Ceramic Tiles: A Sustainable Architectural Skin

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ABSTRACT
This paper aims to underline the potential of ceramic tiles used as a colour and light medium in architecture and urban design. Throughout time, ceramic tiles surfaces have enabled designers and architects to leave indelible marks on the skin of cities, like permanent tattoos, rich in aesthetic and cultural values. This ceramic skin, either as a full or partial cladding, can underline the architect's aesthetic and cultural language, giving character to the building through its colour, brightness, pattern and texture. It also offers an exceptional durability and low cost maintenance when compared to other materials traditionally used in façade covering. Ceramic tile cladding interacts with just as the clothes we wear interact with our bodies, its presence can contribute to a richer perceptive experience in the urban environment, adding sensual, visual and tactile qualities to our everyday life, and also fulfil aesthetical, functional and sustainable goals in maintenance and conservation.

Keywords: Ceramic Tiles; Colour; Perception; Sustainability

1. INTRODUCTION
To uphold the sustainability of ceramic claddings is not simply to assess their environmental impact. The pre-suppositions of this work, which underlines the potential of ceramic claddings in the design of urban spaces, is their socio-economic, cultural and ecological sustainability: socio-economic, through the creation of local employment and prosperity; cultural, through the preservation of operational processes and traditions; and ecological, as a means to protect the equilibrium of the ecosystem, associated with its aesthetic and emotional potential, closely linked to its chromatic richness

2. CERAMIC: MATERIAL, COLOUR AND GLOSS

2.1. Intrinsic Features: Body and Glaze
Due to their intrinsic nature, ceramic claddings are divided into glazed and unglazed. Non-glazed claddings are, in their majority, full body stoneware that, depending on their composition and on the firing temperature, can have very low, or, in the case of porcelain stoneware, almost nil absorption, and a very high
mechanical resistance, thereby eliminating the need for an insulating glaze. The colour of these claddings is determined by the raw materials of the ceramic body, the added pigments, and their finishing: polished (with gloss) or natural. The firing temperature of these materials (1400ºC) limits their colour palette, as the range of high temperature-resistant pigments is not very wide, due to the instability of pigments under higher temperatures. Colours of full body claddings are more related to natural pigments and tend to be dull.

Glazed claddings are mainly feldspar earthenware (whitish), terracotta (reddish) or stoneware (ochre) bodies that, with high porosity after fired, not being compatible to their protective function, requiring to be coated with a vitreous layer that gives them, not only impermeability and mechanical resistance, but also colour and gloss. As the firing temperature is lower (1100–1250ºC) the colour palette is more extensive and colours more vivid.

Glazes can be opaque or transparent, and glossy or matte. Opaque glazes function as a barrier to the passage of light, hiding the colour of the ceramic support, therefore the inherent colour of the piece will be the colour of the glaze; transparent
glazes may be or may not be coloured, and will allow light to pass through, making it possible to see the ceramic body through the glaze. For this reason, according to Lucas [1], a glaze colour perception depends not only on the characteristics of the incident light, on optical properties of the glazes (degree of opacity or transparency), as well as on the characteristics of the ceramic paste the glaze adheres to. For this reason, the inherent colour of the pieces is the result of the mixture of the colour of the ceramic with that of the glaze.

Surfaces covered with glossy glazes reflect light in one direction, creating spectacular reflections; on the contrary, matte glazes show a superficial micro-texture, invisible to the naked eye, thereby reflecting light in a multi-directional way, without creating any reflections as stated by Lucas [2]. Glossy glazes provide a more changeable appearance, due to the influence of gloss and reflection on its surface.

The thickness and evenness of the glaze is decisive for the inherent and perceived colour of the pieces; the thicker the glaze layer, the more saturated the colour will be, therefore, if the application of the glaze is not even, neither will be the colour.

The finish of a ceramic surface gives the piece a tactile and visual value; surface quality is also relevant in colour perception. In smooth pieces, the thickness of the glaze tends to be constant, resulting in a uniform colour. In pieces with reliefs, the glaze that covers them accumulates in the lower points and becomes scarce in the texture reliefs, resulting in colour variations. In this textured surfaces, light is reflected in multiple directions, causing an increase in the brightness of the perceived colour, as well as a decrease in the visualised saturation, maintaining the hue (that is to say, visually we perceive variations in light and saturation of the same colour as referred by Simonot and Mady [3].

Being a protective layer that has been subject to high temperatures, thus stabilising its composition, the glaze shows a stable gloss and a high chromatic durability. According to Fairman and Hemmendinger [4], the chromatic variation, reported in colourimetric terms, was considered insignificant: over 20 years, no change in values higher than 0.5 CIE LAB units was found.

2.2. Perceptual Features

Like a fabric that envelops and protects the body, claddings cover buildings, as stated by Weston, protecting them, articulating with their structural elements, and subordinating themselves to their interior organisation. A cloak of pieces that envelops the architecture, solving problems related to space, light, and acoustics, protecting it from the weather agents, making it more interesting with the introduction of colour, gloss and texture.

Glazed ceramics are constantly changing in appearance, and a simple alteration in the weather or observation conditions (point of view, angle of incidence of light, time of day) provide different perceptions of the same shape, the same pattern, the same colour or texture. Due to the gloss of the glaze, a tile cladding stands out from its adjacent painted or plastered surfaces as described by Lancaster [5].

