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Eco-cement - Development of a Chemical Binder for Use in Construction

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Abstract: Conventional concrete is the second most used product in the world, second only to water, taking this as a major component in their production cement. In short, one of the world's largest consumer products used in the composition of the agents responsible for air pollution, this because during the cement manufacturing process are emitted tons of CO_2 in the air. According to surveys conducted by regulators that value reaches 5% of the world's CO_2 emissions, in addition, promotes soil degradation due to the extraction of raw material (clay, limestone and gypsum) in addition to causing harmful effects on human health and the environment by the release of particulate matter. Within this context, this research aims to develop a chemical binder, called eco-cement, to replace partial and / or full forms the conventional cement in cement mortar, coating and reinforcement, thus minimizing pollution levels caused by the cement industry . For the binder composition in study used four materials: microsilica, nanossílica, sodium silicate and lime, which combined in predefined ratios and analyzed by quantitative and qualitative means gave rise to cementitious compounds necessary to ensure the strength of this. Thus, it prepared a folder with chemical binder, parallel to it, is concocted with other conventional cement, this used as a comparator with the binder in the study. From the best result it began the production of mortar being respected factor water / cement ratio, and standardized the molding procedure of the test bodies and healing methodology. The physical and mechanical properties of the final product was obtained from the dynamic modulus of elasticity tests and resistance to axial compression, proving its effectiveness in the application in brick laying and contributing effectively to the reduction of environmental impacts from their manufacture.

Key words: ecocement, chemical binder, construction, mortar.

1. Introduction

Currently the construction industry has grown increasingly and thereby cement consumption has increased significantly, with this being the second substance most used in the world along with the concrete, as is its main component, behind from water. (MEHTA & MONTEIRO, 2008). Cement is produced by heating limestone and clay until they fuse into a material called clinker and may have to be mixed with various additions or only plaster, depending on the type of cement you want. (BAUER, 2012). The problem is that the heating and chemical reactions release large amounts of carbon dioxide (CO_2), contributing to global warming. The state of Rio Grande do Norte, located in Northeastern Brazil, concluded the year 2014 with a record in production and cement consumption and the possibility of installation of new plants in the region. This framework sets economic growth, new business opportunities and income generation. In contrast, cement production consumes a huge amount of energy and natural resources; emits dust and other pollutants, as well as affecting vast expanse of land during the operational phase of the raw materials. In short, one of the world's largest consumer products is also a major environmental pollutant in its production process. In today's scenario presented, it is understood that there is a need to develop a binder that meets the characteristics required by the regulations in force and in turn does not contribute to environmental degradation effectively. According to this analysis, it has been the main objective of this work to develop a chemical binder where their raw materials do not need to go through the sintering process to form compounds responsible for the mechanical strength of the cement, what happens when joins microsilica, the sodium silicate, lime and nanossílica in an aqueous medium.

1.1 Problem Analyzed

Because it is a basic material for any type of construction, the common cement becomes one of the most used materials in the world. However, the manufacturing process of the product's negative environmental impact of generating potential. This can be seen from the process of extraction of limestone quarries, where there degradation of the explored area, erosion and damage to nearby buildings to these areas due to the vibrations produced by the explosion process and the quarries of abandonment already overexploited. Already clay mining in the rivers can deepening these waterways, decreasing the amount of water in the beds and hurting their existing natural ecosystems, which decreases the biodiversity of the region. In addition, the cement production process consumes about 2% of the global energy and it is expected that this production over the next 40 years, which would cause the cement industries were responsible for 20% of total emissions CO_2 in the world. To avoid this projection, it is necessary that the process undergoes changes or new products are developed, since the demand for cement hardly decrease.

2. Materials and Methods

2.1 Materials

For the realization of the traits under study the following materials were used: CP II F 32; microsilica; Sodium silicate; Cal: CH-I type; drinking water: obtained directly by the local utility; Sand; Nanossílica; Superplasticizer additive: Glenium 3200 HES.

