GEOPOLYMER SUSTAINABLE MATERIAL

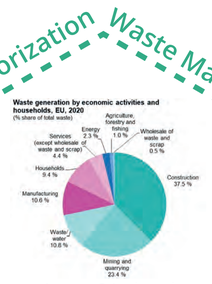
Materials for Circular Economy-Industrial Waste Based Geopolymers Composites with Hybrid Reinforcement

The main objective of GEOSUMAT is to design and characterise new fibre-reinforced eco-friendly geopolymers(GPs) composites based on industrial and mining wastes.

The principal drivers for the GEOSUMAT concept are:

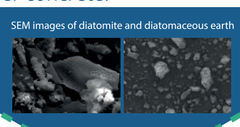
- Re-use of local waste resources to support local businesses and contribute to circular economy principles
- Achieve CO_2 production reductions through the replacement of concrete in construction applications and its capture during casting and curing stages
- Encourage preservation of natural resources.

Waste Valorization — Waste Materials



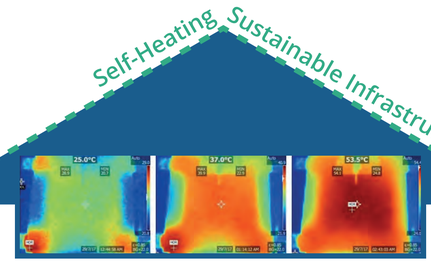
The investigation examines 21 local waste streams from Norway, Poland, the Czech Republic, Romania, and Iceland for use in geopolymerization. The physical and chemical properties of these wastes suggest their suitability as precursors, activators, and aggregates for geopolymers. Most of these materials are currently landfilled, making them ideal candidates for sustainable building materials. Using industrial waste in geopolymers can reduce environmental issues like carbon footprint, landfilling, and the need for virgin materials. Extraction concludes that these waste materials, with minimal processing or activation, can significantly contribute to developing eco-friendly and sustainable geopolymer concrete.

SEM images of diatomite and diatomaceous earth



All partners

Self-Heating — Sustainable Infrastructure



Czech Technical University (CTU) researchers developed self-heating geopolymer composites for de-icing applications, enhancing safety and sustainability. At the GEOSUMAT progress meeting in Prague, partners shared advancements in durability, reinforcement, and circular economy solutions, reinforcing their commitment to low-carbon construction. At ICNAAM Conference 2024, Petr Hotěk from CTU presented the GEOSUMAT project's findings. His paper, "Self-heating Experiment of Multifunctional Geopolymer Board Based on Metashale with Graphite Powder Admixture," co-authored with Lukáš Fiala, introduced multifunctional geopolymers for potential floor heating applications.

Conducted electrical conductivity tests, demonstrating self-heating capabilities of the developed materials.

CTU

Shear Reinforcement — MiniBars — Basalt Fibers

A series of full-scale tests were conducted to evaluate the performance of ReforceTech MiniBars™, composite basalt fibers, as shear reinforcement in concrete beams. The tests included 15 beams with varying MiniBars content (0, 10, and 20 kg/m^3) and dimensions, tested for compressive and flexural strength, as well as shear capacity under four-point bending. Results showed a significant 70% increase in shear capacity for regular beams with 10 kg/m^3 MiniBars and 17% for shallow beams. MiniBars also delayed crack initiation, altered crack patterns, and improved energy absorption. Theoretical calculations confirmed that MiniBars can replace traditional steel shear stirrups, meeting design safety requirements effectively.

ReforceTech

Satisfactory adhesion between the geopolymer matrix and basalt MiniBars verified by modified pull-out test.

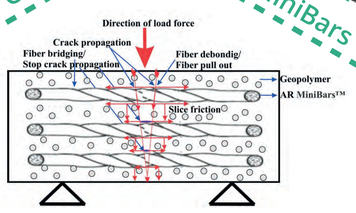
The research work in GEOSUMAT was so far disseminated through 15 scientific publications, 10 conference papers, and other activities such as workshops, summer school, webinar, etc. The research topic was promoted through the inclusion of 13 master's and PhD students and early-stage researchers on the experimental research work. GEOSUMAT project has website where are regularly posted news about our activities,events and achievements.

Marine Exposure — Geopolymer Concrete

The team from The Arctic University of Norway (UiT) has successfully completed production of geopolymer paste using wood waste ash, ELKEM MICROSILICA® 971 and Swecem slag. In close proximity to Narvik, there are 4 wood-burning facilities, and the wood waste ash is landfilled without further use. Initial testing yielded promising results with compressive strengths of up to 66.61 MPa after 24 hours of curing at room temperature. This achievement marks a significant step forward, and a team of UiT researchers and exchange master and bachelor students from Belgium and France is now preparing a series of geopolymer concrete with basalt Minibars reinforcement that will be tested in the laboratory and long-term monitoring station with marine exposure located in Narvik Harbour.

