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Architectural Rehabilitation and Sustainability of Green Buildings in Historic Preservation

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Abstract

The aim of the article is to draw attention to the fact that architecture must comprehend nature and bring it back to the daily life of man, increasing his physical and psychological comfort. "Green" in architectural rehabilitation can have several meanings and approximations. In this article, we address "Green" as both a color and an attitude. This paper has been developed through deepening the hypothesis of the color green in living coatings. The creation of an ecological skin in architecture accentuates the dilution of the presence of interventions in heritage contexts with an attitude of knowing how to add, involving nature. These enable the development of solutions that avoid architectural language formalisms, which is especially important in the context of heritage architectural rehabilitation. Examples of green roofs and green facades are presented, and it is shown that rainwater management improves the sustainability of the historic place. Complementary, as a green attitude, it is essential to use renewable energy in buildings to achieve NZEB—Nearly Zero Energy Building. As a case study, we have selected the rehabilitation of the Cathedral of Portalegre in Portugal.

Keywords: Architectural Rehabilitation; Green Walls; Green Roofs; Algae; Biological Concrete.

1. Introduction

Green is dominant in nature, as it's the color that is best perceived and visible to the human eye. In the shades of green, Chartreuse Green is the most visible to man. As it's compounded by 50% green and 50% yellow, it appears in the middle of the spectrum of colors visible to the human eye.

This fact is due not only to the evolutionary factors of the species, but also to the importance of photosynthesis on our planet. This relationship, inherent in the natural world, benefits our health. Hence the importance of designing green environments, whether it is through urban planning, green architecture, or through architectural rehabilitation with living coatings (Figure 1). They may also have potential social benefits, in case they are accessible not only to building users but also to the general public. It's central to bringing nature to the everyday of the urban man, who is increasingly removed from it, thus enhancing his physical and psychological comfort [1-3].

However, when using green, it is necessary to note that some of the pigments used to make it have side effects, which can lead to poisoning. For example, the emerald green, appreciated by painters like Cézanne, Monet, and Van Gogh, degraded itself spontaneously, causing the paintings to emit vapor of high toxicity based on arsenic.

Nowadays, it is being questioned whether the diseases that those painters contracted would not be provoked by the inhalation of those toxic vapors. Another green shade, which has been proved to have nefarious effects, was Scheele's

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Green (copper arsenite) created in 1778 [4]. It is a vibrant green pigment that was used in paintings of interior coatings, tapestries, and furniture. By extension, we can say that the composition of various natural or artificial materials can also have contraindications, such as the case of granite with radon and the chemical compositions of the materials [5, 6].

Figure 1. Green roofs - Calouste Gulbenkian Foundation, Lisbon. Ribeiro Telles

2. Theory

Green roofs have always been part of the architect's imagination, having reached its climax in antiquity in the Hanging Gardens of Babylon. Whether on the roof, on the facade, or on the floor, living coatings are proposals for quality finishing. Their aesthetic aspect is fundamental, making it possible to obtain completely different solutions by the option of the color changing, according to the seasons of the year.

Plants may be selected depending on the color of the flowers, leaves, or both. There might be green areas of the coatings, while others may appear in red, brown or in various colors through the blossoming of the flowers. Even in green areas it is possible to choose different shades and gradations of color. The green facade built in the *Caixa Forum Square* in Madrid, authorship of Herzog & Meuron and Patrick Blanc, is based on a new technic of vertical culture without a ground (Figure 2).