Figure 1 show the pulverulent materials used in the respective folders following sequence: CP II F 32, whitewash and microsilica.

Fig. 1 - Powdery materials used

The eco-cement is composed of four components: microsilica, whitewash, sodium silicate and nanossílica; the first two are shown in solid phase in powder form, since sodium silicate is presented in viscous colloidal dispersion and nanossílica in liquid phase. Below are the details of each component of the binder.

Microsilica (SiO_2) - is silicon dioxide (SiO_2) that has condensed as spherical particles, extremely small (average diameter of approximately 0.1 0,1μm) and amorphous. The formation of the microsilica is through a by-product of the process of getting the ferrosilicon and silicon metal, these materials used in the production of most common steel and the aluminum, chemical, electronics and others. The silica fume produces both chemical and physical effects on the microstructure of concrete. The reaction $Ca(OH)_2SiO_2$ involving the silica fume is quick and somewhat variable; it is not necessary long periods of curing to achieve the desired resistance. The pozzolanic reaction at a temperature of 20°C begins around the seventh day, while for higher temperatures (35°C) the chemical input is already observed at two days of age. This microsilica has a pozzolanic index of 8.8 MPa, when in the presence of lime, assisting in increased formation reactions of the cement compounds of the chemical cement.

Whitewash (CaO) - It is a binder / natural chemical reaction product obtained by decarbonation of limestone, through its subjection to elevated temperatures (900°C) ovens suitable for the purpose. In construction, it is mainly used in hydrated form as a key component in the preparation of cement mortar and durability of coating and optimal performance. The whitewash used has characteristics classified as a calcitic lime. Contributing to a better reaction in the formation of chemical compounds of cement. Table 1 presents some of its features.

Table 1 - Characteristic of calcium oxide

Calcium Oxide	
CHARACTERISTIC	
Percentage de MgO (%)	10
Specific surface	12000 cm²/g
Specific mass	2,50 g/m³
Color	Branca

Sodium silicate (Na_4SiO_4) - Solutions are silica (SiO_2) and soda (Na_2O) in water, obtained by fusing sand and soda ash (sodium carbonate) and subsequent dissolution of the resulting glass with steam in an autoclave. They can be produced with different ratios SiO_2 / Na_2O and different water contents. Sodium silicate acts as a catalyst in the reaction process between the microsilica and lime. Table 2 shows some of its features.

Table 2 - Characteristic of sodium silicate

Sodium silicate	
CHARACTERISTIC	
Formula	Na_4SiO_4
Specific gravity	2,4 g/cm³
Fusion point	1088 ºC
Molar mass	122,06 g/mol

Nanossílica (SiO_2) **-** It has the same chemical composition as the quartz or silica fume, SiO_2. The main difference with respect to quartz is that it is crystalline, while the active silica and nanossílica are amorphous. From active silica, the main difference is the much smaller size of the particle nanossílica. For example, the typical particle size of microsilica is between 200 and 1000 nm and the nanossílica between 3 and 200 nm. The combination between the amorphous state and the so small size of the particle nanossílica makes this material behaves as an addition to extremely active in the preparation of cement (cement paste), mortar and concrete. The nanossílica rapidly reacts with the calcium hydroxide released during the hydration of cement, to produce similar compounds that are produced by hydrated cement, or gel CSH (calcium silicate hydrate). Unlike CSH gel of hydrated cement origin, the source of origin of nanossílica has a low density of crystal defects, increasing the production of CSH and therefore resulting in optimal mechanical properties. (TECNOSIL Magazine, 2012).

Glenium 3200 HES **-** It is a superplasticizer liquid reducing, polycarboxylate-based, being very effective in the production of concrete mixtures with different levels of workability (Badische Anilin und Soda-Fabrik - BASF)

2.2 Methods

To achieve the purposes of this article the steps of experimental studies were developed. The first consisted in material characterization and measurement of folders with conventional cement and chemical binder, which were made using the same trait. With analysis of the best comparative results between assays of folders if initiated the second stage, in which, started the production of mortars with chemical cement, and then finished up the study with the analysis of mechanical property and so finding a possible application for the material. Table 3 shows the proportions used in the manufacture of pulp and eco-cement mortar.

