Rammed Earth Conservation

Editors
C. Mileto, F. Vegas & V. Cristini
Universitat Politècnica de València, Spain
The Restoration of Tapia Structures in the Cuarto Real de Santo Domingo (Granada)

A. Almagro & A. Orihuela
Laboratory of Archaeology and Architecture of the City (LAAC)
School of Arabic Studies, CSIC, Granada, Spain.

ABSTRACT: The Cuarto Real de Santo Domingo (Royal House of St. Dominic) is a building dating back to the beginning of Nasrid times (second half of the 13th century), in which there was a widespread use of the system of tapia (rammed earth). In the restoration carried out some years ago it was not only necessary to deal with the deterioration of the original tapia, but also of the different historical restorations. In this paper we are presenting the methods used in this intervention, including systems of anchorage in the replacement of fallen expanses of construction, as well as the final outer finish of the renovated areas, in an effort to achieve durability and harmony with the remaining original parts.

1 INTRODUCTION

The Cuarto Real de Santo Domingo is a building of enormous historical, artistic and constructive interest, located in the southern area of the Islamic city of Granada, and whose construction dates back to the beginning of the Nasrid period (second half of the 13th century; Rodríguez Trobajo 2008). We refer to what was in its time a royal property of the Granada sultans, which was known as the Huerta Grande (Main Orchard) of Almanxara at the time of the conquest by Castile, and was donated by the Catholic Monarchs to the Dominican Order to found the convent of Santa Cruz la Real. From then until the seizure of ecclesiastical properties in the middle of the 19th century, it formed part of the convent’s lands. Basically, it consisted of a walled garden and a hall in the shape of a qubba inside the fortified tower of the wall of the Potters’ Suburb (Arrabal de los Alfareros) (Orihuela, 1996, Almagro & Orihuela 1997). The tower and the city wall that are attached to a considerable slope of the natural ground work as retaining elements of the garden; there is a difference in height of almost ten meters between the garden and the outer city area.

2 DESCRIPTION

The outer measurements of the layout of the tower are 14.30 x 9.50 m with a height of 15.50 m and it is formed of an older nucleus of 10.25 x 6.25 m that was later extended to hold the qubba (Fig. 1). Both the heavier construction work of the tower, the interior partition work and the enclosure walling of the garden are built with the tapia (rammed earth) technique, and carried out using natural materials from the area; these are known as “Alhambra formation” conglomerates with lime. “Alhambra formation” consists of conglomerates of cobblestones, different sizes of aggregates and red-coloured clay in different degrees of carbonation, which could be found as completely disintegrated materials or others well cemented together with consistency. The use of this type of materials in the construction of tapias means that it is often difficult to distinguish between re-
parts, both made of *tapia* and with a similar thickness, 0.70 m. The external part had brick corners throughout the whole width. There are also two brick piers on the southern face, set out symmetrically; they could correspond to the base of the jamb of an opening, but as the whole of this structure was destroyed above the level of the floor of the *qubba*, this hypothesis cannot be confirmed. The inner panel is all of *tapia* and was built putting formwork on the inner face only. This attached wall served as a support for the vault covering the resulting space and as an infrastructure or perhaps an accessible basement, leaving most of this first tower empty (fig. 2). The vault pointed in an east-west direction. In an important process of consolidation, no doubt carried out at the beginning of the 18th century, and which we shall mention later, the covering was demolished and the whole of that space was filled with rubble. In spite of this, and thanks to the traces that have survived, we can confirm that the vault was built of bricks composed of rings of flat bricks set edgeways, i.e. with their flat faces parallel to the end sides, to avoid using centering (Almagro 2001), and that its construction began on the western side. For support, a groove was made along the side walls, similarly to how it was done in the tower of Romilla (Almagro 1991). This groove only survives along the southern side of the room, because on the northern side the re-rendering of this facing eliminated all remains of the support. It seems that the profile of the vault was slightly pointed or maybe parabolic. The courses of the interior wall of *tapia* show the signs of the *tapiales* (side shuttering) with the impression of the nails joining the boards. These boards measured 0.80 m in height.

