CERAMICS IN BUILDING REHABILITATION. INNOVATION AND REUSE

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ABSTRACT

This paper presents various proposals for the rehabilitation of exterior envelopes and inner walls in which ceramic materials play an essential role. When talking about exterior envelopes, it is logical to pay special attention to durability and maintenance costs. Both embody the main benefits derived from using ceramics directly in contact with the environment, in all weathers. Concretely, this paper looks at the question of recycling in the construction of deck parapets and exterior wall claddings that improve the energy efficiency and aesthetics of pre-fabricated modules. Inside buildings, ceramic materials can be used in response to specific requirements and two such examples are presented, namely a floor slab rehabilitation project and a mobile partition system.

1. INTRODUCTION

We initiated a research project at the University of Alicante's Ceramic Chair in 2009 designed to develop new applications for ceramic materials in Architecture, precisely in the extremely promising and relevant field of building rehabilitation. In Spain, the census of private homes numbered 14.7 million[1] in 1981, which today, now over thirty years old, represent, together with their surrounding areas and public amenities, an excellent opportunity for such work. Many of these buildings are on the verge of collapse, with a high degree of dereliction and far from meeting the minimum standards of energy efficiency, comfort and quality demanded today. The statistics bear this statement out - over the last decade, rehabilitation work has increased by 25%[2], demonstrating that the rehabilitation and refurbishment of Spain's stock of edifices is an important task to be implemented going forwards. With that reality in mind and given the forecast growth of rehabilitation in coming years, we have assessed innovative applications for ceramic materials in homes and buildings across the entire stock.

According to the Dictionary of the Spanish Royal Academy (DRAE), Rehabilitation is the term used to describe the action of "re-enabling or restoring someone or something to its former state"[3]; however, in the realm of Architecture, it goes far beyond that to incorporate an improvement in living standards, comfort, efficiency and aesthetics.

In our search for new building systems based on a greater use of ceramic material in rehabilitation solutions, we focused on projects where the rehabilitation was mainly aimed at improving energy efficiency, although other features, such as the building's aesthetic character, were also taken in account. As Dr Neila puts it: "Industrialisation that generates little waste, and above all rehabilitation, the maximum expression of material reusage, are the two best paths towards sustainable construction"[4] - both premises have been the subject of study throughout the development of the proposals presented herein.

2. VOLTAGRES: REHABILITATED FLOORING

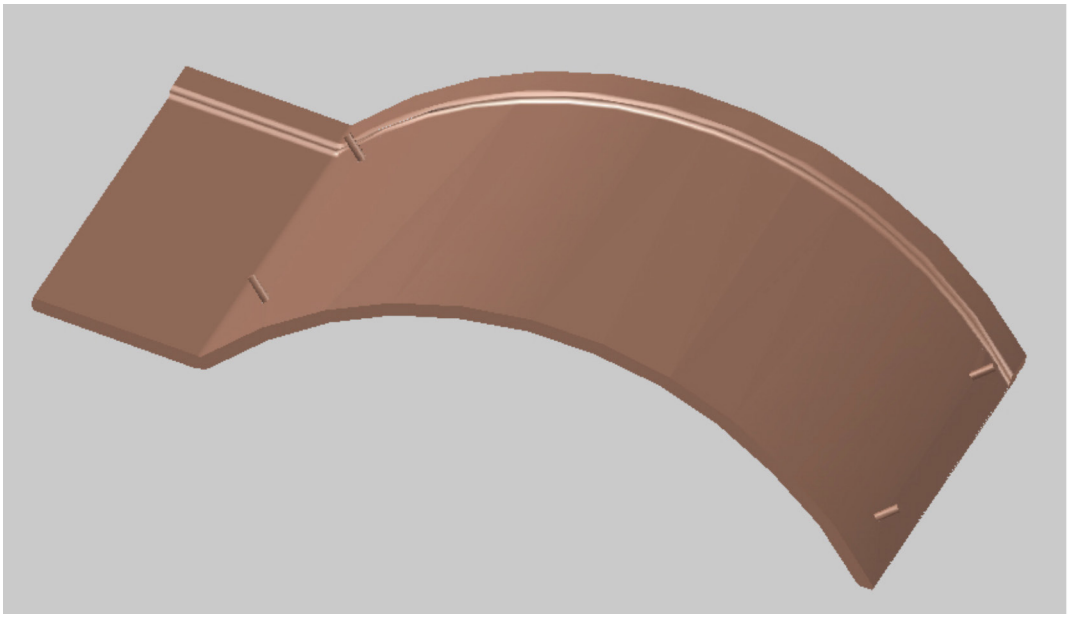
The project consists of using ceramic tiles that act as formwork for the rehabilitation of slabs on which the support structure rests. The tiles are designed with a curvature like a whirl and anchored to the joists by a simple screw clamp which allows them to rotate, thus enabling light concrete to be poured in order to cast the structural slabs. All of this can be carried out without any need for support props, with obvious benefits in rehabilitation construction processes.

