

MASHRABIYA CONTEMPORARY DESIGN: CULTURAL ANCHOR AND ENVIRONMENTAL PERFORMANCE

Khalid Eljaouhari¹, Larbi Amhamdi² & Larbi Bouayad³

¹*Research Scholar, Center of Doctoral Studies, National School of Architecture of Rabat, Morocco*

^{2,3}*Professor, National School of Architecture of Rabat, Morocco*

Received: 03 Jan 2020

Accepted: 08 Jan 2020

Published: 25 Jan 2020

ABSTRACT

Facing the challenges of globalization and sustainability, some architects claim inspiration from traditional crafts in search of regional specificities and environmental performance. This article proposes to invest this practice, trying to understand factors of its emergence. And that, through the study of Mashrabiya which was renewed and interpreted in contemporary projects as ornamental skin of building, claiming to provide a local identity and intelligent climate control. This paper will focus on the concept of Mashrabiya, analyzing its contemporary features in comparison with the traditional ones, evaluating its contributions in contemporary project. Seminars, focus groups, and interviews were conducted to build a comprehensive background supporting the purpose of this study. This article is a modest scientific contribution to understand this trend and find some answers to the critical questions raised by adopting this design approach that resides in transcribing traditional elements in contemporary contexts.

KEYWORDS: *Design, Crafts, Mashrabiya, Interpretation, Context Anchor, Traditional, Contemporary*

INTRODUCTION

In recent years, issues of local specificity and the search for alternatives to the global standardization of architecture and culture led architects to seek solutions in combining contemporary design concepts and engineering methods with traditional crafts. Thereby, architect's speech claiming inspiration from traditional elements to claim a cultural anchor, contextual and environmental project, especially in the territory defined for this research; Morocco and the Arab region where this observation has been found to be more relevant.

Indeed, this trend is accentuated in the Arab region, where a considerable presence of tradition influences architectural design. This research tries to shed light on the sustaining factors of this trend, and to question the relevance of this design approach, through asking the following question: Is the interpretation of the traditional elements in the contemporary architectural project sufficient to claim a natural and cultural anchor of the project in its regional context?

To formulate some answers to this question, the present work proposes to examine the interpretation of Mashrabiya within the contemporary architectural context, to identify relevant factors behind contemporary transcription of Mashrabiya, in addition to examining the Mashrabiya in its historical and regional context, and then, comparing its usage in both traditional and contemporary contexts, in the purpose of providing avenues for understanding the trend of interpreting traditional architectural elements and crafts in the contemporary project.

The main issue is to understand the emergence of this architectural design practice and question its relevance.

First, we will invest the transcription of this element in the contemporary context, analyzing case projects using the item, and explore contemporary literature on Mashrabiya.

In a second time, we will examine Mashrabiya in the traditional context, trying to distinguish its technical and functional characteristics and specific aspects, and then studying their compatibility and limits within the contemporary use.

In a third time, we will try to enrich the existing debate through focus groups, interviews with designers and architects, asking them about the purposes for which the traditional elements and crafts of art and architecture were interpreted and used within the contemporary architectural projects. From a cross-reading of all the data collected in the different moments of this research, the results will be analyzed, interpreted and discussed, articulating critical reflections on the use of elements from the traditional arts within the contemporary project of architecture.

Background

The contemporary architectural production in the Arab region, especially in Morocco, is distinguishable by a remarkable presence of traditional crafts built with modern materials. Tiled roofs, Arches, domes, Arabesques and Mashrabiya, elements that are specific to their time, still in use today.

The use of such elements in the built environment today in Morocco and the Arab region in general, is to claim a local anchor of architecture. This posture in contemporary architecture in Morocco did not start today, but is rooted in the post-colonial era in search of a new identity of the independent state.

The phenomenon takes another dimension today, related, first, to the special interest given to the local context "more resilient" in the architectural discourse, in response to global paradigms of the economy, globalization, climate changes and sustainability. On the other hand, it is especially related to facilities introduced by technology of design and engineering (new production methods such as three-dimensional printing, laser cutting technology, CNC processes, etc.), facilitating the production of geometric patterns in the scale of building; façades skins, ornamental structures are claimed to be durable and anchored in the natural and cultural contexts.

