An active mode of learning:
Students collaboration in a research project on masonry mortar

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1. Introduction – During the 2012-2013 academic year, a practical work was proposed to the students of the fourth year of the School of Architecture of the University of Navarre (ETSAUN), in the Building Construction IV subject of the Building Construction, Services and Structures Department (CIE), in the context of implicating students in academic activities, specifically designed to allow them to improve essential capabilities and abilities required for their future professional exercise.

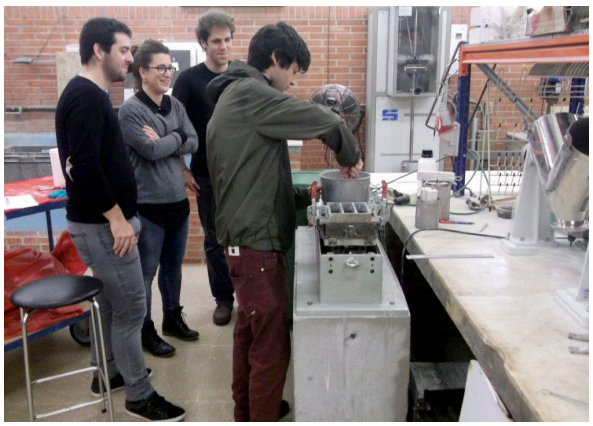
The practice consisted in the manufacturing of various types of masonry mortar samples based on a defined dosing range, in order to be tested afterwards to verify the compliance with the characteristic strength requirements of the Spanish Building Technical Code Basic Document Masonry Structures (CTE DB SE F [1]) in force.

This practical work was a part of a framework research project being carried out by the subject teaching-team. In the first stage of the project, a wide range of mortar dosing was established, on the base of a theoretical model, because CTE DB SE F does not include any specific method for the dosing of a mortar in order to obtain a certain characteristic compressive strength, and there is no other formulation method than the one derived of results of good practice.

Afterwards, the mortar samples manufactured by the students were tested in the Building Laboratory of the ETSAUN, as stated before, in order to determine the main resistant properties and an X ray diffractogram (XRD) of each unit was also done, with the collaboration of the Soil Science Department of the Science Faculty of the same university.

101 students were divided in 24 groups, each one of them responsible for the making of four mortar types samples, so that two of the mortar types were to be made by two different groups, in order to control the samples quality (Images 1 and 2).

The statistic interpretation of the obtained results was difficult, due to two main reasons. One related to the different skills of the students as workmanship and their inexperience in the making of the samples, so that there were significant quality differences among groups. And another, more significant, the fact that the theoretical model on which the mortar dosing was based was too ambitious in the number of variables considered.



Images 1 and 2. A group of students working on the practical work in the Building Laboratory of the ETSAUN.

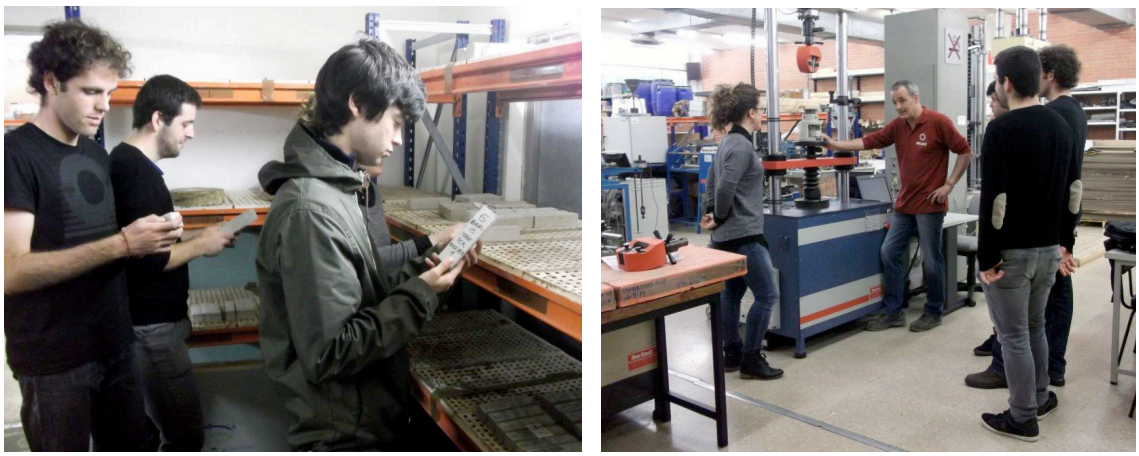
Images 3, 4 and 5. A mortar mixer, the mixing process of the mortar paste and determining the consistence of the fresh mortar, in a flow table

Therefore, the same practical work was proposed again in the academic year 2013-2014. 130 students are already working on it in a very satisfactory way, divided in 32 groups, each one responsible for the making of six mortar types samples, after having simplified the theoretical model, reducing the number of variables and increasing the number of mortar types from 96 to 192.

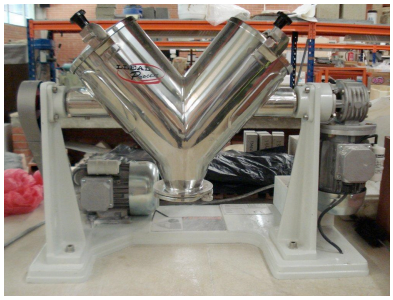
2. Development of the practical work – The first practical work, proposed in 2012-2013 to the students of the fourth year, consisted in the manufacturing of a series of samples of different mortar types. The components to be used in the mix were a single type of ordinary Portland masonry cement (OPC), hydraulic lime and limestone, siliceous and Miga sand (a special Spanish soil of the area of Madrid, with a proportion of clay content quite similar to loamy sand).