[1] García Montalvo, José. LA VIVIENDA EN ESPAÑA: DESGRAVACIONES, BURBUJAS Y OTRAS HISTORIAS.

[2] According to statistics from Spain's Ministry of Development on Construction, section 9. Rehabilitation projects: No. Of buildings and surface area per type of project. [on-line] http://www.fomento.gob.es/BE/sedal/10010900.XLS

[3] Spanish Royal Academy. Dictionary of the Spanish language. 22nd edition.

[4] Neila F. Javier; The SOLCONCER project: contribution of ceramics to the world of sustainability and bioclimatic architecture. Qualicer 12. Castellon. 2012.



Voltagres acts as a sunken formwork for one-way slabs – what is especially interesting about them is that they allow for the joist beams to be visible or concealed as required by the rehabilitation design criteria or in order to comply with the Building Code. The concealed version is achieved by using anchoring devices similar to those used for ventilated façades based on porcelain tiles. The tiles, with the glazed or vitrified face visible, shape the infill between the beams. In the former case, high absorption would ensure adhesion between the concrete and the tile, whereas in the latter case, such adhesion would be achieved by using a fibre fabric or mat on the top surface of the tiles as a means of reinforcement.

FORMATS

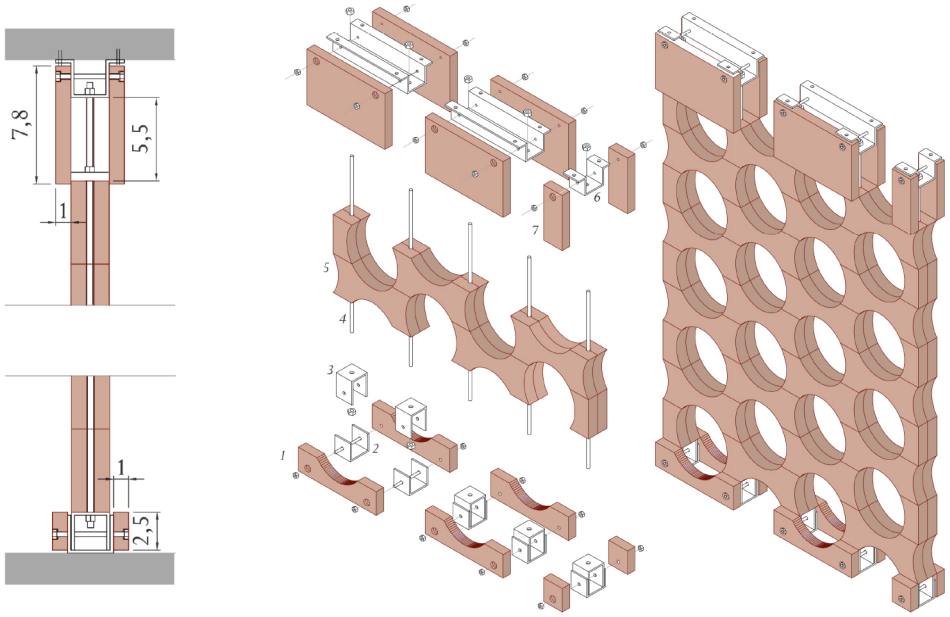
MATERIAL	FINISH	ANCHORAGE	DIMENSIONS	THICKNESS	JOINT
Ceramic whirl: · Porcelain tile for indoor/ outdoor use · Stoneware indoors	Glazed Vitrified Digital injection	KEIL support devices Galvanised steel flats	600x300 mm 500x300 mm 400x300 mm	10 mm	Neoprene

