

FROM DIGITAL COLOUR TO CIRCULAR COLOUR. The color of architectural surface in the circular economy. A review

Katia Gasparini

¹*Department of Architecture, Design and Planning, University of Sassari, Italy*

*Corresponding author: Katia Gasparini, kgasparini@uniss.it

ABSTRACT

Nowadays, circular economy principles have persuasively entered architectural design and façade covering, transforming their visibility. Previously, the facade was “covered” by paint or a flashy and super-colored digital screen; now, the final layer is neutral, typical of recycled materials. The facade has now lost its role as the superficial identity of the building, instead becoming a sacrifice surface for new experimentations. The aim of the paper is to describe the transformation of textures and colors of contemporary architecture, within the circular economy paradigm, through the analysis of some case studies of the last years and the perceptive and social repercussions. Where before the facade was "covered" by a bright and colorful digital screen, now the overlaid layers are neutral color, like the recycled materials. Today the façade is no longer considered an identifying surface of the building, but as a surface of sacrifice for new experiments. The new architectural façades therefore adopt green, grey, carbon-neutral solutions and more, with a focus to circularity and resilience of the contemporary construction system. At the same time, the new environmental demands of the circular economy are leading us to use technical elements made with recycled or natural materials, which completely change the perception of architectural surfaces, in this Era characterized by speed. The colors are the natural ones of the materials, which can then be recycled, or the neutral colors of recycled materials, maybe as 3D printed powder blends. With this new paradigm, do buildings lose their identity and look all the same or do they re-appropriate the identity of the original materials of the place? What is the impact of these new hypo-colored surfaces within urban landscapes? Will the genius loci [1] of urban spaces survive the changes due to the new circular paradigms?

Keywords: circular colour; architectural surface; digital colour; neutral colour; hypo-coloured surface

INTRODUCTION

In the second half of the 20th century, we witnessed the construction of colored and luminous architectural façades, thanks to industrial research and technology transfer, which have brought materials and technologies with high visual impact to the construction field. Silica, acrylic, and siloxane paint in ordinary construction and experimentation with digital technologies in tall buildings (in the late 20th century) transformed the perception of architectural façades and the skyline of big cities and peripheral hamlets. In major European and international cities, building façades were turned into large TV screens, catching the attention of passers-by with luminous colors, saturated and brilliant, moving images, and super-colored advertisements (urban screens). In residential and social housing, long-lasting synthetic colors have subverted historical buildings' tendency toward soft ones, covering houses with bright tones. Saturated and brilliant colors, which can resist any weather, have transformed suburbs into colored mosaics: façades are neon green, cherry red, lemon yellow, light blue, purple, and so on. At the same time, the parable of urban screens concluded in little more than 15 years, leaving room for a revived environmental awareness oriented toward the realization of green façades. Living walls started to invade some of the most famous contemporary architectures and some residential buildings, albeit to a smaller extent. Following the same revived environmental consciousness, contemporary façades have been equipped with new green, grey, carbon-neutral

and other solutions, in a perspective of circularity and resilience. The new environmental needs of the circular economy are leading us to use technical elements realized with recycled materials, whether natural or artificial. They often lose their original color during recycling, moving toward more neutral (achromatic) shades. At the same time, the contemporary construction of Italian suburbs is subjected to a generalized chromatic flattening, with new buildings indistinctly painted in grey shades. Nowadays, circular economy principles have persuasively entered architectural design and façade covering, transforming their visibility. The paper aims to describe the transformation that has invested contemporary architecture's textures and colors within the circular economy paradigm. This will be accomplished by analyzing case studies from recent years for both building typologies. Now, the colors of façades are the natural or neutral colors of recycled materials, sometimes as 3D-printed powder mixes or shades of grey in the suburbs. This leads buildings to lose identity and visibility. What is the impact of these new hypo-colored surfaces in urban landscapes? Will the genius loci [1] of urban spaces survive the modifications of circular paradigms?

METHODOLOGY

This paper employs the descriptive analysis method by combining a literature review with a case study analysis to identify the relevant items for studying the color of contemporary façades. A state-of-the-art analysis was made, including both case studies with materials deriving from a “circular” design and constructive approach (20 case studies) and the color of façades built in the last years in urban suburbs (50 case studies). When possible –in peripheral residential buildings – a survey with an NCS Colourpin II colorimeter (or color survey tool) has been performed [2]. In internal case studies, it was impossible to survey building colors directly; hence, a photographic sample provided by designers or obtained from journals was used. Images have been processed with the Adobe Photoshop software (pixilation method). Color conversion from RGB to NCS has been performed with the conversion tool from e-paint.co.uk [3] to identify the closest NCS value to the RGB hexadecimal one. The analyzed buildings have been built relatively recently: 2008-2022 for the 20 international case studies and 2020-2023 for the 50 Italian case studies. Color variations due to different natural light conditions, artificial lighting, reflections, and other environmental factors were not considered, as they were negligible. The paper will present the first analyses inferred from the case studies, which will have to be further studied and substantiated with multi-disciplinary research in the future. The paper is articulated into 3 items: historical-circular excursus on the colors on the façade, with a focus on contemporaneity; chromatic scales found in the case studies and façade materials in the circular economy; results and conclusions.

