CERAMIC FABRICS: A NEW ARCHITECTURAL OPPORTUNITY FOR CERAMICS

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ABSTRACT

In this paper, a new technology for ceramic fabrics or textiles is presented: an industrialized system, which takes the form of flexible sheets of pieces of baked clay for the construction of cladding systems and laminated or layered structures with a ceramic finish. This system provides considerable construction agility, and it displays significant resistance to mechanical actions and high durability when exposed to wind and weather. The concepts underlying ceramic fabrics, and their advantages and applications, are explained and the latest building projects in which these fabrics are used are also discussed in this paper. These include drainable pavements, roof gardens and hanging trellises, which demonstrate the outstanding architectural opportunities offered by ceramic materials when they are conceived as industrialized systems.

1. INTRODUCTION

The ceramic fabric is an innovative industrialized system based on an interwoven steel wire mesh, which encloses a reticulum of pieces of baked clay arranged in tabular form. With this material, flexible ceramic sheets are obtained for building cladding systems (paving surfaces, façades, roofs) and laminated structures (vaults, catenary arches in pergolas). Its main advantage is that it provides us with a centuries-old material in a new format, which upgrades traditional piecemeal installation. Its great flexibility means that, when it is stored and transported, it can be folded onto pallets so that its installation in long strips is easy, fast and economical.

These fabrics open up an unlimited range of possibilities for dry-assembly cladding systems in architecture. Given that they are textiles, they can "clad" façades, roofs, squares, paths, etc. and new links with textile architecture can be explored. And, as textiles, they display a great deal of variation: the system permits multiple configurations of fabrics (reticulum, staggered joints, openwork) (fig. 1) and a range of colour shades. Individual architects, engineers or designers can personalize the design of their geometrical patterns.

Fig. 1. Various Fabric Configurations: staggered joints, openwork and reticulate elements.

It is a system which contributes to the sustainability of building, owing to its long useful life and the innovation of its composition: it consists solely of two dry-woven materials (the steel mesh and the ceramic pieces), which are easy to separate and recycle.

By simply changing the thickness of the ceramic pieces (paving stone 5 cm, brick 4.5 cm or tile 3 cm), they can be used for paving surfaces, roof or façade cladding and, by modifying the diameter of the steel mesh, they can have structural applications in vaults or catenary arches. Some of these applications, categorized as deposited and hanging cladding systems, are described below.

2. DEPOSITED CLADDING SYSTEMS: PAVING SURFACES, DRAINABLE PAVING SURFACES AND FLAT ROOF GARDENS

The installation of a ceramic fabric as a paving surface is like laying and fitting a carpet, a carpet of paving stones, which can adapt to any curves in the surface it covers. When the strips which are to be installed are smaller than 0.6 m^2 (about 50 kg), they can be laid out manually by two workers to pave small surfaces (paths in gardens, beach areas in swimming pools, etc.). But building performance is optimized on large surfaces, when long strips are manoeuvred by cranes, enabling up to 250 m^2 to be paved per day, in other words ten times faster than piecemeal installation. There is also no need to mark out the perimeter beforehand, given that the confinement of the ceramic elements by the steel mesh avoids the paving stones moving out of position at the edges of the paving surface. Nor does the paving need to be grouted during installation, as is the case for traditional paving surfaces. This enables these work phases to be separated during the building process: first, the sheets are positioned and then they are grouted together, which expedites the operations.

Once they have been laid out, the steel mesh, which has so far facilitated the transport and installation of a large-scale ceramic carpet, now goes on to function in three ways: first of all, it ensures that all the pieces are aligned, something that was difficult to achieve using traditional installation techniques, especially when the paving stones are arranged reticulately. Secondly, in the case of flexible paving surfaces (with sand or soil-filled joints), the steel mesh enables strips of paving to be lifted/replaced easily so the base can be repaired or underground installations can be accessed. And thirdly, the mesh acts as a bi-directional frame. It reduces the usual problems that affect paved surfaces (breakages or tiles coming loose), which are usually caused by the loss of grout from joints or a deterioration of the tile bed, and affords greater resistance to the structure as a whole to the wear and tear caused by heavy traffic. To analyse the behaviour of these paved surfaces, in relation to the movement of dynamic loads, and describe their deformability and tensional state in critical sections, various tests have been performed at the LITEM or Laboratorio para la Innovación Tecnológica de Estructuras y Materiales (Laboratory for the Technological Innovation of Structures and Materials). All the results have confirmed the important contribution of the metal mesh to the final resistance of the paving surfaces that were installed.