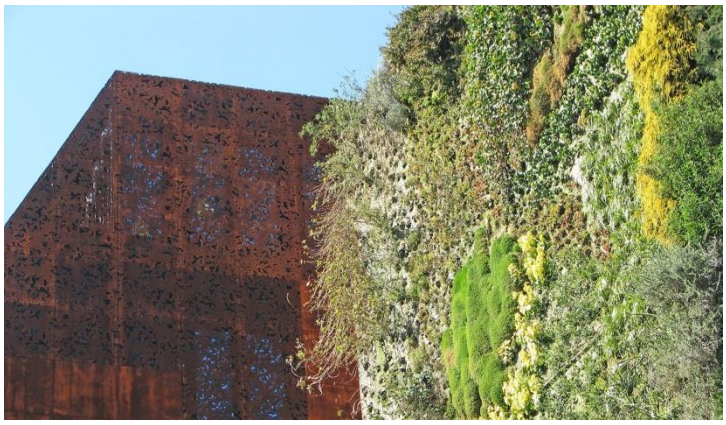

Figure 2. *Caixa Forum* and green facade in the building of the *Caixa Forum* Square, Madrid, 2007. Herzog & de Meuron and Patrick Blanc

This new solution, patented by Patrick Blank (Request of the Patent 08.08.88; in force since 10.07.92), ensures the vegetation of building surfaces, regardless of height, without substrate weight problems. This vertical garden has about 20.000 plants belonging to 3000 different species [7, 8]. There are several competing brands that show variants to this system developed by Patrick Blank.

Another type of green facade was created in 2013 in Hamburg, Germany with the use of microalgae, produced in the skin of the building [9]. The microalgae grant the green color, without being necessary another finishing. With a concept of holistic energy, the microalgae generate electric energy and produce heat. It can be stated that it's a triply green building: color, energy and heat (green energy). This principle of conception can be used in architectural rehabilitation, whether it is on building skins, or in light-breakers, or in building's expansions.

In Spain, at the *Universitat Politècnica de Catalunya* in Barcelona it was developed a new concept of vertical garden that allows the choice in a coloring area, without needing support structures [10]. It was created a concrete that performs as a natural biological support for lichens, mosses and other microorganisms that confer various green

shades (Figure 3). The biological concrete, besides having aesthetic characteristics, it may function as a thermic isolator and regulator. Thanks to its biological coating, it absorbs and reduces de CO2 in the atmosphere.

Figure 3. A cement wall with lichens, Lisbon

3. Green as Attitude

"Building rehabilitation is a sustainable practice, especially when it comes to the rehabilitation of heritage buildings. Rehabilitation also means to articulate the building's ages and must have as key concepts: Reversibility; Sustainability; Versatility; Simplicity. Always respecting the Heritage. The interventions underlying cultural attitude must combine the design process with the principles of economy and environmental impact assessment." [11].

It is critical to address the paradigm shift and reflect on climate change and how it is interfering with all fields of architectural creation. The "Green" as an attitude should be developed from the sustainable rehabilitation point of view - construction, implementation, maintenance, deconstruction - covering its whole life cycle, in order to minimize environmental impact, with applications to the architectural design process (Figure 4).

