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Evaluation of Pozzolanic Activity of Banana Leaf Ash

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ABSTRACT

The present work is aimed at verifying the presence of pozzolanic activity in the deriving ash of the banana tree leaf. In this case, the samples have been collected after combustion in an oven and worn out in mill of balls in the times of (0.5; 1; 2 and 3) . The index of pozzolanic activity of the banana tree leaf ash was determined by means of the established whitewash as in norm NBR 5751/92 and by means of the cement, as norm NBR 5752/92. The results have shown that the ash of the banana tree leaf presented pozzolanic activity, insuring the prescribed minimum requirements, being these superiors 40% for whitewash and 17% for the cement.

KEYWORDS

Banana leaf ash, Pozzolan, Pozzolanic activity**.**

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1 INTRODUCTION

The use of alternative materials in construction has been increasingly intense. MARGON and ROCK (2003) describe that it is due to the large volume of materials consumed and the enhancement of its use in the construction industry and in environmental protection area. JOHN (2000) in their study indicate that the construction supply chain is already the largest recycler of the economy, since it has great potential to increase the volume of materials to recycle, consider the amount and characteristics of waste that consumes. Among the various types of construction waste that can employ highlights are the pozzolanic materials, which are characterized by possessing reactive activity when in contact with compounds of cement.

The use of pozzolanic materials combined with cement and lime to obtain mortar and concrete are durable and economical parts of the new technologies that ensure improvement in their characteristics. The implementation and use of mineral admixtures in mortars and concretes have been widely studied in recent decades in order to promote the improvement of the mechanical and durability of composites. Among them that stand out are the ash of rice husk ash and calcinated clay (NEVILLE, 1997; SOUZA, 2003; Santos, 1992).

Similar to this, buildings have shown a great potential to use waste from other industrial processes. Their use of alternative materials favours not only the correct composition, but also provides technically feasible solutions to technical analysis. The use of these materials is intended to obtain quality, properties, and satisfactory characteristics to be employed while seeking new sources of raw material (MARGON and ROCHA 2003).

The possibility of developing a new material with raw materials reused were studied and add improvements in the technical aspects for the mortar and concrete. In this context the need for the use of banana leaf ash as additive in the production of mortar and concrete is seen that the cement is the most consumed material in the world except water is concrete. However, the increase in the usage of these residues promotes the study of their applications and is a necessity, which not only contributes to the emergence of a new technology, but also a material focused on promoting sustainable practice.

2 MATERIAL AND METHODS

2.1 Materials

To make the mortar for the testing of pozzolanic activity index with lime and cement, we used the following inputs: lime, cement (type CPII - F 32), banana leaf ash, sand and water normalized.

2.2 Methods

The experimental program was based on a sequence of steps, aimed at clarifying the objectives, being:

- Characterization of the banana leaf ash by Diffraction and X-ray fluorescence, to identify the chemical nature present in the material;
- Strength of mortars with and without mineral admixtures;
- Trials to assess mechanical and rheological properties of mortars in the fresh and hardened state.
- Developing a database with statistical evaluation of results and performance of the product.

The experimental steps are described in Figure 1.