THE COLOUR OF FACADES: “CIRCULAR” EVOLUTION

In the past, buildings were made with local materials. Some regions used bricks, others used stone, and in others, the wall had a lime plaster. Colours were composed of local pigments in a solution of water and lime. For this reason, in most urban and periurban historical centres, façades have the colour of natural materials and soils. In broad outline, five different phases of façade colours can be recognised in history (fig. 1):

- The first is the longest one, preceding the Industrial Revolution, where colours were determined by the materials used and by the frescoes and decoration in prestigious buildings;
- The second one is the phase between the two industrial revolutions when the development of glass and steel buildings led to the construction of high-rise buildings with innovative materials;
- The third phase is the post-war phase, that of the reconstruction of large residential complexes (social housing) and the diffusion of synthetic paint;
- The fourth one started in the '80s, with the production of artificial light envelope (overcladding systems) made with coloured components and any type of material, with digital panels (urban screens) and innovative materials that change colour and form, etc.;



- The fifth is the contemporary age, gradually shifting from the construction of living walls to a new type of sustainability, which reuses construction materials and is called “circular economy”.

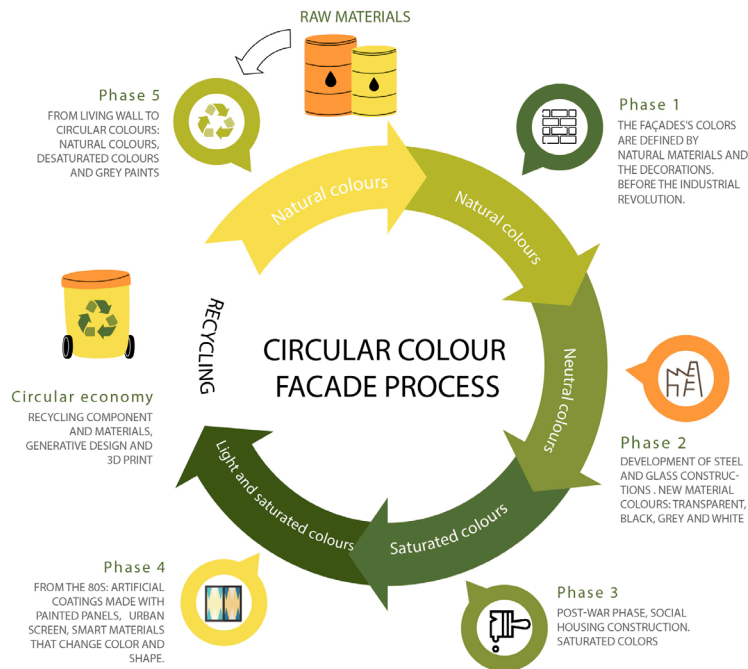


Figure. 1: Circular evolution of the colour of the façade.

It can be inferred that the productive and cultural system's evolution has influenced the built environment's colour. Which colours have characterised these five phases? In small urban centres, the colours of less affluent classes and bourgeois' houses used to derive from locally obtainable materials and components: the colour of bricks (which could be red, grey, or red-yellow according to the place), the colour of local trees (Fig. 2) or stones. In ancient times, plastered houses could be left in their natural colour: in Florence, it was a white grey, which became yellow over time; in Rome, it was pinkish grey, obtained from pozzolana. Throughout the 17th and 18th centuries, façades were painted yellow, red, green, or bicolour, like in Naples [4]. For example, in Tuscany, the 14th and 15th centuries are characterised by the pictorial use of low tones, without flashy colours, due to the practice of frescoes on lime, requiring the use of earth colours (oxides) [5]



Figure 2: Facades of small historical centres built with local materials. On the left, Storo (I), with its typical constructions in stone and timber. On the right, Buddusò (I), with houses built in grey granite blocks.