Table 3 - Proportions of materials used to make eco-cement pastes and mortar.

MATERIALS	PASTES	MORTAR
Microsilica	33,33%	38%
Sodium silicate	33,33%	5%
Whitewash		55%
Nanossílica	33,33%	2%
Additive	-	2%
Sand	-	300%
Water	75%	93%
Dash	1: 0, 075	1: 3 : 0, 93

After admixture of these materials in the proportions previously exposed it reached the desired consistency in the process in Figure 2.

Fig. 2 - consistency of paste and mortar

3. Results and Discussion

According to all executive processes based on the Brazilian Association of Technical Standards (ABNT), was obtained the results, referring to 28 days of curing, the resistance to axial compression of the test folders, and so it was possible to draw up a comparison chart, Figure 3, between the mean values resulting from four specimens.

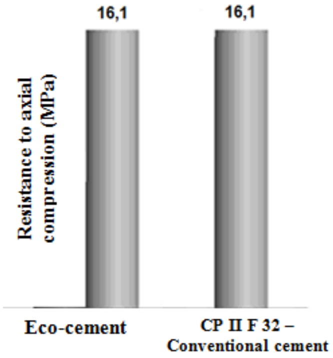

Fig. 3 - Graphic comparing the CP II F 32 and the chemical binder in resistance

According to the above results, it was observed that the paste produced with the eco-cement has mechanical strength equal to the conventional cement paste, which can be explained by means of X-ray diffraction (XRD) performed on a sample taken after mechanical testing, there was the incidence of calcite, CSH, C_2S and SiO_2, Figure 4, being the main compounds responsible for the strength of conventional cement.

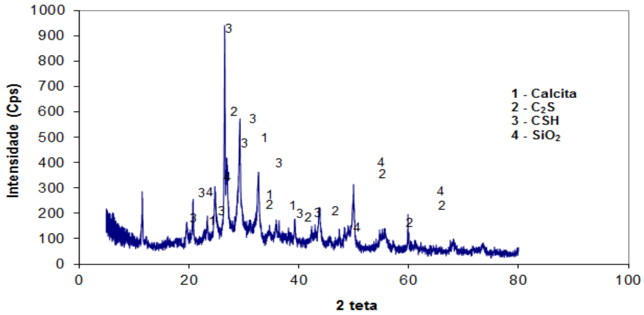

Fig. 4 - DRX test Result of eco-cement paste

To obtain the values of preliminary tests, the advancement of research saw necessary to compose a material that can be used in construction, then, the basis of this chemical binder mortar was developed and tested in order to know their resistance axial compression Table 4.

Table 4 - Results of the test of resistance Axial Compression.

Samples	Curing time (days)	Tension (MPa)	Mean (MPa)
1		11,67	
2	14	11,46	11,14
3		10,29	
4		12,02	
5	28	12,58	13,52
6		15,94	

Being based on the mortar strength after 28 days of curing, it enables the use primarily in ceramic brick settlements because the axial compressive strength is one of the properties that define the quality of the mortar for this application.

4. Conclusion

Given the results, we conclude that the ecological cement developed eco-cement, proved to be a promising material for application in construction, due to their performance be in accordance with current regulations. It was also observed that the preliminary studies presented in the form of paste, a resistance of 16, 1 MPa, matching with the CP II F 32. Already in mortar averaged resistance at 28 days normal healing, equivalent to 13, 52 MPa, which allows their application in settlements ceramic brick, wherein a resistance greater than 8 MPa is required. That said, it is concluded that the use of eco-cement is characterized as sustainable, since when replacing the conventional Portland cement, promote a reduction of negative environmental impacts caused by the cement industry, with the release of CO_2 and aggression on the ground with the extraction of raw materials from its natural deposits.

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