INFLUENCE OF CURING CONDITIONS ON CHARACTERISTICS OF MORTAR MADE WITH RICE HUSK ASH

Ana Marques
(AM - UTL/IST)
Portugal
rita_mac_marques@hotmail.com

Abstract: Mortars are used in various situations and with different functions in construction. The proper choice of a specific mortar for a given application is reflected in economy and durability. The mortar performance depends on several factors, such as its composition, compatibility with the substrate and application and curing conditions.

The main goal of the work here presented is to study the influence of the curing conditions on the lime mortar performance. To achieve this objective it was necessary to evaluate the influence of ash particle size on the pozzolanic action. With the results obtained it was possible to select two different lime mortars, formulated with rice hull ash, with different particle sizes. These two different samples were then analyzed under different curing conditions: dry, humid and in laboratory environment.

On all phases of this study, it was used as reference a lime mortar sample formulated with the same consistency and lime/sand proportion as the lime mortar with rice hull ash under testing.

The curing conditions influence evaluation was done performing different curing conditions tests and by characterizing several parameters for the two different lime mortars formulas. Prismatic specimens were prepared in molds and laboratory prepared specimens of mortar used in brick, which seek to replicate the application of lime mortars with the addition of rice husk ash as a mortar lining. This is intended to identify what factors and how they affect the form of on-site application of lime mortars with rice husk ash.

Keywords: lime mortar, rice husk ash, pozzolanic action, curing conditions.
1. INTRODUCTION

The selection of the binder to adopt on a mortar grouting depends on the characteristics of the masonry support. Thus, the binder for use in mortar for plastering of walls of old buildings tend to be the lime, since this is the binder most often used in the past, before the discovery and control of hydraulicity. Air binder mortars are more deformable and porous than the mortars with hydraulic binder, which are important characteristics when applied on substrates that also have these characteristics, such is the case of masonry walls of old buildings.

When compared with hydraulic binders, especially cement, lime mortars are the most appropriate in the rehabilitation of old buildings due to their compatibility with the old masonry. However, they possess certain characteristics that limit their application in specific circumstances, as is the case of very humid environments, environments with low carbon dioxide content and areas subject to important processes of crystallization and dissolution of soluble salts. To obviate these situations various materials have been considered and studied in order to be used as pozzolanic additions in this type of mortar. The use of these items enhances the speed of mortar hardening, resulting from reactions of hydration and carbonation, and the result is a mortar with higher mechanical strength.

Artificial pozzolanic materials result from burning natural materials under certain conditions or from certain industrial processes.

The artificial pozzolanic materials are siliceous materials subjected to specific treatments, which involve firing at specific temperatures for each type of material in order to avoid the crystalline growth, and leading to the formation of amorphous silica. The rice husk ash is an example of an artificial pozzolanic material.

The chemical composition, crystal structure and mineralogy of the ash depends on the constitution of the husk and on the adopted calcination methodology, including the type of oven used, temperature and time (NAIR, 2007) (NEHDI, et al., 2003). Thus, rice husk ash may result mainly of silica in the amorphous state after proper calcination, which, according to Mehta (METHA, 1983) can be classified as a pozzolanic material of high reactivity.

The pozzolanic reaction is a chemical process in which the pozzolanic material and calcium hydroxide react in the presence of water, forming hydraulic compounds. This reaction is one that defines a material as pozzolanic, the extent of reaction and its reactivity, thereby defining the degree of pozzolanicity (responsiveness), which is influenced by its thermodynamic instability, the surface area and chemical composition.

A pozzolanic reaction is defined as a chemical reaction between pozzolanic material, its silica and alumina reactive compounds, and calcium hydroxide, in the presence of water, originating the formation of hydraulic compounds (SOUSA COUTINHO, 2006).
The pozzolanic reactivity is affected by several factors ((VELOSA, 2007) (UZAL et al., 2008) and (SWAMY, 1993) in (Santos, 2006)), such as: the type of pozzolan, the specific surface and hence the degree of fineness of the pozzolana, the composition of the mortar constituent materials (ratio cal / pozzolana), the amount of water, the temperature to which the material is submitted to, and the curing and heat-hygrometric conditions.