The oldest tower, as we have already mentioned, was extended by an attachment on its outer surface of thick walls, also of *tapia*, that had formwork put on the outer surface only. Here we can see that the average height of the courses is 0.87 m and that they were filled in a continuous way, so we cannot observe any joints or discontinuous elements in the material. In some places, particularly above opening of the lower windows in the *qubba*, we can still see the marks left by the nails of the *tapiales* in the fresh mass, as well as their vertical joints. To uphold the increase in thickness of the original walls, it seems that logs of wood were set out horizontally and at every set distance more or less regularly. In some parts, where the exterior crust was deteriorated or where a greater loss of material has occurred, we can see holes left by the *agujas* (pieces of wood for sustaining the shuttering) that disappeared on all except the northern face, where those holes were formed with flagstones from the river to allow the wood to be extracted. The thickness of the increase in width varied between 3.35 m on the southern side and 2.00 m on the eastern and western sides.
Above the floor level of the qubba, the external walls have a constant thickness of 1.20 m on all sides and are made of tapia throughout, except for the jambs of the openings which are made of brick with tuskings, as already explained. The exterior walls leave an inner space of 11.87 x 7.22 m, subdivided in seven spaces by means of transversal walls defining a central square hall measuring 7.20 m, the qubba and three satellite spaces each side, communicating with the main one by means of arches and doorways. The walls separating these spaces were also of tapia, although the extremities giving on to the central room are of brick with tuskings as already mentioned. As we have indicated, these internal walls had no bonding with those of the perimeter, but were simply in contact.

As from 6 m from the floor of the qubba the external walls are cut short, and from this height a square body stands out, like a lantern (Fig. 3), sustained on the northern and southern walls and on the header faces of the interior transversal walls. This lantern body has five small arches on each side to light the interior and is finished with a square trough collar-beam roof. Constructively, the way in which this higher body was made, of mixed masonry brickwork and tapia, turns out to be very appropriate. Prior to making the lantern, the six satellite spaces were covered with panelled ceilings with beams supported on the eastern and western outer walls and on some thin wooden beams supported on the header faces of the partition walls, and placed very near the wall face of the central hall. Underneath this beam, in the two central wall openings, plaster arches with decoration without any tectonic function were built. The four side wall openings were closed with wooden doors. Over these panelled ceilings the tapiales were prepared, to continue the construction with rammed earth. To avoid loading the weight of the wall which otherwise would have rested on the previously mentioned beams, other beams of a greater section, formed like tree trunks were set into the mixture and were practically concealed. The lantern wall is of tapia up to the height of the windows. They are formed with brickwork, both in the jambs and arches, and above them the tapia continues up to the eaves; the present one is the result of the 18th century restoration. The original one would no doubt have been of leaning wooden corbels, characteristic of Nasrid architecture.

3 DETERIORATION

In spite of the fact that the monument has been regularly maintained and has never reached a state of abandon or ruin, due to the nature of the materials and its topographical situation as a building attached to a sloping ground, certain deterioration has occurred that is typical of this type of building work and that has essentially affected the superficial layers, which have been repaired in different periods and using diverse methods.

The main cause of this deterioration has been the effect of damp coming from the land itself, due to the phenomenon of capillary action, and from rainwater that has in this case particularly affected the walls orientated towards the southwest, the direction of the heaviest rains. In both cases, the presence of water in the mass of the tapia and the consequent process of drying and crystallization of salts that have filtered through have provoked deterioration in the surfaces exposed to the air, though more limited when these surfaces are formed by layers that are strongly carbonatized and in increasing progression as the material exposed has less resistance due to containing less lime. The action of the humidity from rain was particularly serious in the support of the lantern on the western side, as we may assume that the trunks set into the mass of the tapia must have rotted away and meant a turn in the wall that was controlled by substituting those beams for other squared ones. We imagine that this was achieved in the repair work in the 18th century, although it meant that the panelled ceilings on that side disappeared together with part of the interior decoration.

