CIRCULAR DESIGN THROUGH TRADITION: A TRANSFORMATIVE APPROACH TO PROMOTE THE MEDITERRANEAN CULTURAL IDENTITY AND SUSTAINABLE ARCHITECTURAL INNOVATION.

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ABSTRACT | The Mediterranean region, renowned for its diverse cultural heritage, faces challenges posed by globalization and environmental factors. Circular Design, rooted in sustainability principles, emerges as a solution to preserve its unique identity. This study explores Circular Design's role in safeguarding Mediterranean cultural heritage amidst global changes.

Circular Design promotes sustainable practices and materials, revitalizing traditional crafts while aligning them with modern environmental standards. It addresses environmental issues like climate change and resource depletion, reducing ecological footprints and enhancing resilience.

This research integrates Mediterranean architectural culture, developing modular ceramic-based products with solar functionalities for construction. These modules, encompassing passive and active solar features, offer innovative solutions for cladding building surfaces. They integrate elements such as solar thermal collectors and photovoltaic systems, utilizing materials like cork, ceramics, glass, copper, and composites.

The resulting system allows versatile applications, demonstrating the fusion of sustainability, aesthetics, and technological innovation. Circular Design fosters a harmonious blend of Mediterranean architectural identity and solar functionality.

In conclusion, Circular Design bridges tradition and progress, ensuring the preservation of Mediterranean cultural heritage. By embracing circular principles, the region navigates towards a balanced coexistence of tradition and modernity, safeguarding its vibrant cultural legacy amid contemporary complexities.

1. Introduction

The project offers us the opportunity to reflect on the evolution of our design practice and our most relevant concerns. Over the last twenty years we have witnessed the new paradigms of cultural globalization. Architecture needs to use mechanisms, forms and materials that link it to its local culture and identity.The growing interest in sustainable architecture is causing an evolution in design processes and project strategies.

> “Solar radiation is the main source of renewable energy. As well as providing a direct source of energy, it regulates the Earth's climate and gives us the opportunity to obtain energy from wind, waves, tides and a host of biological sources [...] As all aspects of the climate depend on the sun, it is logical to define the techniques adopted in buildings to take advantage of this action as ‘solar design’.” (SMITH, 2001, p.12.)

Our ancestors used simple and ingenious strategies to build their homes, neighborhoods, public spaces, villages and even advanced solar cities. (GUZOWSKI, 2010) The sun and the wind inspired every aspect of Mediterranean architectural development, from construction to layout, from materials to details. Both were always there to cover lighting, heating and cooling needs.

Vernacular architecture that truly utilizes the sun and the wind is more than a sum of passive strategies, technological systems and ecological engineering. Buildings whose forms are defined by these forces of nature reveal how we can utilize renewable resources, promote social, cultural and ecological values and also offer aesthetic values by creating relationships with the place and surrounding environment, supported by references and poetic and modeling attributes of these forces.

Ceramics have a lot of potential as a creative and constructive material for sustainable architecture in a new scenario where the environment in which the city is immersed, the scarcity of resources and the well-being of the community have to be taken into account. Ceramics is a universal material that has been present in architecture for centuries as an ornamental and structural element. Its innovative and avant-garde capacity has led it to become a recurring and prominent material in sustainable architectural projects. Its advantages are increasingly greater than those of other alternative materials. The aesthetic characteristics and customizability of ceramic tiles make it possible to multiply the creative possibilities of architectural projects. In addition to its technical performance and properties, it meets the requirements and assumptions of responsible and ecological construction, minimizing its environmental impact on the environment and its inhabitants.

2. Project Background

> “Ecodesign is the art that reconnects us as sensitive beings who have evolved over millions of years in a marvelous world. We don't need to remake this world, we need to reveal it. To achieve this, we don't need to do more research, we need to rediscover old and forgotten things.” (ORR, 2002, p.34)

In the 1990s, sustainability was a matter for specialists, but today it has become a generalized and paramount awareness. Climate change and the scarcity of resources have become the center of discussion. Western societies must reduce carbon emissions by 50 per cent. Construction, a sector that contributes around 40 per cent of carbon emissions and consumes 50 per cent of our societies' energy, must obviously contribute to this goal and the most pressing question for architects and designers at the moment is how they can contribute and how their activity can influence their way of thinking and their professional habits. It's worth considering both options: the passive reduction of energy consumption through intelligent design, and the active application of energy development or energy generation technologies. The new paradigm has to affect the way we design new buildings, as well as the understanding and applicability of these new technologies in pre-existing constructions. (HUTTON, 2009).

The new generation of ecological architects and designers has been developing new and effective ways of integrating passive design and active systems into projects that combine the ancient traditions of bioclimatism with the most advanced technologies. By responding to the forces of the sun (and the related dynamics of wind, climate, place and the cycles of the seasons and the rhythms of day and night) these projects address ecological issues and also fulfill our deepest aesthetic aspirations. The great sense of urgency has provoked a new spirit of innovation and design exploration, as well as a greater commitment to redoubling the efforts needed to achieve a-greater ecological response.

> “Architecture that truly utilizes the sun and wind is more than the sum of passive strategies, technological systems and green engineering. The new solar architecture has a slim profile that optimizes light and air; it employs an ecological envelope that is sensitive to site and environmental forces.” (GUZOWSKI, 2010, NP)

Solar architecture cannot be reduced to a few isolated measures, such as installing thermal collectors or photovoltaic panels on the roof. The building must be seen as a complete configuration - a total energy concept that makes the best possible use of local natural resources, such as solar, wind and geothermal energy, to fulfill a series of requirements. Passive and active measures complement each other in this approach, from the orientation and division of the building to the integration of systems to produce hot water or electricity. Flexible façades, regulated by intelligent control systems and capable of reacting to changing climatic influences and conditions, offer interesting contributions (SCHITTICH, 2009). In the main examples of the new solar architecture, there is a hybrid approach, which integrates passive and active systems from the earliest stages of design conception. This will be the path towards sustainable and energy-efficient solar architecture.

> “It starts with the use of passive solar energy, which is easy to implement and reliable [...] it can be adjusted using intelligent, self-regulating control technologies. Finally, it combines passive and active solar systems [...]. The key words in this field are hybrid solar systems, micro-climate building envelopes and self-regulating façades. This development of intelligent solar architecture will lead to new technologies and a new architecture that is eagerly awaited.” (HEGGER, 2003, NP)

The project presented here is the result of a complex evolutionary process (survey, analysis, proposal and communication). It was not just the manipulation of forms, but the search for a foundation, at the intersection with other design disciplines and other areas of knowledge. Within his operational context, the designer has to bear in mind, on the one hand, all the cultural heritage derived from the memory of a material culture built up and refined over centuries, and on the other, the evolution of socio-cultural models and new social contents. The project thus gains a condition that allows it to intervene in societies and their values. It has the ability to create new functions and forms of use, to change habits, to activate feelings, to modify the relationship we have with the built environment. Architecture is not just functional, it must be intervening, responsible and transform the perception we have of ourselves, our way of socializing. Searching for the archetypal roots of architecture and the habits or uses it conditions through a design activity that is contextualized in the present become necessary tools for building our identity. In this process, the designer interacts as a filter in the dynamics of the group (society), but also imbues the project with his own language, his perception of the world, his emotions, his cultural values, his personality and his individual identity.

