Chemical and mineralogical characterization of mortars from the Bolonha Palace in the city of Belém, state of Pará - Brasil

Arnaldo Manoel Pereira Carneiro
University Federal of Pará, Center of Technology, Department of Civil Construction, Brazil

Marcondes Lima da Costa
University Federal of Pará, Center of Geosciences, Department of Geochemistry and Petrology, Brazil

ABSTRACT: The objective of this paper is the characterization of ancient mortars used in the facades of Bolonha Palace in the city of Belém, state of Pará, located in the Brazilian Amazon Region. As the Bolonha palace is under restoration, the development of new mortars suitable for restoring this historic building is very important, and the composition of the original mortars must be considered in the process. This is necessary in order to avoid possible incompatibilities between the new and the original mortars. The characterization of the ancient mortars employed traditional chemical analysis, X-ray diffraction, differential thermal analysis, optical microscopy and emission spectroscopy.

The analysis data shows that the mortars were prepared from cementitious materials with calcination temperatures in the range of 600^o C to 800^o C. The composition corresponds to 30% of binder and 70% of aggregate (quartz). Thus, the restoring mortar should not be too stiff in order to avoid any deformation incompatibility with the original mortar.

1 INTRODUCTION

The Bologna Palace is an important landmark of the city of Belém, state of Pará – Brazil, built during the rubber boom that took place in the Amazon Region in the late 19^{th} century. More specifically, the palace is located on Governador José Malcher Avenue, in Belém. Due to natural degradation, this monument is under restoration, and among the many parts of the building to be restored, the external masonry coating is the main investigated originated this paper. The restoration team needed to determined the composition of the plastering mortar of the external balconies, such that it could develop an appropriate mix proportion for the pointing mortar.

The aim of the programme is developing new mortars suitable for restoring the monument

2 MATERIALS AND METHODS

Some mortar samples were systematically taken from the Palace facade with an especial drill, and were subsequently pulverized for the preparation of slender laminae, to be used in the identification of the mortars. The restoring team observed two types of mortars: the first coat and the second coat. The first coat is the most external and thin, and the second coat, under the first, is thicker. The characterization of the ancient mortars employed traditional chemical analysis, X-ray diffraction, differential thermal analysis, optical microscopy and emission spectroscopy.

3 RESULTS AND DISCUSSION

1.1 Traditional chemical analysis

The chemical composition of the first and second layers are presented in Table 1.

Table 1 – Chemical composition of external plastering mortar

Weight (%)	First layer	Second layer
SiO_2	20,94	76,30
CaO	48,28	13,08
H_2O^+	19,05	6,92
H_2O^-	0,05	0,08
Al_2O_3	3,89	1,92
Fe_2O_3	0,34	0,41
FeO	- 0,07	- 0,07
MgO	0,44	0,16
K_2O	0,12	0,02
TOTAL	93,11	98,89

The second layer was characterized by a large amount of $Si0_2$ occuring in the form of quartz and larnite. The first layer has higher concentrations of CaO e H_2O^+, basically representing calcite, larnite and gypsum; the concentration of silica are in the order of 20,94% in the form of larnite, not in the form of quartz. In the second layer Al_2O_3 represented kaolinite, while in the first coat it probably represented gypsite.

3.1 X-ray Diffraction

X-Ray diffraction was performed in the range of 4^o to 60^o 2θ and identified the following mineral compositions, for the first and second layer, in table 2 and 3, respectively.

Table 2 – Mineral composition of the first layer, by X-ray diffraction

Mineral	%
Gipsum	13%
Calcite ($CaCO_3$)	31%
Larnite (Ca_2SiO_4)	50%
Gypsite	6%

According to the data presented in table 2, the first layer is composed essentially by larnite and calcite.

Table 3 – Mineral composition of the second layer, by X-ray diffraction

Mineral	%
Calcite ($CaCO_3$)	14,5%
Larnite (Ca_2SiO_4)	8,5%
Kaolinite ($Al_2(OH)_4Si_2O_5$)	4,0%
Quartz (SiO_2)	71,2%

According to the data presented in table 3 the second layer are composed essentially by quartz and calcite, the aggregate, and the remaining part by larnite and kaolinite.

3.2 *Differential Thermal Analysis*

Figures 1 and 2 present the results of the differential thermal analysis, for the first and second layers, respectively. The plots show that the cementitious material did not reached the temperature necessary to form the clinker, as the temperature of calcination was between 600^o C and 800^o C.