In the second post-war period, has brought about an unconfined transport of goods. Architectures can no longer age and must always appear flawless and impervious to time. Artisanal techniques have disappeared, and artificial materials are used. Saturated and bright colors are preferred, especially as their visual properties are unaltered by the sun and weather over time. This leads to the employment of synthetic paint with improbable neon green or yellow tones, blue and purple, and so on. This is true for residential construction in general. Then tall buildings, constructed of steel and glass, mainly have neutral, reflective colors or colored ceramic or marble cladding. Consider, for example, the buildings Giò Ponti designed and covered with three-dimensional colored ceramics or think to Aldo Rossi and the “Postmoderns.” In the late twentieth century, there was the spread of artificial coatings: colored or grey metal panels, polycarbonates, up to the bright, saturated digital layers (Fig. 3) with an initial environmentalist sensibility that took the form of living walls.



Figure 3: Madrid. Left, a façade with coloured metal panels (social housing on the outskirts of Madrid); right, the digital façade of MediaLab Prado.

Ideally, the circle completes again in contemporary times. The colours of recycled materials and components are mixed to give rise to natural/artificial powder mixtures, which 3D printing transforms into living components or cells. They are the colours of Pla, marble powders, and soils. That is, basically neutral colours. What happened?

THE COLOUR OF CONTEMPORARY FACADES

The analysis of buildings constructed in recent years revealed a trend toward achromatic or low-saturation facades: grey and beige scales. The study focused on two types of buildings: diffuse housing in suburbs (expansion areas) and large architectural projects of office centres, exhibition halls, installations, tall buildings, etc. As for the latter, the colour tends to come from the components of the cladding or exterior walls, often made from recycled materials. Reintroducing materials into the production process usually involves their transformation into another form than the source material, which can lead to colour variation. In this case, this involves reusing stone waste, which can be turned into powder to make blends with other materials (geopolymers) [6] for 3D printing or components from recycled polymers, more colourful, or metals. The case of current residential construction is different. Our contemporary urban environment seems to have mutated into a monochromatic world with a limited spectrum of tones. Examples of this kind of architecture and urbanism are found in large residential projects in the suburbs [7]. Today, variations of grey and beige (Fig. 4) are widely used instead of the saturated colours used until recently. Sometimes, grey colours are also proposed in historic centres. Thus, while historically, the grey colour of facades was typical of poor suburbs, where the wall face was barely plastered (the grey colour of the mortar plaster) and not painted, now grey is deliberately chosen as a valuable finish. Concerning this aspect, it would be appropriate to investigate the reasons through sociological and anthropological analysis. According to Weber’s recent research [7], the reason for the contemporary monochromatic orientation is solely commercial. Neutral colour loosens attention and distracts from imperfections and design errors, “It is [even] believed that there might be a higher margin of

error with grey and white tones.” And for that reason, “visual impoverishment is the accepted consequence.”



Figure 4: Some case study of newly built residential buildings in different suburbs. All new buildings are painted with gray variants.

FAÇADE MATERIALS AND TECHNOLOGIES IN THE CIRCULAR ECONOMY

In the analysed case studies of international architectures, the façades were almost all made by recycling building components: bricks, tiles, and stones salvaged from other demolished buildings and reused with more innovative textures than the historic building.

The result is colours that tend to be neutral and darker than the same new product, with hues ranging from grey scales to beige and brown scales (for terracotta components) (Fig. 5).



Figure 5: color palette obtained from contemporary architectural projects, built with recycled components

These colors belong to components originally made from natural materials (the soils or stones), but their tones have turned darker and less vivid. Examples include the Ningbo Historic Museum project and Kengo Kuma’s China Academy of Arts’ Folk Art Museum, both in China. The former is constructed from building waste of different shapes and materials, and this identity is left exposed on the facade of the building. The general color is grey, with a few bands of brick colour. Recycled materials are deliberately left exposed. Kengo Kuma’s project is grey, too, in a dark shade, and it is interesting because the surfaces are covered with old tiles from local houses but laid at right angles to the vertical wall, set on a metal mesh. In this way, they form a kind of brise-soleil. The innovation in almost every project is in the design process: parametric design and sinuous shapes. Thus, the colors of the circular economy take us back to the basics, to the pre-industrial revolution building tradition, because components made of natural materials are reused in their entirety. There are also plastic wrappers, whose colors tend to be from light blues to whites, reusing recycled plastic components, too. There are still few case studies in which recycled components are crushed or melted and reinserted into a new production process. Then, they are usually used for 3D printing housing components or cells. The colors do not change much from the above, whether polymers or natural materials. In the case of Tecla from Wasp (Fig. 6), the mixture of soils substitutes the beige-brown color of the recycled material. Also, in cases of digital polymer printing such as Killa Design’s of the Future Pavilion or the EU Pavilion by Dus Architect, the colors are white or light blue. In the People Pavilion the colored tiles that make up the Pavilion’s upper facade are made from plastic household waste materials (Fig.7).