2.1 Design References

Figure 1. Detail of BAHÍA PALACE, Marrakech. Photo: Raquel Salomé, 2010.

After deep reflection on Mediterranean geometric patterns, the natural choice of geometry for the project was the hexagon. According to El-Said, it is the most important geometric figure in Islamic art. (BARBOSA, 2007)

The hexagon, like the square or triangle, is able to cover the plane without the participation of another shape. The realization shown here in figure 12 is the application of the star-shaped hexagon. We are thus trying to determine the basic geometries of the complex Islamic patterns (figure 13).
We tried to dismantle all the formal complexity by analyzing the specific characteristics of Islamic art found in each of these ancient creations in gebs (Moroccan sculpted plaster).

The figure of the hexagon is present at the base of almost all geometries, from interlacing to floral decoration, from calligraphy to mougarnas (honeycombs in stucco decorations, wood, on columns and capitals). The hexagon itself functions as a versatile unit of repetition, and is the most common basis for repetition schemes (El-Said & Parman, 1976). Many designs that are apparently very different from each other are drawn from hexagonal networks, as illustrated in figure 2.

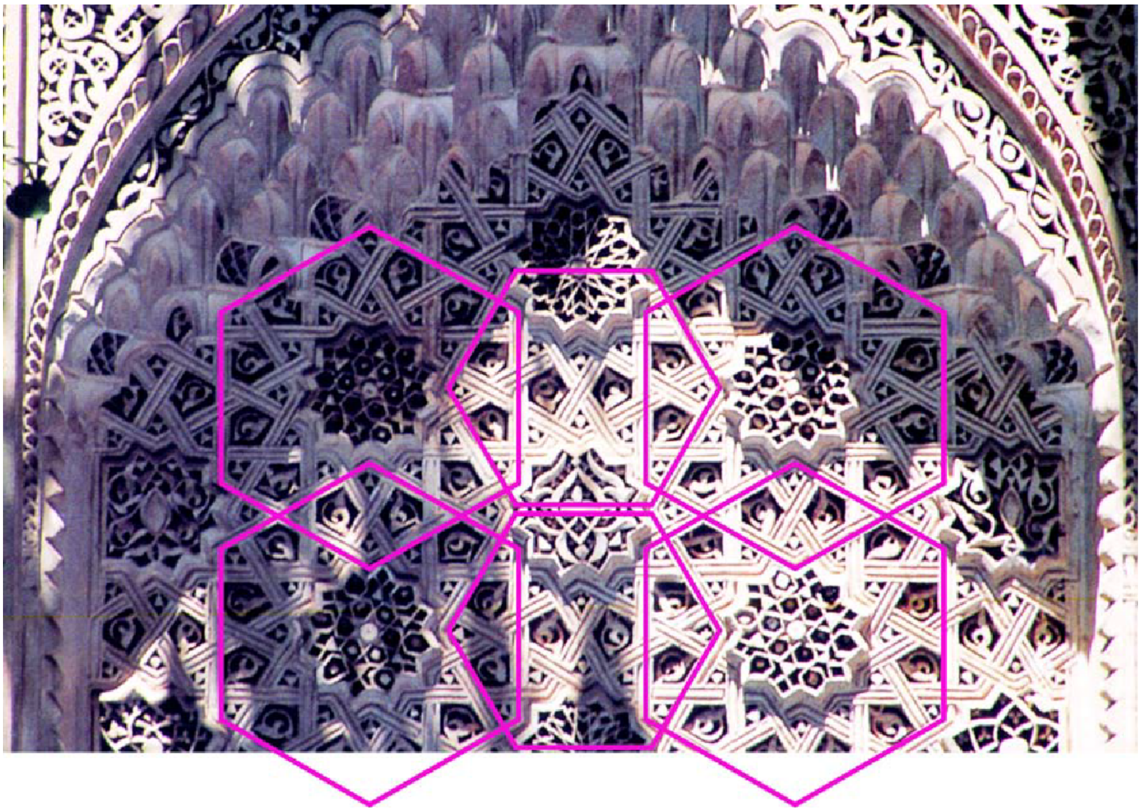

Figure 2. Basic geometries of the complex Islamic patterns. Detail of BAHÍA PALACE, Marrakech. Photo: Raquel Salomé, 2010.

Identification of secret geometries. Here are some of the constructions and properties of the hexagon and the six-pointed star used in geometric drawings.

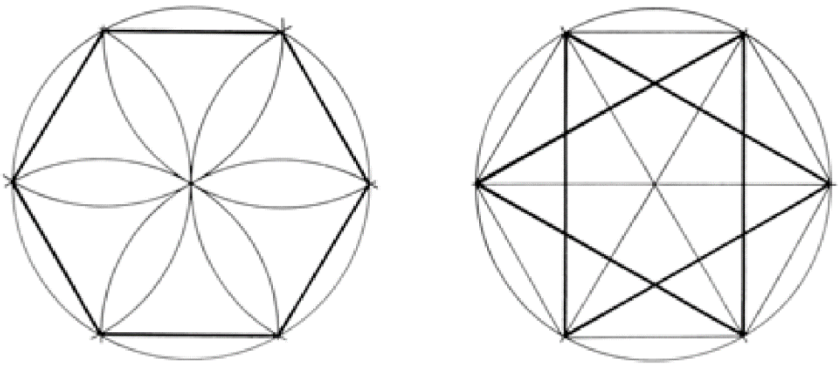

Figure 3. The radius can divide the circumference of a circle into six equal parts. Joining the resulting six points with straight lines creates a hexagon. Joining alternate points with straight lines creates triangles which, in turn, give shape to a six-pointed star.

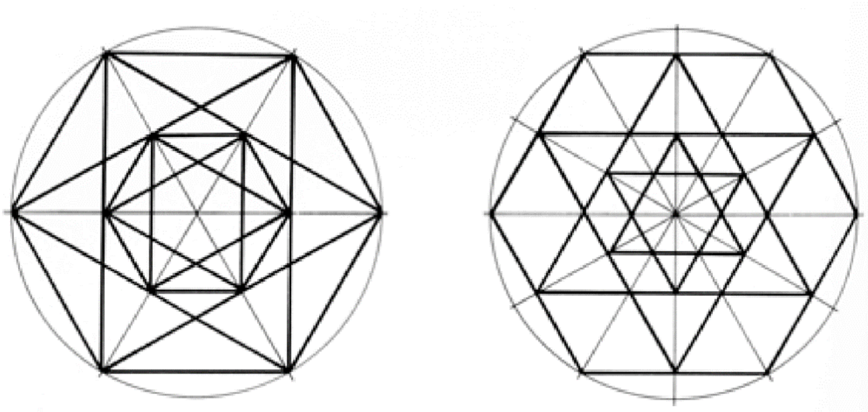

Figure 4. The ratio between the diameters of hexagons based on concentric six-pointed stars drawn from the angles of the hexagon is 1:2.