The methods to evaluate the pozzolanic reactivity can be of two types: mechanical and chemical. The assumptions in which the mechanical methods for evaluating the pozzolanic reactivity are based are simple. These assume that the addition of a pozzolan increases the mechanical strength of pastes and mortars made with lime and pozzolan. Thus, comparing the mechanical strength of normalized paste samples or pastes and lime mortar or lime mortar and pozzolana, is possible to identify the level of reaction of lime with the pozzolan. Within these, the most commonly used method is based on measuring the compressive strength of lime mortars with and without pozzolanic additions (WANSOM, et al., 2009).

2. MATERIALS AND METHODS

The mortars studied in the present study were formulated with river sand, a natural aggregate.

**Lime**

The used Lime is a calcium lime, hydrated, type LC 90, produced by CALCIDRATA. The rice husk ash used in the development of the study is produced by CINCAS.

**Sand**

The river sand was previously dried at 105 ± 5 °C over a period of not less than 24 hours, this time it was experimentally verified to be the necessary and sufficient for the sand to reach a constant value of mass (mass change less than 0.01% in two successive weighings). The characterization of the used sand includes the determination of particle size analysis and mass per unit volume measure.

The sand particle size analysis was based on the provisions of NP EN 1015-1 and consisted of mechanical sieving of the sample for 10 minutes, using for this purpose the following sieves: 8mm, 4mm, 2mm, 1mm, 0.5 mm, 0.25 mm, 0.125 mm and 0.063 mm. After sieving on each sieve, we estimated the mass of sand retained on each sieve, with a precision scale and made the study of the grading curve (Graphic 2.1).

The evaluation of the apparent density of river sand was based on procedures of PN-EN1097: 3, 2000.´, Table 2.1.
Rice Husk Ash

The rice husk ash studied throughout this process were provided by the company CINCÁS, and two lots purchased from the July 28 and August 28, 2008, identified in this work by the letter C. The difference in tone between the recorded particles of ash and the fact that it appears clearly the poor ignition of some particles may be due to, according to information provided by the producer of gray, because the firing of rice husk furnace used to occur in production of lime, it is not possible to guarantee uniform temperature or air flow across the material.

(CHANDRASEKHAR, et al., 2003), (DELLA, et al., 2001) and (ZHANG, et al., 1996) establish a parallel between the color of ash and its chemical composition. According to these authors, the darkest shade of gray (almost black or black) reveals evidence of a high percentage of carbon in its constitution, as opposed to the lighter color gray in a predominance of silica concentration. It is noted that for mortar of lime, the high concentration of carbon can be harmful and therefore separate the material interests on which there is this, that is, the largest particles of ash.

Thus, in order to minimize the use of darker shade of gray (ie, based on literature review, minimize the use of ash with high carbon content), initially proceeded to mechanical sieving ash commercial rice hulls (C) through the 500μm sieve opening, for a period of 10 minutes. In this study, all samples that have been sifting were dried at 60 ° ± 5 ° C until constant mass.

Initially made up the sifting of the material (rice husk ash commercial - C) to separate the ash that was retained on the sieve of 500 micrometre passing on it. Each sample was prepared to separate the same way, were sieved fractions of approximately 400 grams of ash during time intervals of 10 minutes, once found to be necessary to remove the waste (ash badly burned and still too often looked form of rice husk) and optimize the amount of ash used. The particle size grading is shown in the Graph 2.2.
The influence of the fineness of the ash pozzolanic reactivity was studied on the basis of lime mortar, A500, P500, A250, P250, A125 and A75.

The characteristics of these mortars formulated with ash form the subject of comparative analysis on the characteristics of air lime mortar. The characterization included the fresh assessment: consistency for spreading, water retention, bulk density and exudation.

The influence of the fineness of the ash pozzolanic reactivity was based on an assessment of the propagation velocity of ultrasonic and resistance to bending and compression at 14 and 28 days old mortars. The characterization in hardened mortars at this stage was based on the characterization of prismatic specimens subjected to wet curing.

Several authors ((ALMEIDA, 2008) (VELOSA, 2006) (RODRIGUES FARIA, 2004) (Kieling, et al., 2009), ((AMPATZIOGLOU, et al., 2010)) reported that increasing the fineness of gray, and thus increasing its surface area, can contribute to increase the pozzolanic reactivity. Thus, it was felt that it should proceed to grind the ash with the aim of reducing the size of their particles. The milling process was controlled through the analysis of particle size of samples of ash dried in an oven at 60 °C until constant weight. The screening was performed on samples of 500 g ± 0.1 g for 10 minutes using the sieves 500 micrometres 250 microns, 125 micrometres 75 micron and 63 micrometers.

