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Effect of Aloe Vera Dosed in Cement-Sand Mortar Crystallization and Energy Reducing

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Abstract **- The cement industry consumes large amounts of energy to produce products, which also implies emissions, which can be partially mitigated with rational and efficient use. Products or mixtures with cement are widely used in the construction industry and for the elaboration of various structural elements, masonry, and coatings. The reaction process between cement and sand is well known and cement has been considered to produce maximum compressive strength of the mixtures where it is used due to the crystallization process. Cement-sand mixtures were made to which nopal extract was dosed, subsequently determining the mechanical resistance to compression, and visualizing the impact on the surface composition, the result of the modification of the crystallization of cement-sand mixtures in proportion 1:4 in weight is reported, of nopal mucilage. The addition of this component produces the formation of polydentate nuclei and increases the compressive strength. These results allow us to visualize that the modification of the crystallization process increases the resistance, which can allow a reduction in the use of cement in the mixtures and the energy consumption directly related to its production.**

Index Terms - Anisotropy in crystallization, concrete additives, concrete strength increasing.

1. INTRODUCTION

Currently, earth techniques can work as an affordable technique for areas where the social production of housing is required and communities that have a bioavailability of materials & soils, with which resistant mixtures can be made.Cement is an important component for the development of cities, as an accessible material, however it is produced with Portland cement that requires a lot of energy to be produced [1] which is considered unsustainable [2].

There are techniques to reduce the use of cement and concrete [3] and some strategies to increase sustainability in their production [4,5] have been proposed to resume ancestral technologies of land or land stabilized with natural additives [6,7] although it could be agreed in some specific cases. Concrete has important additional uses, for example, plastic concrete allows to repair of cracks in earthen structures [8].

The modification of the crystalline composition improves properties of concrete mixtures, among which can be the modification of the permeability [9] and dosing polymers can modify other properties such as temperature changes [10]. The dosage of nanocellulose has made it possible to modify the freezing and resistance properties of some chemicals in cement mixtures for mortar production [11]. The dosage of biopolymers derived from cacti Shanmugavel et al. 2020 has been carried out where it has been found that

humidity is improved during setting processes by reducing the formation of microcracks [12].

This paper aims to microscopically analyze changes in cement-sand mixtures as well as compressive strength when dosing *Aloe vera* for use in construction

1.1. Mucilage in construction materials

It is common for mucilage to be used for the restoration of materials [13]. It has been demonstrated to increase the resistance by dosing gely components [14], and the species of *Opuntia* can be used to improve material properties [15]. The processes of crystal formation from the carbonation of components can be modified by placing plant saps and various methods exist for the stabilization of mixtures that can be found in architecture, investigated in greater numbers in recent years, and characterized mechanically [16-18] but that still does not reach resistances that are feasible in concrete or mortar mixtures prepared with cement.

There is the possibility of mixing vegetable sage with concrete [19] but that requires further study and verification in Mexico with the current properties of cement and explaining the findings on its mechanical behavior from the variation of the composition, and the possible implications with this.

It is recognized other ways to cure materials to increase showing the importance of compounds self-integrated or added to the blends[20] where mechanical characterization is required.

2. METHOD

2.1. Preparation of samples

Specimens formed with cylinders elaborated, cured, and tested following the Mexican standards NMX-C-160-ONNCCE and NMX-C-083-ONNCCE were elaborated. with mixtures of river sand and CEMEX brand Portland cement. They were mixed with mechanical equipment according to the NMX - C - 085 - ONNCCE standard. Water was added until the requirement specified in the NMX-C-156-ONNCCE standard was reached. Separately specimens were developed in the same way but using an aqueous solution of 1% *Aloe vera*. To prepare the solution, the *Aloe vera* stalks were removed from the aloin and the cortex, working exclusively with the aloe gel mixed homogeneously with drinking water.

2.2. Compressive strength test

Compressive strength is calculated using the following equation:

$$R = \frac{F}{A}$$

Where: *R, F, and A*, are the compressive strength, force, and cross-sectional area of the sample, respectively. In this case, the Mexican standard NMX-C-061-ONNCCE was used, using a Universal Digital Control Brand machine with a capacity of 1000kN at compression.

2.3. Thermal and microscopic tests performed

Heat transfer

The procedure, in this case, is based on the theory of the Linear Transient Heat Source, which is useful for studying the thermal properties of solid materials. It consists of the measurement and correlation of the temperature-induced within a material and its transfer through a thermal needle, for which KD2 Pro Thermal Conductivity Meter was used with the SH-1 Sensor, for a time of 30 minutes for the taking of readings in triplicate.

Electron microscope and scanning analysis.