When the concentric stars are drawn from the midpoints of the hexagons, the ratio between the heights of the hexagons is also 1:2. The ratio between the diameter and height of the hexagons is a root of 3:2.

The repeating unit of the following design was built in two phases: in the top row the double hexagonal frame is based on two hexagons. In the second line, the star is drawn on a grid of three squares (BARBOSA, 2007).

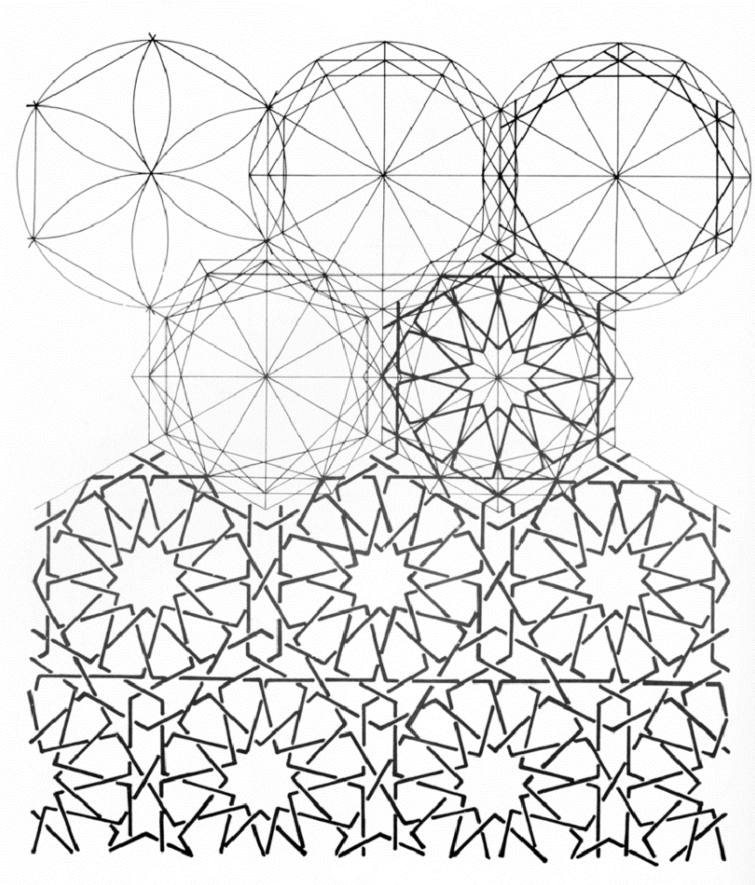

Figure 5. Design created from two overlapping grids (hexagonal and quadrangular).

The motifs were made using a regular weave of hexagons, identical to a weaving. A large-scale hexagonal motif is emphasised above this weave, with a play of more superficially worked areas that act as white dots which, when moving backwards, are read as continuous lines.

Figure 6. Room opening onto the courtyard PALÁCIO BAHÍA, Marrakech, image by Raquel Salomé, 2010.

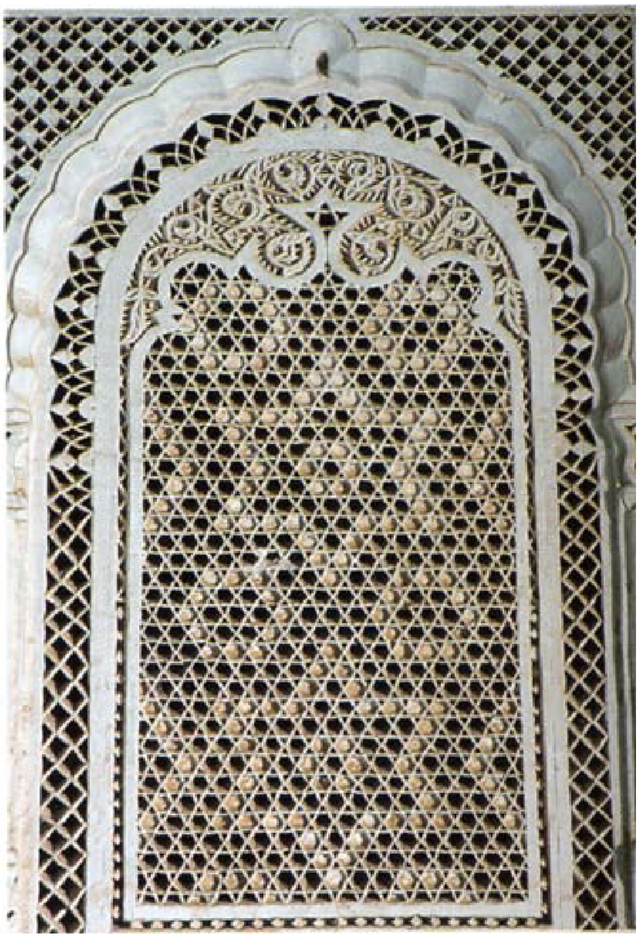

Figure 7. Detail of BAHÍA PALACE, Marrakech. Photo: Raquel Salomé, 2010.

The lacy stucco openings enhance the “venturi effect”. Here are some more magnificent examples of Islamic patterns painted or carved in wood, where the twelve-pointed star inscribed in a hexagonal grid is used (as seen in figure 6 and 7).

2.2 Project Design: Formal/Aesthetic Assumptions

Once the geometry for the construction of the module - the Hexagon - had been found, the process of sketches and drawings that preceded the project began. The aim of the project was not to create a new shape, but to find the essence of the geometrization of Islamic art. The aim was to interpret forms, recreate them and decontextualize them in new contemporary environments.

The advantages and constraints of the chosen shape, the applicability of the selected materials, the support structure and the study of details were identified. Here are some sketches of the preliminary project.

It began as a hexagonal ceramic module, with a glass opening in the centre to let light into the building, an air box to act as a trombe wall, and a copper piping system inside the module for water heating, which ran along the entire façade. The back would be insulated with cork.

The project conceptually resulted in an association of four types of modules with different functions:

1. Ceramic Module (chimney effect)
2. Glass Solar Thermal Module (trombe wall effect)
3. Solar Collector Module for DHW production
4. Brise Module, made of cork (filters natural light)

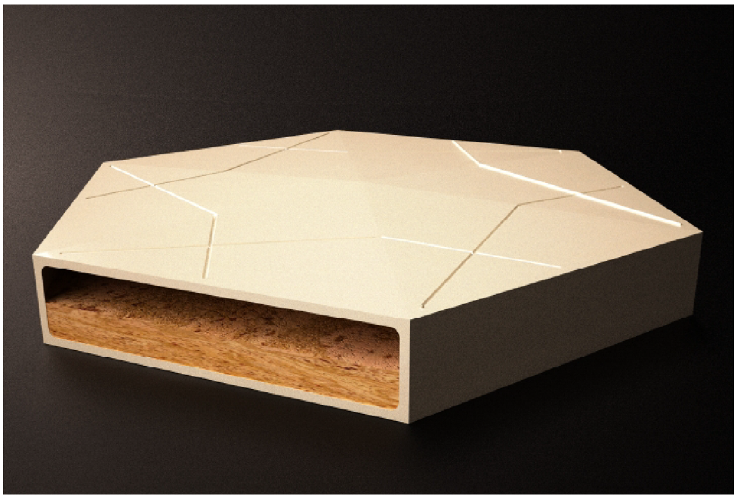

Figure 8. Ceramic Module (chimney effect).