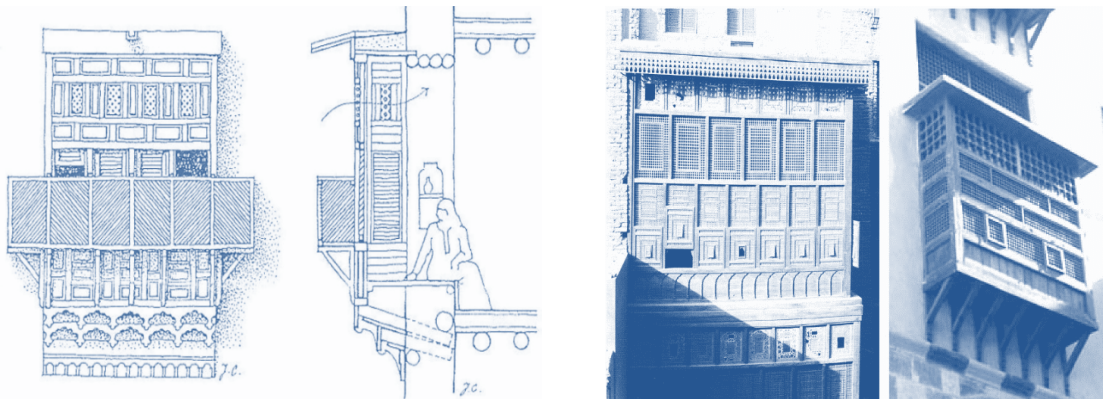
Therefore, the critical question that arises is: Is the interpretation of traditional elements in contemporary architecture project relevant and sufficient to claim a cultural and environmental anchor of the project in its context?

The terrain Study is defined in two scales; Local (Morocco) and regional (Arab region). Particular cases from the world can be discussed.

This study will consider Mashrabiya, this traditional architectural element, which is regarded by architects as an expression of local culture that has been revisited and reinvented in the contemporary project following the progress of technology. How can we understand this contemporary attitude which assimilates architecture to textile and cover entire buildings by almost continuous geometric pattern skins? What are the benefits and excesses of reinterpreting traditional crafts in contemporary architecture? What are the conclusions to underline from this practice?

To do so, we undertake a critical comparative study between traditional and contemporary Mashrabiya, based on an analytic grid of characteristics and use. Does the contemporary use respect the traditional features and characteristics of Mashrabiya, or it is used in a formal metaphoric way? What are the purposes for which the Mashrabiya is used in

contemporary project?



**Figure 1: Left: Traditional Mashrabiya Details In Elevation and Section. Ragette (2006)
Right: Traditional Mashrabiya, Cairo, Egypt**

LITERATURE REVIEW

The Mashrabiya screen is considered a rich topic for social scientists, architects, designers, culture researchers and historians. The literature research on the latticework as a product of an architectural scale and simultaneously a facade device shows that this topic has been the subject for many scientific works presented by researchers like (Mohammed, 2015)¹, Aljawder (2014)² Samuels (2011)³, Aljofi (2005)⁴.

Until now, many important aspects of the Arabic latticework Mashrabiya, have been scientifically studied in doctoral theses, research papers, journals and articles. The book of Hassan Fathy, is among those who have treated this subject in an explicit way. In recent studies, the PhD thesis of Samuels is particularly important since it is among researches that tried to apply theoretical studies to a real project regarding Mashrabiya, it underlines the importance of appropriate design criteria of the Mashrabiya screens.

In addition, he studied the theories of Fathy⁵ and explored Mashrabiya design parameters to produce hybrid models of contemporary Mashrabiya. The thesis of Jehan Mohammed provided information about Mashrabiya history, crafting and woodworking.

The Contemporary Context

The Mashrabiya screen has evolved today to become a shading device (Figure 2) placed outside the windows for aesthetic reasons and protect the curtain walls from direct sunlight. This traditional window with its characteristic element lattice is used in the design process to create skins covering entire buildings as an ornament, claiming to provide a local identity and

¹Mohamed, J. (2015). The traditional arts and crafts of gold turnery Mashrabiya (pp. 12-28).

²Aljawder, H. (2014) Residential windows daylight vs. visual privacy. Thesis (PhD.), University of Sydney.

³Samuels, W. (2011). Performance and Permeability: An Investigation of the Mashrabiya for Use dans le Gibson Desert in Australia (pp 42-57.). Master Thesis, School of Architecture and Design of Victoria University, Wellington, New Zealand.

⁴Aljofi, E. (2005). The potentiality of reflected sunlight through Rawshan screens. In Proceeding of the International Conference on Passive and Low Energy Cooling for the Built Environment (pp. 817-822). Santorini, Greece.