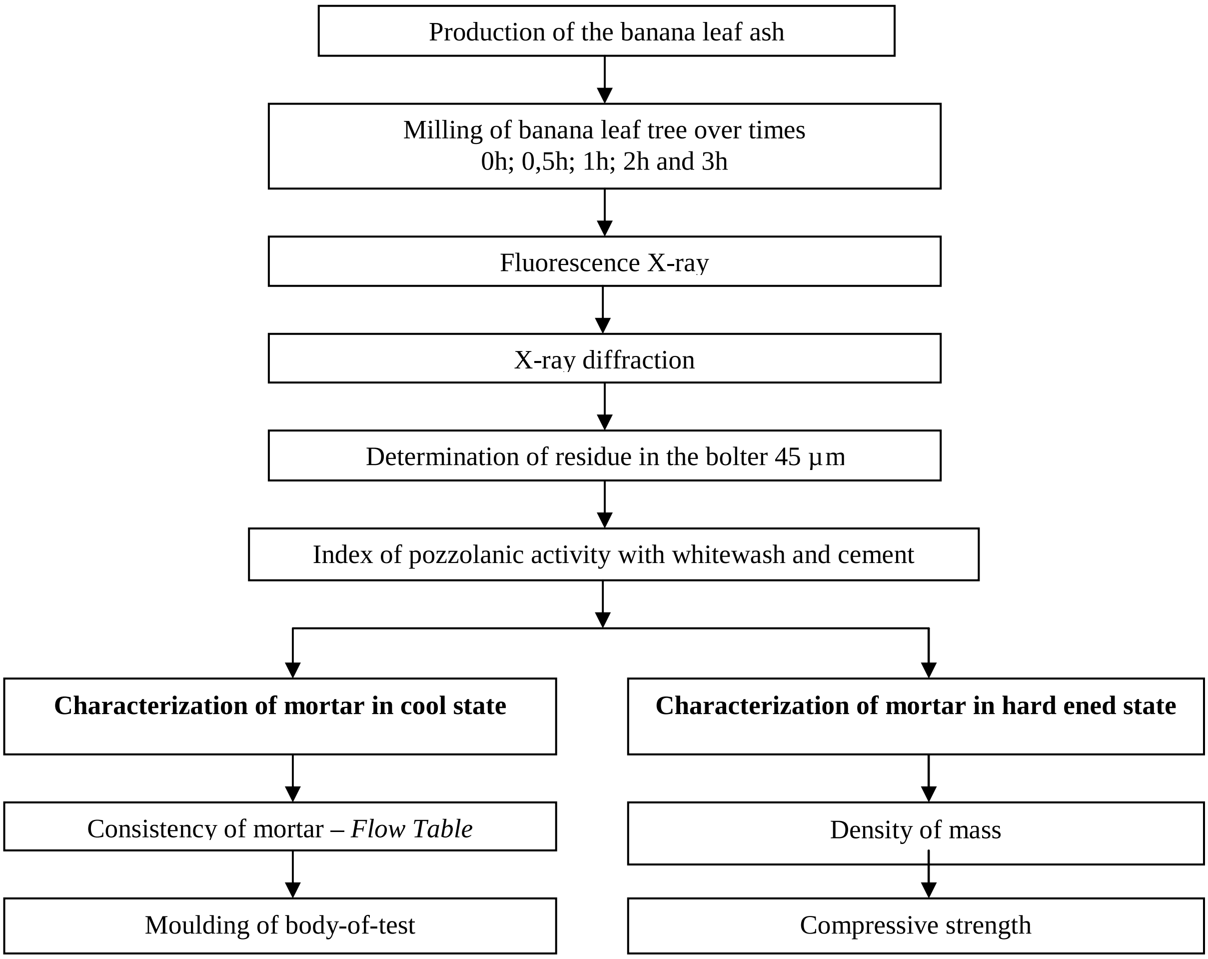

Figure 1. Stages of assay of the Experimental Program.

3 RESULTS

3.1 Production of banana leaf ash

Banana leaves of different lengths and weights were burned in a furnace at different temperatures. The first thermocouple was placed inside the furnace at a distance of 120 cm from the base showing a temperature of 290 ^oC. The second thermocouple positioned at a distance of 90 cm from the base showing a temperature of 850 ^oC. The third thermocouple was positioned at 60 cm from the base and had a temperature of 350 ^oC, and the fourth thermocouple positioned in the oven had a temperature of 85 ^oC.

The variation in firing temperature for the four thermocouples was due to a ventilation system injecting air to the furnace; this consisted of a 100 mm diameter pipe with a mini fan (Cooler RPM/12 3500 V) . As air was injected 60 cm above the bottom layer of gray that lies at the bottom has to be cooled slowly to be collected later.

