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SHEAR RESISTANCE VARIANCE OF THE MORTAR BRICK BOND, CONSIDERING THE HUMIDITY CONTENT

Luís F.R. Almeida[1], J.A.Mendes da Silva[2]

[1]Adjoint Professor – Department of Civil Engineering - E. S. T. T. , I. P. Tomar-Estrada da Serra, 2300 TOMAR – PORTUGAL – tel. +351 249 328195 Fax: +351 249 328106

[2]Auxiliary Professor – Department of Civil Engineering – University of Coimbra – 3030-000 COIMBRA – PORTUGAL

E-mail: raimundo@dec.uc.pt – Phone: +351 239 797206 Fax: +351 239 797207

ABSTRACT

This work studied the influence of the bricklaying conditions in the resistance to the shear of the masonry, with particular emphasis to the humidity content of the bricks at the time of laying.
This consisted mainly of doing experimental tests to determine the shear resistance of the bonds and the adherence between the mortar and the brick, under different laying conditions.

Key words: *Masonry, resistance to shear, facing brick, humidity content, bonds.*

1. INTRODUCTION

The use of perforated "facing brick" has gained increased popularity in the civil construction in Portugal, because it is a solution that involves reduced maintenance costs, and simultaneously giving a high quality finish.

The majority of the defects resulting from shearing are more noticeable and it is more difficult to fix in the buildings using this type of brick, because in general, they don't have another finishing layer.

The principal aim of this study is the experimental evaluation of the influence of the humidity content, of the bricks at the time of laying (executing the masonry), on the shear resistance of the wall.

2. CHARACTERISATION OF THE MATERIALS USED

The choice of the tests carried out, had two principal objectives (1):

- Characterise the main parameters that influence the adherence bonds of mortar/brick,
- Obtain detailed knowledge of the materials used.

To choose the mortar, we followed the suggestions of BS 5628 (2) (volume of cement/sand 1:5). In this study, the water/cement ratio was 1.20, a mortar type M4 was obtained.

To select the sand we followed BS 1200 (3) and ASTM C144 (4). In order to obtain a mortar with adequate workability, we have adopted a 50% mixture of two types of sand available in the centre of Portugal: Tejo and Mira.

The cement used was Portland Compound Cement, Type II - Class 32.5.
The bricks used were "facing brick", perforated with 21 holes in accordance with NP 80 (5), (see table 1).

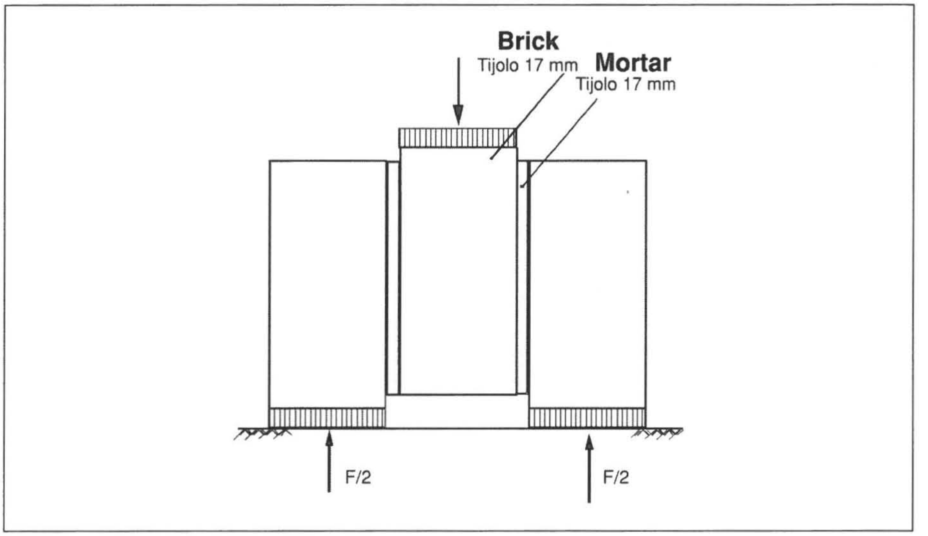
3. DESCRIPTION OF THE EXPERIMENTAL MODEL

This work aims at determining the initial shear strength of the masonry in accordance with the EC6 (1), using the proposed indications for normal masonry in the

Table 1. Characteristics of the bricks.

