SELF-BEARING SYSTEMS IN TILING RESTORATION

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INTRODUCTION

The use of ceramics in architectural tiling applications became an essential part of Spanish architecture, at least after its systematic use in Al-Andalus. The traditions that commenced then were set forth directly in the Christian kingdoms of the Peninsula, involving both isolated ceramic elements, such as ceramic tiles, plates or trims, and panels or large compositions. Sometimes, in these last installations it was necessary to call on technical solutions for their application en bloc, as previously assembled sets of items.

On the other hand, and perhaps more closely related to the subject to be dealt with in this paper, in time it became necessary to preserve and conserve these sets of ceramic items, either in the buildings themselves, or in collections or museums where some of these were eventually housed. A new challenge thus arose, as it became necessary to resolve the issue of how to facilitate the exhibition, conservation and mobility of the compositions.

HISTORICAL FORERUNNERS OF SELF-BEARING SYSTEMS FOR CERAMIC TILINGS

From their remotest origins, ceramic tiles have historically been installed in architectural applications by different methods, including the use of systems that can be termed self-bearing. In general lines, panels or elements formed by slabs or assembled blocks or compacts, which were subsequently fixed to the wall, acted as forerunners to these self-bearing systems. This is the case of the tilings installed using a supporting element, usually a mesh of vegetal fabric, already used at the Djeser pyramid in Sakkara (c. 2.700 BC), whose invention is attributed to Imhotep. The ceramic tiling was sewn to the support by previously fitted fastenings, the whole assembly then being fixed to the wall. A very similar procedure was therefore involved to the one used in the application of mesh-backed mosaic.

In fact, a variant of this procedure was used in the ancient world to make mosaics, as the great mosaic workshops produced their *emblemata*, or major scenes at the workshop, for subsequent application to the building. Many of these elements travelled from one side of the Mediterranean to the other, as items of trade. The mosaic was mounted upside-down on the master drawing, then pouring a slurry of bonding mortar to join all the tesserae and finally a thicker layer of mortar to form the panel.

The Muslims adopted a similar procedure to apply mosaic, as may be observed in the mihrab of the mosque at Cordoba. It was also employed in preparing and installing the wall tilings found in the same mosque or at the Alhambra in Granada. The tiling was assembled in the workshop or on site, but not directly on the wall. Each geometric piece that was to make up the composition was cut out of ceramic pieces of different colours to be subsequently fixed to the wall when the panel was ready. In the case of certain Andulusian patio fountains - such as the two found at the Altamira Palace in Seville, or the one preserved at the National Ceramic Museum, which comes from Valencia - the conclusion can be drawn, based on the composition and form of the substrates that make up the base, that they were mounted independently and subsequently installed in their definitive location. As the substrate (with which the tiling is preserved) contains various horizontal beds of regularly arranged brick separated by layers of mortar backing the ceramic tilings - which is sometimes cut up tiling as in Altamira, and sometimes stencilled geometric tiling as in Valencia - this system appears to have worked perfectly as a self-bearing system.

The same technique was reproduced in the Christian world by the Valencian tile makers, who embedded the tiled rosettes in the brick floor of the Poblet Monastery cloister.

Already in the Italian Renaissance in Florence, the Della Robbia family and the Buglioni workshop sometimes used supports of reed and mortar to apply their reliefs and ceramic tondos to the walls. In fact, many of the products made especially by the latter workshop, were supplied ready for installation.

FIRST EXPERIENCES IN TILING CONSERVATION

Between the end of the 19th century and the beginning of the 20th century, structures made of wood or reed and esparto grass with plaster or gypsum were used quite frequently in the tile collectors' world as a supporting base. This system was limited to conserving panels in collections, as it was apparently not used in architectural interventions, in which tiles were systematically installed directly onto the facings. However, although it cannot yet be absolutely confirmed on not having had access to the work site, it appears that Ricardo Velázquez Bosco (great connoisseur of antiquity) used a self-bearing system in restoring the facade of the mihrab of the mosque at Cordoba, whose technical solution is unknown, but which is currently visible through the large screws that can be glimpsed between certain tesserae and the deformations, revealing slab formation and size. Daniel Zuloaga was likely to have been in charge of applying the system, though this is still an issue of study. It is however quite certain that in 1888, in the Crystal Palace of the Retiro Park in Madrid, both used a type of self-bearing system for assembling the tiles in the spandrels of the first section. The solution was imposed by technical need, as a tile spandrel was to be mounted on a diaphanous iron structure. The solution consisted of mounting an L-shaped iron plate in the shape of the spandrel, anchored to the rest of the building structure. A brick partition was installed inside this to support the tiles, which were fixed with lime mortar [1].