Correlating the data on the percentage of ash of banana leaf with percentages of ash described by Mehta (1992) and Cincotta and Kaupatez (1988) has the results as shown in Figure 2. Note in Figure 2 that the percentage of banana leaf ash (10.57%) generated during the burning of dried material was equivalent to the same amount of gray leaf of wheat (10%) and leaf stalk of sunflower (11%), matching the class E as shown in NBR 12653/92 and class C according to ASTM 618-95. Along with that, on average, the feet of banana produced approximately 1343.3 grams of dried leaves, which represented a potential national annual average generation of 895 309 500 tons of dried leaves and

94634210 tons ash, corresponding to a plantation of 500,000 hectares and an average production of 1333 plants per hectare.

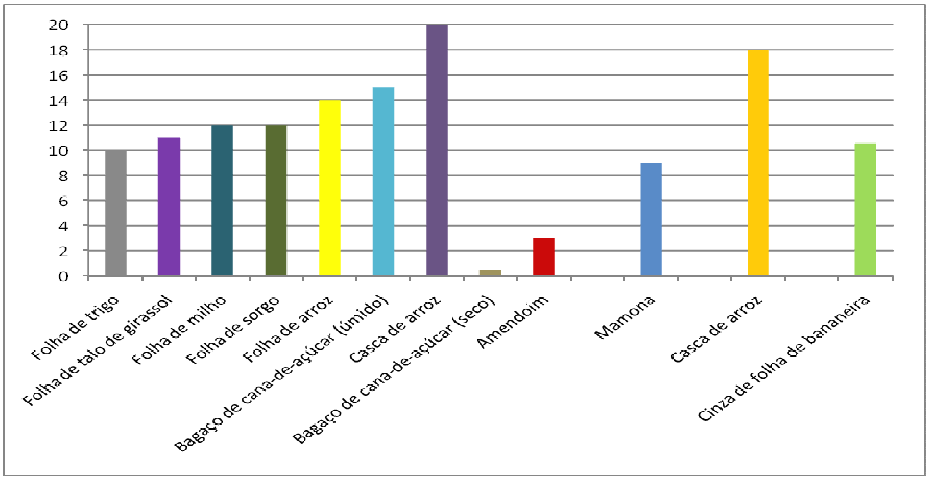

Figure 2. Generated gray amount during the burning for the diverse materials.

3.2 - X-ray Diffraction

The results of chemical analysis by X-ray diffraction can be found in Figure 3. Calcite and quartz were found in the resulting ash, which reduces the pozzolanic activity of the material in question because they are materials of little or no reactivity. Probably the calcite was obtained due to burning and the slow cooling of the ashes of banana leaf inside the oven at temperatures of 80 º C until its withdrawal. The diffractogram also showed small peaks with 2:03 Ǻ and 2.34 Ǻ which refer to the port samples.

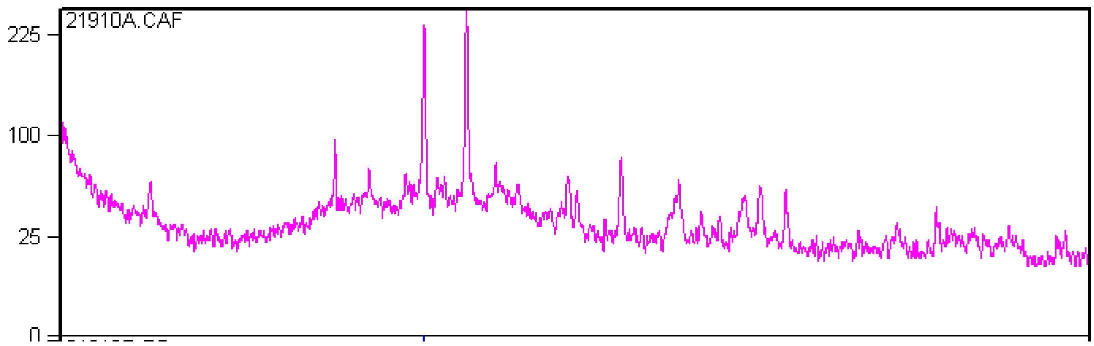

Figure 3. Diffraction of rays X of the banana tree leaf ash.