The grinding and sifting process comprised three phases:

- Screening of rice husk ash commercial (C) through the sieve opening 500μm and 250μm, for a period of 10 minutes. The ash in the last 500 micrometre sieve opening was called CP500 and passing the sieve 250μm was called CP250 (Figure 2.3);
- CP500 milling ash by means of the wear machine in Los Angeles, with the aim of increasing the fineness of the ash using six steel balls;
CP500 milling ash by means of the wear machine in Los Angeles, with the aim of increasing the fineness of the ash using 10 steel balls.

Ash CP500 was introduced into the drum wear in Los Angeles and subjected to the wear during a total period of 75 minutes, divided into periods of 15 minutes. From 15 to 15 minutes, proceeded to evaluate the size of rice husk ash. The milling was performed using steel balls with a mass of whose 400g/sphere. The number of balls used during milling was not always the same. It began with six grinding steel balls, and these were used between 0 minutes and 45 minutes of grinding. The particle size was measured after each 15 minutes of grinding, i.e., at 15 minutes (CPm15), 30 minutes (CPm30) and at 45 minutes (CPm45). From then proceeded to grind using 10 steel balls, which is the total number of balls that were used before the end of the trial (and CPm60 CPm75). Figure 2.4 shows the evolution of particle size of CP500 as a result of its milling for 15, 30, 60 and 75 minutes of milling, respectively, CPm15, CPm30, and CPm60 CPm75.

The use of 6 steel balls ended after 45 minutes of milling, due to the fact that from 30 to 45 minutes, grinding held not to have changed in a relevant way to a particle size of CPm30. Figure 2.4 shows the effect of 30 minutes of grinding on particle size of CP500.

It was the failure to register change of particle size of ash keeping the ball 6 and increasing the time, which meant that if you increase the number of balls in the Machine from Los Angeles. So we went from 6 to 10 balls, which are used up to 75 minutes of grinding, as stated above. This point represents the transition from the 1st to the 2nd stage of the milling process. In a general, the first stage of milling was responsible for increasing the quantity of ash with dimensions between 0.125 mm and 0.500 mm.
Comparative analysis of the ash before the milling process (CP500) and obtained at the end of this process (CPm75) shows that this process was effective with respect to the reduction in the size of ash particles.

After the milling process, the ash was fractionated by sieving CPm75, which used the sieve 500mm, 250mm, 125mm and 75mm.

The gray morning in CPm75 sieves above, leads to the synthesis of CM500, CM250, CM125 and CM75, which corresponds to the material passed through the sieve CPm75 500mm, 250mm, 125mm and 75mm, respectively.

**GRAPH 2.5 –CPm75 CM500, CM250, CM125 E CM75 GRADING CURVES**

### 3. CURE CONDITIONS

The selection of cure conditions and period of stay in the molds of the specimens was carried out with general guidance on the requirements of ASTM 593-06 and "Specification for the Provision and Receipt of pozzolans.

ASTM 593-6 states that the demolding of the specimens must be held seven days after preparation and should be retained until the mold release in a chamber with water vapor at 54 ± 2º C. Under this standard, after demolding, specimens should be kept up to date in a test environment at a temperature of 23 ± 2 ºC and a relative humidity of 95 to 100%.

The "Specification for the Supply and Receiving pozzolan", states that the specimens must be kept in the molds for a period of 24 to 72 hours in an environment with 20 ºC ± 1 ºC and 95% relative humidity, was pointed out that the molds should be covered by a metal plate. According to this document, after demolding the specimens must be kept immersed in water at 20 ºC ± 1 ºC until testing.
In this study, all samples were prismatic uncaser 7 days after their execution. All pieces of the mortar of lime used as reference in this were kept before and after demolding, an environment temperature of 23 °C ± 2 °C with relative humidity of 50% ± 5%. These conditions are referred to here as dry cure.

The prismatic specimens for the assessment of the influence of particle size on ash pozzolanic reactivity, were kept in an environment at 20 ± 2 °C with a relative humidity of 95 to 100%, from production to date of trial. These conditions are referred to here as a wet cure.

The prismatic specimens for the assessment of the influence of curing conditions were studied in the following three curing conditions:

- **dry cure** - **CS** - temperature 23 °C ± 2 °C and relative humidity of 50% ± 5%;
- **wet cure** - **CH** - temperature 20 ± 2 °C and relative humidity of 95 to 100%;
- **healing environment** - **CA** - preserving specimens obtained at room temperature, not air-conditioned, from production to date of trial.