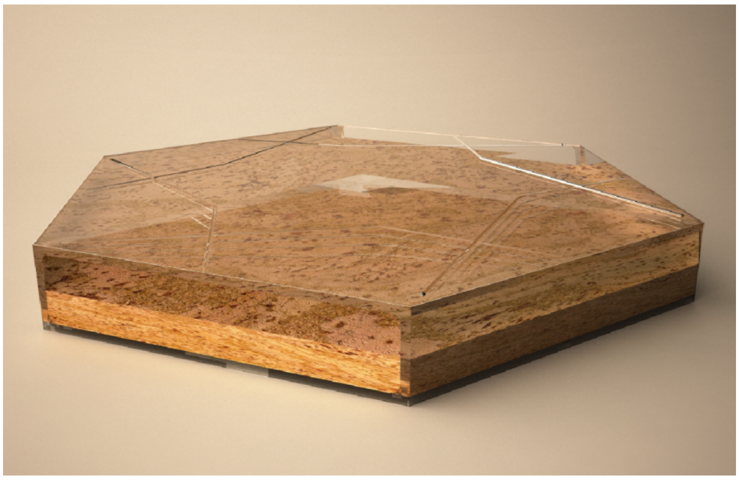

Figura 9. Glass Solar Thermal Module (trombe wall effect).

Figura 10. Solar Collector Module for DHW production.

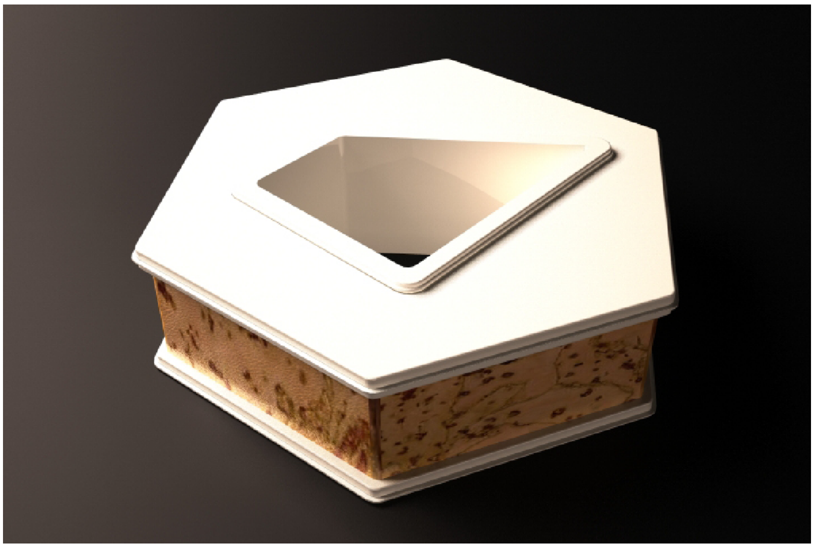

Figure 11. Open BRISE module in cork + ceramic (filters natural light).

Figure 12. Open BRISE module, in cork + ceramic, simulation of the BRISE effect, inside the space. Filters natural light, creates an intimate and introspective atmosphere and protects interiors from direct light.

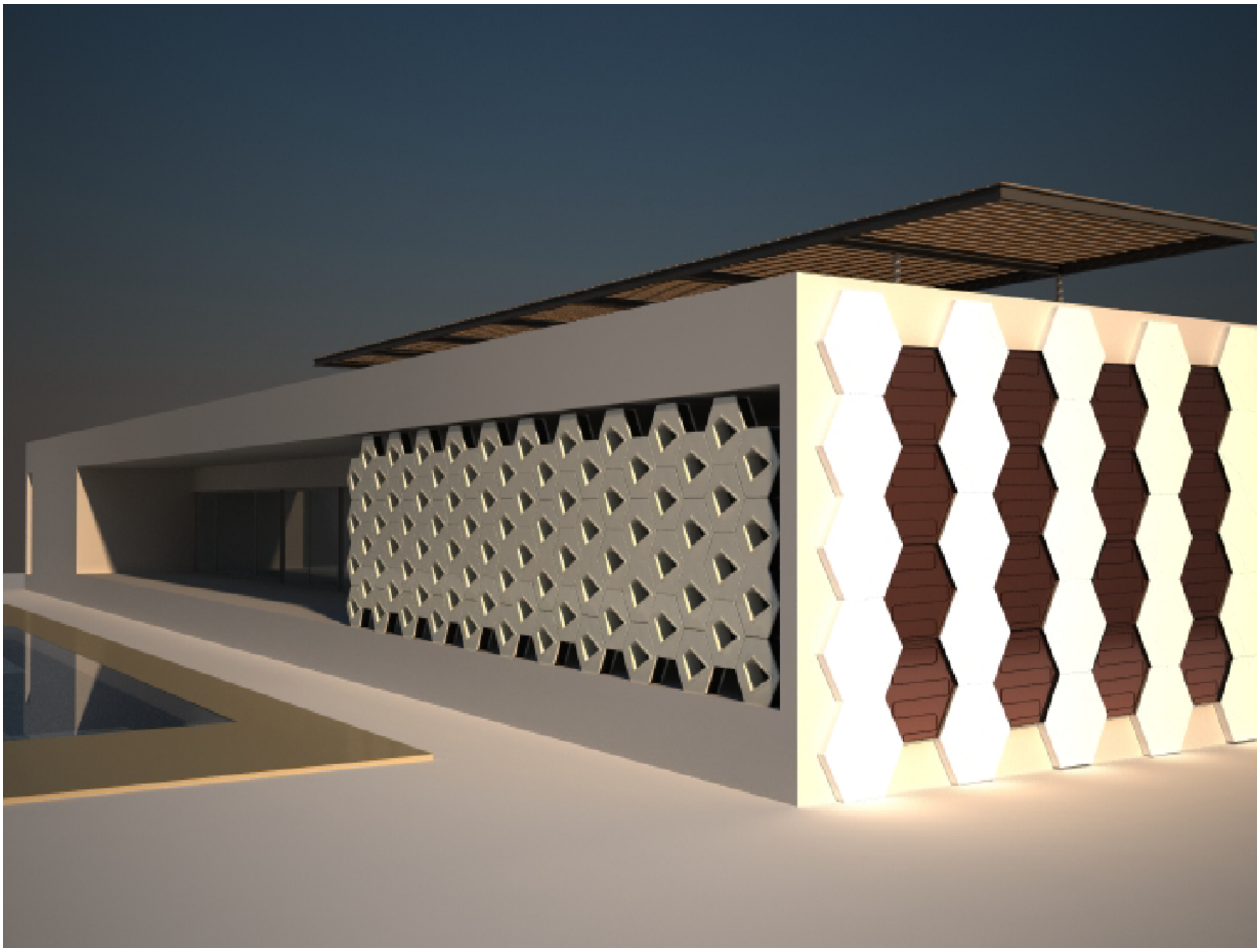

Figure 13. Solar orientation study. The ceramic modules allow cross-ventilation between the north and south façades. Ceramic modules and solar thermal modules, alternating on the south façade. Open BRISE module in cork + ceramic, open on the west façade, adjustable. (All 3D simulation by Nuno Martins).

