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Use of Mortar Plaster and Reinforcement For Repairing and Stiffening of Non-Structural Masonry Walls

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Abstract: *Many constructions built using the techniques of daub, paving clay or adobe have presented many pathologies and sometimes even risk of ruptures of some walls. In order to reinforce such walls, it is suggested in this work the use of mortar plaster, or reinforced mortar plaster with welded steel mesh, applied to the wall with non-structural blocks.Nine walls were tested for compression, being three walls of non-structural blocks without mortar plaster, three walls withmortar plaster and finally three walls with the same blocks plastered with reinforced with welded steel mesh.Three specimens had the dimensions of 1.20 m by 2.60 m andthe other six, called small walls,had dimensions of 0.90 m by 1.04 m. Simple compression loads capacity were obtained and it can be concluded that the application of the mortar plaster substantially increased the load capacity of the walls, as compared to the walls without mortar plaster.An increase of up to eight times in the rupture load was observed. The tests performed with the walls containing welded steel mesh inserted in the mortar plaster were not conclusive, although comparing them with the walls without mortar plaster, there was also gain of significant mechanical resistance.*

Keywords *- experimental analysis,non-structural clay brick,reinforced mortar plaster,wall with mortar plaster, welded steel mesh.*

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I. Introduction

In Brazil, the evolution of the masonry went through mud, daub, stone masonry, masonry of bricks, to masonry of industrialized blocks. Oliveira [1] states that the mud required a lot of construction space and evolved to the stick to obtain larger useful spaces. In this sense of searching for material that met the expectations of that time, the stone masonry was developed, which was the use of faceted rocks. Even so, he affirms that, in the nineteenth century, pestlemud still predominated in the building site. Only in the 1940s the Brazilian Association of Technical Standards (ABNT) set the dimensions for the baked clay brick, with the aim of standardizing the masonry execution services. Despite the lack of standardization, many Brazilian historical constructions were made using constructive techniques applicable to the execution of small constructions, mainly those that use the ceramic brick with functions of structural masonry.Oliveira [2] states that the reinforced mortar has been used as a form of reinforcement and recovery of masonry and that its use brings very positive results of increase of resistance, ductility and durability. Thus,it is suggested that the use of steel mesh inserted in mortar plaster is the best way to reinforce or recover it. It is known that the durability of the constructions is directly proportional to the protection of the steel reinforcement.So the care with the covering and protection of steel reinforcement is fundamental, since the mortar protects against corrosion.The calcium hydroxide provides a highly alkaline environment, with a pH around 12, which passivates the reinforcement, in the recovery and reinforcement of masonry, using reinforced mortar.In any case, studies indicate that the use of reinforcement in structural masonry is positive. Oliveira [2] reports that positive results in work with ceramic brick masonry was found. According to them, the plastered walls acquired strength and ductility. They also add that the failure behavior changed when the specimens were subjected to compression, because there was separation of the facing plates of the masonry.Oliveira [2] analyzed the effect of the reinforced mortar plaster on the axial compressive strength of concretblock walls. Fig. 1 shows in part (a) the steel mesh installation on a wall of concrete blocks, before being plastered. In part (b)the cracks after the test are presented in the case of theuse of mortar plaster and finally in part (c) the cracks in the wall with reinforced plaster with steel mesh.

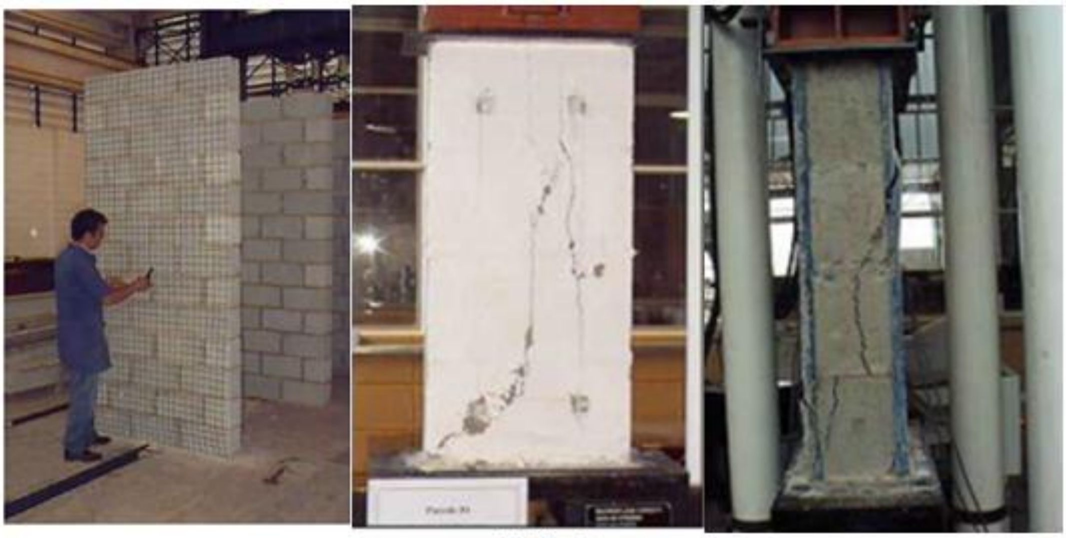

Figure 1. Tests done by Oliveira [2]in plasteredwalls

The graph of Fig. 2 represents tests performed by Oliveira [2]. It is extracted from it that the plastered wall has achieved a compressive strength much higher than that of the walls without plaster. Nevertheless, recovered walls, i.e.those which have undergone load until acquiring small cracks and later was plastered, also presented great load capacity, revealing the excellent recuperative capacity aggregated by the mortar plaster.