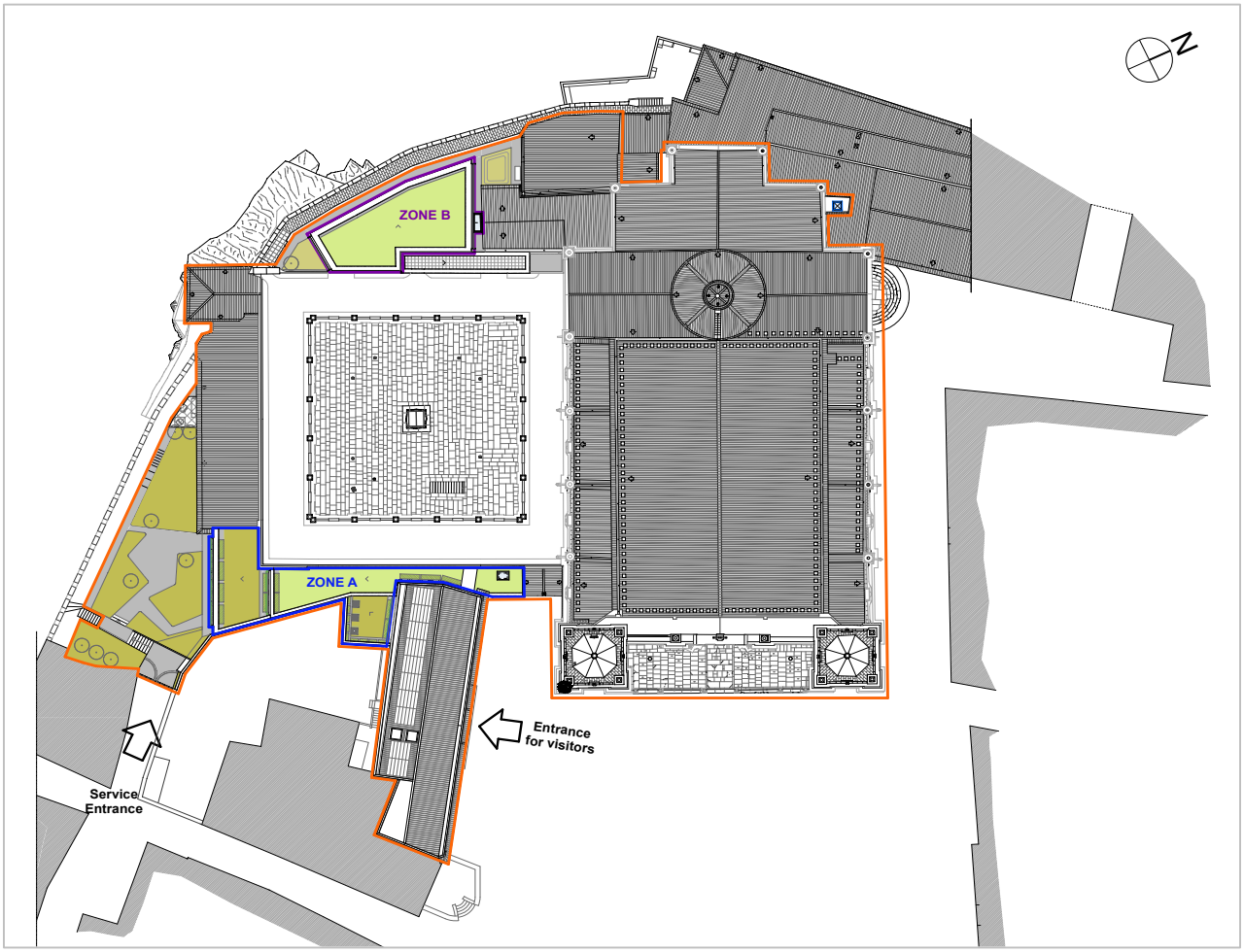

Figure 4. Cathedral of Portalegre. Rehabilitation made by RBD.APP, 2016

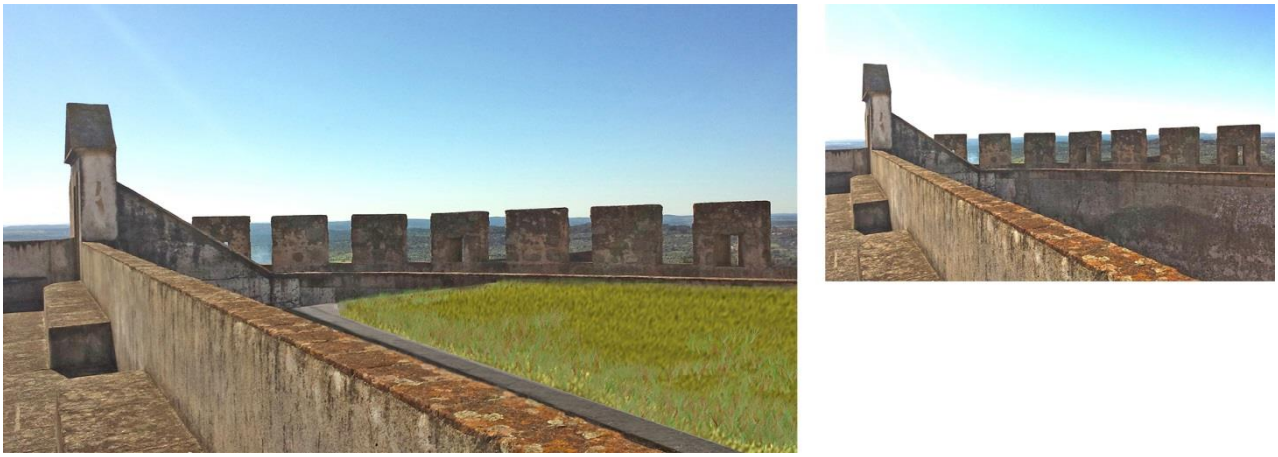

Figure 5. Cathedral of Portalegre: Terrace View to the Green Roof of the Permanent Exhibition Room in the southwest courtyard – Zone B. Rehabilitation made by RBD.APP, 2016 (left). Terrace View to southwest courtyard, 2015 (right)

Living coatings allow the creation of solutions that avoid formalisms of architectural language, being of special relevance their application in the Architectural Rehabilitation of the Heritage (Figure 5 - left). There are cultural obstacles in addition to technical and ecological ones, when choosing to utilize green roofs. Green roofs and green walls increase the thermal and acoustic insulation of buildings and allow natural shading. In addition, they improve the quality of the air, purifying it, increasing the comfort of the users.

In the Rehabilitation of the Cathedral of Portalegre it was used the traditional system of coating with creepers like the existent situation (Figure 6–left), although supported by loose steel wall cables (Figure 6–right). Its adequate spacing allows the development of the plants and the continuity of visualization to the outside (Figure 7). It is intended to create a green filter in sunlight, and to obtain the green surrounding effect of plants without damaging the walls.

Figure 6. Cathedral of Portalegre: South courtyard before Rehabilitation, 2015 (left). Zone A. Rehabilitation made by RBD.APP. Landscape: ARPAS, 2019 (right).

Figure 7. Temporary Exhibitions: view to the south courtyard, 2019