The experiments were undertaken during the months of July and August 2010, with the temperature in the laboratory to the date of the dents was around 35 °C.

### 4. TEST PLAN DESCRIPTION

Mortars production was based on procedures in defined by EN1015-2, 1998 (EN1015-2, 1998).

Prismatic specimen preparation was based in the following specifications: LNEC E29-1979 and NP-EN 196-1. Each mixing allowed the execution of a cast of three prismatic specimens with 160 x 40 x 40 [mm].

All mortar show consistency in the order of 165 ± 5mm and the following composition: 180g of hydrated lime, 360g of rice husk ash, river sand 1480g (dash weight of about 1:2:8.

The hardening of mortars made exclusively from lime is processed by carbonation, a process in which the presence of carbon dioxide is fundamental. Since the diffusion of CO2 is very slow in saturated environments, the curing of the mortar made solely based cal (Cal) was carried out always with an ambient relative humidity and temperature, respectively, 50% ± 5% and 23° C ± 2° C.

### 5. POZZOLANIC REACTIVITY – ASH FININESS INFLUENCE

Table 5.1 presents the ratio water / binder mixture used in all mortars studied, the values of scattering, bulk density, water retention and purge.
Figure 5.1 presents the values of water / binder mixture used in the formulation of mortars and Figure 4.8 represents these values as a function of the maximum size of the ash, it is considered as the maximum size of the gray mesh sieve through, which it proceeded to the splitting of CPm75 to obtain CM500, CM250, CM125 and CM75, respectively 500μm, 250μm, 125μm and 75μm.

The analysis of the values of scattering and the reasons / water (mixed ligand) of the mortars made with the corresponding gray with lime mortar, it appears that the incorporation of ash triggered a reduction in the amount of water which are necessary to obtain a scattering de165mm order, regardless of their size. Mortars made with rice husk ash, reducing the size of the ash, particularly below 250μm, led to a reduction in the amount of water needed to obtain the desired consistency, Chart 5.2.

The list of values is consistent with what others have had, when added fly ash and found that this addition allowed for the same consistency for spreading, decrease the amount of water used in mixing, ((SANTOS, 2009), (PINTO , et al., 2010), (LANGE, 1997)).
With the mortar exception A500, the presence of ash was responsible for reducing the water retention capacity of lime mortar, Figure 5.3. The values obtained for water retention in mortar A250, A125 and A75 indicate the reduced capacity of water retention of mortar made with gray with increasing fineness of the ash, Figure 5.3. It is possible to conclude that by observing the Chart 5.4, the amount of water exuded increases with the size of the gray and lowering the degree of fineness.

Increasing the fineness of the ash was accompanied by increased density of the mortars, which could be explained by the existence of a lower volume of voids occupied by the particles of ash smaller and reducing the water / binder mixture. Crossing these values with the evaluation of the bleeding, it appears that the larger particle size, the greater the need for mixing water and the greater the amount of water exuded.

The Table 5.2. presents the characteristics of hardened mortar in the states studied.

### TABLE 5.2 – SUMMARY TABLE OF RESULTS OBTAINED IN PHASE 1

<table>
<thead>
<tr>
<th>MORTAR</th>
<th>WATER/ MIXED LIGAND RATIO</th>
<th>COMRESSIVE TESTS [MPA]</th>
<th>FLEXURAL TESTS [MPA]</th>
<th>ULTRASONIC PULSE VELOCITY [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>14 days</td>
<td>28 days</td>
<td>14 days</td>
</tr>
<tr>
<td>Lime</td>
<td>1.83</td>
<td>0.3</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>A500</td>
<td>1.15</td>
<td>2.7</td>
<td>4.7</td>
<td>1</td>
</tr>
<tr>
<td>P500</td>
<td>1.15</td>
<td>-</td>
<td>4.9</td>
<td>-</td>
</tr>
<tr>
<td>A250</td>
<td>1.15</td>
<td>3.4</td>
<td>5.6</td>
<td>1.4</td>
</tr>
<tr>
<td>P250</td>
<td>1.15</td>
<td>-</td>
<td>5.3</td>
<td>-</td>
</tr>
<tr>
<td>A125</td>
<td>1.14</td>
<td>3.6</td>
<td>5.7</td>
<td>1.4</td>
</tr>
<tr>
<td>A75</td>
<td>1.09</td>
<td>3.5</td>
<td>6.2</td>
<td>1.5</td>
</tr>
</tbody>
</table>
The evaluation of the reactivity of the fineness of the ash of rice husk was carried out by determining the compressive strength and bending of the lime mortar, A500, P500, A250, P500, A125 and A75 at 14 and 28 days old. Prior to the evaluation of the resistance, was done also to assess the speed of propagation of ultrasound.