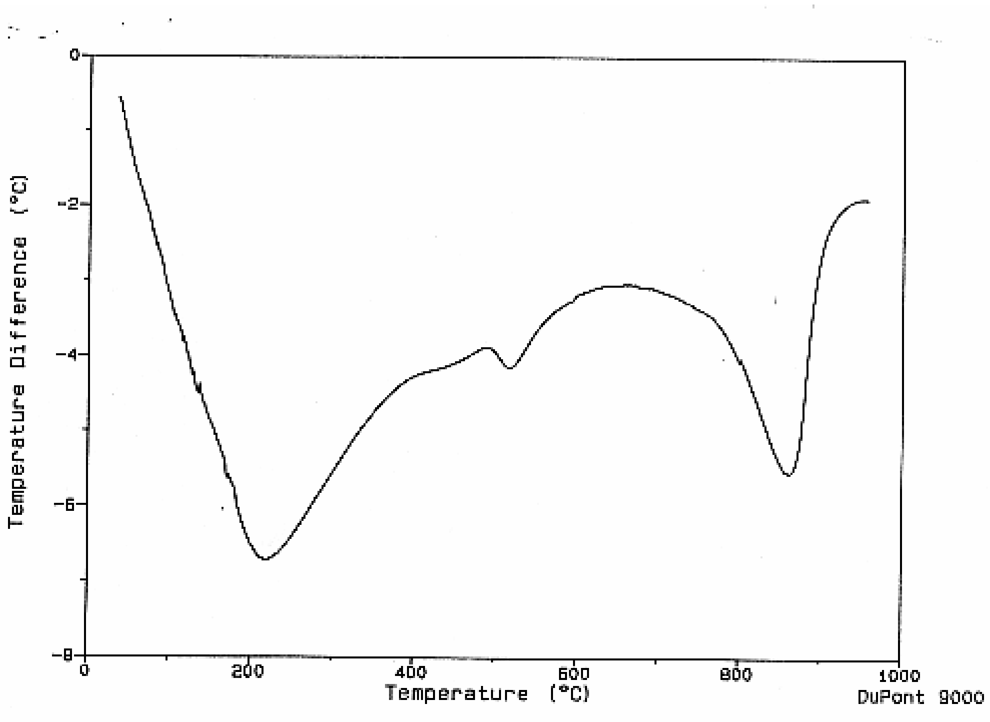

Figure 1: Plot of the differential thermal analysis for the first layer

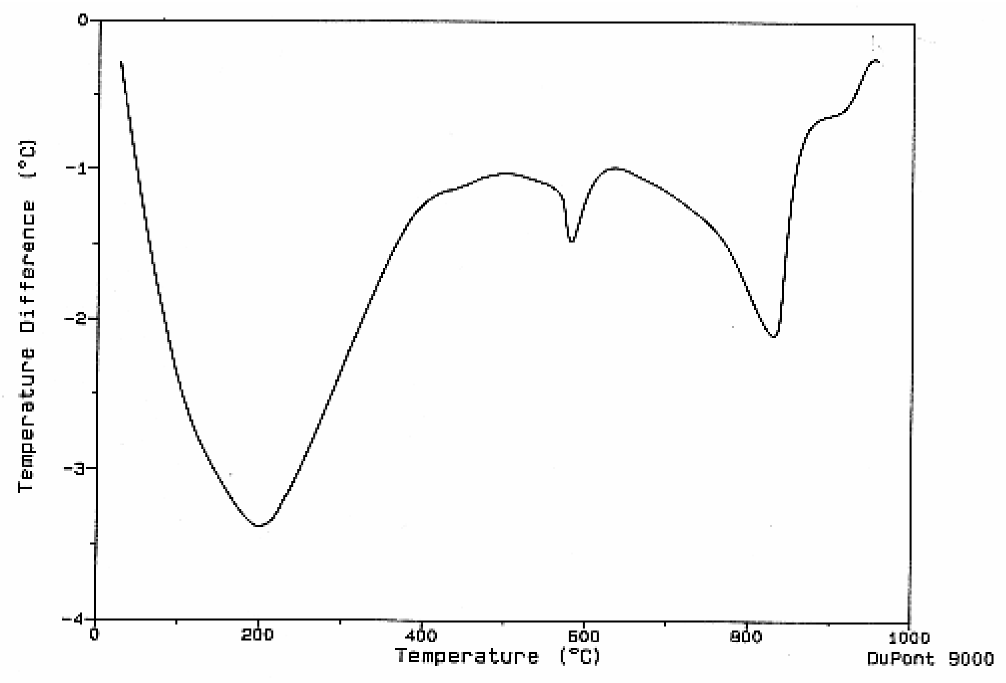

Figure 2 : Plot of the differential thermal analysis for the second layer.

3.3 Optical Microscopy

Optical microscopy was a important tool in the analysis of the texture aspects of the mortar grains. It was observed that the material of the first layer is microcrystaline, which did not allow distinguishing the relationship between calcite, gypsum and gypsite. The larnite grains are formed by pentagonal and irregular aggregates.

For the second layer, the grains of sand, formed primarily by quartz, have forms that vary from rounded to completely irregular, in different sizes. These grains are cemented by calcite, larnite and kaolinite.

4 CONCLUSIONS

The obtained data shows that the first and second layers are formed by mineralogical and chemically different materials. The first layer is essentially formed by larnite, calcite, and gypsum, which reveals that this layer is formed essentiality by material binders. The second layer is formed by 71,2% of quartz and 4% of kaolinite, which represents 75,2% of aggregates; and by 14,5% of calcite and 8,5% of larnite, which represents 23% of binder material.

The chemical composition shows that: the first layer has gypsite and the second layer has kaolinite; the first layer is formed essentially by CaO and SiO2, and the second layer is formed essentially by SiO2 and CaO.

The presence of calcite in the composition of the mortars reveals that these materials were not calcinated at the temperature necessary to former the clinker. The presence of larnite, an undesirable composite for the cement, reveals that the calcination temperature was between 600^{o} and 800^{o} C.

After analysis of the data, it is concluded that the new mix proportion for the mortars of the second layer should be stiffer than the mortars of the first layer. It is recommended that the restoration mortars have the same proportions of cement and aggregate, of the respective historic mortars, in order to avoid incompatibility between new and original materials.