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Core, connectors and crust: Methodological restoration options for reinforced rammed earth wall with bricks

V. Cristini & J.R. Ruiz Checa
Universitat Politècnica de València, Valencia, Spain

ABSTRACT: Rammed earth walls with bricks (*tapia valenciana*) belong to the "family" of earthen structural techniques, where reinforcements, by means of layers of bricks protected by a crust of lime, are present. This ensemble of materials obeys secular constructive technology and a balanced system based on specific material hierarchy. This is because walls made using this technique base their constructive logic on the union of the strata, in response to possible low lying forces (movements, settling) as well as absorption of horizontal pressure from the inner filling. Today, understanding the historical technique is necessary in order to weigh up possible intervention criteria. In doing so, various questions arise: in which areas of the combination of core + connectors + crust can we intervene? How are we able to do this? The authors will outline an excursus of guidelines used in recent interventions, and consider the different methodological criteria visible in the several cases of study analyzed.

1 INTRODUCTION

1.1 *General features about this type of wall*

Tapia valenciana is a hybrid wall, where the earthen and lime mortar work together with specific brick reinforcements, a mixture of lime, gravel and rammed earth. Because of this, the resulting coating of the wall face is sometimes misleading, halfway between traditional rammed earth wall and brick masonry. In the majority of cases, the finish is comprised of the same crust of lime which, due to the removal of the planks, creates a peculiar texture in the form of a fine layer of mortar overflowing on the bricks' edges (Fig. 1).

This technique, a curious blend of earthen and brick application, is not documented in any archaeological sources until the second half of the 13th century (Siam, *Servicio de Investigación Arqueológico Municipal de Valencia*). In fact, the name itself is not explicitly detected until the 16th century (Galarza 1996). The name "Valencian walls" is significant, despite the fact that the employment of this technique spreads far beyond the city of Valencia (Vegas, Mileto, Cristini, García 2011a/b) and its surroundings (Alcira, Xàtiva, Alaquàs, Castellón, Mascarell, Masamagrell, Sagunto, villages among others …), and even beyond the Valencian Community (Murcia, Aragón, Andalucian city of Guadix up to north Africa coastal regions- Chennaoui 1997).

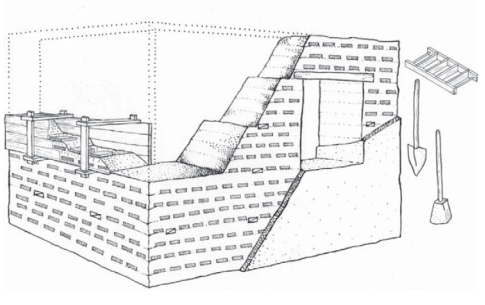

Figure 1. Construction of a tapia valenciana wall. (Authors: García, Cristini & Tibor).

In fact *tapia valenciana* walls offer an appearance of simple brickwork but, after careful observation, it is possible to see that the mortar joints can reach a thickness of up to 10 cm, so that the walls are made by planks form.

If on the other hand we are to analyze the metric characteristics of these walls, we have to recognize the heterogeneous nature of the used bricks. In spite of the arrangement of regular "key" bricks, it's always possible to find bricks of multiple sizes and clay types, varying along the same wall (Font-Hidalgo 2009). That is why it is necessary to consider the use of recycled raw materials, perhaps defective or recovered, in the configuration of these walls (Cristini-Ruiz Checa 2009 a/b/c).

The presence of irregular bricks is not gratuitous, since it is a question of punctual reinforcement, by way of ceramic connectors, and as such the constructive/structural logic moves away from a "simple bond concept". For this reason,

Figure 2. Mortar core, ceramic connectors and crust. Three detached parts of a *tapia valenciana* wall. (Authors: Cristini & Ruiz Checa).

the heterogeneity of the raw materials is not unintentional. In this case, the bricks' function is more that of connecting the strata rather than traditional brickwork masonry. Because of this, it is possible to identify three detached and well defined parts that form a *tapia valenciana* wall: a rammed earth and lime mortar core, a few ceramic connectors and finally a lime crust (Fig. 2).

2 HOW IS POSSIBLE TO RESTORE A *TAPIA VALENCIANA* WALL?

The present study has arisen from an empirical demand of the authors who proposed the analysis of *tapia valenciana* walls, focusing particular attention on the connectors (bricks) and their role in the wall bond.

Nevertheless, when it came to analyzing, measuring and drawing the walls, we inevitably found different examples of restored or modified walls, transformed using inconsistent logics and heterogeneous criteria.

Hence the idea of documenting these cases and collating different intervention techniques, with the final aim of proposing possible actions and identifying common practices and different alternatives.