3.3 Determination of the residue in bolter 45 µm - NBR 9202/85

The determination of the residue in bolter 45 µm was stablished according to parameters of NBR 9202/85 and results presented as Figure 4.

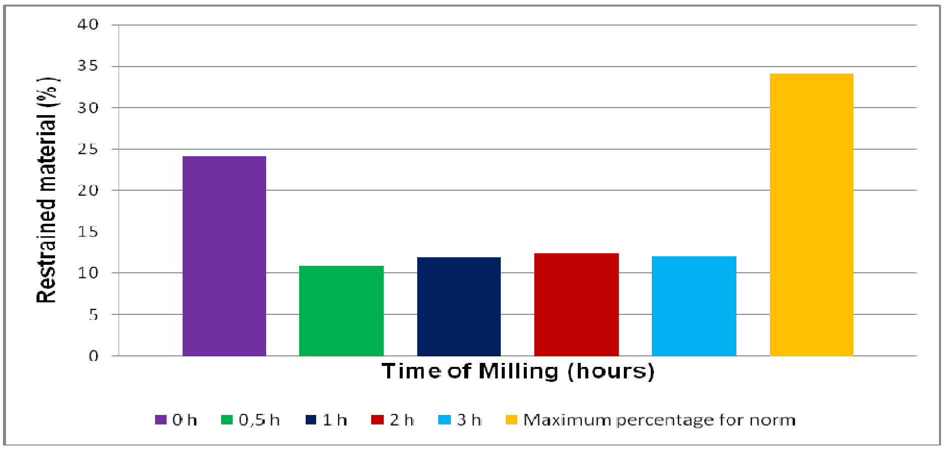

Figure 4. Percentage of restrained material in the bolter 45µm for each time of milling.

The results showed variations in the order of 24.1%, 10.9%, 11.9%, 12.4% and 12.0% for (0, 0.5, 1, 2 and 3 h) in the percentage of material retained on the sieve 45 micrometres with values below the permitted maximum of 34% by NBR 12653/92.

This factor may have been due to the particles after burning furnace already having a small footprint. Analyzing the results of the quantity of material retained on the sieve 45 micrometres before and after grinding times by the statistical method ANOVA, it was noted that the p-value = 0.838618 was greater than the significance level of 0.05, well as F <Fcrítical, demonstrating that the results do not present statistical differences, as shown in Table 1.

Table 1. Analysis of Variance (ANOVA) for the restrained material in bolter 45 µm.

Source of the variation	SQ	gl	MQ	F	value-P	F critical
Between groups	1,87E-05	2	9,33E-06	0,179487	0,838618	4,256495
Inside of the groups	0,000468	9	0,000052			
Total	0,000487	11				

Notes: SQ – it adds square shaped; gl – degree of freedom; MQ = SQ/GL – average square shaped; F – calculated value de F; Fcrítical – priced value of F for level of significance 0,05.

3.4 Specific mass of the ash of banana leaf - NBR NM 23/01

The results of density for milling times of 0, 0.5, 1, 2 and 3h are shown in Figure 5.