Figure 5.5 shows the average values of tensile strength in bending and compression at 14 and 28 days old, of the studied mortars. This figure shows ash reactivity and the influence of the fineness of the ash used as the gray mortar and proved clearly superior to the mechanical strength of lime mortar and there was an increase of mechanical strength with increasing fineness of the ash. The speed of ultrasound was sensitive to increasing the pozzolanic reactivity shown by the gray with the increase in its fineness, A500, A250 and A125, Figure 4.13.
As stated previously, the set of tests to be experimental at this stage of the campaign was to assess the influence of particle size on ash and pozzolanic action based on the results obtained selecting two formulations of lime mortar with gray coat of rice used to study the influence of curing conditions.

6. POZZOLANIC REACTIVITY – CURE CONDITIONS INFLUENCE

The aim of this part is to assess the influence of curing conditions of lime mortars with incorporation of rice husk ash with different particle sizes, in which the pozzolanic action became manifest. For this three mortars were used: a mortar of lime mortars taken as reference named “Cal” (without the addition of CCA) and two mortars, CP500 (lime mortar with gray passing the sieve 500μm) and CP250 (mortar Lime with ash passing the sieve 250μm).

The characterization in hardened was performed at 28 days old mortars and was based on the study of prismatic specimens of samples where mortars were applied as coating layers of clay bricks.

Curing conditions adopted in this study are: dry (CS), wet (CH) and in a laboratory environment (CA). The mortar of lime, used as reference, was kept in a dry environment (dry cure) to its characterization at 28 days of age.

The mortars studied (P500 and P250) were produced with a ratio by weight 1:2:8 – lime:pozzolan:aggregate.

The main test for determining the open porosity (Figure 6.1 and Figure 6.2) and density aims to realize the influence that the various constituents of the mortars take on the hardened and therefore understand the influence of pozzolanic reaction of these characteristics.
In general, observing the Chart 6.1 and Chart 6.2, it can be said that compared to the reference mortar of lime, whatever the size and condition of healing, specimens in which enters the formulation CP500 and CP250 have porosity open top.

Noting the mortars with the addition of CP, those undergoing the wet cure, in two particle sizes studied (P500CH and P250CH), are lower in the dry cure (P500CS and P250CS) and environment (and P500CA P250CA) which may be due is because it is a more compact mortar. These results may be associates the fact that in dry curing environment and the evaporation loss of water to give way to more rapid healing than in wet.

In the case of wet curing water loss by evaporation does not occur in the same way or with the same speed. Thus, the mixing of the water contributes to the pozzolanic reaction between silica and alumina in the ash of rice hulls and calcium hydroxide in lime, for the formation of hydraulic compounds. When this process of water loss through evaporation, which leads to the existence of pores, occurs in addition to being much less than the amount that evaporates in the other cures, there is a time when they are already guaranteed consisões sufficient mechanical strength which causes the pores to remain with the volume equal to that occupied the mixing water.

The higher porosity in prismatic specimens subjected to dry and cure environment may be associated with the least amount of water arriving to participate in the pozzolanic reaction since the time it takes to giving the evaporation is less than it takes to make you give pozzolanic reaction. So there is a greater amount of water to evaporate and therefore a higher percentage of pores.

The test for determining drying after immersion in water to assess the capability of removing water by evaporation from a mortar. This feature allows you an idea of the permeability of the same and so characterize it as to its durability.
This test assesses the ability of a mortar to water loss by evaporation or drying after being immersed in water and being subjected to a controlled environment.

In this test means test pieces were conditioned to an ambient temperature of 23 ° C ± 2 ° C and relative humidity of 50% ± 5%.

The analysis of Chart 6.5 and Chart 6.6 shows that it is the first 5 days of drying that occur the most important differences, differences that do not show progress on the drying kinetics of the mortars studied very significant.