2.3 Designing Other Geometries

After reflection, we thought about developing a geometry that could be used together with other hexagonal modules that had already been developed. This gave us multiple aesthetic options for architectural cladding.

From a hexagonal grid we can create a new model as shown in figure 12. Module Y (Figure 14) was based on the art of basketry and traditional handicrafts. After a 90º rotation we can combine it with other hexagonal modules, in this case the solar collector module (Figure 13).

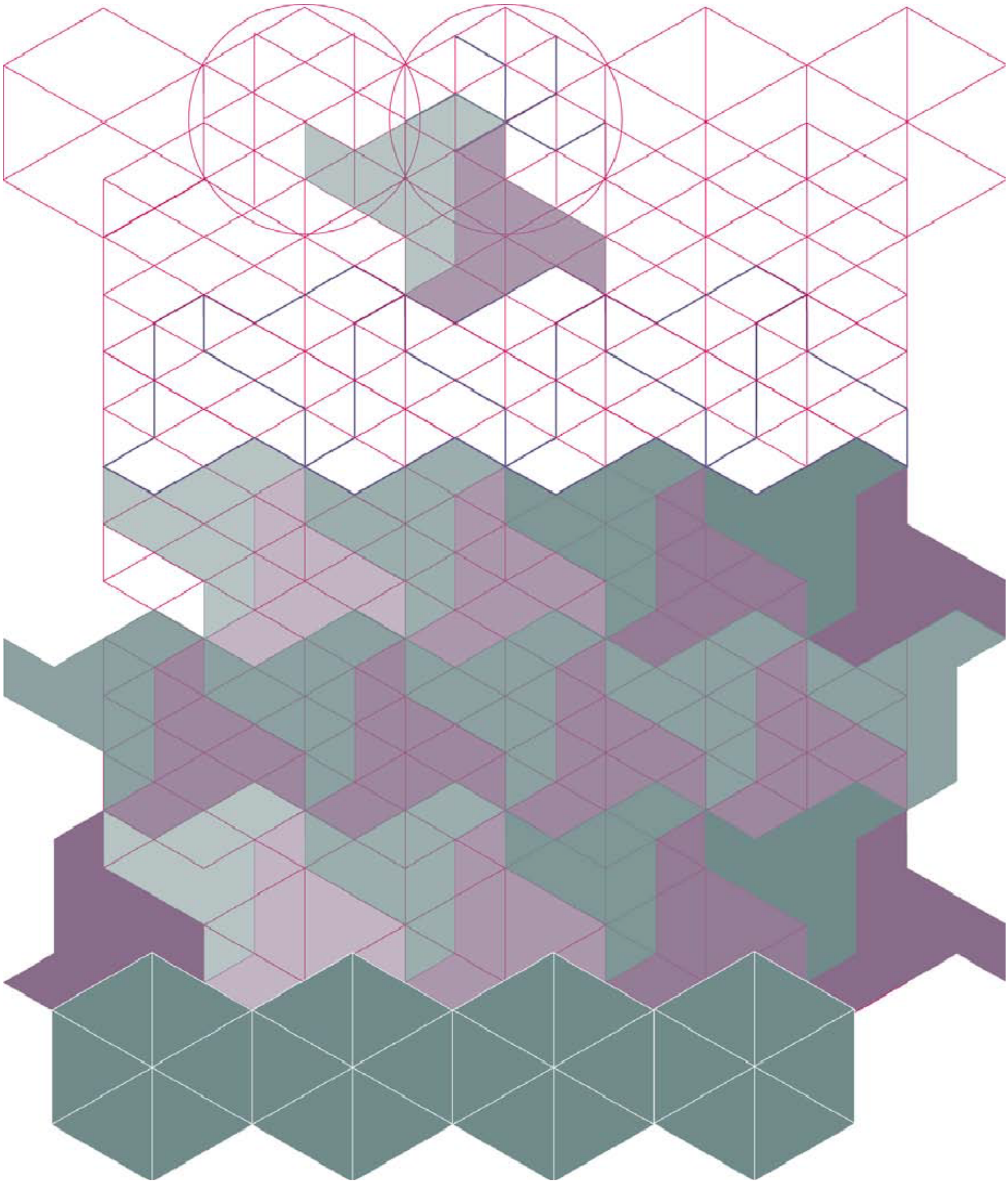

Figure 14. Illustration of the development of the new module Y, using a hexagonal grid as a reference.

Figure 15. Illustration of the combination of the new module Y with the solar collector module, after a 90º rotation.

Figure 16. 3D simulation of the new module Y, based on the art of basketry and traditional handicrafts.

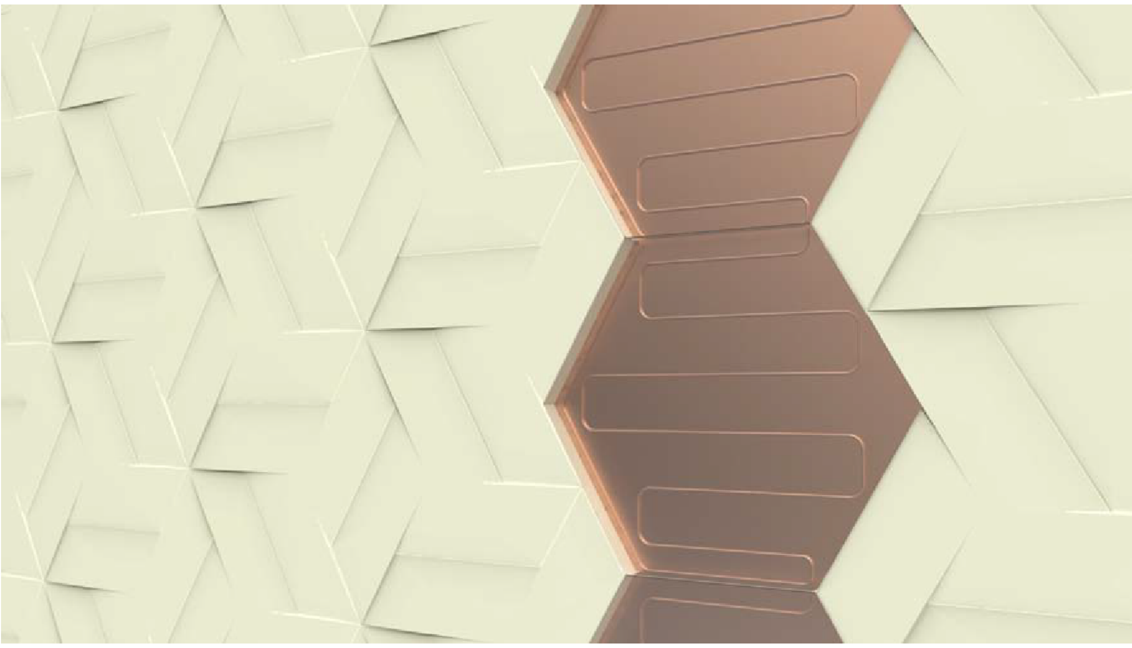

Figure 17. 3D simulation of the combination of the new module and the solar collector module, after a 90º rotation.

