Melbourne, 2002, pp. 1-16.
[2] Provis J.L., van Deventer J.S.J.: *Geopolymers: Structure, Processing, Properties, and Industrial Applications*. A volume in Woodhead Publishing Series in Civil and Structural Engineering, Woodhead Publishing: Cambridge, 2009.
[3] Sharma U., Gupta N., Bahrami A., Özkılıç Y.O., Verma M., Berwal P., Althaqafi E., Khan M.A., Islam S.: *Behavior of Fibers in Geopolymer Concrete: A Comprehensive Review*, Buildings 14 (1) (2024), pp. 1-28. DOI: https://doi.org/10.3390/buildings14010136.

*Cracow University of Technology, Poland, e-mail: michal.lach@pk.edu.pl

[4] Bazan P., Kozub B., Łach M., Korniejenko K.: *Evaluation of Hybrid Melamine and Steel Fiber Reinforced Geopolymers Composites*, Materials 13 (23) (2020), pp. 1-15. DOI: https://doi.org/10.3390/ma13235548.
[5] Łach M., Kluska B., Janus D., Kabat D., Pławecka K., Korniejenko K., Guigou M.D., Choińska M.: *Effect of Fiber Reinforcement on the Compression and Flexural Strength of Fiber-Reinforced Geopolymers*, Applied Sciences, 11 (21) (2021), 1–21. DOI: https://doi.org/10.3390/app112110443.
[6] de Azevedo A.R.G., Cruz A.S.A., Marvila M.T., de Oliveira L.B., Monteiro S.N., Vieira C.M.F., Fediuk R., Timokhin R., Vatin N., Daironas M.: *Natural Fibers as an Alternative to Synthetic Fibers in Reinforcement of Geopolymer Matrices: A Comparative Review*, Polymers 13 (15) (2021), 1-21. DOI: https://doi.org/10.3390/polym13152493.
[7] Viskovic A., Łach M., Hojdys Ł., Krajewski P., Kwiecień A.: *Experimental research on new sustainable geopolymer concretes reinforced and not reinforced with natural fibers*. Building for the Future: Durable, Sustainable, Resilient: proceedings of the fib Symposium 2023, Springer Nature, 2023, pp. 329-338. DOI:10.1007/978-3-031-32519-9_31.
[8] Viskovic A., Łach M., Hojdys Ł., Krajewski P., Kwiecień A.: *Experimental research on new sustainable geopolymer concretes reinforced and not reinforced with natural fibers*. Proceedings of the International Conference of Steel and Composite for Engineering Structures : ICSCES 2022, Springer, 2023, pp. 149-160. DOI:10.1007/978-3-031-24041-6_12.
[9] Korniejenko K., Łach M., Dogan-Saglamtimur N., Furtos G., Mikuła J.: *The overview of mechanical properties of short natural fiber reinforced geopolymer composites*, Environmental Research and Technology, 3 (1) (2020), pp. 28-39. DOI:10.35208/ert.671713.
[10] Korniejenko K., Łach M., Hebdowska-Krupa M., Mikuła J.: *Impact of flax fiber reinforcement on mechanical properties of solid and foamed geopolymer concrete*, Advances in Technology Innovation, 6 (1) (2021), pp. 11-20. DOI:10.46604/aiti.2021.5294.
[11] Gholampour A., Danish A., Ozbakkaloglu T., Yeon J.H., Gencel O.: *Mechanical and durability properties of natural fiber-reinforced geopolymers containing lead smelter slag and waste glass sand*, Construction and Building Materials, 352 (2022), 1-20. DOI: https://doi.org/10.1016/j.conbuildmat.2022.129043.
[12] Bariş K.E., Tanaçan L.: *Durability behavior of banana fiber-reinforced natural pozzolan geopolymer*, Journal of Green Building, 18 (4) (2023), 49-168. DOI: https://doi.org/10.3992/jgb.18.4.149.
[13] Asim M., Uddin G.M., Jamshaid H., Raza A., Tahir Z.R., Hussain U., Satti A.N., Hayat N., Arafat S.M.: *Comparative experimental investigation of natural fibers reinforced light weight concrete as thermally efficient building materials*, Journal of Building Engineering, 31 (2020), pp. 1-11. DOI: https://doi.org/10.1016/j.jobe.2020.101411.
[14] Daza-Badilla L., Gómez R., Díaz-Noriega R., Avudaiappan S., Skrzypkowski K., Saavedra-Flores E.I., Korzeniowski W.: *Thermal Conductivity in Concrete Samples with Natural and Synthetic Fibers*, Materials, 17 (4) (2024), pp. 1-21. DOI: https://doi.org/10.3390/ma17040817.
[15] Łach M., Mierzwiński D., Korniejenko K., Mikuła J.: *Geopolymer foam as a passive fire protection. MATEC Web of Conferences*, Fire and Environmental Safety Engineering, 2018, pp. 1-6. DOI: 10.1051/matecconf/201824700031.
[16] Mohamed O., Zuaiter H.: *Fresh Properties, Strength, and Durability of Fiber-Reinforced Geopolymer and Conventional Concrete: A Review*, Polymers 16 (1) (2024), 1-50. DOI: https://doi.org/10.3390/polym16010141.
[17] Lv C., Liu J., Guo G., Zhang Y.: *The Mechanical Properties of Plant Fiber-Reinforced Geopolymers: A Review*, Polymers 14 (19) (2022), pp. 1-22. DOI: https://doi.org/10.3390/polym14194134.
[18] Addis L.B., Sendekie Z.B., Satheesh N.: *Degradation Kinetics and Durability Enhancement Strategies of Cellulosic Fiber-Reinforced Geopolymers and Cement Composites*, Advances in Materials Science and Engineering, (2022), pp. 1-22. DOI: https://doi.org/10.1155/2022/1981755.
[19] Omoniyi T.E., Akinyemi B.A.: *Durability based suitability of bagasse cement composite for roofing sheets*, Journal of Civil Engineering and Construction Technology, 3 (11) (2012), pp. 280-290. DOI: 10.5897/JCECT12.041.
[20] Ramakrishna G., Sundararajan T., Kothandaraman S.: *Evaluation of durability of natural fibre reinforced cement mortar composite-a new approach*, ARPN Journal of Engineering and Applied Sciences, 5 (6) (2010), pp. 44-51.
[21] Javadi A., Srithep Y., Pilla S., Lee J., Gong S., Turng L.S.: *Processing and characterization of solid and microcellular PHBV/coir fiber composites*, Materials Science and Engineering: C, 30 (5) (2010), pp. 749-757. DOI: https://doi.org/10.1016/j.msec.2010.03.008.
[22] Bilba K., Arsene M.A.: *Silane treatment of bagasse fiber for reinforcement of cementitious composites*, Composites Part A: Applied Science and Manufacturing, 39 (9) (2008), pp. 1488-1495. DOI:https://doi.org/10.1016/j.compositesa.2008.05.013.
[23] Claramunt J., Ardanuy M., García-Hortal J.A., Filho R.D.T.: *The hornification of vegetable fibers to improve the durability of cement mortar composites*, Cement and Concrete Composites, 33 (5) (2011), pp. 586-595. DOI: https://doi.org/10.1016/j.cemconcomp.2011.03.003.
[24] Pehanich J.L., Blankenhorn P.R., Silsbee M.R.: *Wood fiber surface treatment level effects on selected mechanical properties of wood fiber–cement composites*, Cement and Concrete Research, 34 (1) (2004), pp. 59-65. DOI: https://doi.org/10.1016/S0008-8846(03)00193-5.