Another application, which is of increasing interest in a sustainable urban context, is drainable or openwork paving surfaces, or paving surfaces with wide joints, as a resource for avoiding the loss of rainwater down drains or to reduce the impact of flooding as a result of torrential rain. Until now, installing these paving surfaces with wide joints without sealing them with cement posed the problem of how to hold them in place. However, ceramic fabrics prevent any movement or detachment of the ceramic pieces because the mesh holds them in place, thus enabling drainage to occur at their joints, no matter how wide they are. In paving surfaces with much openwork, their combination with other materials or landscaped areas enriches the finish of this type of paving surface and, at the same time, increases drainage surfaces considerably.

Fig. 2. Drainable Paving Project in the Jardín Niel (archs. Michèle & Miquel).

Fig. 3. Execution of the Drainable Paving Project for the Jardín Niel (archs. Michèle & Miquel).

The first example of a park with drainable ceramic fabric paving surfaces is currently underway in the Jardín Niel in Toulouse. It was also designed by architects Michèle & Miquel. In this project, the architects plan to convert 21,000 m² of parkland into an "undulated surface", in which the paved areas gradually fade away at their edges, so that their borders lack definition and merge with the vegetation (figs. 2 and 3). To achieve this unique effect, as many as 12 different models of ceramic sheets have been created for the 11,000 m² of paving surfaces, in which continuous and openwork paving elements are alternated. The architects have been able to personalize not only the pattern but also the format of the paving stones, which are longer than standard models and measure 30 x 5 cm (generally they are 20 x 10 cm).

And on conventional or inverted, flat accessible roofs, which are landscaped or have substantial people flow, ceramic fabrics are deposited as a surface which can be walked on and serve as ballast. They offer architects a third option and are a viable alternative to current systems that use gravel or porous concrete slabs with insulation incorporated into them, given that they provide a higher quality finish than the former, and they weigh less and adapt better to drainage gradients than the latter. Like drainable paving surfaces, they are easy to inspect, if their waterproof sheets need to be repaired, and they make changes in the layout of landscaped and paved walkways easier. The way they are laid out, with wide joints between ceramic pieces, also allows vegetation to grow interspersed amongst them.

A recently completed example is the conversion of the flat roof of the Giscosa office building in Terrassa (Barcelona) into a roof garden. Initially, the roof was finished with concrete, which meant that in the summer it could reach temperatures of up to 70ºC. By combining trays of vegetation with walkways paved with ceramic fabrics, they have managed to reduce the temperature significantly, at the same time achieving interesting finishes with different patterns and textures for the new ceramic carpets (fig. 4).

Fig. 4 – Roof Garden on the Giscosa Office Building in Terrassa (archs. Sarrablo and Colom).

3. HANGING CLADDING SYSTEMS: CURTAIN WALLS, TRELLISES AND SLOPING OR CURVED ROOFS

In this case, the installation of a ceramic fabric as a façade or sloping roof is similar to hanging a curtain: it merely requires stainless steel rails to be attached to the ceramic fabric to sustain it (optionally, they can be hidden using rectified ceramic tiles). They are bolted onto support brackets, which have previously been anchored to the facing slabs (fig. 5). A posteriori, and only in the case of façades, a few simple retaining anchors to counteract the effect of the wind will ensure the fabric is easily fixed in place (fig. 6). The great advantage, from an economic point of view, is that they require no vertical profiles to secure and regulate them (the most expensive part of conventional dry assembly), given that they are plumbed by their own weight, saving the cost of accessory materials, and, if the strips are long, spectacularly improving the time it takes to install them.