The analyses were performed in two magnitudes. A first with optical microscopy and later another with electron and scanning microscopy, with an acceleration of 200V and 20keV in a half vacuum with an FEI equipment. ESEM-QUNTA 200 with 10nm resolution at 500, 1000, and 2000X.

2.4. Energy Saving Analysis

All sustainable buildings must demonstrate a decrease in heat gain of at least 10% compared to the reference building calculated according to the calculation methods established in the NOM-020-ENER-2011 standard.

NOM-020-ENER-2011 seeks to reduce heat gains in residential buildings through the building envelope, and thus decrease the amount of energy needed for cooling. To support compliance, the Ministry of Energy (SENER) and the National Commission for the Efficient Use of Energy (CONUEE), with support and technical advice from the Danish Energy Agency, developed a calculation tool that allows determining the energy budget of a building and compares them against a reference building. This tool was used to know the impact of modifying the mortar used in the coating of a building with a concordance of -15% for which the changes detected and reported in this article were used

3. RESULTS AND DISCUSSION

3.1 Compressive strength results

In the case of mixtures, no significant change in density was obtained, which was found at 1,856±0,029 g/cm^3

Table 1.- Results of the compression test

Sample	Compressive strength (kgf/cm^2)
Conventional	60.35±0.56
With nopal mucilage	86.42±0.47

The results show an increase in resistance by just over 43%, which may mean a possible reduction in cement consumption for the preparation of the mixture.

3.2. Heat transfer results

Table 1. shows heat transfer results

Table 1.- Heat Transfer Values obtained with equipment.

Material	α	λ	ρ	C
	mm²/s	W/mK	°C.cm/W	MJ/m³K
Mortar with dosage	0.099	0.131	765.5	1.314
Conventional mortar	0.151	0.220	754.0	1.461
Error	0.002	0.015	0.1	0.048

Being the Thermal Diffusivity α, Thermal Conductivity λ, Thermal Resistance ρ, and Specific Heat C. Significant differences can be observed between the results. Although the values in both cases are low, it is important to note that they correspond to a proportion of the composition of the elements. The concrete has an even higher conductivity, as well as the blocks that are used, being, under the NOM-008-ENER-2002 standard, up to 0.87 W/mºC (for red partition) and 1.74 W/mºC (for concrete).

3.3. Microscopic analysis results

Figure 1 shows the micrographs for mortar produced with and without dosage at the slightest magnification.
In the field of visualization of the sample with dosed *Aloe vera* gel a greater number of irregularities is distinguished, which is also distinguished in the morphology of the crystals.

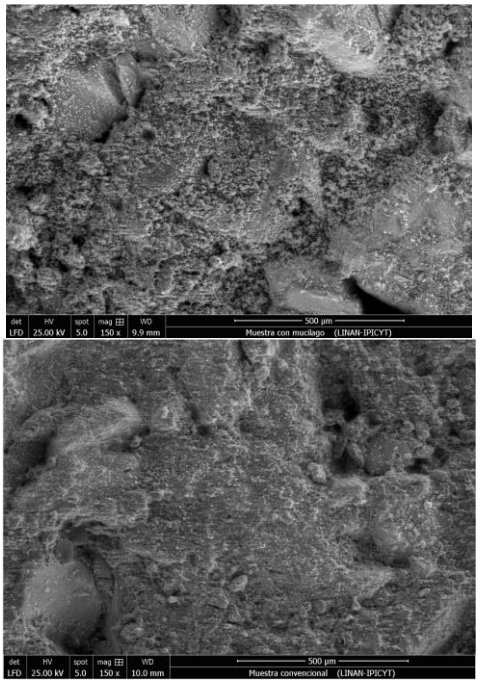


Figure 1.- Sample with mucilage Above and sample without mucilage Below.

To elucidate the morphology of the crystals, an analysis was carried out on the magnification that can be seen in Figure 2. In Figure 2