Resistance		Durability		
Minimum	Medium	Cold water absorption (A)	Boiling water absorption (B)	Saturation coefficient (A/B)
188 Kgf/cm^2	219 Kgf/cm^2	THE 10%	10.5%	0.95

Figure 1. Experimental model.



EN1052-3 (12). For that effect, small "triplet", type specimens of masonry were made, varying the humidity contents of the bricks in the laying phase. To determine the shear strength, the specimens were tested until they showed a double break without applying any restrictive tension (see Figure 1).

Testes were made on samples laid in 3 different manners;

- Groups I - The bricks were laid in the traditional manner.
- Groups II - the bricks were laid and all the holes were filled with the mortar during the laying operation.
- Groups III - We tried to reduce the possible influence of the penetration of the mortar in the holes, the holes of the bricks were filled with extruded polystyrene.

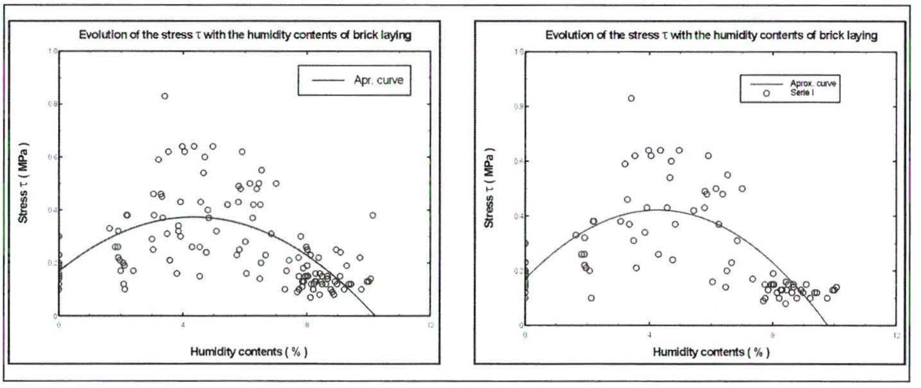
4. DISCUSSION OF THE RESULTS

4.1. Resistance to shear

Figure 2a shows the general results of the tests made, to which a polynomial regression curve in 2nd degree was adjusted.

From the analysis of Figure 2a we see that, independently of the type of mortar joint, the results obtained on the resistance to shear could be grouped in the following manner:

Figure 2. Evolution of the stress t with the humidity contents of brick laying.



- Humidity content between 2,5 and 7,5%: high average resistance: great dispersion of results.

- Humidity content below 2,5 or above 7,5%: reduced average resistance: minor dispersion of results.

In Figure 2b we only show results of test samples laid in the traditional manner (Groups I). It shows that, in this case, there was a general conclusion to all the tests made.

For the lowest and highest values of humidity content (<2,5% and >7,5%) the dispersion is reduced, which indicates that the humidity during the laying is a determinant factor in the resistance. The dispersion of the central band could indicate that there are other non-controllable factors, which affect the resistance, in a significant manner.