⁵ Fathy, H. (1986) Natural Energy and Vernacular Architecture, the United Nations University by the University of Chicago Press.

⁸Source: Web article: Hicham Berraj (2017) New Terminal Marrakech Abdou Lahlou. Platform: Amush. Link: <https://www.amush.org/nouveau-terminal-marrakech-abdou-lahlou>, Last visit: January 2018.

sun protection. The designers have reinvented this traditional structure, often on a massive scale, assisted by the progress allowed by advancements in technology of design and production.

This Research Reveals Three Main Goals for the Transcription of the Mashrabiya In Contemporary Architecture.

First, the Mashrabiya is used as an adaptive architectural skin. Its environmental value was a key concept in a number of important applications around the world. The production of architectural skin that can respond to sun exposure and the variation of angles incidence during times of the day and year was the objective of the project Al Bahar Towers by Aedas (2012). The skin of this project uses specialized programming methods and thermal sensors that open automatically the Mashrabiya skin as origami. An earlier project considered pioneering in this field was the Arab World Institute in France designed by Jean Nouvel (1987).

Secondly, the Mashrabiya is used as a structural unit to provide shade and play a structural role. In the project of St. Joseph University in Lebanon designed by the109 Architects (2011), the Mashrabiya was transformed into a structural membrane. The Pattern House in Iran (2012), was made of local brick pattern using available materials and local skills of craftsmen.

Thirdly, the Mashrabiya is used as a cultural value, interpreting its formal aspect; architects use it in a metaphorical symbolic way in reference to the traditional identity. Its applications can be seen in Master sustainable City in Abu Dhabi (2010) and Mashrabiya House in Palestine (2011), and many projects in Morocco, like the Marrakech airport (Figure 2).

Factors behind Mashrabiya Reinvention in Contemporary Architecture

Several factors have played an important role in the contemporary revival of Mashrabiya. In this paragraph we will discover the role played by manufacturing processes, parametric programming and new protocols in the contemporary revival of Mashrabiya. If at the beginning of twentieth century, glass was known as a new technology that could potentially create a shift in architecture fabrication, today new smart technologies have triggered major changes in architecture that have altered the expectations of architects. It is a fact that every time a new technology appears, new styles and architectural movements appear too.

New technologies create a new literature in the world of architecture; the parametric design, digital architecture and the genetic architecture, etc, are the result of the continued emergence of technology in architecture. Some projects today are not only born digitally, but they are also made digitally via the process "file to factory". In the traditional software of modeling, a static geometry is produced. But the new generation of digital tools offers parametric design and algorithms, instead of designing a fixed geometry. A product or building can be generated parametrically in a flexible way and can be reconfigured at any time by changing settings.

Marsa Dubai Tower by Zaha Hadid, for example, shows the formal influence of these tools on the facade of the residential tower. For the structure of the tower, the proposed solution was to use a structural unit based on a parametric pattern for the skin that has openings that become wider while ascending. This solution increases the efficiency of the structure due to the position of openings on the upper part of the building.

The project of Al Bahar Towers shows the integration of an interactive facade. Its designers claim inspiration from traditional Mashrabiya to create a project integrated to the cultural and environmental context. The shape of the on temporary skin reminds the traditional Mashrabiya, while the dynamic movement of the skin component units are a

mimicry of wild plants. The use of digital technology has made the design of this project possible through parametric modeling and algorithms.

Therefore, in this new design methodology, different building parameters are defined in a virtual environment, in connection with the concept chosen by designers such as environmental principles that can be manipulated to produce an optimized pattern.

The Housing project in Master is another example of contemporary integration of the Mashrabiya. The windows in residential buildings are protected by a contemporary reinterpretation of this traditional latticework. They are built using GRC (Glass Reinforced Concrete) powder mixed with local sand. "The perforations for light and shade are based on patterns found in the traditional architecture of Islam."(Foster + Partner, 2010).

Using the new algorithms of parametric modeling and 3D printing, The Emerging Objects Group re conceptualize a thermal cooling brick called "Frescoes" based on the concept Mashrabiya. The project was inspired by the natural cooling features of traditional Mashrabiya. The brick nest is based on circulation of cold water through its inner walls, cooling the air that flows through its external pores.