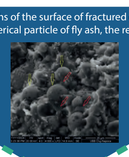
UiT

Geopolymer Composites — AR Glass MiniBars



Researchers at Babeş-Bolyai University (BBU) found that geopolymer concrete reinforced with AR Glass MiniBars™ offers a sustainable alternative to Portland traditional fiber reinforced concrete. Adding AR Glass MiniBars™ to fly ash based geopolymer paste significantly improved mechanical properties, with flexural strength increasing 18.80–30.71 times, tensile strength 3.49–8.27 times, and compressive strength 2.75–3.61 times. Scaning electron microscopy (SEM) and optical microscopy confirmed good micromechanical adhesion, highlighting fiber reinforced geopolymer composite as a promising eco-friendly construction material.

SEM micrographs of the surface of fractured geopolymer
(yellow is a spherical particle of fly ash, the red arrow is geopolymer).

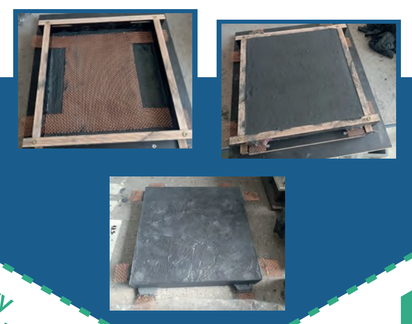


BBU

Project GEOSINK was developed as one of the tasks of GEOSUMAT and proposed to the European Innovation Council funding programme under Horizon Europe - Pathfinder 2024 "Towards cement and concrete as a carbon sink". GEOSINK: TECHNICAL, DIGITAL, AND SOCIAL SYMBIOSIS FOR NOVEL MATERIALS AS CARBON SINK aims to develop new materials based on industrial and concrete waste for applications such as rainscreen cladding, wall tiles, and other non-structural 2D elements with high surface area for carbon capture, utilization, and storage.

Geopolymer Applications — Industrial Trial

CHEMSTR - ŠAFAŘÍK conducted the first industrial trial by fabricating and testing geopolymer floor tiles. This trial represents a significant step in the development of sustainable building materials, showcasing the potential of geopolymers in practical applications.

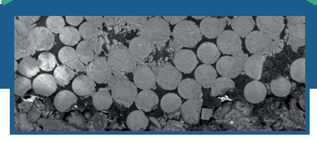


CHEMSTR

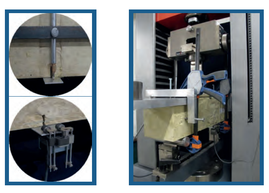
Developed geopolymer mixes contained up to 94% of waste material including recycled concrete aggregates,recycled geopolymer aggregates and sea water achieved early-age strength as high as 60.9 MPa in 24 hours.

Conducted the first industrial trial by fabricating and testing geopolymer floor tiles.

Porosity Reduction — Durability



Researchers at Cracow University of Technology (CTU) found that GGBFS reduces porosity in alkali-activated concretes, allowing room-temperature setting. A quasi-linear relationship between GGBFS content and mechanical properties confirms its potential for utilisation in durable and sustainable construction.



CUT

Investigated fiber interaction with geopolymer mortar.

Achieved compressive strength of 30 MPa in geopolymers based on calcium fly ash, sand, and calcined and non-calcined activated diatomite, provided by GORTECH.

Icelandic Innovation Award — CO_2 Activity

GEOSUMAT won the Icelandic Innovation Award in January 2024. Heiðar Snær Ásgeirsson and Gonzalo Patricio Eldredge Arenas received the award from President Guðni Th. Jóhannesson for their work on AlSiment, an eco-friendly, cement-free binder. The research focuses on reducing carbon emissions in construction while using conventional aggregates. The project was supervised by Sunna Ólafsdóttir Wallevik, Dr. Kristján Friðrik Alexandersson, Dr. Jan Prikryl (Gerosion), and Dr. Sigrúna Nanna Karlsdóttir (University of Iceland).

GEROSION

Carried out CO_2 enrichment at the input material level to enhance carbon reduction.

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Duration

06/2022 – 05/2025

Budget

Total budget: 1.6 mil. €

Partners

UiT The Arctic University of Norway · Universitatea Babeș-Bolyai · Cracow University of Technology · Czech Technical University in Prague · CHEMSTR · DIATO sorbent diatomitowy · ReforceTech Creating Greener Opportunities · gerosion

Funding Agencies

M-ERA.NET

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