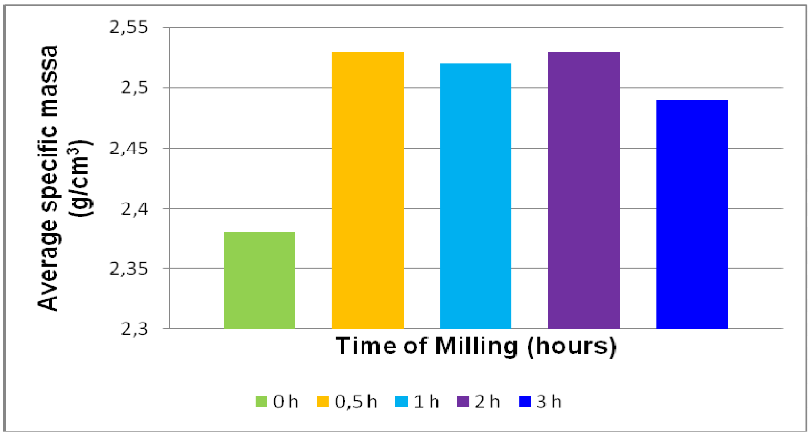

Figure 5. Specific mass of banana leaf leached ashes.

It was observed that the difference between the values of density when compared with the ash without grinding stood at 6.3%, 5.9%, 6.3% and 4.6% for milling times of 0.5; 1; 2 and 3 h, respectively. The values of the density of the samples showed high peaks and its variance resulted in 0.00333. It can thus be considered equal. Based on the data obtained an analysis was carried out of the variance in order to verify whether the values of density for different milling times were, on average, different; their data are presented in Table 2.

Table 2. Analysis of the variance for the specific mass of leached ashes.

Source of the variation	SQ	gl	MQ	F	value-P	F critical
Between groups	0,000117	2	5,83E-05	0,132075	0,877942	4,256495
Inside of the groups	0,003975	9	0,000442			
Total	0,004092	11				

Notes: SQ – it adds square shaped; gl – degree of freedom; MQ = SQ/GL – average square shaped; F – calculated value de F; Fcrítical – priced value of F for level of significance 0,05.

With a reliability level of 95% it was concluded that significant differences of specific mass had not existed statistical enter the different times of milling, a time that the value-p = 0.878 was greater that the level of significance of 0.05. Observing the values of F and Fcrítical, F was < Fcrítical, thereby accepting the hypothesis of the equality and concluding that there had not existed differences in the average between groups.

3.5 Method of air permeability - method Blaine - NBR NM 76/98

The data obtained from the results of air permeability in Figure 6.

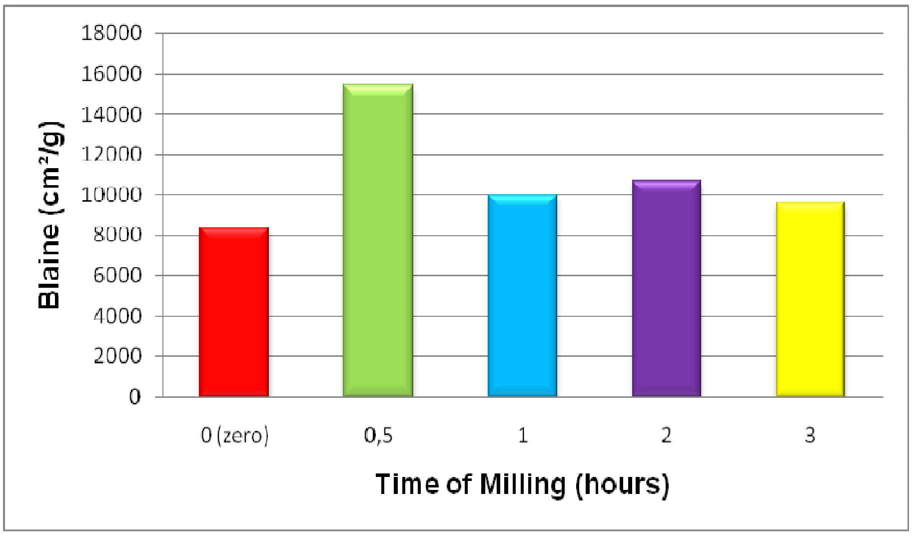

Figure 6. Variation of the Blaine fineness index for milling time.