Combining ventilation and air purifying plants, the green facade increases the quality of the air, while associating scents of nature. The importance of nature is also reflected in the concept of Biophilia, the need that man has to be in direct contact with Nature [12].

It is important to provide the use of a vegetal covering with little maintenance, by selecting sustainable native plants which are resistant to drought and do not require excessive watering. There are no recipes for a generalized application of this principle, as the context in which the construction is inserted, may condition or encourage this option. It is a matter of aesthetic framework and opportunity that can be solved through creativity [11]. The vegetation should be selected in order to not excessively grow, starting to be visible from the outside and, therefore, removing the character of the building. The plants can still be used to treat grey water and can contribute to the innovation of water management and ventilation systems (Figure 8).

The proposed vegetation is Mediterranean vegetation, well adapted to the climatic conditions of the place, with little irrigation and maintenance requirements. They are ornamental species, with various sizes and types depending on the location to be used, such as rosemary, lavender, myrtle, lantanas, honeysuckle, (Figure 9). It is possible to optimize the consumption of water, whereas carefully choosing the ornamental vegetation and optimizing the association of cacti and grasses. The irrigation system for the various spaces is drop-by-drop irrigation, which allows a more efficient use of water, avoiding unnecessary losses, whether due to the action of the wind, placing obstacles, or the very development of plants.