The assembly with mobile panels held in a metal frame was used systematically in some important collections, such as the installation of the tilings of the Gulbenkian Foundation in Lisbon. At the national Ceramic Museum established by Manuel González Martí in 1954, the panels were mounted on metal lath with an L-shaped metal frame, fastened to the wall by hooks welded to the structure. In other cases, the panels lost their mobility by being fixed to the walls. For smaller panels, designed to be moved the tiles were adhered with plaster and nails to a base consisting of mesh or chicken wire together with the wooden frame.

When Manuel dos Santos Simões was faced with the installation of the Museu Nacional de Azulejo, in Lisbon, he reviewed the systems used till then without finding a satisfactory solution. The processes that have been briefly mentioned entailed problems that even worsened the conditions of traditional tile fixing methods: material incompatibility, limitation to small-size surfaces to avoid fractures by deflection and torsion, and especially by the excessive weight of the solutions. These problems were heightened when gypsum and plaster was replaced by cement mortar, often reinforced with metal lath. Unfortunately there have been recent interventions in which, disregarding experience, these methods have still been used.

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[1] In a recent restoration at the Crystal Palace, the brick partition walls were replaced by a stable surface capable of absorbing the possible deformations of the structure, consisting of two layers of polyester and glass fibre sandwiching an aluminium honeycomb core. This surface was screwed, using eyelets, to the original frame and the tiles were then fixed to the surface with an epoxy mortar applied in dabs.

The work was directed by: José de la Dehesa, architect; Carlos Jiménez Cuenca, architect; Federico Prieto, quantity surveyor; and Antonio Perla, heritage conservation specialist and art historian

RECENT EXPERIENCE

The needs that arise daily in preserving ceramic tilings vary inevitably according to the situations, but they can differ considerably in particular when decontextualised items are involved, conserved in museums, or preserved in situ, especially if exteriors are involved. However, the solutions applied in each case may sometimes be similar or identical, despite their idiosyncrasy. However, the priorities and necessary courses of action for conservation will differ according to the specific case involved.

On the other hand, the evaluation of recent experiences described below allow establishing the technical validity of each solution, as well as their suitability in terms of economic cost for solving the problem at issue.

Over the last few decades, a considerable number experiments have been undertaken on mounting tilings on supporting surfaces seeking to fulfil certain basic requirements. These include the stability of the materials, resistance to bending and torsion, resistance to physico-chemical alterations, reversibility of the materials used, compatibility with the adhesive materials and low specific weight.

At the start of the 80s, people began using **methacrylate** as a self-bearing surface. The possibilities of seeing the back of the item on display made it an ideal solution, especially when original references or replaced pieces were visible at the rear. The bonding adhesive used in these assemblies was transparent silicone, it being considered suitable because of its elasticity and presumed adhesion to the smooth methacrylate surface. Tilings such as the Panel of the Pelican of the Ruiz de Luna Museum were mounted along these lines, housed at the time at the Santa Cruz Museum of Toledo (Amitrano, Revista de restauración del MC). The system was also used systematically for mounting the collections of the Museu Nacional do Azulejo in Lisbon, and in numerous interventions performed by this Centre for other local museums. However, the problems arising with silicone adhesion to the crystalline methacrylate surface forced the same museum to equally systematically substitute all the assemblies prepared with this system. It has since been confirmed that besides the actual problems associated with silicone (fungus, excessive contribution of grease to the bodies), which have been largely solved in the new generation of silicones, there was also the problem of sliding on the smooth methacrylate surface because of the tiling weight. In a recent intervention we were unfortunately able to verify that previous experiences had not been adequately assessed.