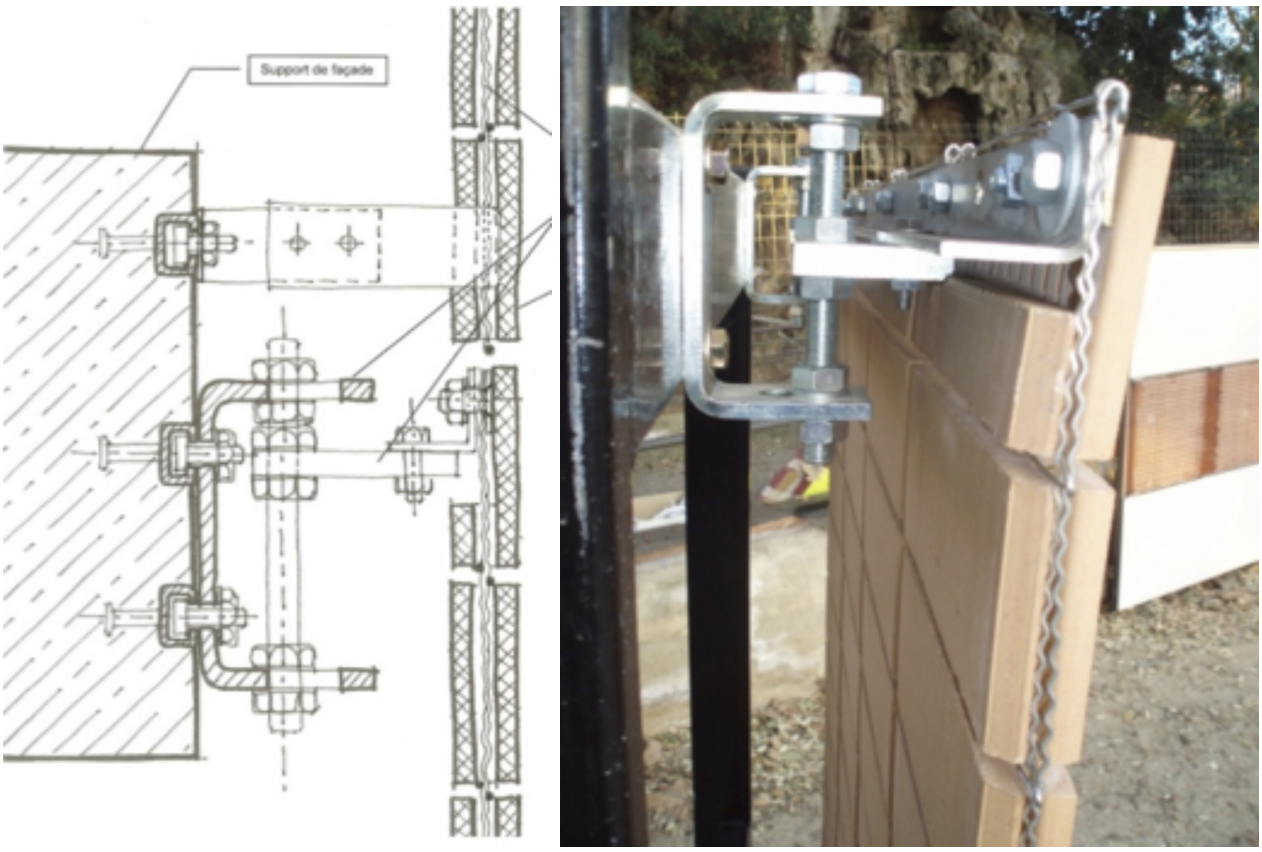

Fig. 5. Anchoring Devices and Upper Support Rails.