The colour reflection on its surface is much stronger than that of a matte surface, and variations in the perception of colour saturation can be observed, depending on whether the gloss reflection is visible or not from the observer’s
point of view as Dalal [6] emphasize, which does not happen with a plastered or painted surface. In textures and glossy surfaces, a phenomenon referred by Anter [7] as angle metamerism may occur, in which certain colours appear similar or different when viewed at different angles. The reflectivity of a glossy glaze, articulated with light and the angle of vision may turn the tile surface into a mirror surface, bringing light to narrow and dark roads, enlarging the space through the introduction of what the author refers as “absent present”, bringing us the surrounding landscape that our visual field cannot cover. This phenomenon of the reflection of the adjacent image contributes not only to a dematerialisation of the corporeity of the buildings, as Lancaster [8] described, but also to the integration of the building into the surrounding urban fabric. Its high reflectiveness makes possible to use glazes with darker and more saturated colour covering large areas. Since the gloss makes the surface “vibrate”, an apparent reduction in the size of the building is achieved. Weston [9] emphasize that this feeling of dissolution of the matter and the sense of lightness are often reinforced by the use of texture and pattern.

Ceramic claddings allow tactile and visual graphic elements that, associated with colour, create visual points of interest at several distances. Through the combination of design and colour, volumnetry and depth effects emerge which, from a certain distance or from a given angle of vision, and due to an optical mixture, turn into another colour and another surface. Patterns evolve from the repetition of motifs of various colours into a continuous fabric animated by a uniform visual texture.

3. A SUSTAINABLE SKIN

Traditionally, the production of ceramic tiles represented large amounts of energy consumption and significant amounts of inert and toxic waste. Over the last few years, the environmental measures imposed by the governments of the producing countries, and the companies’ needs to reduce their costs, improve production efficiency, and increase profits have led to significant alterations in their methods. Between 90 to 95% of the energy consumption of the production process is ascribed to firing. The use of electrical energy and natural gas was the first step, and now researches are being conducted to create a system that utilizes renewable fuels to fire a kiln from start to finish. Other measures have been widely implemented, such as, for instance, the re-use of the heat liberated in firing for supplying energy to drying ovens, and for the production of electric energy; the replacement, whenever possible, of intermittent kilns by continuous kilns, where the temperature levels are more controlled; or the re-introduction of manual tasks instead of machines, which not only reduces energy consumption, but also increases employment, as reported by Russo [10].

At recycling level, the reintegration of both the liberated dust and the conformation waste into the composition of the paste; the transformation of inert waste into dust that may be partially introduced into the composition of the ceramic paste and the re-use/recycling of water in a closed circuit system, have all contributed towards a very significant reduction energy consumption and of the post-production waste.

At health impact level, both on workers and users, toxic components are been steadily eliminated, such as, for instance, the use of lead to give gloss and visual depth, replacing them with other non-toxic compounds.

With regard to the use of ceramic cladding, several relevant factors can be found in its environmental potential,
namely its long life-cycle (which reduces, in the long term, the number of times raw-materials need to be extracted, manufactured, transported, installed, demolished, and debris removed); according to Carter and Norton [11] the fact that it contributes towards temperature regulation, moisture management and high resistance to temperature variation and poor electric and thermal conduction, deriving from the nuclear bonding of electrons; is chemical insensitivity not absorbing or emitting pollutants because it becomes inert after synthesis; its easy cleaning and maintenance that does not require chemical treatments; and also because it disintegrates into inert non-allergenic powder.

The fact that tiles claddings remain almost unchanged is due, not only to the ceramics’ properties, but also to its relation with its support. If the application is in accordance with the standards for each material and the application method is in agreement with the materials’ expansion coefficients, and an adequate paste material is used, then the adhesion to the plane will last for a considerable time.

4. CONCLUSIONS
A society’s sustainable growth is based on its capacity for cultural and natural evolution. We agree with Shum [12] who defends that to create prosperous and socially cost-effective communities, re-establishing the connection between nature and man without compromising the future of our ecosystem through a socially just, economically viable, culturally and ecologically acceptable development, and reflecting local values and traditions, has become a pressing need.

Contrary to most materials, which have an intrinsic colour and texture, in ceramic claddings visual characteristics may be defined by the project. The customisation of ceramics can take place at the product’s intrinsic level, in the composition of the paste and the glaze, so as to exploit its colour and interaction with light, and/or as response to functional requirements; or at an extrinsic level, changing its shape and surface/texture, thereby altering the perception of its visual appearance.

Its superficial qualities, its chromatic variety and longevity, the gloss associated with colour; the possibility of creating designs with elements of different colours and hues, as well as random patterns, graphics or textures, increasing the surface’s possibilities, are visual and haptic properties that make ceramic claddings desirable in the building of a sustainable environment.

Ceramic claddings urban performance is enhanced by the presence of other materials. Functional performance can be increased, and visually they can turn into an integration element of the building in the environment, or a detachment factor.

This manipulability allows architects and designers to decide not only what is produced, as also what to produce. Ceramic claddings are a sustainable response to habitation’s aesthetic and functional needs, providing an aesthetic solution to some of the buildings’ protection and maintenance problems and making it possible to introduce artistic visual elements that may influence the living practices of the inhabited areas.
REFERENCES