2.1 *The core*

Tapia valenciana walls usually present different thicknesses, depending on the destined use of the constructed buildings, varying from simple fences and dividing walls, to city walls or load-bearing walls. For this reason, it's possible to say that, of the three variables that form this type of wall (the core, connectors and the crust), the mortar core is in fact the part that can vary the most according to different cases studied, both due to its depth, and its composition (mortar/sand).

2.2 *The connectors*

The bricks, in this type of wall, are not really bonded, but in fact are more like pieces arranged in the frame, positioned in each layer, in a non-random way, always placed next to the lateral boards.

The connectors are always heterogeneous, both in color and dimension, as well as raw material and texture. In some cases it is possible to find fragmented pieces of bricks, a feature that also helps establish possible hypotheses on the reuse of bricks as raw materials. Another common point is the halo of crust around the bricks' surface. The connectors remain misaligned, invariably embedded in the crust. Nevertheless, the presence of bricks can change from a headers pattern into a traditional bond, with stretchers and headers, especially in buttresses, corners or pillars (Cristini-Ruiz Checa 2009 a/b/c).

2.3 *The crust*

As already touched upon in the previous point, the lime crust that seals the wall surface is formed by a combination of layers that overflow into the plank frame (Fig. 3).

In addition, the distribution and thickness of the bricks, as well as the crust, do not change according to the wall sections of the wall or the building's purpose; instead finer and more sifted sand, and more pure lime can sometimes be seen … but the final coating of the wall is always the same.

Figure 3. Well preserved surface of a *tapia valenciana* wall, *Iglesia de S. Juan de la Cruz*, Valencia (Authors: Cristini & Ruiz Checa).

Undoubtedly, the fact that this type of wall is formed by an "all in one" constructive process, characterized by a single sequenced operation (the preparation of earthen and lime layers set into a timber board frame, with ceramic brick connectors arranged in each strata), inevitably opens up possible questions on possible intervention options at later stages in the walls' lifespan.

It is quite difficult to find examples of *tapia valenciana* walls that have not been modified (AA.VV. 2007), in good condition, and without pathological signs, that could be used as basis for case-study (Cristini 2012). Precisely because of this, the authors have relied on the different interventions, which in part have helped in understanding the structural technique and process (Amando Llopis, R.F. 1998; Tormo Esteve, S & Cortés Meseguer, L. 2008; García Martínez, V. 2008 … between others).

3 INTERVENTION ANALYSIS

After the interventions, the majority of the analyzed walls reveal processes carried out mainly in the crust. Many of the cases deal with plasters, anti graffiti treatments, or coatings that distress on the walls' "surface of sacrifice", and replace or cover the original surface (Figs. 4–5). A few cases display simple epidermis consolidation, in order to avoid micro-fissures and discontinuities, thanks to jointing processes.

In reality, crust interventions on these walls, carried out in many cases by puncturing the crust and then coating the structure with a new thick layer, have been due to the fact that historically they have not enjoyed extensive aesthetic consensus.

This irregular wall surface is historically associated with more humble structures, and as such considered less "respectable" than most regular brick masonries.

Figure 4. Whitewashed surface of *tapia valenciana* wall, *Ermita de S. Jaume de Fadrell*, Castellón (Authors: Cristini & Ruiz Checa).

Figure 5. Whitewashed surface detail, *Ermita de S. Jaume de Fadrell*, Castellón (Authors: Cristini & Ruiz Checa).

For this reason the tendency was to conceal these rammed earth walls with matt finishing, thus improving the surface aesthetics (many of today's monumental buildings can be found amongst these cases). In the last few years this was a widely accepted practice.

This process, depending on the material used (more or less compatible with the support), has either produced well-adhered finishes or, in some cases, layers with pulverization, chipping and erosion problems.

Moreover, in some cases, the original wall texture displays new renderings that simulate the primitive wall bond, which they aspire to, with more or less successful results. Some contemporary interventions have featured stencil decoration and graphic images, in search for abstract plans that recall and simulate the header bricks (Figs. 6–7).

Other, more structural interventions, replace the connectors, typically the most degraded and flakey ones, extracting the deteriorated elements and replacing them with new bricks.

In these cases the operation can also be more or less compatible with the support that acts in the exterior layer, i.e. the crust (it is recommended to use ancient, handcrafted bricks, in tune with the size, color and texture of the originals).

The interventions thus create patches of mortar in the areas next to the bricks, in a process carried out after the placement of the new connectors.

On the other hand, interventions in the core are less common. The depth of this type of intervention in itself signifies the need for a change in approach; these types of interventions need to be considered as volumetric reconstructions. Undoubtedly a huge loss in percentage of historical wall is inevitable in these cases, often rebuilt solely with mortar without brick connectors.