Having observed the influence of curing conditions on the results of tensile strength to compression (Figure 6.7) it appears that the wet cure has values substantially above those of other cures. Comparing then cures and dry environment, by examining the graph it appears that the specimens subjected to dry curing had higher values obtained for the samples submitted to CA. Also in this situation to higher reactivity of ash logs into mortars made with the smallest particle size (P250).

Regarding the results of resistance, it appears that mortars with addition of rice husk ash with higher modulus of fineness (P250) in all curing conditions studied, show flexural strength (Figure 6.8) slightly higher when compared with those of lower fineness modulus under the same curing conditions.
Analyzing then the influence of curing conditions on flexural strength, it appears that the values obtained for similar formulations but subjected to different curing environments such as the dry cure and healing environment, exhibit similar values of flexural strength. The approximation of results may have been caused by a similarity in the conditions they were subjected to the test pieces for your healing, since they met in a dry cure and others in healing environment, whereas in lab environment were felt at high temperatures (the order of 30 to 35) given the period of the year they were executed (Summer). Since the samples which were subjected to wet curing, there flexural strength values than the values of the other cures.

In short, it can be said that mortars made with sizes of less gray (P250) are more sensitive to the results of flexural strength when they enter into the formulation has higher ash particle size and therefore smaller surface area (P500). So, the gray afternoon at 250μm sieve is more reactive than the last in a sieve with greater openness. The conditions for healing, it is concluded what had been described in Chapter 2 of this work, the higher the moisture content more favorable to give the pozzolanic reaction.

These results are consistent with those obtained by (SOUZA COUTINHO, 1958) who studied lime mortar with added pozzolans of St. Anthony, with different curing conditions, keeping the specimens in water up to different dates: one up to 28 days and others up to 90 days. This study found that the shorter the time in water less resistance obtained. According to Sousa Coutinho initial rapid loss of water prevents the pozzolanic reaction is complete, since it is a slow reaction and evaporation is a relatively fast process. The rapid evaporation at a stage where there is still some freedom of movement within the mortar causing constant interior alterations and therefore no power caking properties and consequently the resistance characteristics. By analogy to the cure conditions studied in this paper realizes that one can also justify the lower strength of
specimens in dry and healing environment for the occurrence of a premature failure of water to promote pozzolanic reaction.

As mentioned when describing the test for assessing the speed of ultrasound on specimens prismatic effectively to cure wet-recorded higher values, independent of particle size of ash used (Graph 6.9). The discrepancy between propagation speeds for the two types of mortar placed in moist cure (P250 and P500 CH CH) but there is not very noticeable. Ash mortars produced with the highest amount of fines (P250) gives rise to speeds of propagation of ultrasound in prismatic specimens superior to those recorded for mortar specimen in a P500 CH.

There is a general form of the test pieces with rice husk ash with a higher fineness (P250), have higher speeds, when compared with the sample from the other gray (P500) subjected to the same cure conditions.

These results are in agreement with the study by (Alves, et al., 2010) in which the author found that the ultrasound test is affected depending on the cure and there is greater difference to the wet cure.

The values obtained for dry and cure the condition and environment may result of cracking in existing samples.

Graph 6.10 and Table 6.1 presents a compilation of the results obtained on the mechanical characteristics for prismatic specimens to this stage for the two particle sizes and different ash studied curing conditions analyzed.

As can be seen, it is not possible to draw a parallel between the tensile strength and speed of compression ultrasound. Theoretically it should be verified that mortars with values greater originate breakage under compression speeds of ultrasonic higher. In this case it is not clear
what that finding may be explained by the amount of water present at the time of trial in each mortar.

<table>
<thead>
<tr>
<th>Mortar</th>
<th>Relation water/(lime+ash)</th>
<th>Compressive Strength [MPa]</th>
<th>Flexural Strength [MPa]</th>
<th>Ultrasonic pulse velocity [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime</td>
<td>1.83</td>
<td>0.5</td>
<td>0.2</td>
<td>1500</td>
</tr>
<tr>
<td>P500 CH</td>
<td>1.15</td>
<td>4.9</td>
<td>2.3</td>
<td>2592</td>
</tr>
<tr>
<td>P500 CS</td>
<td>1.15</td>
<td>4.0</td>
<td>2.0</td>
<td>865</td>
</tr>
<tr>
<td>P500 CA</td>
<td>1.15</td>
<td>3.5</td>
<td>2.0</td>
<td>876</td>
</tr>
<tr>
<td>P250 CH</td>
<td>1.14</td>
<td>5.3</td>
<td>2.4</td>
<td>2546</td>
</tr>
<tr>
<td>P250 CS</td>
<td>1.14</td>
<td>4.1</td>
<td>2.1</td>
<td>899</td>
</tr>
<tr>
<td>P250 CA</td>
<td>1.14</td>
<td>3.6</td>
<td>2.1</td>
<td>1011</td>
</tr>
</tbody>
</table>