It was observed that the values of Blaine for the various mills were situated close to the values of silica (13,000 cm^2/g) described by Holland (2005). The decreased levels of Blaine may have been due to fragmentation and better packing of particles of ash.

3.6 Pozzolanic activity index with lime - NBR 5751/92

The results obtained from tests for pozzolanic activity index with lime are shown in Figure 7.

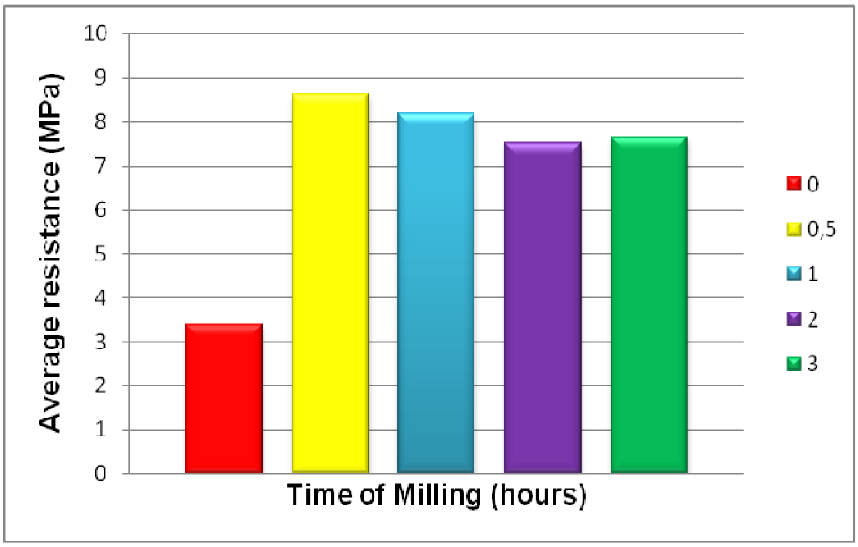

Figure 7. Index of individual pozzolanic activity for the different millings.

The increase in strength of body-of-proof banana leaf ash in 153.98% 141.88% 121.53% and 125.07% after passing through the process of grinding in ball mill by periods 0.5, 1, 2 and 3 h, may have been due to a possible reduction of particle size as shown in the test of air permeability (Blaine method).

Although the ash without grinding has not reached the minimum strength of 6 MPa at 7 days as prescribed by standard grinding NBR5751/92 caused reduction of the particles and increased its reactivity.

3.7 Pozzolanic activity index with cement - NBR 5752 / 92

The test results of pozzolanic activity index with cement are presented in Figure 8.

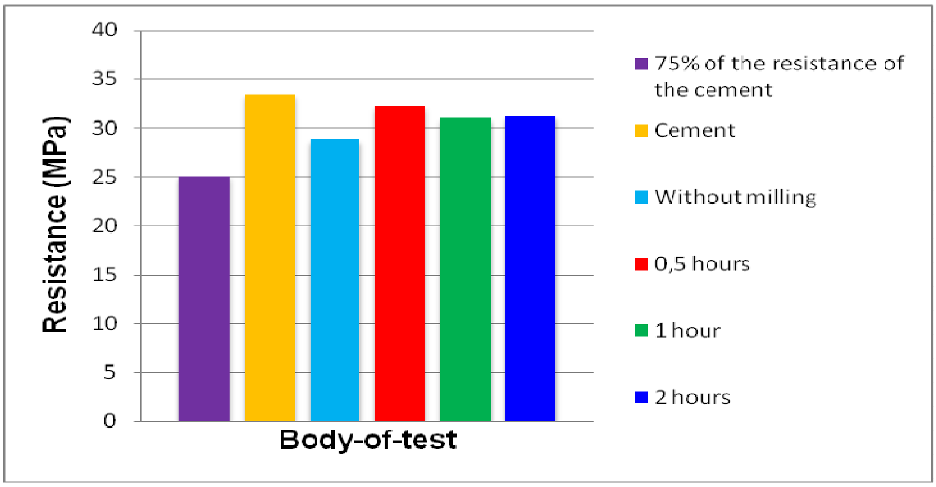

Figure 8. Pozzolanic activity of the leaf ash of banana tree with cement.