In certain cases it was decided to use ***polyvinyl chloride*** (PVC) panels instead of methacrylate, probably because of the lower cost. The need for considerable thickness to achieve the same strength, and its specific weight ratio, however advise against using it. Tiling adhesion to this support with silicone did not yield a better performance.

The search for lighter supports led to using a system sometimes employed for transporting mural paintings. The first ***sandwich*** panels with a pitted ***cardboard core*** and ***cardboard*** or ***plywood*** facing on the sides were thus used. These continued to exhibit strength problems with large surface areas, though they solved the problem of

weight, as the material was much lighter. Different types of such boards are marketed, amongst which those with plaster facings and a cardboard, wood, or aluminium core are particularly to be noted, which were originally designed for drywall constructions. These supports have worked well in backing small-size tilings, although it has been necessary to take into acount their low fracture strength. We are obviously not referring their use as actual wall facings, as in these situations, they can be tiled over like any other wall. In fact, they can be used as self-bearing structures of a certain size, by incorporating a reinforcing backing, thus considerably heightening their strength. One of the advantages of this type of board is the possibility of using inert mortars - preferably with a plastic filler - with a high degree of reversibility and high bonding power to plaster. Such supports are obviously not advisable in external contexts, or in internal locations where they could be exposed to water or excessive humidity.

In 1989, when the restoration was to be tackled of the small Mudéjar Cloister in the Cartuja de Santa María de Las Huertas in Seville [2], it became necessary to use a wholly inert material that could be used risk-free outdoors. As a result of news on the supports that had been recently tested in Italy for transporting mural painting backing, it was decided to use ***sandwich*** board comprising ***two glass fibre and epoxy resin surfaces with an aluminium honeycomb core.*** The material's very high performance characteristics are undoubtedly the result of its original use for making structural features in the aeronautics, automobile and building industry. Its resistance to torsion and deflection, shear, impact and compression resistance, and low specific weight [3], together with ductility and ease of handling, make it a particularly suitable material for use in self-bearing supports. The multiple possibilities of creating fastenings and supports in the same panel, without needing to fit any type of auxiliary structure for ensuring its stability are other features of its suitability.

Various procedures were followed for mounting tilings on these supporting boards. One of these, performed at La Cartuja, involved applying a salt-free, synthetic mortar, based on hydraulic binders, to the back of the tiles [4]. The application of this mortar had a twofold purpose: it joined and reinforced the whole tiling (together with a reinforcing polyester mesh) while also acting as an intervention layer, so that the assembly could be taken down if necessary. The tiles and mortar were adhered to the panel using an epoxy resin-based adhesive. The assembly has functioned perfectly satisfactorily to date, even though it is located outdoors.

In the compositions of the entrance to the Velázquez Palace, and in the spandrels of the Crystal Palace in the Retiro Park in Madrid, the assemblies on the self-bearing

[2] PERLA, ANTONIO: *El programa de restauración de Bienes Muebles en La Cartuja Recuperada: Sevilla 1986-1992,* Conjunto Monumental de La Cartuja, Junta de Andalucía, Sevilla 1992, pp. 63-83; PERLA, ANTONIO: *Sistemas mecánicos de arranque en azulejería: la Estación del Vasco (Oviedo) y la Cartuja de Sevilla,* en Rehabilitación de la Azulejería en la Arquitectura, Asociación de Ceramología, Alicante, 1995, pp. 103-134.

[3] The physical tests on the material have not been included because at the moment, at least two companies market very similar products, though product performance varies considerably to judge by the laboratory test data provided by both companies. However, it may be stated that the level of performance of the different boards exceeded the specific requirements for the use involved.

[4] Various mortars featuring these characteristics are commercially available, though mortar behaviour and suitability are obviously not all the same.

systems were mounted directly with epoxy mortars containing inert aggregates. The decision not to use an intervention layer was taken after weighing various circumstances. In the former case, these related to matters of security, and in the latter the physical constraints of the actual space where they were to be installed. The reversibility of the process was verified beforehand, and this was found to be feasible, albeit laborious. Tests were similarly commissioned on the tensile strength and slip resistance of the mortar used, to ensure the mortar was appropriate.