The large-scale development of these technologies continues to change the design and production of forms. By using rapid manufacturing, genetic algorithms, CAD technologies (Computer Aided Design), BIM (Building Information Modeling), CAM (Computer-Aided Manufacturing), as well as parametric design; the architecture teaching, the discipline of architecture and the profession will face profound questions.

5- The Mashrabiya in traditional architecture

In what follows, we will examine the concept of the Mashrabiya in its traditional context to understand its functions, in order to shed more light on its use in contemporary design and interpretation.

The Mashrabiya was an element of traditional architectural heritage related to crafts, culture and tradition that evolved through time. It is the foreground window that overlooks the street or the courtyard of traditional Arab houses. In the past, the name of Mashrabiya was given to the space which is enclosed with openings with wooden lattice, where water pots were placed for cooling by evaporation which is caused by the movement of the air through the grid openings. Later, the name was given to Mashrabiya wood lattice screen itself.

This architectural element had a reputation in the Arab world, Islamic and South Asian countries like India and Pakistan and has even reached Peru and Spain. It was used in Islamic countries for reasons of privacy, while in the countries of South Asia, it has been used for its light control performance, cooling, air flow control and the temperature reduction.

Previously, the Mashrabiya was manufactured by developing and assembling a network of small pieces of wood that are then assembled to form the big assembly. Historically, this system has five maintained architectural functions by the parametric variation of its functions, the passage of light, control of the air flow, cooling the temperature of the air flow and visual privacy (Fathy 1986).

A descriptive definition of Mashrabiya is presented by Samuels (2011), which says it is a carved wooden screen that allows ambient light to enter and restricts direct light. In addition, the Mashrabiya ensures the privacy of the

occupants, an important factor in Muslim countries. The basic principle of Mashrabiya is simple, being a lattice constructed based on oval tours, attached and composed by short links turned and ribbed. Samuels (2011).

Seminars and Discussion Groups

Seminars and discussion groups around the subject were conducted under this study to deepen reflection on this topic. Bryman (2012) mentioned the importance of focus groups in deepening knowledge; it is again of time listening to the views of various people together in one place. The targeted persons or participants, as explained by Bryman (2012), can express and discuss issues as a member of a group rather than an individual interviewed person. This may be beneficial to research, because people can exchange and share ideas developed by themselves.

The purpose of the focus group with professionals and academics was to get feedback on specific themes of the research. The limitation of this method was evident regarding the difficulty of analyzing a large amount of data, a data transcription method was adopted, on which the analysis will focus.

Field Surveys and Questionnaires

In addition to the focus groups and for further research around the subject a questionnaire was addressed to architects and designers practicing in Morocco, considered a country of strong presence of traditional arts and crafts where the Mashrabiya was interpreted in several important projects. The questionnaire was qualitative in nature, multiple responses, restricted and anonymous, and has included a random sample of two hundred architects who have used elements of traditional architecture, crafts and arts in their design.

The question was this: Why do you use or interpret elements of traditional architecture, crafts and arts (mainly Mashrabiya, traditional and geometric patterns) in your projects? The questioned had to choose from the following list, two most recurring options for their case: Aesthetics; functional; Technical (materials, design technology, construction technology); Environmental (Ecology, Landscape); Heritage (architectural and cultural heritage, tradition); Economic; social; Policy. The questionnaire results are presented in the following diagram (Figure 6).

After analyzing the results, we note that the motivation behind the use and interpretation of the elements of architecture, handicrafts and traditional arts is varied. Comes first, the desire to revive the heritage, secondly Aesthetics, Followed by the need for environmental integration.

In these results the technical function comes last. The results validate our initial hypothesis regarding the main motivation, which is the regional, cultural integration (heritage) and natural (environmental). We underline, also from the results that the use of traditional elements is for formal purposes (aesthetic 18 %), more than functional (10 %) and technology (6 %), which validates our initial hypothesis questioning the relevance of this approach, the use is motivated more by form than by seeking solutions and convenience of use (functionality, technicality).