Nor should we forget actions caused by man, opening up windows to adapt the building to uses other than those originally designed, and some of the restoration work that in specific cases has been definitely aggressive.
Another important operation at this moment was the repair of the west side of the lantern, already mentioned, which must have involved renovation of the eaves. On the cornice of the wall of the lantern, which must have been in bad condition, part of the work of the tapia was substituted by brickwork that on the western side reached almost the whole of what existed above the small arches of the windows.

Finally, on the western façade of the tower the tapia was covered with masonry brickwork after having cleaned up and enlarged the corresponding space, to be able to place at least half bat of it. The masonry brickwork was covered with mortar and certain ornamental motifs were set on the higher part while at the same time some windows with balconies were opened in the outer walls (Fig. 4).

The 1910 restoration involved both structural aspects and interior adornment. Regarding the exterior, repair work was done on the southern front elevation, incorporating coverings of brick which were in this case facing brick, without any mortar. At some stage between the 18th and 20th centuries the interior compartmentalization walls were eliminated, leaving only their brick header faces as mere pillars, and because of losing their bracing they were subjected to serious deformation. For this reason other new pillars were attached to them, closing up the original accesses of communication of the auxiliary spaces with the main hall. The lantern also proceeded to be stabilized by means of metallic tie bars that were visible from the inside, attached by means of metallic profiles fixed to the outer wall faces, all of which gave considerably unfortunate visual effects.

In the last restoration not only the deterioration of the original tapia had to be dealt with, but also the historic restoration work that showed signs of decay, incompatibility of the materials used with the original masonry and detachment from this.

In our restoration we have followed criteria based on an effort to recuperate the original structure of the building, and repairs have been accomplished using materials and techniques similar to the original ones, therefore trying to safeguard the aesthetics of the monument itself. Whenever possible we have maintained the transformations that had some symbolic historic value, just as long as they did not involve aggressive action or deterioration of the fundamental values of the original work. Anyway, we have endeavoured to achieve correct documentation of all the information that the monument provided.

As far as the tapia is concerned, we would like to point out that we have followed methods that are very similar to those used in previous actions, with the intention of improving and resolving the problems that were presented.

We must recognize that when tapia is dilapidated it is difficult to reintegrate, since the new masonry of one type of earth or another has less powers of adhesion than the old materials. We can say that his-
torically two methods have been applied, according to the degree of deterioration. If it was only superficial and hardly reached a few centimeters down, it was generally reinstated with a straightforward rendering of mortar, which always has the difficulty of achieving adequate adherence. But normally, the deeper the damage, the less the resistance and compactness of the material of the *tapia*, and although the new mortar sticks to the layer on the exterior, with any tension it will detach itself from the rest together with wide expanses of the new mortar.

When the loss of material was more serious and it was impossible to reinstate it with layers of mortar, what was missing was rarely completed with new *tapia* because of the difficulty of implementing the work as well as the problems of adherence. The most frequent solution was to complete the lost areas with masses of masonry brickwork or rubble work of sufficient thickness to be stable on its own and not to have to depend on adherence to the old part. In many cases part of the eroded part in the old material was enlarged to allow at least one whole brick to fit in the new filling. These patches were later plastered, the same as the other less serious damage, so in many cases it was quite possible to manage an almost complete plastering of the whole construction work.

All the historical interventions carried out on this monument followed these techniques, and almost all the deterioration affected the restoration with which in many cases the initial damage had been aggravated. This was particularly visible in many of the brick coverings; in spite of being apparently firm on their own, having at least half bat of thickness, their excessive slenderness when detached from the nucleus of the wall and the pressure exerted on them by the materials that became detached from the wall because of disintegration from the *tapia*, had caused them to fall or at least had created instability.