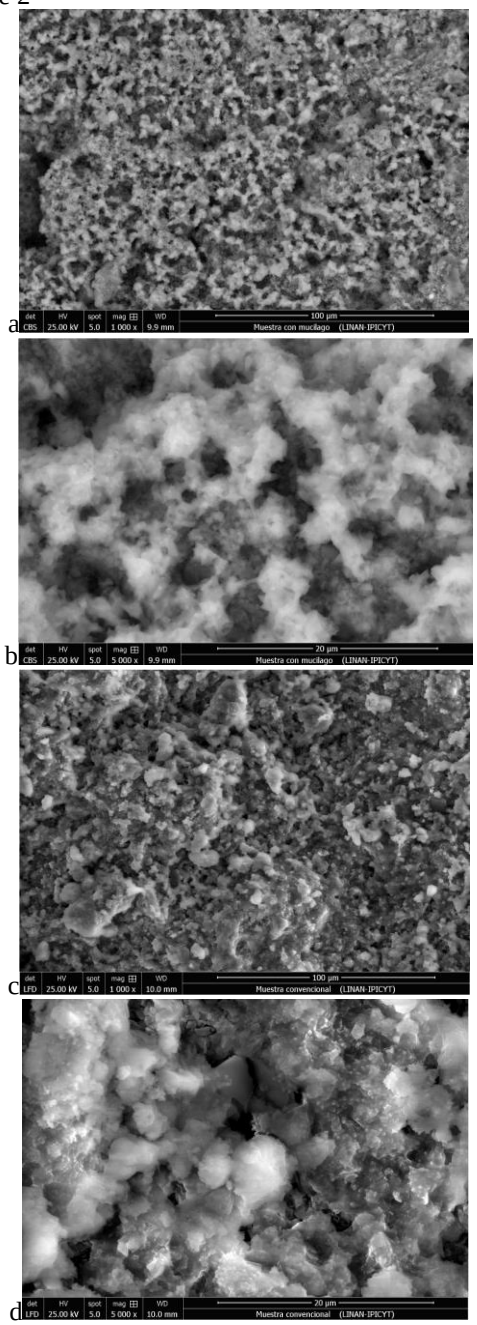
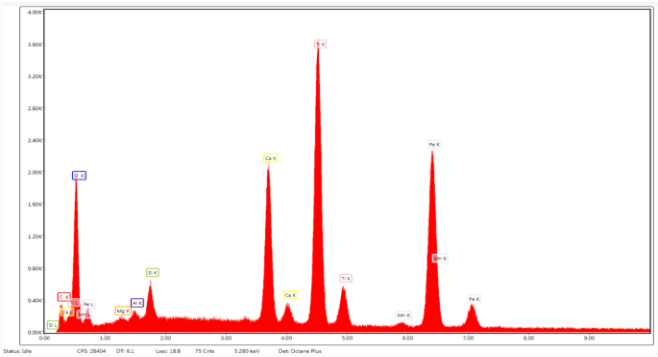


Figure 2.- Sample in two magnifications, with a scale of 100 and 20 micrometers, for mixing with *Aloe vera* (a and b) and without dosed acíbar (c and d)

The result of the elemental analysis, where the main components corresponding to silicates and aluminosilicates can be observed, is found in Figure 3. There is no a significance change in the elemental characterization, but

gives the information about the possible interaction among them.

a



b

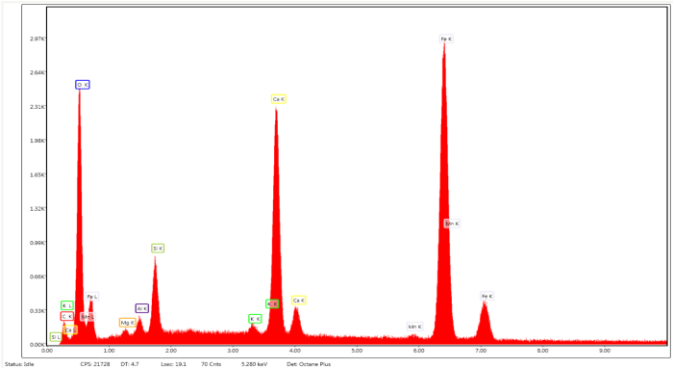


Figure 3. EDS for a) without and b) with *Aloe vera*.

Implications of the properties found

From the quantification of the mechanical resistance to compression, an increase in this value is observed when a syrup solution is dosed. This implies a reduction in the use of cement to obtain the same strength. For the observed case the value has an approximate equivalence of 18%. Simultaneously, the analysis of two elements was carried out where the coatings were calculated with the material without dosage and with dosage, with the tool of the NOM-020-ENER-2011 where it is found that there is a benefit of 2.8% when used in a space of 12m2 of exposure to a sun side.

4. CONCLUSION

The dosage of Aloe vera can increase the compressive strength of cement mixtures, which means reducing approximately 18% of cement for the same strength. Additionally, the mixtures improved their thermal properties without modifying the density of this. Micrographs show that the dosage of Aloe vera implies a modification in the spatial arrangement of the components of the mixture, increasing the anisotropy of the system. In the determination under the standards established by the ENER in Mexico

In further work, from the results obtained, it is necessary to continue with other determinations and perform durability tests repeating the determinations indicated in this article.