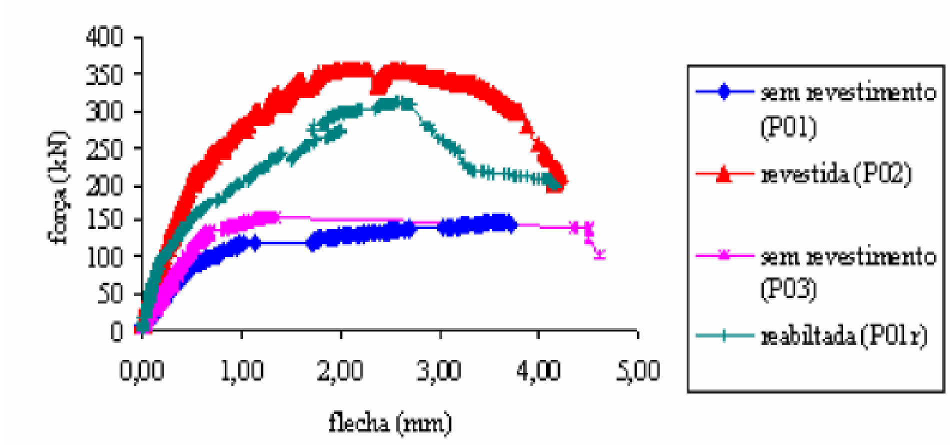

Figure 2.Graph of tests results byOliveira [2]

II. Experimental Procedure – Materials and Methods

This study aims to study the recovery of non-structural masonry, but which perform structural functions, as occurs in many Brazilian historical constructions, at a low cost, and preserving their artistic value. The technique that is intended to show is the one that contemplates the recovery of masonry with the use of plaster and reinforced plaster. The option adopted to evaluate this technique was to plaster the walls without having been previously loaded, and to evaluate the increase of resistance when compared to the resistance of the wall without plaster. Next the sequence of tests performed by Cyrino [3] is presented.

II.1 Reinforcement with mortar plaster

The basic idea is to add resistant capacity to the non-structural masonry submitted to axial loads, through mortar plaster. Obviously, the larger the wall thickness, the greater its strength. However, it is necessary to know which favorable conditions are necessary for this to occur, like the ideal plaster thickness to be incorporated. Furthermore, it is necessary to analyze the influence of the plaster's adhesion to the masonry.

II.2 Reinforcement with mortar plaster with steel mesh

The idea of incorporating steel meshes into the plaster goes back to that of reinforced concrete, when it increases the strength of the element, increasing its efficiency in the tensile stresses and resistance to compression. Singly, the name given to this association is reinforced mortar.

II.3 Methodology

The study consisted basically of applying resistant plasters to the masonry in order to obtain a mixture of masonry, which would be the core of the element, and mortar plaster, reinforced or not, on the external faces. To do this, in order to elaborate a correlation, three different situations were compared, namely:

✓ Wall without mortar plaster;
✓ Wall with mortar plaster; and
✓ Wall with reinforced mortar plaster with steel mesh.

Previous studies conducted in Brazil, such as Oliveira [2], were based on this technique and obtained good results. However, in these works, in general, reinforcement with plaster occurred in walls of structural masonry, which already had a good resistance to compression. In this work, it is proposed to apply the reinforcement technique in non-structural clay brick, which, for the most part, does not reach a resistance of more than 1.5 MPa. Therefore, it is to be expected that the plaster will have a more significant in the resistant capacity of the wall.In order to carry out the tests, nine walls were constructed, being three with dimensions of 2.60 m of height by 1.20 m of length (Fig. 3a), and six small walls with dimensions of 1,04 m of height and 0,90 m in length (Fig. 3b). All walls were built with clay bricks (29 x 19 x 9) cm. The proportion of the laying mortar was 1: 6 (cement: sand) by volume, with a water / cement factor of 0.55. The cement used was CP-V of high initial strength. All plastered walls received a layer of roughcast 1: 3 (cement: sand) before the mortar.
The following nomenclature was adopted in order to identify the specimens:

✓ PAR-1: 1,20 m x 2,60 m wall, without mortar plaster;
✓ PAR-2: 1,20 m x 2,60 m wall, with mortar plaster;
✓ PAR-3: 1,20 m x 2,60 m wall, with mortar plaster with steel mesh;
✓ MPAR-1a e 1b: 0,90 m x 1,04 m walls, without mortar plaster;
✓ MPAR-2a e 2b: 0,90 m x 1,04 m walls, with mortar plaster;
✓ MPAR-3a e 3b: 0,90 m x 1,04 m walls, with mortar plaster with steel mesh.
✓

(a) (b)

Figure 3.(a) Wallof1,20 m x 2,60 m with roughcast and plaster,(b) Wallof 0,90 m x 1,04 m with roughcast

The application of the welded steel mesh did not involve advanced technique or use of specialized labor. For fixing the mesh to the masonry, small holes were drilled through the wall, in which PG7-type wires were used, normally used in steel reinforcements and that greatly facilitate the work.