BENEFITS

The benefits offered by this design are numerous:

- The same tile provides both the formwork and the top face.
- Quick and easy to implement – less labour.
- Fire protection in line with Fire Safety regulations (no need to treat existing structure)
- The edges of the tiles can be ground to adjust to varying measurements.
- Tiles finished with inkjet technology, which enables printing on surfaces of up to ø 320 mm.

3. FLEXIBLE CERAMIC LATTICE



This refers to a pre-fabricated construction system based on porcelain stoneware pieces that uses steel turnbuckles to join one to the other so they can be rolled up for transportation before being fitted. They are of great use in rehabilitation projects for translucent and permeable partitions given their light weight and clean aesthetics.

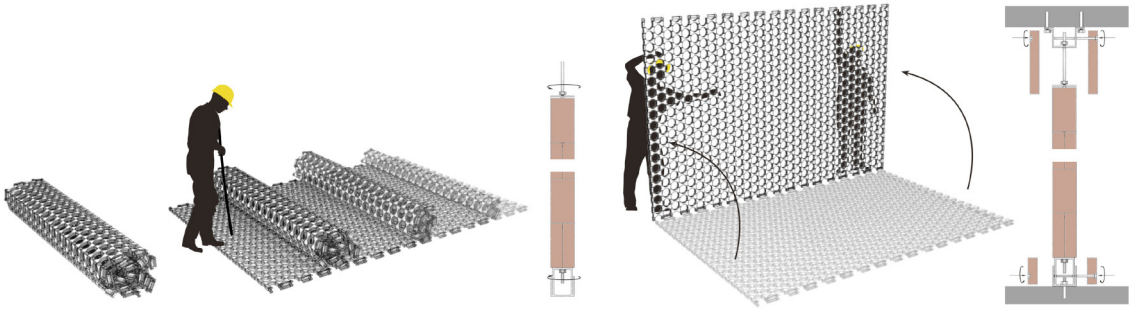
Looking at the visual effect of walls made from overlapping pipes, the result does have a certain charm that is not apparent in any other conventional, pre-fabricated wall. Its effects vary from filtering light in such a special way that it depicts patterns on the floor, or a permeable screen which you have to walk through in order to discover the area concealed behind it; or a more formal plasticity achieved by sliding the tubes horizontally and crossways to the wall, which produces a very attractive wave effect.

That was the starting point for the idea of imitating such behaviour using a ceramic lattice but with the addition of different qualities and improving the characteristics of the wall itself. One of the major flaws of a wall made of pipes is the large cross-section required, which renders it economically unattractive because square footage is lost. Reducing pipe section to a thickness of 3 cm can achieve the same light and pictorial effects while reducing the size of the circles. When thickness is reduced, a further difficulty arises, namely the stability of the lattice, since the overly thick wall had been self-supporting. At that point, a wire frame had to be incorporated to make the projected workpiece stable and safe for use.

On the other hand, reducing the cross-section of the lattice increases its usability and indeed it can be more widely employed for façades, floors and interior partition walls. At first, installing the lattice was somewhat awkward and slow since it called for skilled labour to set up the wire frame and fit the pieces one by one. That was when the idea of industrialising the installation process was hatched using tapes to modulate the system. That in turn led to the possibility of making the lattice flexible and capable of being rotated using the wire strands as the rotation axes.