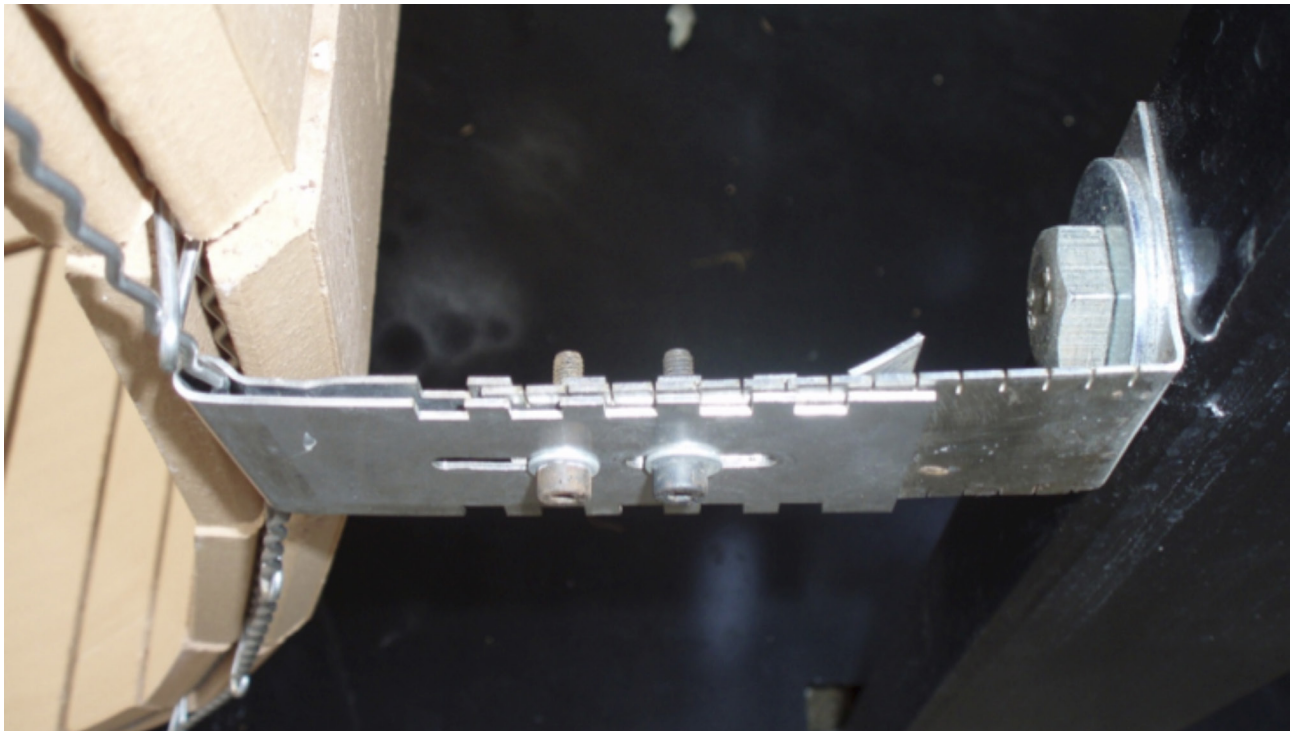

Fig. 6. Mesh Retaining Anchor.

For this application, the ceramic elements are small 3 cm-thick slabs, which offer enough impact resistance[1] for non-accessible zones and ensure the fabric is very light (40 kg/m^2 or less in trellises, depending on the percentage of gaps). The meshes, the support rail and the retaining anchors are always made of stainless steel in order to give the cladding system a long useful life and avoid galvanic coupling. In addition, all the components of the system can be regulated, avoiding any possibility of collapse of the backfill and enabling cavity thickness to be selected. The system is very safe, as the installation of each retaining anchor involves weaving two adjacent sheets together and acts as a safety device if there is seismic movement or a natural disaster. All these anchors and mechanisms have been tested at the LITEM (Laboratory for the Technological Innovation of Structures and Materials).

Cladding devices for sloping roofs also behave like hanging cladding systems, making it faster to finish roofs with roof tiles and permitting the aforementioned material continuity with the cladding system of the façade. Their large format and the flexibility afforded by small ceramic pieces ensures adaptation to any curvature (figs. 7 and 8) or gradient changes in support structures, in the case of vaults, for examples. Up until now, anyone who wanted to clad a curved roof without resorting to expensive metal sheets either had to use an elastic rubber paint, which eventually got dirty and developed cracks, or either had to stick small pieces onto it using cement glue or nail flat roof tiles onto it, both of which were time-consuming. These fabrics, which are available in very long formats, are deposited without adhering them to the roof, enabling their installation to be accelerated and achieving speeds which until now were reserved virtually exclusively for civil works.

[1] The materials have passed the hard and soft body impact tests in compliance with the UNE EN ISO 10545-5 standard (1998) and the draft version of the 034 (ETAG 034) Guideline: Kits for external wall claddings.

Fig. 7. Covering the Vault for Casa Mingo (architects Sarrablo and Colom).

Fig. 8. Building a Curved Roof in Berga (architects Eidee).

There are many design options for cladding systems: ranging from proposals for a continuous paving envelope + façade + roof to trellis configurations. In this case, the ceramic tiles in the meshes, like the notes in a stave, can play with the arrangement of gaps and blanks more freely, achieving greater variety than in the case of traditional trellises built by bricklayers. Undoubtedly, any number of options remain to be explored in this new paradigm of hanging façades, permitting a versatility we associate with textile architecture, both in terms of form and pattern.

Two projects with hanging trellises which demonstrate these endless opportunities have already been completed. The first is the renovation of a holiday cottage in San Vicente de la Sonsierra (Logroño) designed by Blur architects. In this refurbishment, the back of the building has excellent views of the landscape of La Rioja and the hanging trellis protects the large window when there is too much sun (fig. 9).

Fig. 9. Hanging Trellis on a Holiday Home in San Vicente de la Sonsierra (Blur architects).

The other hanging trellis was built for a group of houses in the Calle Pomaret in Barcelona by Pich-Aguilera architects. In this case, it does not serve as a solar screen, but as an openwork surface so the vegetation can climb up on the inside of the trellis and emerge through its gaps (fig. 10).

Fig. 10. Houses in Calle Pomaret in Barcelona (Pich-Aguilera architects).