Figure 6-7: Left, Tecla by Wasp (ph. WASP); right, People Pavilion (ph. Pretty Plastic)

In the color analysis of residential buildings, the color palette is drastically reduced to grey scales (Fig. 8). In this case, it is not the reuse of waste material but newly produced synthetic paints that somehow “mimic” the color scheme of houses built between the wars. In that period, houses remained plastered with grey cement mortar without a layer of colored paint. The phenomenon almost exclusively occurs in new construction.

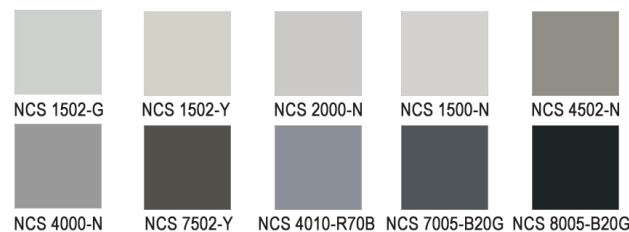


Figure 8: Colour palette derived from residential building plans

RESULT AND CONCLUSION

The findings of this study highlight that, in the time of the circular economy, even architectural facades are adapting their appearance to the increased environmental sensitivity. The reuse of building components and materials in the construction process affects the color of façades at the level of large-scale architecture. It is well known that architecture represents its own time. This is perhaps the time for the recovery of a more honest relationship with the environment and the resources available to us. This new approach manifests itself through facades with duller, more opaque colors. These are the colors of recycled materials that, for that reason, have been ageing due to exposure to the elements over many years. In fact, the color palette derived from the 20 case studies (Fig. 6) reveals the original materials: the beiges/reds of bricks, the grey tones of concrete, and the white/blue tones of polymers. However, they are decidedly low-saturation colors. In the case studies shown, only one (Tecla) was built by 3D printing with a local soil-based mixture that influenced its final color. However, other non-structural components made with marble powder binder-jetting technology are being tested. In this case, the color will not realistically match the source stone but be more similar to a mixture of stone and other materials, fading the color. The other analysis, performed on residential construction, from the material point of view, is apparently unrelated to the logic of circular economy and recycling. The new buildings are all grey; the materials are newly manufactured paints. What is the reason for this generalized color flattening? Weber cites purely commercial reasons. Maybe other explanations are more related to environmental sociology and anthropology, which would be worth exploring. The grey color does not draw attention to either the object or the design flaws, is welcomed by most people (how many grey cars do we see along the streets?), and

keeps the profile low compared to the quality of the building. However, interventions with recycled materials and those with grey paints are strongly self-referential, prioritizing experimentation, economy, and emulation. In the era of Industry 5.0, with even the European community issuing documents on the importance of a Human-Centered (HCD) approach to manufacturing [8], we are going in the diametrically opposite direction, regardless of urban color plans and the valorization of the identity of historical centers and suburbs.

REFERENCES

1. Norberg-Schulz, C. (1980). *Genius loci. Towards a phenomenology of architecture.* Milan (I), Rizzoli.
2. <https://ncscolour.com/product-category/shop/digital-colour-tools/> (access on 20.07.23)
3. <https://www.e-paint.co.uk/compare-colours.asp> (access on 20.07.23)
4. Quaroni, L. (1977). *Progettare un edificio.* Milan (I). Mazzotta, pp.196-197
5. Zennaro, P. (2002). *Il colore degli edifici.* Florence (I). Alinea, pp. 27-29
6. See research on 3D printing of geopolymers made from stone dust: Gobbin, F. et al. (2021). Large scale additive manufacturing of artificial stone components using binder jetting and their X-ray microtomography investigations. *Open Ceramics*, 7: 1-1, <https://doi:10.1016/j.oceram.2021.100162>; Elsayed, H. et al. (2022). Additive manufacturing of inorganic components using a geopolymer and binder jetting. *Additive Manufacturing*, 56:, <https://doi:10.1016/j.addma.2022.102909>.
7. Weber, R. (2023). Monochromatic design in a polychrome world. Why our cities have become increasingly gray: A dichotomy between production and reception in architectural color design. *Color research and Application*, <https://doi.org/10.1002/col.22876>
8. Breque, M., De Lars, N., Petridis, A. (2021), “Industry 5.0. Towards a sustainable, human-centric and resilient European industry, European Commission. https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/industry-50-towards-sustainable-human-centric-and-resilient-european-industry_en (Access 02 August 2023).