Under these circumstances we must realize that the possibilities of action are still quite limited. Our intention has been to endeavour to improve the integration and adherence of the new materials supplied with the original building work, although we have continued to use the same repair methods as we recognize that there are no other procedures with a better guarantee. What is quite clear is that the deteriorated masonry cannot be left in this state, because as it has lost the strongly carbonated crust of the initial surface, there will definitely be progressive deterioration. On the other hand, the appearance of the *tapia* is totally different from the original; therefore there may be a rather undesirable aesthetic alteration in safeguarding the values of the monument.

The methods we have resorted to in our interventions have included attachment systems both in the replacement of important expanses of fallen masonry and in the rendering used in repairing superficial losses. To carry out this attachment we have resorted to very traditional materials and processes, inspired in the solutions used in old times.

The attachment has been made with wood, since that was the material that was used to a great extent in the *tapia*, as we have been able to establish in this building itself and in other places. Therefore, in the constructions in Meknes (Morocco), probably one of the most impressive complexes of *tapia* constructions, with over 30 km of walls built with this technique, we have been able to observe a systematic use of wooden elements set into the mass of the walls to give them greater bonding, in particular in the angles and corners where cracks tend to happen with ease, due to differential settlements or other earth movements.

With this experience behind us, we began to take advantage of any opening in the original wall, whether of *agujas* (pieces of wood for sustaining the shuttering), or previous strengthening elements, to introduce pieces of wood covered with plaster and hemp to guarantee good adherence to the masonry and protection of the material. These pieces had sufficient length to reach a few centimetres from the outer face of the walls. In the areas where there were no holes or they were set a long distance away, orifices were opened using an electric drill with a bit and wooden laths were put in, of the type used to make tenon joints in carpentry and which have a high degree of resistance and a fluted surface that improves adherence. They were covered with plaster and hemp like the pieces of a wider section (fig. 5). All of these attachment elements, placed every 40 or 50 cm and entering 25 cm into the old wall, were absorbed into the brickwork masonry with which we reestablished the openings produced due to the *tapia* having receded or previous repair work having fallen away. This brickwork was made with lime mortar scarce in conglomerates (1:3) and the openings existing behind it were filled in to ensure some adherence with this method.

To repair superficial deterioration a similar method was followed, using wall ties of shorter
wooden laths, similarly coated in plaster and hemp joined together with bands of these fibers covered in plaster. Over this mesh the lime mortar rendering was extended, and in this way it was more solidly secured to the wall (Fig. 6). We consider that this simple and economic procedure improves the bonding between the two materials, the restored and the original; by maintaining the methods of traditional restoration, which are certainly not perfect, we must admit that up until now there are not other methods that offer a better guarantee or durability.

A particularly delicate problem is the one referring to the final outer layer of the restored areas regarding their adherence to the crumbled masonry which we have already dealt with, their durability and impermeability and their harmony with the remains of original wall faces. In this case a rendering of lime mortar was used, to which a superficial texture was given which was very similar to that of the original wall, and making richer in conglomerate the outer layer which was smoothed under pressure to reduce the pores and achieve a surface richer in lime. This rendering was applied in horizontal bands that were made to coincide in both position and height with the courses of the original tapia. The joints that are generated between the application of one band and the next produce a similar visual effect to that of the joints of the courses. In this process we did not only cover the brickwork masonry replaced by us, but also the previous masonry that had been left uncovered and that had a disconcerting effect on the overall aspect of the monument.

A final and none too trivial issue was to achieve an adequate chromatic tone. Although from the beginning aggregates were used to give the mortar the colour that was most similar to the existing surfaces of the original tapia, these had great variations in tone between some areas and others. This was due to the action of water and other atmospheric agents that had taken effect in various ways, therefore it was impossible to achieve an overall tone, nor on the other hand would this have been desirable, since it would have deprived the monument of its original image. Finally, we chose to apply a medium toned mortar and to apply glazes to smooth the differences in those parts that are in contact with old and darker rammed earth parts. As a final result the original areas of wall are clearly distinguishable, while there is a homogenous and coherent image in the wall faces as a whole (Fig. 7).

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REFERENCES