III. Experimental Results

III.1 Mortar

Twelve specimens of the mortar used in the 1: 6 trace (cement: sand) by volume were tested for compression, obtaining an average strength of 6.0 MPa. This mortar was used for both laying and execution of plaster.

III.2 Clay bricks

Specimens of the clay bricks were tested under simple compression (Fig. 4), according to the recommendations of ABNT NBR 15.270-3 [4], which imposes the saturated condition. A total of six specimens were tested and the average strength obtained was 1.6 MPa, with a coefficient of variation of 15%, higher than the prescribed minimum value of 1.5 MPa for non-structural clay bricks.

(a) (b)

Figure 4. (a) Clay brick before test, (b) Clay brick after test

III.3 Prisms

Three specimens of two-block prisms with mortar were also tested (Fig. 5), with an average strength of 0.7 MPa with a coefficient of variation of 10%

(a) (b)

Figure 5.(a) Prism before test,(b) Prism after test

III.4 Walls and Small Walls

Three walls of 1.20m x 2.6m, six small walls of 1.04m x 0.90m, without plaster, plastered and plastered with steel mesh were tested for compression.

In Fig. 6, the walls without plaster, with plaster and with plaster with steel mesh, respectively, are shown after tests. The results for the various test specimens are listed in Tab. 1.

Figure 6. Failure modes of 1,20m x 2,60m walls

Table 1. Results for axial compression tests of specimens

Wall	Type	Dimension(m)	Area(cm^2)	RuptureLoad(kN)	Rupture Stress (MPa)
PAR-1	Without mortar plaster	2,60 x 1,20 x 0,09	1080	64,88	0,60
PAR-2	With mortar plaster	2,60 x 1,20 x 0,13	1560	595,00	3,81
PAR-3	With mortar and steel mesh	2,60 x 1,20 x 0,13	1560	410,00	2,63
MPAR-1A	Without mortar plaster	1,04 x 0,90 x 0,09	810	51,20	0,63
MPAR-1B	Without mortar plaster	1,04 x 0,90 x 0,09	810	40,09	0,49
MPAR-2A	With mortar plaster	1,04 x 0,90 x 0,13	1170	80,49	0,68
MPAR-2B	With mortar plaster	1,04 x 0,90 x 0,13	1170	140,50	1,20
MPAR-3A	With mortar and steel mesh	1,04 x 0,90 x 0,13	1170	146,01	1,25
MPAR-3B	With mortar and steel mesh	1,04 x 0,90 x 0,13	1170	124,00	1,06

From the observations on the failure modes of the walls, it was noticed that the block adherence with the mortar was perfect and that, due to the shape of the loose plaster plates, the wall would have broken more by shear stresses in the plaster than by compression. For the wall with reinforced plaster, unexpectedly, the rupture occurred with a 31% lower load. The failure was caused by the separation of the reinforced plaster from the masonry, as was the case with PAR-2 (plaster only). However, the presence of the steel mesh in the plaster induced a more accentedseparation since it uniforms the plaster. Besides that, it was also noticed that part of the steel meshbuckled inside the plaster and was expelled.

IV. Conclusions

This work aimed to find a solution to the problems of lack of strength of masonry that were executed with non-structural clay bricks, which receive load and end up performing the structural function. The main objective was to find an alternative that was inexpensive, easy to implement and that could be applied to non-structural walls, even if constructed with another technique, such as mud. From the tests carried out it was possible to conclude that:

- ✓ From the observed rupture configurations, it was found that, firstly, none of the walls actually reached their maximum rupture stress, since the local ruptures occurred either in the base or in the top of the walls, and it was not verified any vertical crack;
- ✓ The capping on the plastered walls, with or withoutsteel mesh, led to the formation of a small slab, which was supported on the plaster. As the wall core, that is, the masonry, had a much lower compressive strength than the plaster, this small slab ruptured by bending, pushing the masonry down and the plaster to the sides;
- ✓ The results obtained with the small walls presented strength much smaller than expected, which may have been caused by the use of a neoprene plate as a support and may have induced horizontal tensile stresses in the septa of the low resistance bricks;

- ✓ The insertion of welded steel mesh in the plaster did not indicate, as expected, an increase in the resistant capacity of the walls, compared to the walls only plastered, perhaps due to the spacing of the bars (150mm x 150mm), since it was observed buckling of these bars.

Therefore, it can be stated that the technique of reinforcing walls with the application of reinforced or non-reinforced plasters can be applied both to the rehabilitation of walls and other masonry elements and to the design and execution of elements with special performance properties. Hence, the technique can be applied in the recovery of constructions of non-structural masonry. However, it is important to emphasize that further tests must be taken, using other materials as core wall, such as mud and daub, so that this technique can be generalized.

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