

# Recovery of traditional mortars in the laboratory of materials at the school of architecture of Madrid

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## THE LABORATORY SEMINAR

The Laboratory of Materials seminar is an optional course offered to students in the School of Architecture in Madrid. It is taught during 35 class hours in the laboratory of materials distributed in 2 hours and forty minutes weekly. One of the working lines is the preparation of traditional mortars made by students groups, each one of 4 or 5 members. It is basically a practical course, and students have to prepare a group of tests pieces in order to confirm the initial hypothesis, or when needed, make innovations. The test pieces are of 150x150x10 mm and applied to big size hollow bricks, prismatic test pieces of 40x40x160 mm to apply physical and mechanical tests and brick wallings of varied dimensions.

## AIMS

The main aim is to spread the traditional masonry because of its great importance in preserving the historical heritage. In addition, extending the use of prepared mortars would allow the replacement of lost parts and a better adherence between the old and the new mortar.

Although well known writers such as Vitrubio, Bails, Pascual Diez, specify the proportions of the conglomerate and the aggregate within the batch, nothing is said about the quantity of water being used for

the mixture. Therefore, the first phase is to establish the water quantity in order to determine the correct consistencies (draining diameter in the bump tray) being dry or plastic.

Once the batch has been prepared, either manually or in a lab mixer (of 3kg capacity), it can suffer variations in the aggregate proportion or in that of the conglomerates in order to increase the superficial hardness, its impermeability, a colour change, or so as to lighten them. The students characterize the different mortars by performing the different tests:

physical and chemical tests: hardening time, obtaining the pH, bulk and true density, absorption coefficient, suction coefficient, capillary height, water steam permeability, aging, superficial hardening, sand granulometry and colour.

Mechanical tests: compressive strength (pointing mortars), flexion strength and tearing (cladding).

Mortars, sometimes present fissures and do not adhere to the support. These are some of the problems, which have to be solved. Finally, throughout the Seminar, changes and modifications are made so that students can reach conclusions about the batches with best characteristics.

## MATERIALS AND WORKING LINES

The conglomerates used are: lime paste, lime powder (Ca hydroxide), black gypsum, grouting gypsum, plaster, clay, white cement and grey Portland cement.

Due to lime slow hardening, test pieces have to be prepared in advance or of a width equal or smaller than 10 mm more or less. Dry and humid sands are used (10% moisture), of silica, limestone, marble, granite, sandstone etc. In light aggregates, perlite and expanded clay are used. As pigments, synthetic or recycled ones are used. Vegetable fibres have also been used, as well as sawdust of different woods for clay mortars. The student groups simultaneously worked in the following topics:

**Mortar for masonry pointing.-** The proportions for masonry pointing mortars are established including the ones specified in the Spanish standard NBE-FL-90, of lime-cement and of lime. Therefore, the chosen batch is prepared, and a wall of height four to five courses of solid brick or perforated brick and with a width equivalent to three bricks screwed to a board base is constructed. Extremely good results have been obtained with a volume proportion of 1 lime, 1 gypsum, 6 sand and 30% water, as well as with another batch frequently used in restoration works 1:1:6 (cement, lime, sand).

Using traditional mortars allows observing, in the contact surface suction tests for example, that greater water suction speed is produced in waterproof or seen face bricks in the brick-mortar interphase. Therefore, it is necessary to additivate them to increase their adherence.

**Cladding mortars.-** The proportions stated by the specialist writers have been reproduced. For example, for the first rendering layer recommended by Pascual Díez, with 1 volume lime, 2 of gypsum and 3 of sand, a batch was prepared with a granulometry smaller than 0,063 mm, and water in a proportion of 30% of the batch quantity. A superficial hardness of 79 units was obtained, measured with a Shore C durometer<sup>1</sup>.

In lime-sand-puzzolana mortars (Vitruvio, Bails), the brick or tile powder was manually prepared.

In one of the works performed<sup>2</sup>, ten different rendering test pieces were prepared, adding even propylene fibres to determine the results obtained in superficial hardness, flexion strength, compressive strength and the water vapour permeability. The renderings chosen were: M-8PPf (gypsum+lime+fiber), M9 (gypsum + lime + marble sand) and M10 (gypsum + lime + clay) –the clay coming from Lisbon where it is used in renderings tests. These mortars were applied

on the wall constructed for it (Fig. 1 from left to right respectively).

Another working line has been lightening mortars to achieve other services apart from that of cladders, as can be seen in fig. 2. The base layer is of grey cement, sand and expanded clay (1:1:2) and the outside definite layer is of white cement, sand and perlite (1:1:4)<sup>3</sup>.

**Repairing mortars.-** The works are divided into two fields: reparation of concrete and of stones.

Prepared mortars are used, only with the addition of water. But in the laboratory sand and white cement have been added to compare the obtained results. One group of students prepared three different situations to repair a damaged corner due to surface loss. From half of the test piece<sup>4</sup> (fig. 3) only water was used as binding agent, but to ensure the reparation, the second one was reinforced with glass fibre.

In the concrete reparation made with grey or white cement<sup>5</sup> and with limestone, one of the difficulties has been to achieve the same colour tone of the piece to be repaired.

Therefore, white cement has been used to lighten concrete reparation mortars. Two tests have been performed after the reparation mortars have been applied. One of them is to wet the surface in a similar way to a heavy rain, in order to observe the tone difference between the original surfaces and the repaired surfaces (manufacturers have solved this problem applying a matching and waterproofing coat).

The other test performed has been to subject the test piece to mechanical tests to determine if fracture is produced in the joining interphase of the old and the new repairing mortar. In order to carry out this test, test pieces had to be prepared with voids filled with expanded polystyrene, prior to the mortar emptying (fig. 4).

Another test carried out consisted on stating the suitable joint adherence among the different type and time period mortars and the supports made with various materials.

In this case, the students had to reproduce in a small scale the constructive system of a timber frame with brick or gypsum packings.

**Pigment mortars.-** Normally inorganic pigments are used, either from recycling or synthetic. According to the used conglomerate and the pigment treatment, the



Figura 1  
Mortars applied on the brick wall constructed for it



Figura 2  
Two layers of 10 mm each applied on brick base

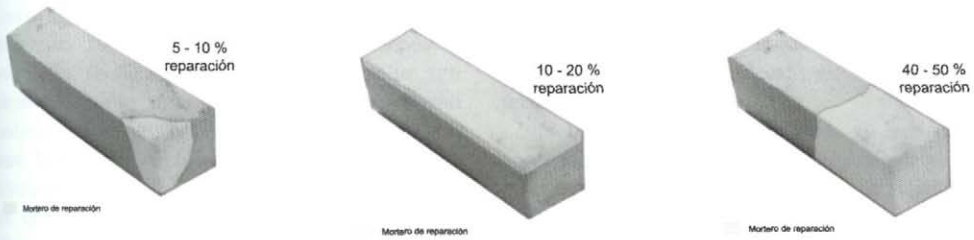


Figura 3  
Repairing mortar applied on prismatic test pieces in three different situations



Figura 4  
Prior hollow in cubic test piece made in plywood cast

saturation coefficient varies considerably, reaching percentages from 9 to 20%.

## CONCLUSION

This working line on traditional and repairing mortars, due to its practical and direct use with the chosen materials, enhances the theoretical knowledge the students already had and implies a further step in this research field.

## NOTES

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