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Durability of alkaline activated materials from two industrial by-products: diatomites and sewage sludge

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Objetive

The main objective of this work is to study the durability, in different media, of a set of alkaline-activated materials. For their manufacture, two industrial by-products have been used as precursors: **diatomites (Diat) and sewage sludge (SS).**

Introduction

These industrial by-products, taken separately, do not provide good mechanical properties. But a combination of both (Table 1) has a suitable chemical composition to act as precursors in the manufacture of activated alkaline materials.

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	LOI
Diatomites (Diat)	89.09	3.22	2.72	1.21	0.42	1.35	0.21	0.41
Sewage Sludge (SS)	26.95	8.13	8.21	21.80	4.64	1.93	1.31	3.79

Table 1. X-ray fluorescence (FXR)

In a previous study, alkaline activated materials were made with mixtures of both residues. Five different mixtures were made, from 30% diatoms with 70% sewage sludge to 70% diatoms with 30% sewage sludge. All the mixtures were made using the same procedure and the same conditions.

1. Activating solution

Mixture of **50 wt % 8M NaOH** (98 % purity) with **50 % Na_2SiO_3** (29.2 % SiO_2, 8.9 % Na_2O and 61.9 % H_2O)

2. Optimal conditions

- **Curing:** room temperature
- **Liquid/ solid ratio**: 1-1.2
- **Particle size**: 100 µm

3. Mixtures

Five different mixtures were formed:
1. 30%Diat+70%SS
2. 40%Diat+60%SS
3. 50%Diat+50%SS
4. 60%Diat+40%SS
5. 70%Diat+30%SS

4. Results

After 28 days of curing, the results obtained from this study were quite optimal, reaching compressive strengths of 14.9 MPa with 30% Diat up to a maximum of 32.8 MPa with 60% Diat.

Durability study

Testing conditions

After 28 days of curing were subjected to durability tests in four different testing conditions: **HCl 0,5 %; HCl 2 %; NaCl 3.5 % and Na_2SO_4 4.4 %.**

Materials and Methods

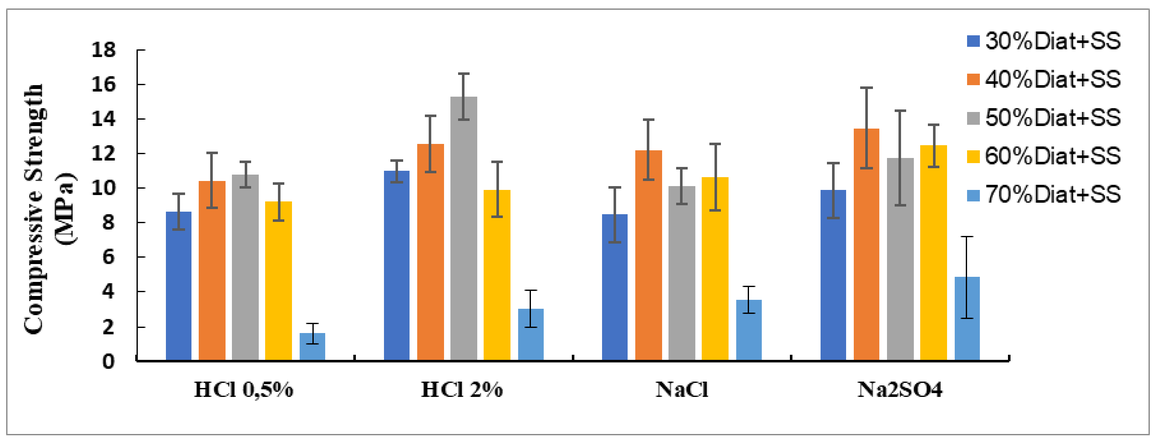
1. The dry specimens were first weighed and then immersed in the corresponding solutions.

2. The saturated specimens were weighed 24 hours after immersion and then every 7 days until 28 days.

3. The solution was replaced by a new one where they were immersed again until the next control.

4. On the 28th day of immersion, the mechanical tests, such as compressive strength, were carried out.

Results



Graph 1. Compressive strength (MPa)

It can be concluded that the **acid medium** that provides the best results is **2% HCl**, where the mixture that offers the highest compressive strength results is **50% Diat+SS (15.25 MPa)**. While the **basic medium** with which the best results are obtained is **Na_2SO4 4.4%,** in this case the mixture that works best is **40% Diat+SS (13.44 MPa).** Likewise, it should be noted that the **70% Diat+SS** mixture is the one that suffers the most from the effects of the durability test, since **no** medium **exceeds 5 MPa**.

Conclusion

- In addition to offering good physical and mechanical properties, most of these mixtures have excellent and sufficient mechanical resistance in contact with different aggressive media.
- Thus, it can be affirmed that the manufacture of activated alkaline materials using industrial by-products of diatoms (Diat) and sewage sludge (SS) as raw material is a good alternative to the use of traditional Portland cement (PC).
- In this way, the sector is offered a new type of material that is less aggressive with the environment since it requires less energy consumption than PC, reducing greenhouse gas emissions into the atmosphere and avoiding the extraction of new natural raw materials. .
- In the same way, a new use is found for the use of waste, entering a circular economy.

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