Mortar Improvement Using Nopal Additive♦

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SUMMARY

Nopal has been used in many applications of building construction in Mexico, since remote times. Now, previous knowledge is being used to find new applications in hydraulic cementitious materials, such as Portland cement used in mortar fabrication. Results of the investigation demonstrate that mortar made with nopal as an additive had a greater compressive strength than mortars made without the additive. The time of setting was improved enormously, that means that the nopal acts as a retardant in mortar manufacture.

Key Words: Nopal, Portland cement, mortar, building construction.

INTRODUCTION

At this time, the construction industry is really interested in finding research about new materials that help optimize construction processes. Portland cement is a material of great importance for the development of such processes. It is the basis for the fabrication of concrete and mortar. For such reasons, we were devoted to finding a way to improve the physical and mechanical properties of concrete with the help of a natural additive.

According to Mexican Standard NMX-C-021, Portland Mortar is the masonry cement used in masonry works and it may contain one or more of these materials: Portland cement, sand, or gravel.

The Cement Concrete Terminology, ACI SP-19, defines an additive as a material other than water, aggregates, and cement that is used as a mortar or concrete compound and is added to the mixture immediately before or during mixing.

Document No.162 of Agricultural Services of the Food and Agriculture Organization (FAO), refers to the "Agro-industrial use of the nopal". Saenz (2006) declares that many industrial sectors can benefit from the use of nopal. Among these sectors are the nourishing and their associated industries, the construction industry, pharmaceutics, and cosmetics industries.

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Mexican natives used nopal mucilage to bind adobes in ancient times (Granados, 1997). They also used lime and mucilage mixtures as walls stucco. This information prompted our investigation to study the physical and mechanical properties of mortars.

Recent investigations demonstrated the benefits of adding nopal to products such as lime, plaster, and Portland cement (Hernandez-Zaragoza, 2007).

Noriega (2005) demonstrated that nopal works as an additive for construction materials when used whole, that is, mucílage and rind of nopal dried at high temperatures.

MATERIALS, EQUIPMENT, AND METHODS

Materials

Materials that were combined to produce the mortar studied were Portland cement, water, and nopal powder.

The cement used for the physical and mechanical tests was the so-called CPC 30R cement (Mexican name for Type I Portland cement) trade name of our country (Mexico), generally found in stores in a 50 kg bags.

The water used to manufacture the mortar is potable water used for human consumption. The Standard that regulates the characteristics that the water used to make the mortar must fulfill is NMX-C-122, Construction Industry - Water for Concrete.

Finally, the natural additive used came from nopal (known in Mexico as nopalito) dehydrated in a furnace.

Equipment

Specimens were tested using cubical molds, a universal testing machine, and Vicat needle.

Stainless-steel molds were used for the test specimens because this material is inert to cement pastes. Each side of the mold is 5 cm. Walls of the mold are rigid enough to prevent deformation during molding. The mold parts must be firmly attached to one another and held firmly during specimen fabrication.

The universal testing machine used to evaluate the compressive strength has a uniform load-application range, can control the applied load, and is calibrated periodically to guarantee precision testing.

According to Specification NMX-C-057, Determination of the Normal Consistency, we used the Vicat needle, which meets the following requirements: it takes a 10 mm diameter movable rod with a minimum length of 50 mm. The other end of the apparatus has a detachable needle of 1 mm diameter and 50 mm in length.

Methods

This research was carried out at the Materials and Soil Mechanics Laboratory of the Engineering Division of the Autonomous University of Queretaro (UAQ) in Mexico.

The following specifications were used at this stage of the research:

To carry out the compression tests, we used the Mexican Official Norm NMX-C-061-ONNCCE, Determination of the Compressive Strength of Hydraulic Cement Mortars.

Tests to determine the normal consistency of the cement paste were carried out following the standard NMX-C-057-ONNCCE, Determination of the Normal Consistency.

To determine the initial and final setting time, we used the standard NMX-C-059-ONNCCE, Time of Setting of Hydraulic Cement by Vicat Needle. Neville (1999) uses the term setting to describe the rigidity of the cement paste. In general terms, the setting time deals with a change in physical state from a fluid to a rigid state.

Mortars were made with water to cement ratio of 0.40 in both mixtures (M1 and M2), but only mixture (M2) had an additive of nopal of 5% per kilogram of cement.

RESULTS

The compressive strength of both mixtures M1 and M2 was evaluated at early ages: three, seven, and fourteen days. The compressive strengths show an increase at all ages in mortars having additive of nopal (M2), when compared with regular mix mortars (M1) (Figure 1).

According to the results obtained, as far as the normal consistency of the pastes is concerned, mixture M2 had a more fluid consistency than mixture M1. This shows that the nopal additive improved the workability of the mixture. Tables 1 and 2 show the normal consistency results for the two pastes.

We concluded that the initial setting time (fi) for mixture M1 occurred at 330 minutes after placing the sample in the Vicat apparatus and the final setting time (ff) occurred at 390 minutes. For mixture M2, fi occurred at 435 minutes and ff at 495 minutes. Therefore, the additive of nopal slowed down the setting time (Figure 2).

CONCLUSIONS

The use of nopal in the construction industry shows promising results when used as an additive to the water-Portland cement mixtures. According with the collected data, we can emphasize that the compressive strength of mortars was improved up to 72% at early ages by using nopal additive. The normal consistency tests also showed an improved workability for the Portland cement-water-nopal powder M2 mortar mix when compared with paste M1. It was verified that the nopal acts as a retarder of the initial and final setting times.