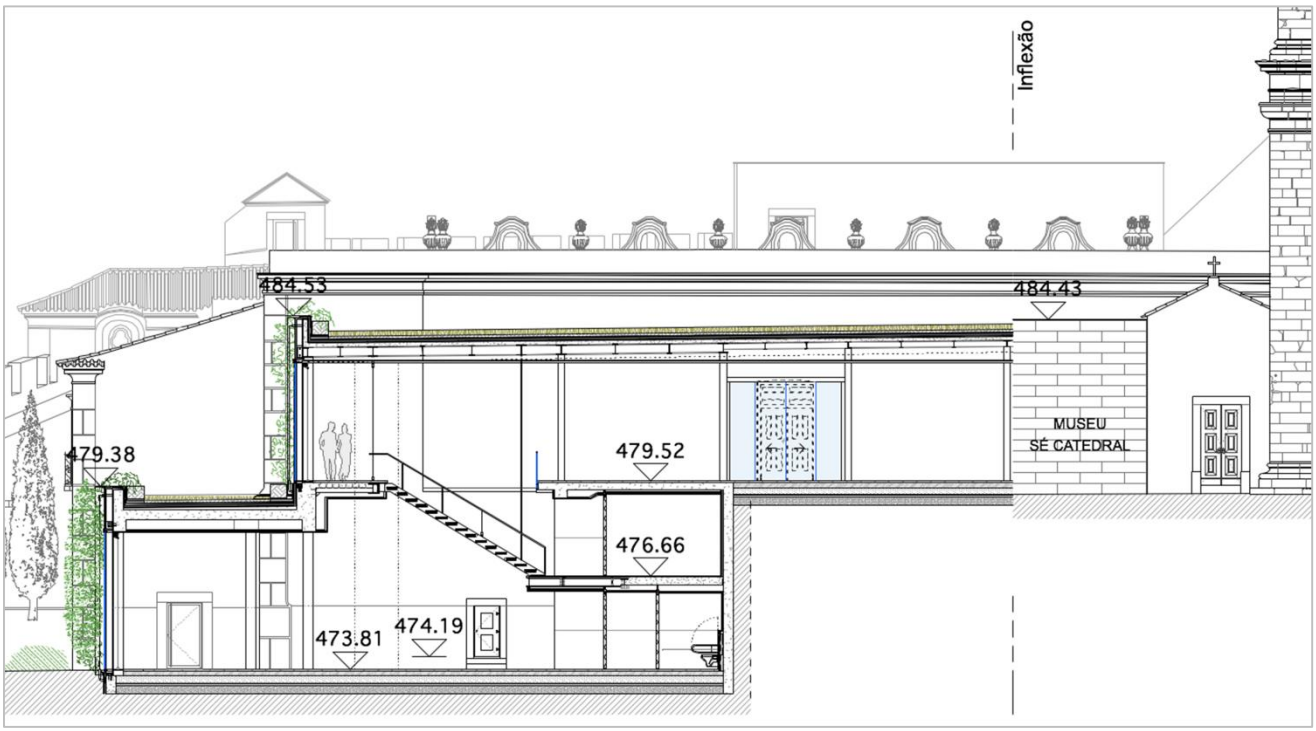

Figure 8. Cathedral of Portalegre: Section by access to South courtyard with green roofs and green walls. Rehabilitation made by RBD.APP. Landscape: ARPAS, 2019 (right)