The Y-Module applied to the façade harks back to local/traditional references.

We also developed another geometry that allowed us to combine it with other hexagonal modules we had already developed. The conception of new geometry, a design based on a “split dry rope” tile pattern produced in Seville in the second half of the 15th century, with Mudejar geometric motifs known as “crow's feet” (SALOMÉ, 2012), shown in figure 18.

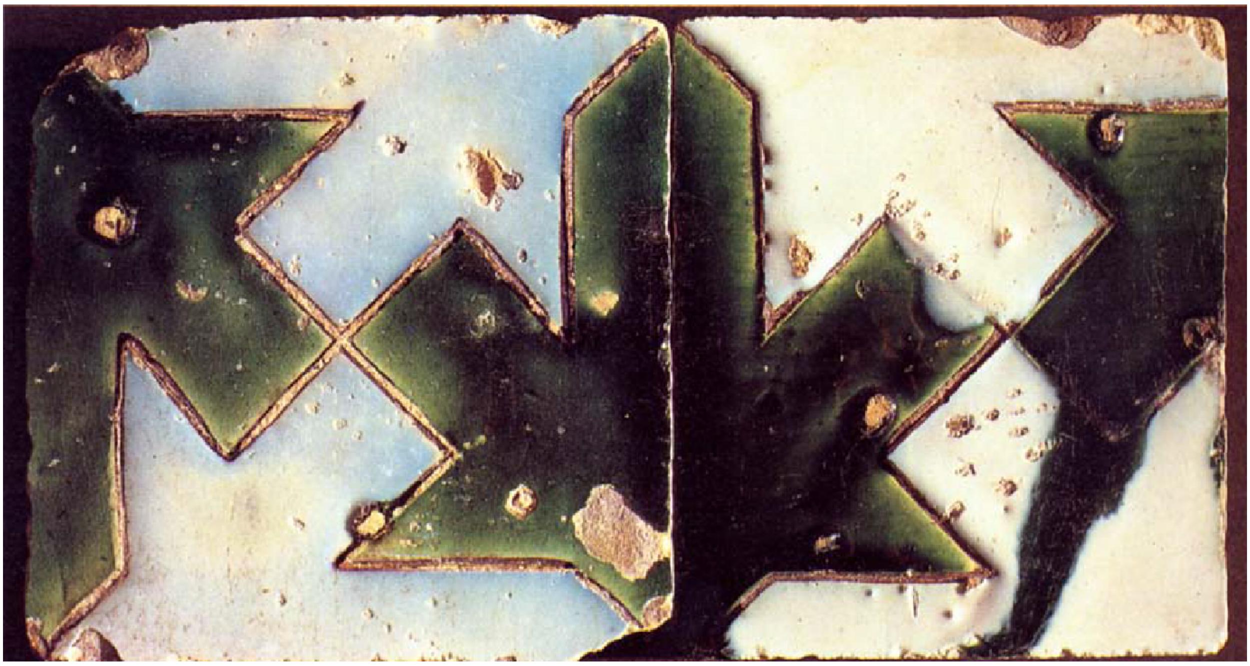

Figure 18. “Cracked dry rope” tile produced in Seville in the second half of the 15th century, with Mudejar geometric motifs known as “crow's feet”. Adapted from (SALOMÉ, 2012).

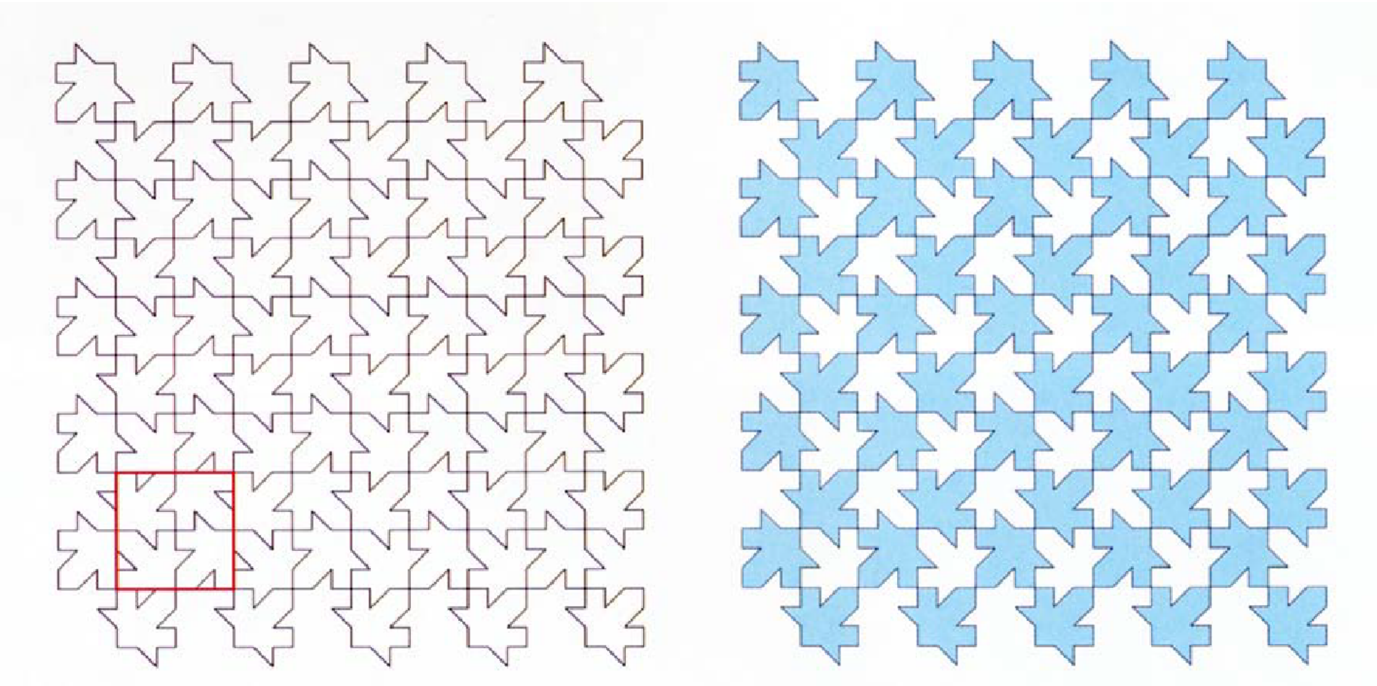

Figure 19. Mudejar geometric. Experiences gained during the design process.