The values of pozzolanic activity of banana leaf ash with cement were higher than 10.46%; 21.41%; 17.81%; 18.41% and 10,46%, respectively for the times 0; 0 5; 1; 2 and 3 h. The NBR 5752/92 recommended a minimum of 75% of the reference mortar for 28 days of age. It was noted also that despite the grinding times values were found to be very close to mechanical compression of the reference mortar which showed a considerable ash pozzolanic activity of banana leaf. Based on data obtained an analysis of variance (ANOVA) was performed to investigate the statistical differences in the results of pozzolanic activity index with cement for different times of grinding of banana leaf ash, according to Table 3.

Table 3. Analysis of Variance (ANOVA) for the IAP with cement.

Source of the variation	**SQ**	**gl**	**MQ**	**F**	**value-P**	**F critic**
Between groups	96,2696667	5	19,25393333	23,96755187	1,3141E-08	2,620654
Inside of the groups	19,28	24	0,803333333			
Total	115,549667	29				

Notes: SQ – it adds square shaped; gl – degree of freedom; MQ = SQ/GL – average square shaped; F – calculated value de F; Fcríticcal – priced value of F for level of significance 0,05.

As seen in Figure 8 and the results of analysis of variance, the mechanical strength to mortars dosed with ashes in the ground times (0,5; 1; 2 and 3) h did not differ significantly from the values obtained by cement mortar since the p-value = 1.3141 E-08 was lower than the significance level of 0,05.

4 CONCLUSIONS

The banana leaf ash when burned at temperatures of 850 °C and subsequently milled in a ball mill showed pozzolanic activity above 40%the minimum stipulated by the NBR 5751/92 and 17% for the NBR 5752/92 standards. The optimum time for grinding banana leaf ash is 30 minutes. The banana leaf ash without grinding presented no activity with lime pozzolanic established by the NBR 5751/92. Also, as a result brought the appearance of crystals of calcite and silica in their composition. For relatively short times of milling, the reduction of the crystals sizes generates pozzolanic activity. It has been proved statistically that the pozzolanic activity of banana leaf ash with cement for various times of milling did not differ. It was concluded so that the ash originated from the burning of the banana leaf shows pozzolanic activity and can be used with addition in the cement, concrete and mortar.

REFERENCES

John, W.M. Reciclagem de Resíduos na Construção Civil - Contribuição à Metodologia de Pesquisa e Desenvolvimento. Tese de Livre Docência. Escola Politécnica da Universidade de São Paulo. 102p. São Paulo, 2000.

Margon, P.; Rocha, J. Argamassas com cinzas de carvão mineral dosadas por curva granulométrica. V SBTA – Simpósio Brasileiro de Tecnologia em Argamassas. São Paulo, 11 à 13 de junho de 2003.

Margon, P; Rocha, J. Argamassas dosadas com cinzas de carvão mineral de termelétrica. V SBTA – Simpósio Brasileiro de Tecnologia em Argamassas. São Paulo, 11 à 13 de junho de 2003.

Neville, A.M. Propriedades do Concreto, 2ª. edição, Editora PINI Ltda., São Paulo (1997).

Souza, P. S. L. Verificação da influência do uso do metacaulim de alta reatividade nas propriedades mecânicas do concreto de alta resistência. Porto Alegre. Tese de doutorado. Programa de Pós-Graduação em Engenharia Civil da UFRGS, 2003. 203p.

Santos, P.S. Ciência e tecnologia de argilas. 2ª ed. São Paulo: Edgard Blücher, 3v, 1992.