Andra Call for Projects
with the support of the
Investments for the Future Programme

INIFUGE

Development of an innovative fire-resistant geopolymer binder

Project supported by Andra under the "Investments for the Future Programme" ("Investissement d'Avenir") - Selected under the Andra Call for Projects: "Optimisation of post-dismantling radioactive waste management", organised in cooperation with the French National Research Agency (ANR).

Duration: 48 months

Project launch: 10/2017

Total project cost: €4.03 million

Sum covered under the Investments for the Future Programme: €598,000

Type of financial support: Subsidy

Locations:
Limoges,
Clermont Ferrand,
Toulouse

Coordinating body: Institut de Recherche sur les Céramiques (IRCER), University of Limoges

Partners:
- IRCER, University of Limoges
- PEREINE laboratory, University of Limoges
- Institute of Chemistry of Clermont-Ferrand (ICCF)
- Laboratory of Materials and Durability of Constructions (LMDC), Paul Sabatier University, Toulouse

Contact: Sylvie ROSSIGNOL, sylvie.rossignol@unilim.fr

BACKGROUND

As part of design studies on the Industrial Centre for Geological Disposal (Cigeo), research is being conducted to find new durable materials with fire-resistant properties. These materials could be used to build disposal drifts and specific disposal containers for protecting radioactive waste sensitive to high temperatures, particularly in the event of a fire.

Geopolymer materials are formed when an aluminosilicate source is activated by a low-temperature alkaline solution and have been generating considerable interest over the last several years, as their manufacture produces less pollution than traditional cement materials, and they have excellent mechanical, chemical and thermal properties. They are just as easy to use as cement materials. One of their specific features is their temperature resistance of up to 1000°C, and the development of their mechanical properties within 24 hours. They therefore seem to be promising candidates for use in the disposal of radioactive waste.

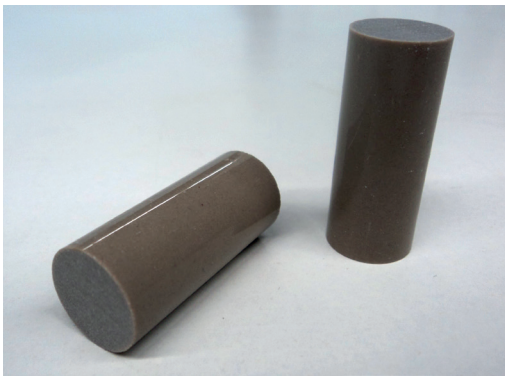
The INIFUGE project focuses on developing an innovative fire-resistant geopolymer binder and identifying and understanding the properties of this material.

OBJECTIVES

INIFUGE is a research project that presents a fundamental approach to understanding the end properties (fire resistance, durability) of geopolymer materials depending on the properties of the raw materials used (aluminosilicate sources and activation solutions), and the protocols for using these materials.

The project has three main objectives:

- develop methods for making raw materials highly reactive for geopolymer manufacture (aluminosilicates and activation solutions);
- develop different compositions for meeting mechanical or thermal requirements depending on the desired characteristics of the fresh and hardened geopolymer;
- understand and optimise performance in terms of rheological properties (viscosity), fire resistance and durability.



▶ Photo of consolidated geopolymer materials.

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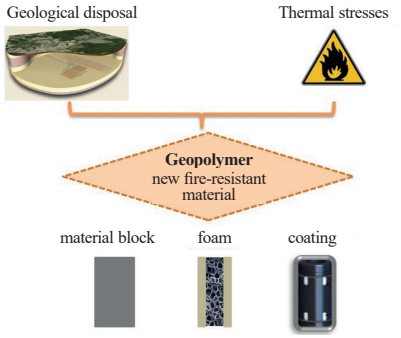
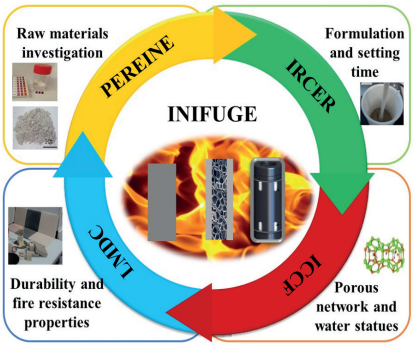


▶ Goal of the INIFUGE project: develop various forms of geopolymer materials for Cigeo packages and structures.



▶ INIFUGE project organisation

- PEREINE: initial reactants: alkaline solution and aluminosilicate source
- IRCER: geopolymer binder reactant mixture
- ICCF: porous structure of the geopolymer
- LMDC: geopolymer durability

PROJECT SEQUENCE

INIFUGE is a four-year research project broken down into four interdependent tasks that cover the full life cycle of binders (from the raw material to the hardened fire-resistant material). The means implemented include the study of raw materials and the formulation and process involved in the formation of geopolymer binders (rheological study). The precise characterisation of the porous network will then be decisive in determining the fire-resistance properties of the material. Finally, durability will be studied to classify the performance of these materials based on their characteristics, such as setting time, compatibility with the surrounding environment and temperature resistance.

EXPECTED RESULTS

This fundamental research project should lead to the production of charts for determining the thermal properties of different geopolymer binders based on their composition and/or setting, workability and durability characteristics.

Innovation

The innovative technology in this project lies in the development of different formulations of geopolymers combining:

- controlled viscosity at room temperature;
- quick or slow setting time;
- immediate mechanical resistance;
- fire resistance of up to 1000 °C.

Economic impact

The geological layer in which the future disposal facility for the most radioactive waste will be built is Callovo-Oxfordian argillite, approximately 500 metres underground in eastern France. The creation of the disposal facility will require the excavation of several million cubic metres of this argillite throughout the operating period. The future of the excavated argillite has yet to be determined. The INIFUGE project will explore the possibility of developing fire-resistant geopolymer materials using the excavated argillite as a potential option for direct reuse of this material.

Impact on radioactive waste management

INIFUGE will contribute to improving the safety of the disposal facility through the thermal protection of waste disposal containers in the event of fire. These materials could be used for making the packages or as fire-resistant coatings.

Social impact

This project will generate four three-year employment contracts.

APPLICATION AND COMMERCIALISATION

The direct application for the INIFUGE project is the fire protection of radioactive waste disposal containers and civil engineering materials for the future Industrial Centre for Geological Disposal (Cigeo). The project also proposes a way of reusing the argillite that will be excavated for the future geological repository.

More generally, the development of charts to determine the thermal properties of different geopolymer binders based on their composition and/or intrinsic properties could be of valuable interest for the development and use of these new materials in the civil engineering industry as a whole.