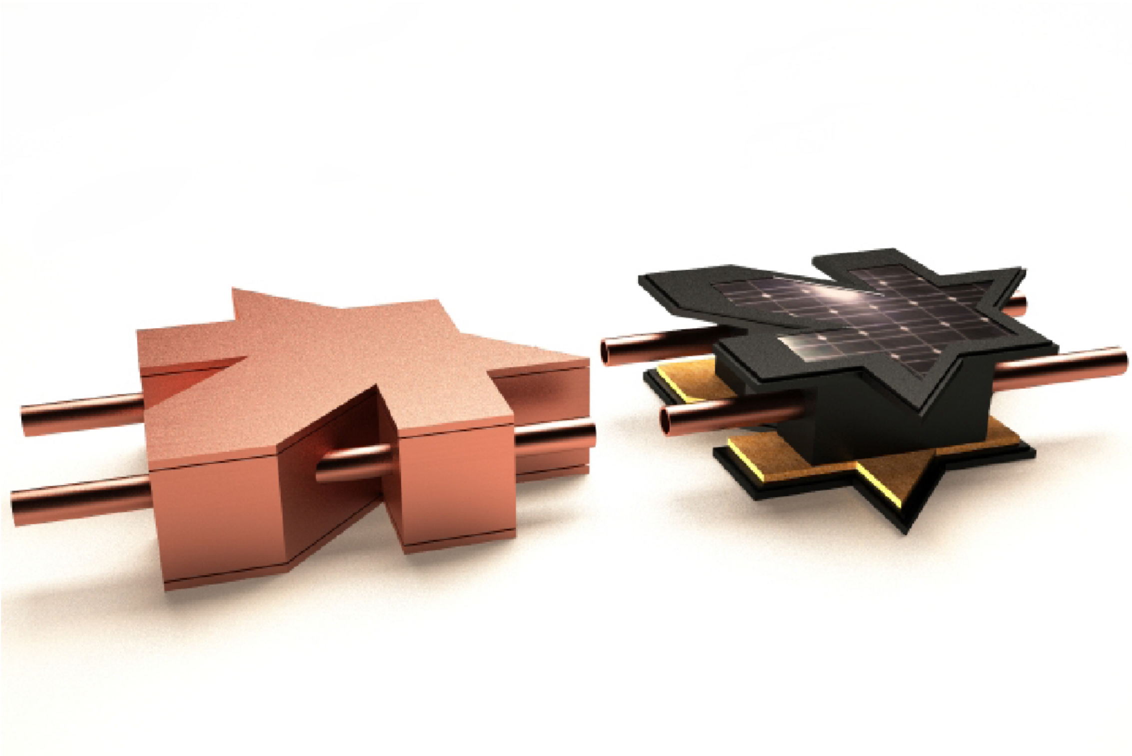

Figure 20. “Cracked dry rope” - 3D illustration of the mudéjare module known as “crow's feet” associated with another incorporating photovoltaic technology.

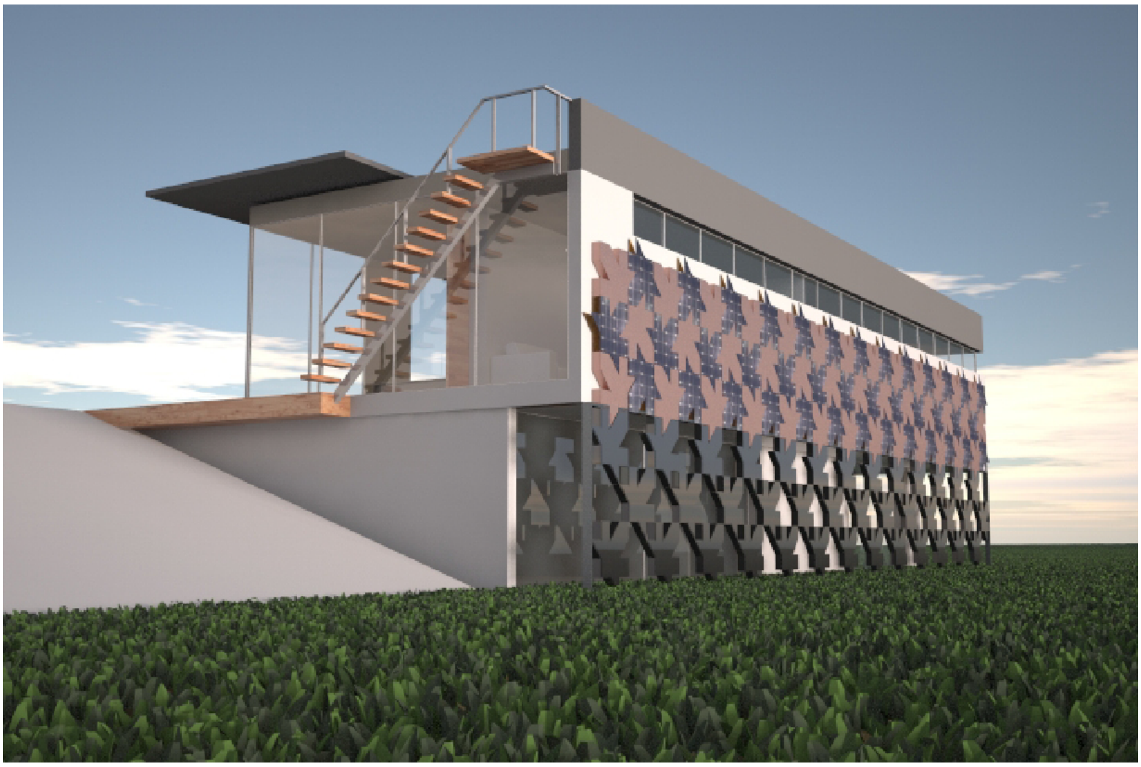

Figure 21. 3D façade simulation of the mudéjare module known as “crow's feet” associated with the photovoltaic energy module.

2.4 Reflection on Results and Literature Review: Mediterranean Cultural Identity and Sustainable Architectural Innovation

The study of the interconnection between materials and sustainability has garnered increasing attention in contemporary academic and practical discussions. Growing environmental awareness and the pressing need to mitigate the negative impacts resulting from unbridled consumption have led to a critical reassessment of the relationship between materials and sustainability. Within this context, two fundamental principles stand out: circularity and efficiency (SALOMÉ, 2012).

Material circularity emerges as a pivotal paradigm to advance sustainable practices by fostering closed production, consumption, and recycling loops. This approach aims to diminish reliance on virgin resources and minimize waste generation. Achieving circular systems necessitates innovative strategies across product design and waste management, facilitating resource regeneration and reducing environmental footprint.

The convergence of renewable energies and agriculture presents a unique opportunity to enhance sustainability and efficiency across both sectors. This synergy not only facilitates the shift towards cleaner energy sources but also optimizes land utilization and encourages sustainable farming practices. The fusion of these domains underscores a promising and mutually beneficial alliance.