In view of the laboriousness of the first procedure, different mortars were tested for application to the tiles with a greater reversibility than epoxy mortars. Actually, one of the major challenges of the fibre glass and epoxy resin surfaces was the issue of bonding, as impermeable, plastic surfaces are involved on which mortars without a considerable plastic component are difficult to fix. Thus, in some experiments the mortar peeled off the board. To solve this problem the panel surfaces were also worked to produce a better bonding key, and although the system's strength was tested in the laboratory, the end result presented serious complications and adhesion problems. In any case, we believe that after deciding to use a support of this type (it should not be forgotten that a considerable cost is involved), it does not appear logical to impair the properties of the support, even though preliminary surface roughening only has a minor effect on board strength.

For internal applications, especially for assemblies in museums, in view of the development of the silicone branch, we believe it should be possible and is necessary to find a silicone with enough strength to provide a good bond between the tile and board surface, without adding grease to the body, protected against fungi and ageing. This would facilitate mounting these assemblies tremendously, and would undoubtedly make them cheaper.

Finally, in this type of supporting surface, the board edges need to be well protected and insulated to prevent the cellular core from deteriorating and coming off the glass fibre surfaces. This point needs to be stressed, because some assemblies have been found in which this was not done, and it could undoubtedly affect the future of the assemblies. The edges can be protected in a variety of ways, although the simplest involve sealing the channel that is left on slightly flattening the core with an epoxy resin mortar or fitting a sealed U-shaped aluminium strip in the core.

Although the glass fibre and aluminium honeycomb core backings have proven to be suitable self-bearing systems, it should be remembered that there are also other assembly options that can equally serve the relevant needs, including, be it not forgotten, with regard to the available economic resources.

Such an assemble option is ***stainless steel lath*** built up strip by strip. In the case of large compositions, backed by the original brickwork, this metal lath can be installed at the back of the wall, reinforced with glass fibre and polyester resin or epoxy, plus a series of vertical fastenings for safety between the lath and the brickwork, to hold the composition in a block, with the original mortars (as long as these are sound) with the original backing. Although no experience is available to date in this sense with tilings, it may be mentioned that in 1996, assemblies were prepared

with two mural paintings recovered in A Coruña, each of which was 2.50 metres high and 4 metres wide. These were held together as a block, with their original backing, and are currently preserved in this way [5]. We can undoubtedly do the same with large tilings.

For smaller-size surfaces, the metal lath can also be used to reinforce the mortar (hydraulic binder-based, salt-free, synthetic mortar) for direct tile fixing. To reduce weight, a ***polyester mesh*** is also marketed, which performs very similarly to the iron or stainless steel lath, though it is difficult to find.

A variation on this system was the one used in 1997 to assemble a panel of the Factory of Salvatierra-Agurai (Alava), belonging to a private collection. In this case, an L-shaped framework of stainless steel strips was made, with a crossed structure of similar strips at the back (the owner had ready access to this material). A series of vertical fastening holders were screwed in the strip grid, and anchorings were arranged in the lightweight mortar cake reinforced with glass fibre mesh backing the tiles, to house the screws and thus provide the fastening to the frame. This currently hangs in a house entrance.

To end these notes, which are by no means meant to be a decalogue, and much less to be complete, on the possibilities of self-bearing systems, we should like to mention the possibilities that other materials afford, such as chipboard made with medium density resins or plywood, which may be suitable for certain, basically small-size, assemblies.

CONCLUSIONS

In many recent interventions, attention has tended to focus on better performing materials, sometimes involving excessively costly and unnecessary media. However, detailed analysis of the adopted solutions reveals that there are actions in which this is not indispensable and other cheaper solutions could have been chosen, which would equally have ensured the stability and preservation of the items at issue. The use of high-performance boards for mounting small assemblies may sometimes be unwarranted and unnecessary, as they do not usually need high resistance to deformation. In any case, the use of over-size supports also makes the final result more expensive, just as the unacquaintance with the mechanical capabilities of the boards used, which are sometimes reinforced with structures that duplicate or are superimposed on the board's technical conditions increase costs unnecessarily.