These wire strands, now transformed into threaded tie rods clamped to the structure, confer much greater stability to the whole unit and offer the possibility of tensioning the bars using the steel's tensile strength while at the same time compressing the ceramic parts.

Unlike patented system that exist on the market, whose main disadvantage is that they are not in themselves stable and thus always operate as an auxiliary item, this ceramic fabric could function both as a standalone element or as a secondary element coupled to another more robust item.



The result is a dry-fitted lattice with many applications and especially attractive for designing interior partitions, which, furthermore, can be varied in configuration and size over time by simply fitting new parts or removing those that are no longer needed.

4. CE PETO

This is an original solution for the breastwork on old buildings. Given that it is dry-fitted with non-aggressive fastening to the support structure, it provides excellent performance in earthquakes to prevent such traumatic experiences as in the town of Lorca (Spain) in May 2011. It would use the obsolete stock of ceramic pieces that are no longer marketable.

The starting point for this study was the rupture of breastwork on buildings subjected to the stress and forces of the earthquake.

To make construction sustainable, the initial premise contemplated reusing ruptured materials, starting with reused porcelain tiles under the pre-conceived notion that they could be recycled after demolition[5]. The system thus developed comprises a continuous succession of ceramic tiles placed vertically on edge that form a horizontal breastwork when the cable or rod running through them is tensioned.

In this way, the system would replace existing hollow brick sills so that they would undergo microrupture when subjected to seismic forces rather than breaking off in a single block.

Given that tiles can be laser-cut and drilled, the best way of reusing stocks of obsolete tiles is determined so they interlock with each other while also absorbing the variations in tolerance that exist among tiles made by different manufacturers.

Visually, the only influence on the end result is the side edge of the ceramic tile, so that the use of tiles with different outer surfaces is also feasible.

[5] Neila F. Javier; Las aportaciones de la cerámica al mundo de la sostenibilidad y la arquitectura bioclimática; proyecto SOLCONCER. Qualicer 12. Castellón. 2012.

5. IMAGINE CERAMICS

Our last example of ceramic materials used in building rehabilitation is the Imagine Ceramics project.

The project consists of rehabilitating and outfitting pre-fabricated metal cabins to be used for teaching purposes. The social problem generated by a shortage of teaching facilities or installations that are lacking in character and inappropriate for such use could be mitigated if they were given a certain identity by applying ceramic tiles that teachers and pupils could decorate themselves.

Our research on pre-fabricated cabins was born from observing how in certain towns in SE Spain, such as Torrevieja, that type of construction had been adopted as a temporary measure and yet had remained at schools for a number of years.

In both this and similar cases, we observed a number of related deficiencies:

- Poor thermal and hygrometric comfort: the construction revealed insulation cavities where they joined the metal structure.

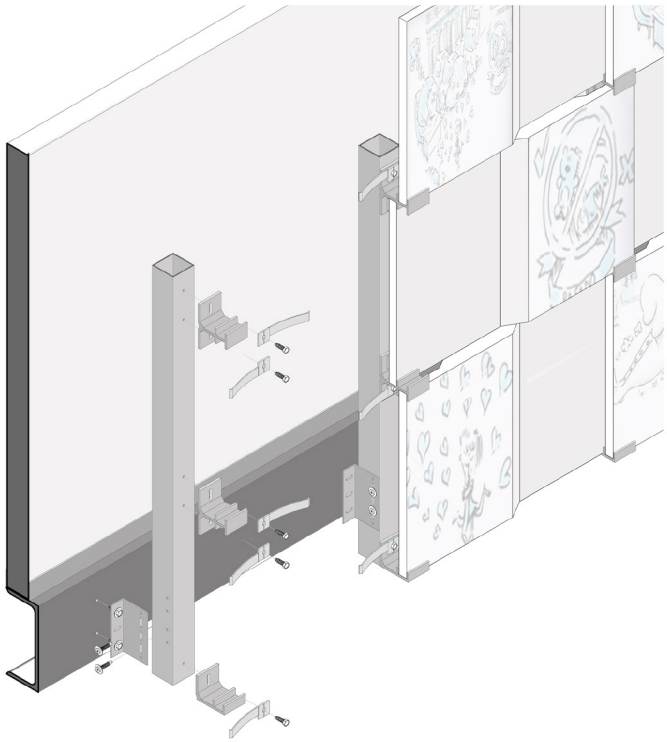
- A lack of space to install service utilities: all the service piping is visible on the outer wall and the A/C appliances are left on the roof.