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REFERENCES

[1] Ma, F., Sha, A., Yang, P., & Huang, Y. (2016). The greenhouse gas emission from Portland cement concrete pavement construction in China. *International Journal of Environmental Research and Public Health*, *13*(7), 632.

[2] Van Damme, H. (2022). Cement and Concrete. In *Between Nature and Society: Biographies of Materials* (pp. 55-73).

[3] Nwankwo, C. O., Bamigboye, G. O., Davies, I. E., & Michaels, T. A. (2020). High volume Portland cement replacement: A review. *Construction and Building materials*, *260*, 120445.

[4] Adesina, A. (2020). Recent advances in the concrete industry to reduce its carbon dioxide emissions. *Environmental Challenges*, *1*, 100004.

[5] Sivakrishna, A., Adesina, A., Awoyera, P. O., & Kumar, K. R. (2020). Green concrete: A review of recent developments. *Materials Today: Proceedings*, *27*, 54-58.

[6] Avila, F., Puertas, E., & Gallego, R. (2021). Characterization of the mechanical and physical properties of unstabilized rammed earth: A review. *Construction and Building Materials*, *270*, 121435.

[7] Morel, J.C., Charef, R., Hamard, E., Fabbri, A., Beckett, C., & Bui, Q.B. (2021). Earth as construction material in the circular economy context: practitioner perspectives on barriers to overcome. *Philosophical Transactions of the Royal Society B*, *376*(1834), 20200182.

[8] Shepherd, D. A., Kotan, E., & Dehn, F. (2020). Plastic concrete for cut-off walls: A review. *Construction and Building Materials*, *255*, 119248.

[9] Drochytka, R., Ledl, M., Bydzovsky, J., Zizkova, N., & Bester, J. (2019). Use of secondary crystallization and fly ash in waterproofing materials to increase concrete resistance to aggressive gases and liquids. *Advances in Civil Engineering*, *2019*.

[10] Xu, Y., Yuan, Q., Dai, X., & Xiang, G. (2022). Improving the freeze-thaw resistance of mortar by a combined use of superabsorbent polymer and air entraining agent. *Journal of Building Engineering*, 104471.

[11] Barnat-Hunek, D., Grzegorczyk-Frańczak, M., Szymańska-Chargot, M., & Łagód, G. (2019). Effect of eco-friendly cellulose nanocrystals on physical properties of cement mortars. *Polymers*, *11*(12), 2088.

[12] Shanmugavel, D., Selvaraj, T., Ramadoss, R., & Raneri, S. (2020). Interaction of a viscous biopolymer from cactus extract with cement paste to produce sustainable concrete. *Construction and Building Materials*, *257*, 119585

[13] Alisi, C., Bacchetta, L., Bojorquez, E., Falconieri, M., Gagliardi, S., Insaurralde, M., ... & Tatì, A. (2021). Mucilages from Different Plant Species Affect the Characteristics of Bio-Mortars for Restoration. *Coatings*, *11*(1), 75.

[14] Ravi, R., & Thirumalini, S. (2019). Effect of natural polymers from cissus glauca roxb on the mechanical and durability properties of hydraulic lime mortar. *International Journal of Architectural Heritage*, *13*(2), 229-243.

[15] Guevara-Arauza, J.C. (2021). Industrial Uses of Opuntia spp. By-products. In *Opuntia spp.: Chemistry, Bioactivity and Industrial Applications* (pp. 707-752). Springer, Cham
[16] León-Martínez, F.M., Cano-Barrita, P. D. J., Castellanos, F., Luna-Vicente, K.B., Ramírez-Arellanes, S., & Gómez-Yáñez, C. (2021). Carbonation of high-calcium lime mortars containing cactus mucilage as additive: a spectroscopic approach. *Journal of Materials Science*, *56*(5), 3778-3789
[17] Gallipoli, D., Bruno, A. W., Bui, Q.B., Fabbri, A., Faria, P., Oliveira, D. V., ... & Silva, R. A. (2022). Durability of earth materials: Weathering agents, testing procedures and stabilisation methods. *Testing and Characterisation of Earth-based Building Materials and Elements*, 211-241.
[18] Zhang, K., Wang, L., Tie, F., Yang, F., Liu, Y., & Zhang, Y. (2021). A preliminary study on the characteristics of Lime-Based mortars with egg white addition. *International Journal of Architectural Heritage*, 1-15.
[19] Torres-Acosta, A. A., & Díaz-Cruz, L. A. (2020). Concrete durability enhancement from nopal (opuntia ficus-indica) additions. *Construction and Building Materials*, *243*, 118170.
[20] M. N. Bajad, 2021. Influence of Self-Curing Compound on the Strength of High-Performance SCC. International Journal of Applied Engineering and Technology 3(2).