We thus wish to conclude that it is necessary to analyse the relevant needs in each case and seek solutions that match the intervention possibilities, without unthinkingly falling back on previous strategies, using this knowledge however as fully as possible to allow choosing the most appropriate course of action.

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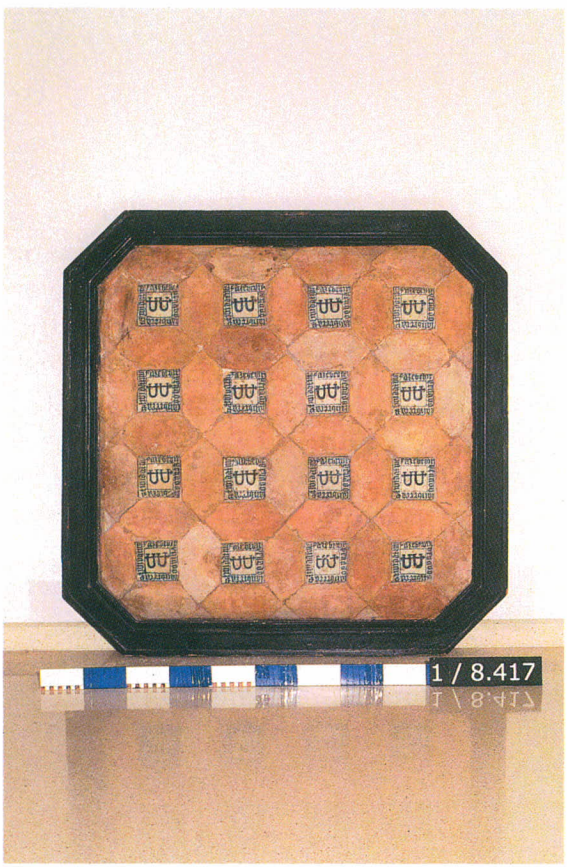
[5] RALLO, CARMEN Y PERLA, ANTONIO: *La recuperación de las pinturas murales del edificio de Antiguos Sindicatos en A Coruña. (Desprendimiento, traslado y reubicación de unas pinturas de 2,50 x 4 metros con su soporte)* en Revista de la Escuela de Restauración de Pontevedra, nº 0, Pontevedra, 1998.

PLATES

1- Front view of a tile assembly on a wooden frame, with mesh and plaster made about 1950.

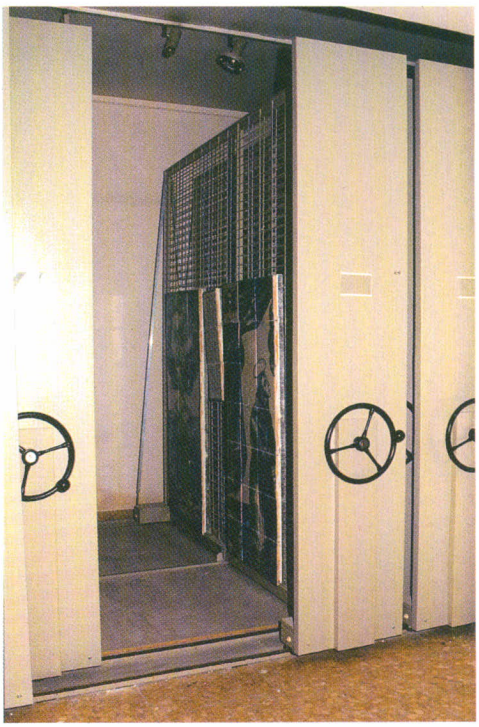
2- Rear view of the foregoing assembly.



3- Front view of an assembly of Gothic tiles on a wooden frame with a plaster layer. Assembly made about 1950.

4- Rear view of the foregoing assembly.

5- Ceramic panelling mounted on selfçbearing systems of aluminium honeycomb core resin.



6- Museographical system of storing selfçbearing systems. Tile library of the National Ceramic Museum.