Nopal, being a renewable product and being easy to harvest in barren places, shows great potential for the construction and repair industries, as an additive that enhances mechanical properties and retards the setting time of mixtures.

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APPENDIX

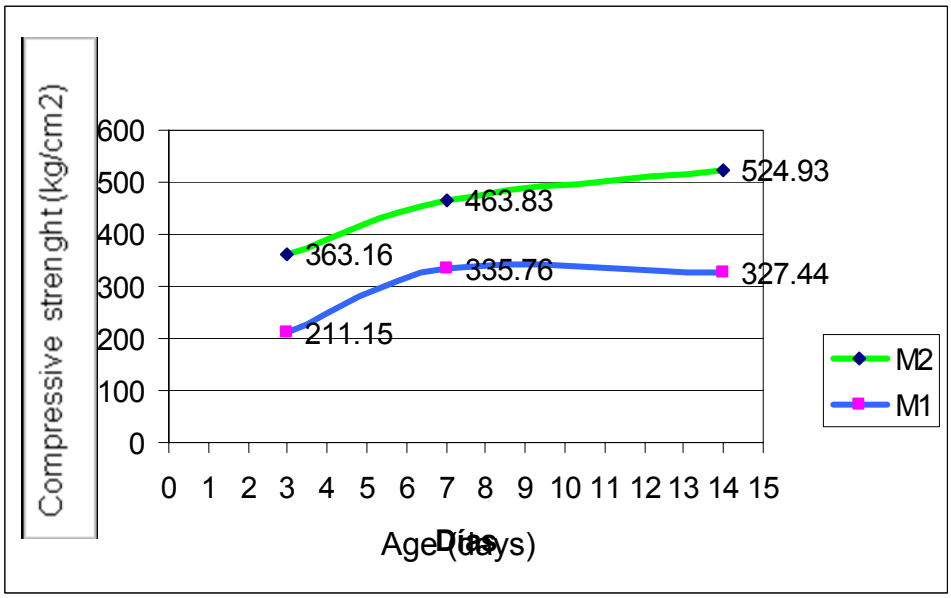

Figure 1. Compressive strengths of mixtures M1 (0% cactus powder) and M2 (5% cactus powder) at 3, 7, and 14 days of age

Table 1. Results of the consistency of mortar M1

Mix	Bar Penetration (mm)	Average of the Bar Penetration (mm)	Standard Deviation σ (mm)
M1 (0% cactus powder)	2	3	1.4142
	2		
	3		
	5		

Table 2. Results of the consistency of mortar M2

Mix	Bar Penetration (mm)	Average of the Bar Penetration (mm)	Standard Deviation (mm) σ
M2 (5% cactus powder)	6	8	1.4142
	8		
	9		
	9		

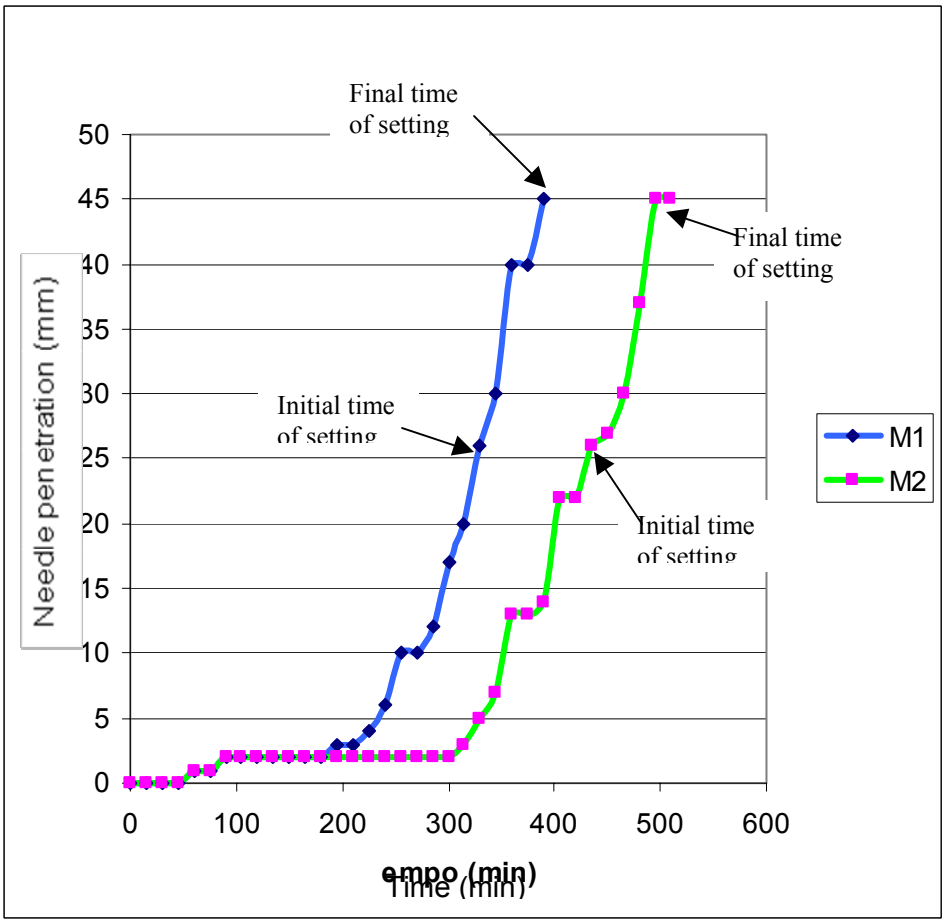

Figure 2. Comparison of initial and final setting times
of mortars M1 (0% cactus powder) and M2 (5% cactus powder