The different volume ratios of the components dosing of the total number of mortar types, were defined according to a theoretical model based on good-practice codes criteria, elaborated by the teaching team and explained in class. Afterwards, the students had to test the mortar samples they had previously fabricated, in order to establish which mortar types complied with the characteristic compressive strength values required in CTE DB SE F.

The students were provided with all the technical information, standards, materials and equipment required for the making of the standardized prismatic mortar samples (Images 1-3 and), according to the European and Spanish standard UNE-EN 1.015-2:1999/A1:2007 [2].



Images 6 and 7. Examing the manufactured samples and testing one specimen, under close surveillance of the Laboratory personnel.



Images 4, 5 and 6. V type mixing machine, three gang mould for mortar samples (40 x 40 x 160 mm) and jolting table for compaction.

An area was specially set up for the purpose in the ETSAUN Building Laboratory facilities, the same place were the samples were after to be tested to determine their flexural and compressive strength (UNE-EN 1.015-11:2000 [3]), as well as other properties, more specific of masonry mortars, such as permeability (UNE-EN 1.015-19:1999 [4]).

Most of the students developed the practical work in a regular way during the scheduled time for it in the academic timetable of the subject, but quite a significant number of them preferred to do it at their convenience, as this option was given by the teaching team, in order to facilitate the activity development and increase the commitment of the students.

Only one condition was imposed for it: those students pretending to work in different hours than those previewed were required to fulfill a written form in advance for the approval of the Laboratory personnel. Their assistance, advice and supervision was required at any time during the development of the students work, either to give them operating or handling instructions for the safe use of the manufacturing and testing equipment or comments on practical aspects of the students skills on the mixing of the components of the mortar paste or the making of the samples.

Thus, the time spent by every student in the Laboratory was conveniently registered, allowing the teachers to control the frequency and duration of all the practice sessions, as well as the number of components of each group attending at the same time. Regarding this, it should be pointed out that in most cases, all of the members of the groups attended approximately the same number of hours, a clear symptom of the positive response of the majority of the students to this new kind of practical work in a subject such as Building Construction.

In the academic year 2013-2014, the practice was proposed for the second time, after the adjustment of the dosing theoretical model and the total number of mortar types. During the term-time, 104 complete series of mortar samples were fabricated by the students and 67 of them were also tested, the 54% and 35% of the total of 192 mortar types, respectively.


Images 6 and 7. Hardening process of the prismatic mortar samples and compressive strength testing of a specimen.

The practical work was proposed to the students as an optional activity, not included among those to be evaluated for the final subject grade. In spite of it, the number of them who decided to complete it is very relevant. In Spain, Architecture students, like those of any other technical degree, carry a heavy burden of compulsory practical works and mid-term and final exams. That is way they are usually reluctant to participate in extra-academic activities requiring a certain amount of their time, dedication and initiative to the detriment of their academic workload. But at the same time, students always claim that there is no balance between their theoretical instruction and practical training, above all, regarding building construction products and systems. The high level of participation in this practical work is due to the fact that it was designed to improve their ability to put into practice the theoretical concepts about mortars learned in class by means of the development of the whole process required by themselves, from the mixing of components to the analysis of the testing results obtained.

3. Conclusions - Two relevant aspects of the practical work have been modified by the Building Construction Chair in the second year it was proposed to the students. The scope has been readjusted, defining it more precisely, reducing the number of mortar types for a better evaluation and systematization of the results obtained. And also, to prevent the quality difference found between the samples manufactured by groups with different skills, the students of this 2013-2014 academic year were provided with the advice and assistance of those who had succeeded in the practice the former year, 2012-2013, currently in their fifth year.

A new procedure in the form of a protocol has been drawn up to guarantee the continuity of the proposal in the following academic years, with the same criteria regarding the dosing components and manufacturing and testing requirements of the mortar samples. It establishes that all the mortar types samples missing will have to be fabricated in the first stage. Next, these samples and those manufactured but not tested in the previous two years will be tested to characterize their resistant properties, including properties varying in time. Finally, the permeability of the whole ensemble of samples will be determined by testing. This property is required for the research project, but could not be tested in the two first academic year due to the lack of time of the students.

The protocol includes also the organization of a storage unit for the samples in the Laboratory facilities, intended for the safe conservation of all the samples manufactured and tested, so that in they can be easily compared and analyzed in the future, when the number of them may be large.

Finally, considering the positive students response obtained and the learning improvement achieved, the teaching team is considering the convenience of proposing the same sort of practical work to the students of the last academic year of the Architecture degree or even to those developing the Final Degree Project. They could collaborate in even more theoretical research projects of the Building Construction Department Chair, introducing them this way, in an attractive manner, into research issues.

4. References

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[4] AENOR (1999). *UNE-EN 1015-19:1999 Methods of test for mortar for masonry - Part 19: determination of water vapour permeability of hardened rendering and plastering mortars.* Madrid, AENOR.