EVALUATION OF THE INFLUENCE OF THE ADDITION OF WASTE FROM A WATER TREATMENT PLANT ON CERAMIC TILE CHARACTERISTICS

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1. INTRODUCTION

The study of the recycling of waste from a Water Treatment Plant in ceramic tile masses is important because it contributes to reducing the consumption of natural raw materials, and to the useful life of waste landfills. [HOPPEN, C. *et al* 2005]. The waste used in this study was generated at the Water Treatment Plant of Guaraú, which captures water from the Cantareira system, consisting of four large reservoirs formed by the Jaguari-Jacareí, Cacheira, Atibainha and Juqueri rivers, where the first three are located in the hydrographic river basin of the Piracicaba river, and the last in the Alto do Tietê river basin (SABESP, 2006). The treatment consists of the precipitation of wastes by precipitators, based on $Al_2(SO_4)$.

The objective of this work is to evaluate the influence of the addition of the waste originating from the water treatment plant on the characteristics of the ceramic tiles, and its technical feasibility in the use of this product.

2. MATERIALS AND METHODS

The waste used was generated at the Water Treatment Plant – Guaraú, and the material collected was filter pressed to a moisture content of approximately 70%. After drying, the waste displayed the chemical composition shown (Table 1). As a reference material, a semiporous tile mass was used which had a water absorption between 6% and 10%, with a light yellow colour, fired at 1140 °C. In addition to the reference mass, additions of 0.5%, 1.0%, 3.0% and 5.0% solid waste were incorporated while maintaining the chemical oxide proportions of the reference mass (Table 2).

OXIDES	WASTE
PPC.	35,89
SiO_2	21,88
Al_2O_3	31,02
TiO_2	0,52
Na_2O	0,08
K_2O	0,97
Fe_2O_3	8,17
CaO	0,13
MgO	0,15
MnO	0,24

Table 1. Chemical composition of the waste

RAW MATERIAL (STD)	COMPOSITION OF THE FORMULATIONS (%)				
	REFERENCE	0.5	1.0	3.0	5.0
Phyllite	66.11	65.80	65.74	64.95	64.19
Clay	22.80	22.33	21.62	19.35	17.10
Talc	5.84	5.84	5.83	5.84	5.82
Calcite	4.11	4.11	4.10	4.08	4.04
Quartz	1.14	1.43	1.71	2.78	3.88
Waste	-	0.5	1.0	3.0	5.0
Total	100	100	100	100	100

Table 2. Distribution of the compositions.

Table 2 describes the raw materials used with their percentages and the waste increases. The compositions were prepared in the wet milling process with the following control parameters: density of the liquid mass 1.70 g/cm^3, 5% percentage retained on 325 mesh, and viscosity of 40 seconds in Ford cup no. 4.

After the milling the ceramic masses were dried in the spray dryer, with a moisture content of 6%. The test piece dimensions were 4x0.5 cm and the pressure used was 200 kg/cm^2. They were dried at a temperature of 110°C for 24 hours and fired in an electric furnace at a temperature of 1140°C, heating at a rate of 2.5°C/minute, and time of one hour. For the physical characterisation of the formulations, the metrologies described by Santos (1989) were used and defined as preliminary tests. These were done in accordance with the following tests:

- Forming moisture content;
- Mass loss after firing (LOI);
- Water absorption (WA);
- Apparent porosity (AP) and specific mass of the solid (Mea);
- Dry shrinkage (Rs), firing shrinkage (Rq) and total shrinkage (Rt);
- Green and fired bending strength (TR).

3. RESULT AND DISCUSSION

Table 3 displays, in the first column, the tests done with the test bodies dried at 110 °C. The following columns are the results of these tests relating to each prepared formulation.

TEST	RESULTS OBTAINED OF THE FORMULATIONS				
	REFERENCE	0.5 (%)	1.0 (%)	3.0 (%)	5.0 (%)
Mea (g/cm^3)	1.97	1.97	1.97	1.94	1.90
Moisture content (%)	5.99	5.89	5.95	5.77	6.04
Rs (%)	0.08	0.05	0.09	0.05	0.2
TR (kgf/cm^2)	22.45	23.19	46.28	40.26	23.86

Table 3. Results with the dry test bodies

The specific bulk density (Mea) shows that there is a trend to reduction with the increase in the quantity of the waste. This is due to the high concentration of the organic matter. The pressing moisture stayed constant, approximately 6%, and the drying shrinkage was directly proportional to the forming moisture with a reduced variation. The shrinkage was also very close to each other. It is important that the shrinkage should stay at low levels, since an increase could favour the appearance of drying cracks. The ideal shrinkage values for ceramic tiles vary from 0.2 to 0.4%, which indicates that the waste does not jeopardise this characteristic.

The mechanical strength, with the addition of the wastes, obtained a significant influence, displaying a great improvement in comparison with the reference material, adding 1.0%, which achieved an increase of almost double, approximately 50kgf/cm^2. However, with an increase in waste exceeding 1%, the mechanical strength began to decrease, reaching the results of the reference composition. That is, the increase up to 4% contributes an increase in dry mechanical strength. Table 4 presents the results obtained by the tests conducted on test bodies after firing at 1140 °C, in reference to each formulation.

Test (STD)	Results obtained of the formulations				
	Reference	0.5 (%)	1.0 (%)	3.0 (%)	5.0 (%)
Rq (%)	4.45	5.14	4.95	5.41	6.06
Rt (%)	4.51	5.22	5.03	5.46	6.15
TR (kgf/cm^2)	373.81	458.94	411.69	399.88	386.53
PPC (%)	6.68	6.59	6.74	7.03	7.57
WA (%)	8.83	6.97	7.90	8.97	9.95
AP (%)	18.08	14.65	16.41	18.25	20.05
Meas (g/cm^3)	2.50	2.48	2.49	2.49	2.50

Table 4. Results with fired test bodies

The firing and total shrinkages of the formulations indicate a gradual increase with the addition of the waste. This increase is also observed in the loss on ignition, which is characterised by loss of the organic matter present in the waste, elimination of the structural water in the clay, and elimination of CO_2 in the calcite. The waste displays high mass loss when it is subjected to firing and its increase in the formulations also increases the mass loss during firing of the formulated masses. The results of the mechanical strength indicate a small increase in strength, though porosity and water absorption increase.

All the compositions with the waste obtained positive results in relation to the reference mass. To be noted is the composition with the equivalent in waste mass of 0.5%, which presented improvement in the physical parameters. That increase was not relative to the addition of sludge, and may be explained in relation to the water absorption, and apparent porosity. Although the apparent bulk density of the solid does not increase significantly, the increased mechanical strength may be due to a degree of sintering of the particles that make up the ceramic mass, since the values obtained indicate that the formulations display a similar degree of sintering, which is the independent of the larger or smaller waste addition.

4. CONCLUSION

In accordance with the results obtained in this study, it may be concluded that it is possible to use the waste from the Guaraú water treatment plant in the formulations of ceramic tiles in a quantity up to 3.0% of solid waste.

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