

Is gypsum external rendering possible? The use of gypsum mortar for rendering historic façades of Valencia's city centre

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Abstract: Valencia is a city located in the East of Spain by the Mediterranean Sea. It has a huge historic centre with ancient winding streets that contains buildings with a singular architectural heritage. The buildings' façades are protected by a traditional external rendering, sometimes in bad state of conservation or modified or substituted in restoration works. The study carried out on historic renderings in Valencia points out the great employment of gypsum mortar or gypsum-lime mortar, among other peculiarities. Gypsum external rendering is one of the many uses for gypsum mortars in Valencia traditional architecture. This fact contradicts the general belief of the exclusive use of lime mortars for rendering a façade. The knowledge of the characteristics of historic mortars will allow us to implement a proper restoration work of architectural heritage with suitable mortars, as it is essential to guarantee the adherence and compatibility of any repair.

Introduction

External renderings represent the skin of buildings with the main mission to protect and embellish their supporting walls [1]. External renderings in historic buildings are to be respected and looked after as if they were the skin of a live being, moreover, in many cases they are the only witnesses of already abandoned traditional techniques and constructive materials. To conserve and restore external renderings requires to know their characteristics and peculiarities. For this reason, a study of the traditional external renderings in Valencia's city centre was been undertaken. The present paper contains a summary of the documental study carried out and the preliminary results of the laboratory tests. It has also meant supposed a thorough revision of the characteristics of buildings' external renderings in Valencia's centre and the use of gypsum mortar as exterior rendering in History.

Characteristics of the buildings of Valencia's historic centre

The city centre is characterized by five different neighbourhoods where buildings and, therefore, their façades have suffered many modifications and changes throughout time. However, most of the historic buildings are dating from the end of the 18th century and the beginning of the 19th century. Generally, they are residential buildings and 3-5 storey blocks of flats, made of supporting brick walls, brick columns and wooden beams. The use of external renderings in order to cover and protect brick masonry walls has a long tradition in residential buildings because it was cheaper than stone masonry. Stone masonry was used exclusively for public buildings and possibly for isolated lintels, jambs...in brick fabrics. In addition, the ornamental coat of external renderings has allowed the imitation of fashionable bonds in every history moment (Fig.1).

According to the study carried out on historic coatings in Valencia, they are mainly made of gypsum-lime mortars or gypsum mortars. The former are called "trabadillos" because the two materials, gypsum and lime, are mixed consciously in order to get more properties [2]. And basically, the renderings have only two layers, the basecoat and the finish coat, instead of the three-coats recommended for example by Vitruvio in his treatise.



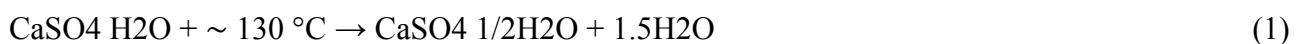
Fig. 1: Façade of a historic building in Valencia's city centre with historic external rendering. V. La Spina.



Fig. 2: Map of gypsum deposits in Spain, adapted by D. Sanz Arauz, from the original map of Riba and Macau (1962).

Gypsum mortar: history, properties and uses

Gypsum is a very soft mineral, hydrate calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) used in order to produce gypsum plasters and mortars. If its chemically combined water is driven off, calcined gypsum will be obtained which is the main component of the historically called plaster of Paris (Eq. 1). Therefore, the plaster of Paris is a calcined gypsum, used as a base for gypsum plaster, an additive in lime plaster or material for creating ornamental casts.



The transformation is reversible: when the calcined material is mixed with water, it becomes a paste that sets quickly to form tough crystalline gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ that hardens into a solid (Eq. 2).



Historically, gypsum mortar has been used in construction since Antiquity in many different ways such as bedding or pointing mortar, plastering and rendering in vaults, interior partitions, stairs, or sheathing for floors, walls or ceilings. The geological abundance of this material, the low temperature required to obtain it, in comparison with lime, and the easiness of extraction, transformation and distribution, turned it into a very suitable material for construction.

The most important property of gypsum mortar is that hardens and dries off in a short period of time. It is not inflammable and therefore an excellent passive fire-fighting material. On the other hand, one of its main problems as a construction material is its higroscopicity and water absorption.

Generally, gypsum mortar has been used more frequently as bedding mortar or as rendering on the façades only in countries or regions with a dry climate, while its employment in the interior is especially to be found in plasters and stuccoworks everywhere. For instance, in some Paris' central neighbourhoods there are excellent gypsum external renderings because in the Montmartre region there were 18 gypsum deposits already in exploitation in 1292. That is why the traditional use of the calcined gypsum gave origin to the name of plaster of Paris when the product was exported to London after the great fire in 1666 [3].

Specifically, in Spain most of gypsum mortars are found in constructions from the 18th, 19th and the first half of 20th century, in cities and towns in the East of Spain such as Cuenca, Albarracín or Ademuz [4]. This has been possible thanks the existence of large gypsum deposits in this area of Spain (approximately 35.000 km² of surface) (Fig. 2). Moreover, there are traditional constructions in this area where gypsum is used both to render exterior façades and to build up walls, floors or pillars. In the area of Valencia there were also gypsum deposits at an only 20 km distance and a gypsum manufacturing industry already existed in the 16th century. Therefore, gypsum was abundantly used in external renderings in Valencia.