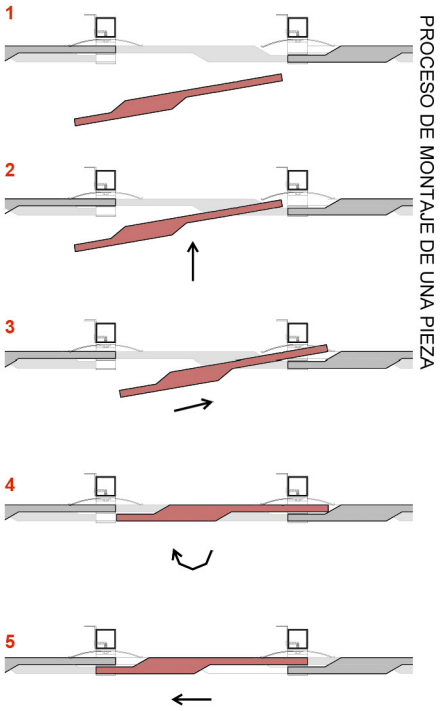
- Industrial resemblance: as can be seen in the Torrevieja school, the pupils painted the outer walls of the cabins to give the setting greater identity and to switch from the appearance of an industrial site to a warmer sensation more commensurate with children.

- Lack of identity.

In view of the above situations, the idea was to create something that creates a direct relationship with the user via interaction. A ceramic tile, given its vernacular, traditional, expressive and resistant qualities, is the ideal medium with which to address the problem.

The ceramic envelope is customisable and each student can depict a printed illustration of his/her first year at school. An easy-to-fit tile has been designed so that each year the façade can be changed for new students. Further research into modulating its assembly and the various components has been carried out in order to define the optimal size for the tile, made by pressing. Digital printing is used to transfer students' drawings.





At the same time, a tile anchoring system has been designed so that tiles can be (re)moved one by one. The system thus developed allows for tiles to be removed and subsequently refitted or reused on other cabins or buildings.

6. CONCLUSIONS

As has been seen from the wide spectrum of solutions presented herein, ceramic tiles serve as excellent materials for the overall rehabilitation of buildings and can be used on façades, floors, and partition walls, as well as on roofs. A huge variety of lines of innovation and research are being conducted in this field, although some of the solutions presented herein have yet to be tested and the results quantified. Even so, we can safely state that ceramic pieces can be incorporated into any stage of the project and subsequently moulded by the architect to suit each of the required needs.

A further conclusion of this paper is that ceramic materials are effective in the design of sustainable and energy efficient solutions for the rehabilitation of interior and exterior building envelopes, thus aiding the creation of more sustainable architecture.

Promoting in our schools of architecture the use of ceramic tile as a building material benefits the renewal of the building sector and focuses it on more sustainable and increasingly industrialised construction.

It is essential first that these prototype solutions be tested and secondly that tools be created that are capable of assessing construction solutions and recognising their benefits for society.

REFERENCES

[1] DE MIGUEL, Eduardo (2008). "Cerámica, materialidad e identidad", en Público, privado, efímero: la cerámica en arquitectura. ASCER Pages 113-115.

[2] ECHARRI, Víctor (2010). "Cerámica y eficiencia energética: sistemas de acondicionamiento pasivos y activos", en Ritmos, ciclos, comportamientos: la cerámica en arquitectura. ASCER. Pages 92-95.