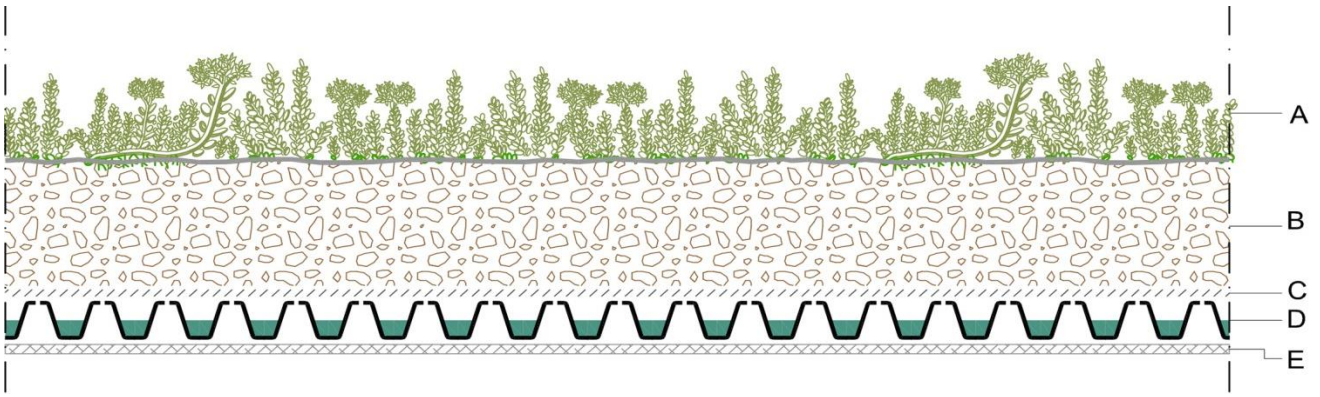

Figure 1. The green roofs will be an extensive system consisting of: A - Landlab's "Sedum Carpet" plants, made up of 11 Sedum varieties; B - Substrate approximately 8 cm thick; C - ZinCo SF system filter; D - Floradrain FD25 drawing element, by ZinCo; E - Protection and absorption blanket SSM45, by ZinCo. Landscape: ARPAS, 2019

Figure 10. Proposal. Ground Level - South courtyard: rainwater circuit from the cistern, 2019

The rehabilitation proposal revitalizes the cistern's importance by including it in the exhibition route and takes into account several essential aspects: ensuring the flow of water from the cistern whenever necessary; avoiding bad smells in the spaces to be created; using the cistern water channel on the pavement as a security system, directing it directly to a new storage tank provided for in the south courtyard; guaranteeing the flow of excess water; providing for manholes in the new plumbing; using the water in the tank to water the green areas. The rainwater retention tank will be used for water reuse on site (Figure 10). Green roofs are also a water management system as they filter rainwater. This entire integrated system comprises a selection of plants adapted to the location, which consume little water and are easy to maintain, reinforcing the economic and environmental sustainability of this historic place.

Another very important green attitude is the NZEB (Nearly Zero Energy Building). To achieve NZEB, it is essential to use renewable energy in buildings. However, the dark color of the photovoltaic cells has a negative visual impact on the image of traditional brick-colored ceramic tile roofs. This problem is aggravated when thinking about the architectural rehabilitation of the heritage because it creates a huge contrast with the colors of the roof tiles.

In Portugal, there are no solutions that incorporate renewable energy into straw tile (*canudo*) roofs that are mandatory for use in heritage buildings. Thus, it was decided to place the photovoltaic system in the rehabilitation of the building that will serve as the entrance to the Cathedral's exhibition complex. This building is not classified as cultural heritage and has already functioned as a fire station. Therefore, it was proposed a straw tile (*canudo*) coating on the roof slope facing the side of the entrance square of the cathedral and *SOLESIA* tiles to cover the slope facing the south since that is not visible from the entrance side (Figure 6–right). This type of solution is called tile, but in reality it resembles a photovoltaic panel [13, 14].

4. Negative Factors

There are negative aspects to the use of live facades and roofs in architectural rehabilitation: the plants may catch diseases, they may die, or they may need to be pruned. The existence of vines that cling to the walls through their tendrils can cause problems if there are cracks through which they can penetrate.

It is necessary to wisely choose what kind of plant to use in order to avoid this type of situation and to minimize its respective maintenance. Green roofs aren't always the best option in architectural rehabilitation as their weight is superior to traditional roofs. In addition, they are difficult to apply to roofs with a slope greater than 30°.

5. Conclusion

Greenery is essential in human life. Therefore, architecture must comprehend nature and bring it back again to the daily life of man, increasing his physical and psychological comfort. The green wall acts as a filter, and it is a shading

plan that dilutes the presence of the new exhibition spaces that have been created and highlights the white walls in the cathedral and the existing building that has been remodeled. In this case, the green filter cancels out the presence of the glazed window, anonymizing the building. The green roof's greatest potential lies in the ability to cover impermeable surfaces with permeable vegetal materials.

Green roofs also allow to neutralize the presence of construction, both seen from the pedestrian point of view and seen from above, apart from the aesthetic and aromatic qualities of flowering and green areas. One can conclude that the rehabilitation of architectural heritage and design constitutes an integrated set that must have in mind sustainability [11]. Complementarily, it is necessary to think about architectural rehabilitation in order to achieve a Nearly Zero Energy Building (NZEB).

6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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