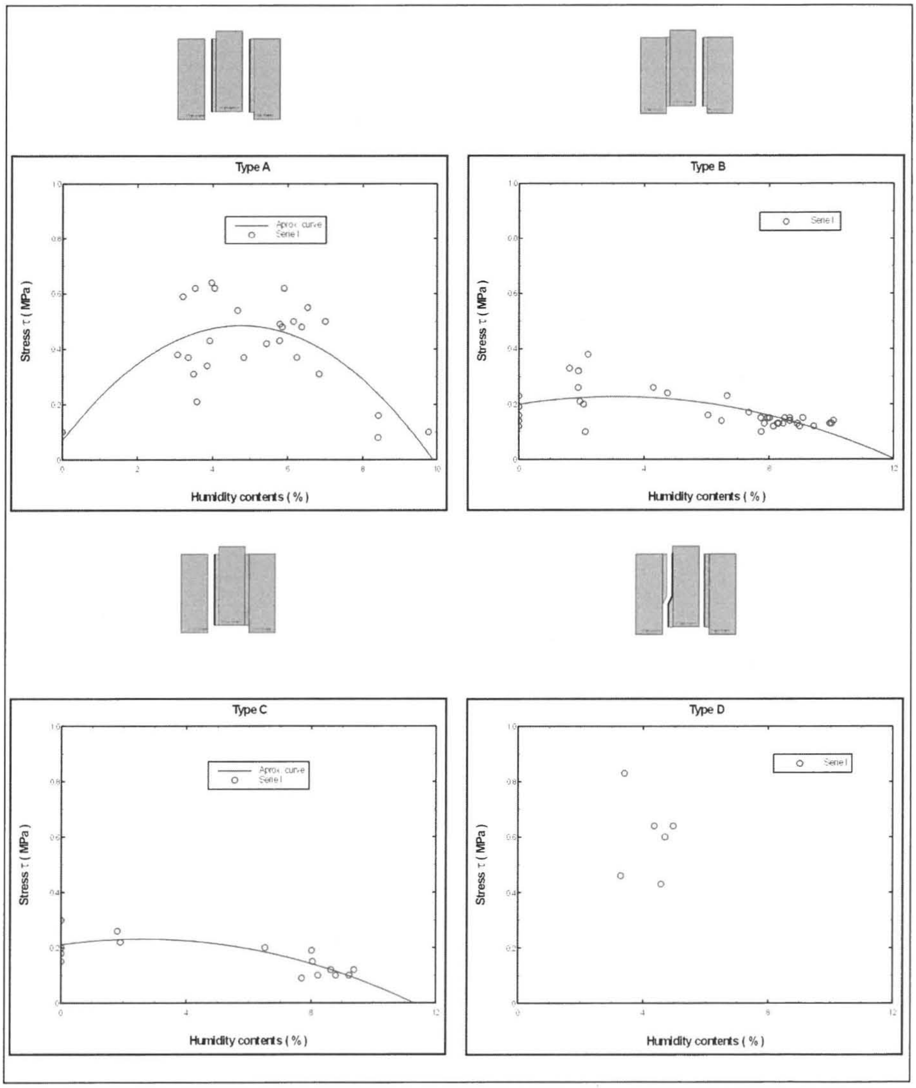
4.2. Types of rupture

Observing all the samples tested it is possible to identify 4 types of rupture, A,B,C and D:

- *type A* : the rupture occurs on both sides of the mortar joint;
- *type B* : the rupture is seen only on the first mortar joint;
- *typeC* : the rupture is seen only in the second mortar joint;
- *type D* : the rupture occurs in both mortar joints, but now through shear of the mortar in the laying and not due to loss of adherence.

In the graphs of Figures 3a and 3d we can observe both the representative points of each test, which indicate the tension of the rupture according to the humidity contents of the bricks at the time of laying, and the regression curves adjusted to the results. In these curves the value difference of the rupture of the type A or D ruptures is notorious compared to the rest of the configurations.

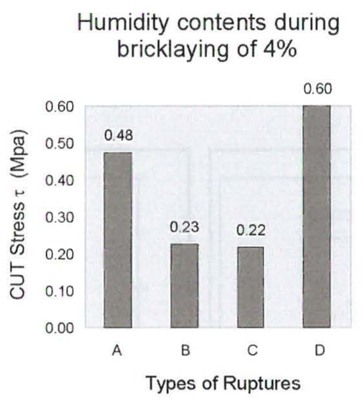
Figure 3 (3a, 3b, 3c, 3d). Evolution of the stress t with the humidity contents for the several failure types.



