ECOLOGICAL CONCRETES AND MORTARS

PATENTED TECHNOLOGY

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ABSTRACT

A multidisciplinary public-private research consortium has developed a simple and innovative process to transform submerged arc welding slag waste into activated materials (geopolymers) that can be used as environmentally friendly substitutes for Portland cement to manufacture concrete or mortar-based construction materials.

These new materials are characterised by low production costs, are environmentally friendly, sustainable, do not generate waste in their production process, and have excellent physico-chemical properties.

Companies interested in acquiring this technology for its commercial exploitation are sought.

INTRODUCTION

Concrete is the most widely used building material in the world because its application is so versatile.

The essential ingredient of concrete is Portland cement. However, the manufacture of Portland cement presents a number of environmental problems:

- It consumes a large amount of natural minerals.
- It requires a considerable amount of energy.
- It emits a large amount of CO_2 and other greenhouse gases into the atmosphere (the equivalent of 4 billion tonnes/year) due to the decomposition of calcium carbonate ($CaCO_3$) into calcium oxide (CaO) and carbon dioxide (CO_2).

For these reasons, alternative materials are currently being sought to replace conventional Portland cement as a binding ingredient in concrete.

In this respect, geopolymers are positioning themselves as promising candidates to ordinary Portland cement in the development of sustainable products for the manufacture of concrete or mortar-based building materials.

Geopolymers are inorganic synthetic polymers formed from aluminosilicates activated by a basic solution at room temperature, and can be easily manufactured from different raw materials or wastes. These wastes include submerged arc welding slag from the structural industry, shipbuilding, boilermaking, railways, etc., whose aluminosilicate composition makes it particularly suitable for transformation into geopolymers.

Industrial welding generates large quantities of slag, and for this reason, a suitable procedure for its treatment and revaluation is necessary.

TECHNICAL DESCRIPTION

In order to overcome the limitations described above, a new process has been developed to obtain Portland cement-free construction products from submerged arc welding slag.

Submerged Arc Welding Slag (SAWS) is a waste that must be disposed of because it is not biodegradable. In addition, it requires landfill space, and its proper management is costly.

It is therefore of particular interest to find new applications for submerged arc welding slag waste.

The process to obtain geopolymers from submerged arc welding slag involves the following steps:

1. Mixing the slag with an aqueous alkaline activating aqueous solution.
2. Curing the mixture obtained in the previous step.

By mixing the geopolymers obtained with aggregates and/or gravel in different proportions, it is possible to prepare concretes and mortars with compressive strengths up to 55 Mpa at 28 days.

TECHNOLOGY ADVANTAGES AND INNOVATIVE ASPECTS

ADVANTAGES OF THE TECHNOLOGY

Among the main advantages of the geopolymers obtained using this novel technology, as well as of the construction materials based on the concrete or mortar containing them, the following should be highlighted:

1) Their low production cost.

2) They are environmentally friendly and sustainable.

3) They require a minimum amount of natural materials to obtain them, which leads to a saving of non-renewable mineral resources.

4) They generate few industrial by-products in their manufacturing process.

5) They emit a reduced amount of CO_2 during their production, thus reducing the carbon footprint by up to 80% compared to conventional Portland cement.

6) They have excellent physico-chemical characteristics, such as:

- Early compressive strength.
- Hardness between 4 to 7 on the Mohs scale.
- Low permeability.
- Good chemical resistance.
- Good fire behaviour.
- Thermally stable at very high temperatures (1.000-1.200ºC).
- Improves the ductility of concrete, increasing its flexible capacity.
- Ideal behaviour against acid and sulphate attacks.
- Low alkali-aggregate expansion.
- Good resistance to changes in freeze-thaw cycles, sulphates and corrosion.
- Suitable encapsulation of hazardous waste

7) It allows the revalorisation of waste from submerged arc welding slags.

8) They show similar or higher performances than those achieved when ordinary Portland cement is used.

INNOVATIVE ASPECTS OF THE TECHNOLOGY

The main innovation is that it is the first time that submerged arc welding slag is used to obtain alkaline activated materials (geopolymers).

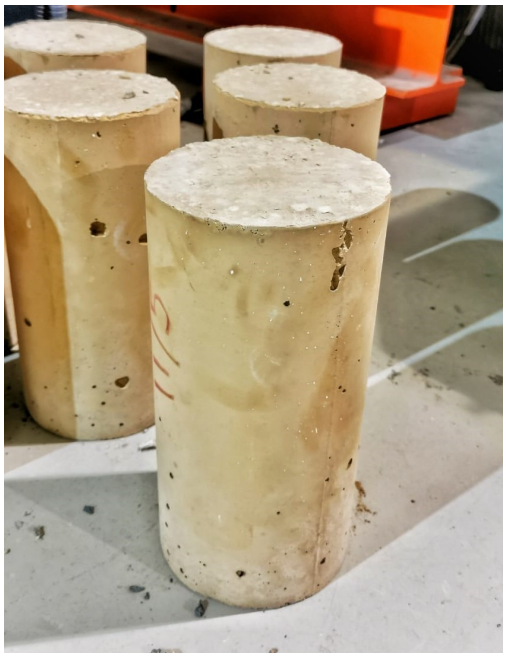
Moreover, the major difference in composition between a concrete comprising a geopolymer and conventional concrete is that Portland cement is completely replaced by an inorganic synthetic polymer (geopolymer).

Furthermore, geopolymers do not form calcium silicate hydrates for the formation and strength of the matrix, but use the polycondensation of silica and alumina together with a high alkali content to achieve structural strength, thus obtaining an adequate behaviour of the concrete, even if it does not contain Portland cement in its composition.

CURRENT STATE OF DEVELOPMENT

The technology has been successfully developed at **pilot scale**, and is at Technological Readiness Level (**TRL**) = **4**.

The next milestone to be achieved is validation.



Ecological concrete test tube for compressive strength tests.

Cross-section of ecological concrete specimen after flexural breakage.

MARKET APPLICATIONS

This invention falls within the technical field of **construction**.

Specifically, it refers to obtaining **geopolymers as ecological substitutes for Portland** cement in the production of concretes and mortars, giving the latter excellent physico-chemical properties.

Given the **great versatility** of these novel materials, they can be applied in the following industrial sectors:

- Construction materials.
- Advanced materials.
- Fire resistant materials.
- Refractory materials.
- Bituminous mixtures and asphalts.
- Waste immobilisation.

- Soil stabilisation.
- Other applications.

COLLABORATION SOUGHT

Companies interested in acquiring this technology for **commercial exploitation** through patent **licensing agreements** are sought.

Company profile sought:

- Cement manufacturers.
- Concrete manufacturers.
- Mortar manufacturers.
- Manufacturers of clay bricks.
- Manufacturers of asphalt mixtures.
- Manufacturers of inorganic polymers, geopolymers, etc.

INTELLECTUAL PROPERTY RIGHTS

This invention is protected through a **utility model**:

- Title: "Geopolímero, procedimiento de obtención y usos dados al mismo".
- Application number: U202330291.
- Application date: 28th June, 2022.

MARKET APPLICATION (3)

Construction and Architecture
Materials and Nanotechnology
Stone and Marble