These cases are those that usually use new timber-frame designs (for both single face or double face) with mortars of different compositions, textures

Figure 6. A surface detail, simulating header bricks. *Almudin*, Valencia (Medieval Granary) (Authors: Cristini & Ruiz Checa).

Figure 7. A surface detail, simulating header bricks. *Palacio del Gremio de Carpinteros* (Ancient Carpenters' Trade Centre) (Authors: Cristini & Ruiz Checa).

and relations with the pre existing structure (with new alignments, overlaps and cuts). Following these observations new limits and challenges can be established for restoring the different parts of *tapia valenciana*.

Figure 8. Core and surface interventions: *Alaquás* Castle, Valencia and *Palacio d'en Bou*, Valencia (Authors: Cristini & Ruiz Checa).

But why is it so complicated to work in this tripartite system, made up of core, connectors and crust? Perhaps in order to answer the question, we have to refresh our understanding of the constructive technique itself. The *Tapia valenciana* wall, formed by three different materials, mortar, cooked bricks and lime crust, owes its characteristic features in particular to the inlay bricks.

It is these connectors, which partly contribute to the absorption of low-lying forces, which play a fundamental role in the wall. They are, as explained before, the real connectors that join and fix the crust with the core; anchoring the parts and helping to join the exterior and the interior layer. Working on a *tapia valenciana* wall means dealing with a structure that features a non-refundable frame adhered to it (Fig. 8). It is this mold itself, made up of binomial bricks and crust that provides decent protection of the earthen and lime mortar core, this being the most vulnerable part of the structure.

4 CONCLUSIONS

The analyzed interventions in *tapia valenciana* walls usually answer to different needs, often guided by wall degradation levels and by a change in the use of the building. The degree of manipulation ranges from processes with minimal levels of intervention (such as consolidation/re-filling of the crust), the substitution and repair of parts (relaying, renewing or supplementing bricks) to pure volumetric reconstruction (Fig. 9).

We can therefore say that the intensity of the intervention is greater the deeper or closer you get to the rammed earth and lime core. However, if we consider *tapia valenciana* a structure with a non-refundable form adhered to it, the interpretations

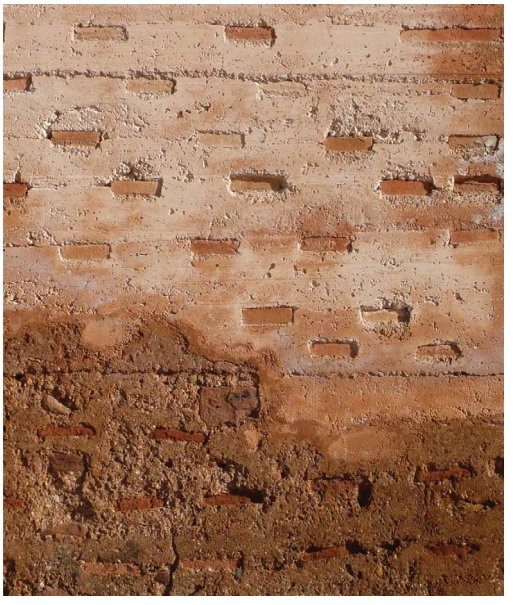

Figure 9. Example of *tapia valenciana* volumetric reconstruction. *Mascarell* city wall, Castellón (Author: Cristini & Ruiz Checa).

of the technique, and the possible interventions, change.

Working on a non-refundable form incorporated into the wall (created by the bricks + crust system) is an extremely delicate process, based on the assumption that the wall works as an "all in one system". It is possible therefore to consider two extremes: on the one hand minimal intervention, which scarcely fixes thin skin crust and guarantees its adhesion, or on the other hand the ex-novo volumetric reconstruction.

Thus an "intermediate" position which proposes changes in the key connectors (removal, substitution, repair or addition) is possibly the most delicate. Since the risk of separating the parts is quite high, the bricks in these cases tend to drag part of the mortar with them, the repair of mortar ends up by being heterogeneous (both regarding the core and the finishing layer). Therefore the risk of adhesion loss is more marked, and the connection between the parts is weaker.

Finally it is possible to conclude that crust interventions, in many cases with partial substitution and puncturing/pitting, are not always influenced by the thickness of the walls/are not always determined by the thickness of the walls. In some cases load-bearing walls with sections thicker than 60 cm, are modified by the removal of renderings and in there-joining process. These processes are not necessarily structural; instead they tend to be carried out for urban decoration or project purposes. These considerations regarding the intervention criteria on *tapia valenciana* are proposed as short summarized guidelines, without want of criticism, but rather to collate common practice and understanding of these walls and their constructive/structural logic.

NOTE

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