Efficiency in material usage stands as a cornerstone in the pursuit of sustainability, involving the optimization of resources, waste reduction, and maximizing material performance throughout their lifecycle. Material selection, considering technical properties, origin, manufacturing processes, and recyclability, plays a vital role in enhancing efficiency and mitigating environmental impacts. So, transitioning towards a more sustainable relationship, between materials and society encounters various challenges, including resistance to change, inadequate legislation, and the necessity for specialized recycling infrastructure. Nonetheless, these hurdles also present opportunities for innovation, research, and the development of new technological and social solutions.

The coexistence of renewable energy installations and agricultural activities is evolving positively, particularly through innovative methods such as agrivoltaics. Through initiatives like the InSPIRE project (2019) which uses solar panel shading to enhance water efficiency and protect crops, tangible benefits are being observed. For instance, a cherry tomato plantation in Arizona has significantly reduced water demand and doubled its yield. Furthermore, advancements in photovoltaic technology, exemplified by Enel Green Power's HJT double-sided panels (2019), are further optimizing land use and increasing efficiency. Debunking myths of excessive land use and conflicts with agriculture, these innovations promise to drive the energy transition while benefiting agricultural practices. Success stories like the photovoltaic-battery hybrid system at St. Luke Hospital in Ethiopia highlight the transformative potential of sustainable energy solutions in enhancing both sustainability and innovation.

Projects aiming to embody Mediterranean cultural identity through design and material selection emphasize the bioclimatic aspects of Mediterranean architecture. By valuing cultural diversity and reconnecting with Mediterranean heritage, such initiatives strive to reintegrate cultural identity through form, materials, and concepts.

Eco design serves as a transformative vehicle for ecological education, prioritizing the cultivation of appreciation and assimilation of ecological principles. By fostering awareness of sustainability's possibilities and limitations, Eco design promotes a harmonious balance between human behavior and nature, amplifying ecological competence and consciousness. Initial tests indicate the potential of tested materials and concepts, underscoring the promise of sustainable practices and innovations in advancing circularity, renewable energy integration, and cultural sustainability. Continued research and implementation efforts are essential to realize the full potential of these transformative approaches in promoting a sustainable future.

The aim is to find a balance between human behavior and respect for nature, promoting awareness of the possibilities and limits of sustainability. Sustainable design thus becomes a way of spreading our awareness of nature and our ecological competence.

After reading and analyzing the results, preliminary tests indicate the potential of the materials and concepts tested. In future work, we intend to continue with the tests, explore new mechanisms, and apply the concepts to new materials and geometries.

The study outlines a comprehensive set of objectives aimed at addressing various aspects related to the promotion and preservation of Mediterranean cultural identity within a global context. These objectives include reflecting on existing methodologies, evaluating the impact of modernity on traditional cultures, bridging industrial production with handicrafts, re-contextualizing traditional materials for contemporary use, analyzing contemporary definitions of design practice, discussing Western material culture, fostering critical thinking for sustainable development, and promoting communication between Product Design and Engineering disciplines. These objectives collectively seek to advance understanding, appreciation, and integration of Mediterranean cultural heritage while fostering sustainable practices and critical discourse in design and engineering fields (RAQUEL, 2014).

This approach not only fosters climate change mitigation but also advances economic and environmental sustainability in rural regions, marking a significant stride towards resilient and ecologically conscious systems. The solution to prevailing challenges is encapsulated in the concept of a “Green Recovery”. This strategy advocates for investments in green technologies, renewable energies, consumption efficiency, sustainable mobility, and the circular economy. Furthermore, it presents an avenue to merge the energy transition with employment generation. Prioritizing social impacts is paramount. Achieving a just transition necessitates dedicated focus on the most marginalized communities, particularly those associated with the coal industry. Mitigating job losses in specific sectors requires concomitant efforts to create new opportunities and implement retraining programs to ensure equitable inclusion for all. In essence, while the energy transition is imperative, meticulous management is indispensable to mitigate disparities. The pursuit of a Green Recovery not only tackles present challenges but also lays the groundwork for cultivating a more sustainable and equitable society.

3. Conclusion: Navigating Towards a Sustainable Future

This comprehensive exploration of the intricate relationship between materials and sustainability underscores the urgency of adopting circular design methodologies. The imperative principles of circularity and efficiency emerge as keystones in the pursuit of a more sustainable and responsible future.

Addressing our immediate challenges, the call for a Green Recovery allows us to identify challenges stemming from unbridled consumption and environmental degradation and necessitates a strategic response. The proposal for a “Green Recovery” stands as a foundational concept, advocating for investments in green technologies, renewable energies, consumption efficiency, sustainable mobility, and the circular economy. (SALOMÉ, 2012) This approach not only addresses the immediate challenges but also presents an opportunity to intertwine the energy transition with job creation, contributing to a holistic and inclusive solution.

Challenges and opportunities in the transition to a more sustainable energy landscape presents challenges that demand careful consideration. A just transition requires a nuanced approach, particularly in supporting vulnerable communities tied to sectors like coal. Mitigating job losses in these sectors necessitates the creation of new opportunities and comprehensive retraining programs to ensure an inclusive and equitable transition. However, that doesn’t mean that energy efficient projects can only be expensive answers to the planet’s problem or first country solutions.

Striking a Balance between energy transition and social justice becomes the overarching goal of a Green Recovery. Not only to build a more sustainable future but also a just society. Balancing the energy transition requires a meticulous management strategy to avoid exacerbating existing inequalities. By addressing social impacts and prioritizing inclusivity, the journey toward a sustainable future becomes a shared responsibility and opportunity.

> "Right now, what's most interesting to me is what we can do to catalyze the most abundant resources we have on the planet, which are our human capabilities. (...) If we consider that we have a very small heavily populated planet, to move to sustainability we have to make best use of all the resources we have." (MANZINI, 2011, NP)

Synergies between circularity and efficiency can represent the future of the relationship between materials and sustainability. In a way it lies in creating synergies between circularity and efficiency. Advocating for a circular economy, where materials are continually reused and enhancing efficiency in production and consumption are imperative steps toward achieving a harmonious environmental and social equilibrium.

Collaborative Engagement for a Sustainable Future The complexity of the intersection between materials and sustainability demands collaborative engagement. The synergy between academia, industry, and governments becomes essential in driving this transition. Through collaborative efforts, society can be empowered to confront emerging challenges, fostering a collective commitment to a more sustainable and responsible future.

A Vision for Tomorrow: Beyond Consumed Resources In essence, this exploration underscores the dynamic and complex nature of the materials and sustainability landscape. Circularity and efficiency emerge as fundamental principles in crafting a future where materials transcend being mere consumed resources. Instead, they become integral elements in a sustainable and responsible vision for the well-being of future generations.

In the words of Tom Dixon,

> "We want to know everything about the materials. Where they come from, how to work with them, how far they can go, what else we can do. And we like them to be as dense, generous, and simple as possible." (2007, NP)

This ethos encapsulates the essence of the journey toward sustainable design, where a profound understanding of materials guides us toward a more conscious and responsible coexistence with our environment.

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