**TABLE 6.1 – SUMMARY TABLE OF RESULTS OBTAINED FOR 28 DAYS FOR DIFFERENT CURING CONDITIONS STUDIED**

7. **CONCLUSIONS**

The rice husk ash used to make this a visually presented study heterogeneity in its color and size of particles, verifying that the larger particles had a darker shade. This may be due to poor ignition at which the rice husk was subjected in the process of transformation to gray. Asked adequate references to the topic showed that this difference of tone could indicate the presence of particles rich in silica and other carbon-rich. By chemical analysis of samples of gray and gray commercial sieved passing the sieve with 500 micron opening noticeable increase in the percentage of silica. This justifies the need to carry out the screening in order to alleviate the evil calcined particles, or large ones.

The influence of curing conditions of lime mortars with the addition of rice husk ash was carried out by assessing the reactivity of the ash including the evaluation of mechanical strength characteristics and the physical characteristics.

It was found during the various phases of this study that increasing the fineness of the ash used in the mortars had resulted in a reduction of the amount of water used for mixing the same so that if he achieved a pre-defined consistency. By visual inspection and by measuring the amount of water exuded concluded that the water used was still greater than required for kneading. These results may be indicative of the fineness of the ash is responsible for the amount of water retained by mortars, being greater the lower the degree of fineness.

During the process of mixing was found that with the passage of time increased the workability of the mortar, which can be stated that if the mixing time was greater than would be achieved for the same consistency set, decrease the amount of water used . This was also observed by (RODRIGUES FARI A, 2004) which states that "in lime mortar workability depends in large part to a mixing energy, vigorous and prolonged. Lime mortars should be crushed before (so to mature along with the lime sand) and just be stirred immediately before use)."
The values of tensile strength to compression and bending, as well as the speed of propagation of ultrasound, showed the influence of the fineness of the ash and the curing conditions, since there was an increase of mechanical strength with increasing fineness of Gray and conditions for thermo-hygrometer with higher levels of humidity.

The speed of ultrasound and was sensitive to increasing the pozzolanic reactivity shown by the gray with the increase in its fineness.

The results obtained by open porosity and water absorption are indicative of the behavior of mortars due to the presence of water, since they mirror the larger amount of water or a mortar which penetrates the ease with which penetrates and consequently the capacity of the dry mortar that amount water. Thus was demonstrated the influence of curing conditions on pozzolanic reactivity.

Generally refers to when applying lime mortars with pozzolanic additions, including the ash of rice husk should be examined with greater caution and cures dry environments (when environments are characterized by high temperatures and low humidity). This is because the water used for mixing evaporates rapidly, which goes against the process that pozzolanic reaction is slow. The reaction between silica and alumina from rice husk ash and calcium hydroxide in lime is a reaction that occurs, as stated above, slowly and as such, to submit to a mortar with the components of such a condition of this kind of healing power will be finished before the the process of time.

The rapid loss of water by evaporation leads to non-occurrence of the formation of hydraulic compounds, or aluminates and hydrated calcium silicates and early carbonation of lime. Thus, one of the components used in mixing pozzolanic not play the role for which they "thought" and assume a role of an inert binder, since its only function is to fill the gaps.

It should be noted that the more rapid the evaporation of mixing water will last less time and less pozzolanic reaction will be utilized components. One can also assume that the larger the particle size of pozzolan used the greater the need for water to be used and therefore will be slower to react.

As we could see the wet cure everything favors the pozzolanic reaction since it allows the loss / evaporation of water is slower and so coincident that time to give such a reaction. It will be interesting to study means of on-site application of lime mortars with the addition of rice husk ash ensuring moist curing conditions.

In summary, the presented study showed the reactivity of rice husk ash studied the effect of curing conditions and the strengthening of its features when applied lime mortars subjected to wet curing conditions and the interest of continued study its use as a pozzolanic addition in lime mortar.
8. BIBLIOGRAFY