It was not possible to adjust a curve to the ruptures type D, because of the reduced number of points, but the values found are greater than the previous because there is a participation of the mortar resistance to the shear.

Observing Figure 4, where we show the average tension of the shear of the various rupture types for a humidity content of 4%, we can conclude that there were other parameters, besides the water at laying, responsible for the values obtained; of these, we can consider probable the significant influence of the eccentricity of applying charges to rupture type B and C.

Figure 4. Variation of the stress t with the failure type for humidity contents of 4%.



Observing the graphs A and D of Figure 3, (which correspond to ruptures type A and B) we see that all the tests were done with a humidity content between 3,5% and 7,5%.

Comparing the values of dispersion of results of rupture A and D samples and the values of dispersion of results of all the samples, we found that the dispersion was lower for rupture A and D, except for humidity values of 4%.

In this manner, the necessity to deepen the research in the variety of humidity content is confirmed, to see where the average shear resistance values are highest.

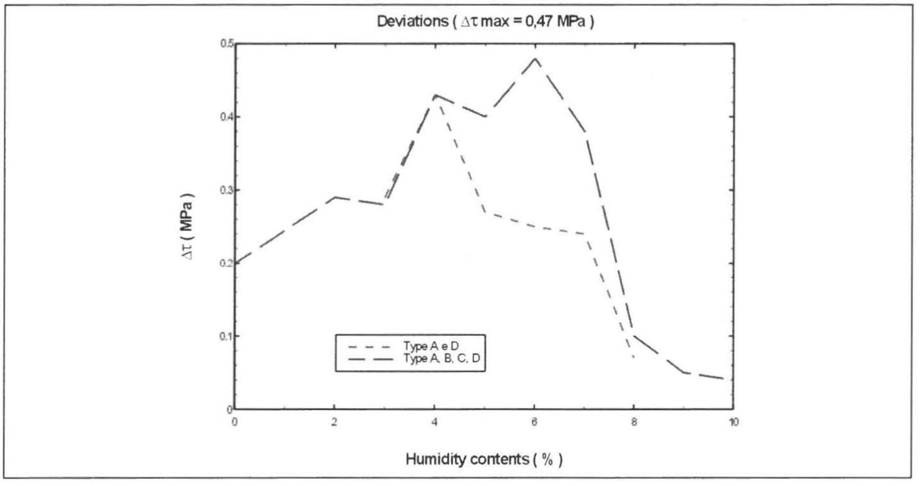
It is considered useful, for example, to carry out comparative tests using other types of samples and other laying conditions on the pressure plates.

5. CONCLUSIONS

The results of the this experimental study proved the great influence that the humidity content, at the time of laying, has on the shear resistance of masonry, and the need to research this and get the values applicable in the masonry design.

In spite of the great number of tests, the desired statistic significance has not been reached yet. However the indication is that for the type of brick and mortar studied, the humidity content favourable to a greater shear resistance of the mortar joints is in the band of 3.5 to 6.5. Furthermore it was possible to identify the areas with a greater dispersion of the results which coincide with the best average results. This means it is necessary to do a deeper study in order to eliminate the parasite influences in the tests.

Figure 5. Variation of the deviations of stress Dt with humidity contentsç



Remember that the EC6 shows simplified formulas and standard values, namely of resistance to the initial shear of the masonry f_{v0i}. Only an adequate experimental study of the material behaviour, individually or together, will permit these formulas to represent the reality with the desired efficiency.

In this context in the work carried out, we saw that the humidity content at laying time was lower than 3,5% or above 6,5%. The average values of the resistance to the initial shear of masonry obtained, were found to be below the EC6 values claimed; these values confirm the necessity for the adaptation of the EC6 parameters to the portuguese reality and the promotion of the Eurocode in Portugal (8).

We verify that there is still a vast study to be done, namely in the characterisation of the portuguese market, where it is urgent to take measures to stimulate the national industry to characterise its product better, namely in the aspects concerning the water absorption. We believe it would be useful that the process of certification of the brick, could also include information about the adherence between the brick and a type of standard mortar.

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