[25] de Lima T.E.S., de Azevedo A.R.G., Marvila M.T., Candido V.S., Fediuk R., Monteiro S.N.: *Potential of Using Amazon Natural Fibers to Reinforce Cementitious Composites: A Review*, Polymers 14 (3) (2022), pp. 1-20. DOI: https://doi.org/10.3390/polym14030647.
[26] Lv C., Liu J.: *Alkaline Degradation of Plant Fiber Reinforcements in Geopolymer: A Review*, Molecules 28 (4) (2023), pp. 1-22. DOI: https://doi.org/10.3390/molecules28041868.
[27] Abbas A-G.N., Aziz F.N.A.A., Abdan K., Nasir N.A.M., Huseien G.F.: *Experimental study on durability properties of kenaf fibre-reinforced geopolymer concrete*, Construction and Building Materials, 396 (2023), pp. 1-23. DOI: https://doi.org/10.1016/j.conbuildmat.2023.132160.
[28] Qin L., Yan J., Zhou M. et al.: *Mechanical properties and durability of fiber reinforced geopolymer composites: A review on recent progress*, Engineering Reports, 5 (12) (2023), pp. 1-22. DOI: 10.1002/eng2.12708.
[29] Liu J., Lv C.: *Durability of Cellulosic-Fiber-Reinforced Geopolymers: A Review*, Molecules, 27 (3) (2022), pp. 1-23. DOI: https://doi.org/10.3390/molecules27030796.
[30] ASTM G-155 – Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials https://www.astm.org/g0155-21.html (Accessed 15 June 2024).
[31] PN-EN 12390-5:2019-08 – Testing of concrete – Part 5: Flexural strength of test specimens https://sklep.pkn.pl/pn-en-12390-5-2019-08p.html (Accessed 15 June 2024).
[32] Lilargem Rocha D., Tambara Júnior L.U.D., Marvila M.T., Pereira E.C., Souza D., de Azevedo A.R.G. A.: *Review of the Use of Natural Fibers in Cement Composites: Concepts*, Applications and Brazilian History, Polymers, 14 (10) (2022), pp. 1-22. DOI: https://doi.org/10.3390/polym14102043.