Study of the historic mortars in external renderings of Valencia's historic centre

Currently, there is not a simple and quick method for the identification of historic mortars used for external renderings. Since they are composed by a set of heterogeneous materials and have been exposed for centuries to hard mechanical and environmental loads. This is why it is necessary to carry out several combined analyses in order to be able to characterize them physically and chemically and to understand the original building processes and methods.

Hence, the study of historic mortars of Valencia's historic centre has been undertaken in order to know the nature of the materials. For that, 40 different samples have been taken from at least 20 buildings situated in the five different neighbourhoods of the city centre. Specifically, it has been tried to obtain samples from the different coats of renderings and in various zones of the building in order to realize the following analyses:

- Optical observation under microphotography
- Determination of the principal mineral composition through X ray diffraction (XRD);
- Determination of the organic components through gas chromatography-mass spectrometry (GC/MS);

The analytical data shows that the historic mortars of Valencia's historic centre have a great percentage of gypsum, over 90%. However, only 60 % of the samples are exclusively made of gypsum, as some of them have simultaneously gypsum and lime (Fig. 3). According to the estimated dosages, it is possible to state whether the mortar was a gypsum-based one mixed with some lime or if the gypsum was used as an additive to accelerate the hardening of a lime-based mortar. And, other traditional additives have been detected in the composition of some mortars such as hair, vegetal fibres or other impurities that improve their performance and qualities.

It is also necessary to highlight that the composition of the mortar is different in every layer of the external rendering. In some cases it is only a different quantity of each material (Fig. 4). Nevertheless, in other cases, the kind of mortar is different in every applied layer, and for example the finish coat is a gypsum-lime mortar while the basecoat is a gypsum mortar. Likewise, there are areas in the façade, such as the lintels and the jambs of windows and doors, where it has been possible to observe a better quality of mortar, and specifically in the case of gypsum mortars, a scarce use of sand in order to increase hardness and resistance for the external rendering.

In relation to the total thickness of the coating, a criterion is difficult to be determined as it may change depending on the irregularities of the support base, the particular zone of the façade and the specific decoration. Nevertheless, it is possible to assert that generally the thickness of finish coat is thinner and has smaller and better materials than the basecoat. And finally, most of the failures of historic Valencia's external renderings that have been observed are mainly the superficial dirt due to a lack of maintenance, the superficial wash by rainwater and the detachment of the mortar, these two last due to an inadequate protection against rain.

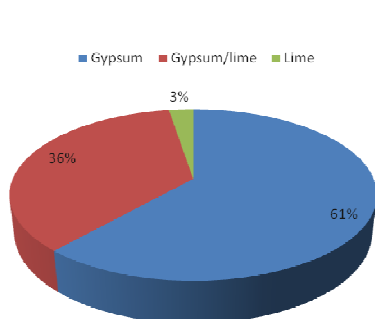


Fig.3: Percentage of raw materials in historic mortars of Valencia's coatings.

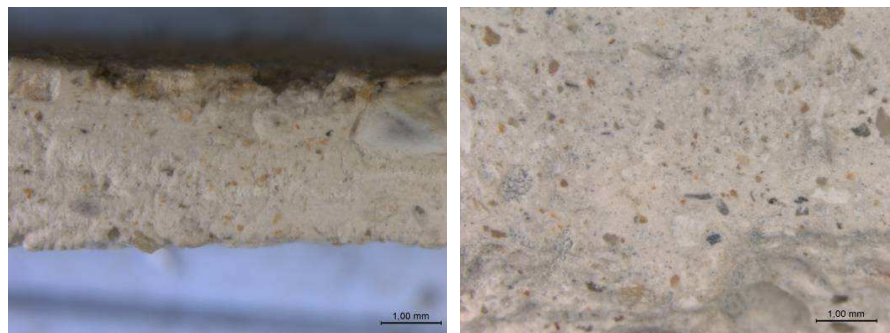


Fig. 4: Microphotographies (x8) of a gypsum external rendering. Left: 3mm thick finish coat containing 83% of gypsum. Right: 91% gypsum basecoat and with bigger size of sand.

Conclusions

It is very important to know the raw materials of a mortar in order to avoid inappropriate repairing methods or inadequate materials. So, the characterisation of the historic mortars of the buildings situated in Valencia's historic centre will allow us to determine the best reintegration mortar for future restoration works. The existence of gypsum in their composition warns against the use of repair mortars with aluminates such as cement, because they may cause the appearance of ettringite, (calcium hydrate of aluminate trisulphate), also called Candlot salt [5]. The ettringite is the result of the reaction between calcium aluminate and calcium sulfate, an expansive reaction that produces the disaggregation of the mortar and contributes to the failure of external renderings.

In addition, the extraordinary use of gypsum for rendering the façades of the buildings invites us to rethink about the need of preserving these examples of traditional constructive techniques and materials and, at the same time, to learn from them in order to implement the teachings in contemporaneous architecture. Gypsum is an ecologic, low-cost energy consumer, breathable, fire proof material with good insulation properties. Therefore, it may be stated that gypsum external rendering is possible. Moreover, being these gypsum renderings a specific characteristic of traditional Valencian architecture, they should be preserved and protected as an important part of its built culture and architectural heritage.

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