And the architects Pm,Mt are about to build a house in Barcelona, which will have glazed tiles included in the ceramic fabrics in different shades of green, the intention being to camouflage it in a setting full of trees. The same project will also feature another innovation: the trellis will take the form of a continuous façade-roof envelope, in which the vertical screen will be able to shift to a horizontal position (figs. 11 and 12).

Fig. 11 y 12. House in Barcelona with Glazed Tile Trellis (archs. Pm,Mt).

Finally, we present two other projects with a hanging trellis, the building of which has also recently started. One is a high-rise car park in Montpellier, designed by the team of architects, Archikubik, in which the use of ceramic fabric as a trellis enables the different levels to be ventilated and, at the same time, by combining different patterns and textures to create a patchwork effect, it re-scales the imposing façade without sacrificing any of its intensity in a metropolitan setting (fig. 13). And the other project on which work has already begun is the extension to the Colegio de las Teresianas (a famous work by Gaudí) designed by Pich-Aguilera architects. In this case, the ceramic trellis on its façade links this extension with the brick building by Gaudí (fig. 14): the ceramic material is the same, but it has a new hanging format, managing to link the past, present and future of a material which offers new opportunities in the panorama of architecture.

Fig. 13. Saint Roch Car Park in Montpellier (archs. Archikubik).

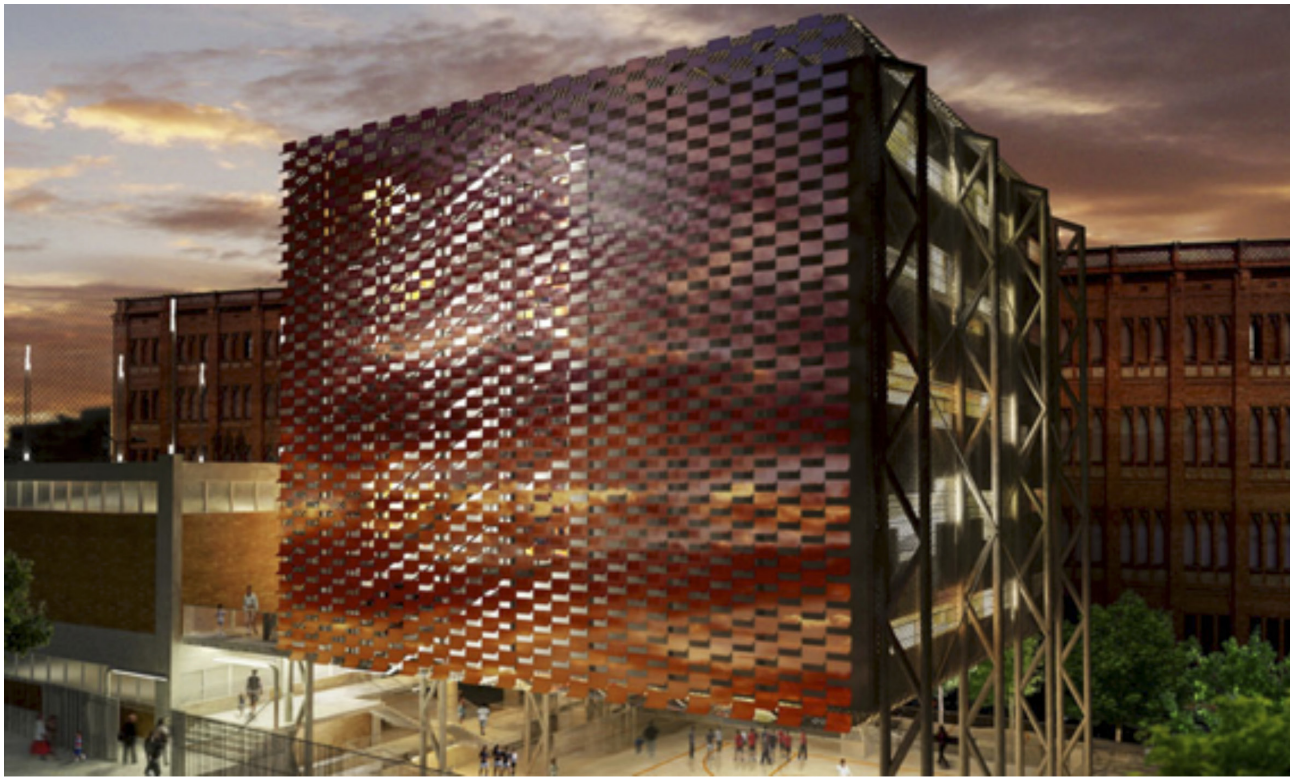

Fig. 14. Extension of the Colegio de las Teresianas (archs. Pich-Aguilera).