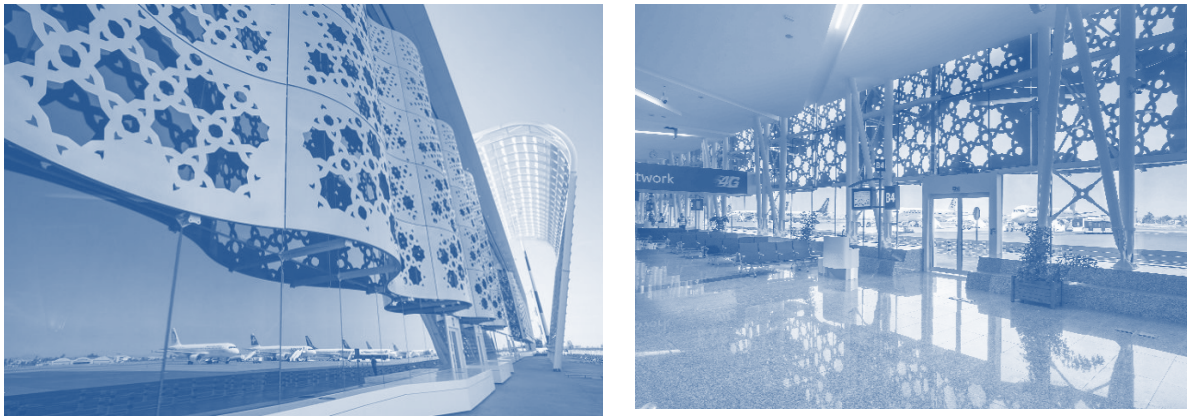


Figure 2: Mashrabiya at the Façades of Marrakech's Airport.

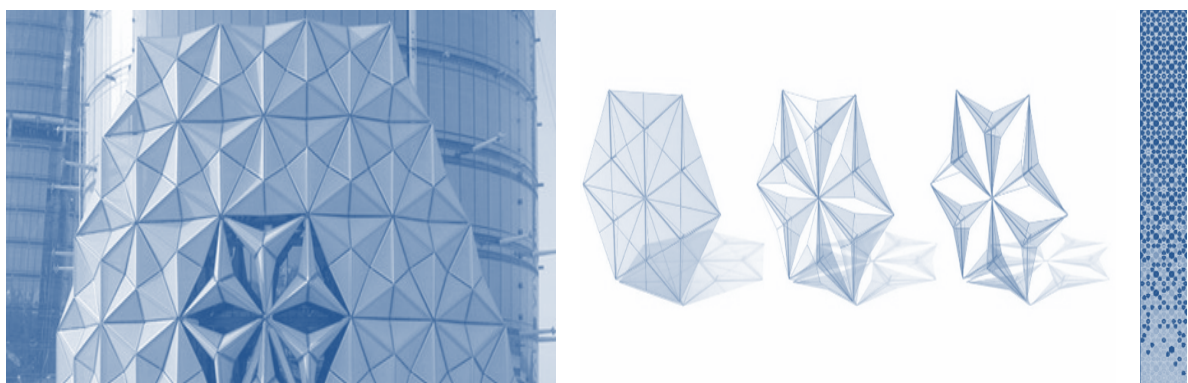


Figure 3: Left and Middle: Intelligent Façade System Details Inspired Mashrabiya, Project Al Bahr Towers Aedas 2012. Right: Detail of the skin of the Marsa Residential Tower in Dubai, by Zaha Hadid.

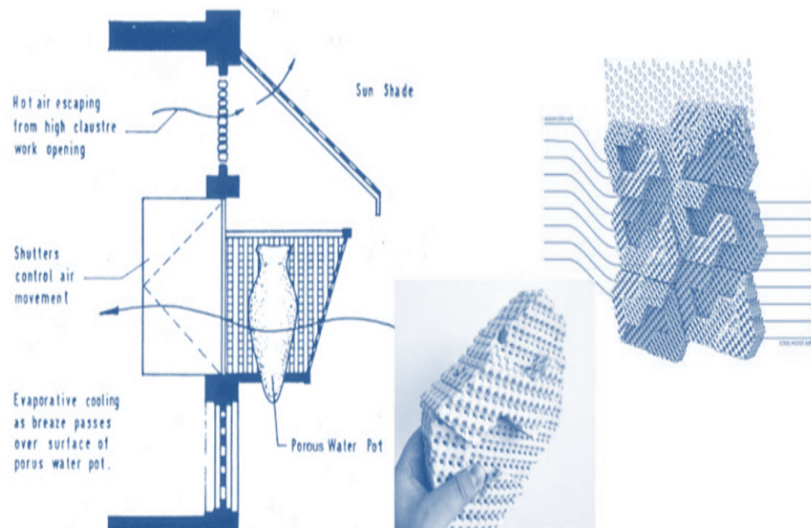


Figure 4: Cool Brick by Emergent Objects 2015.⁶

⁶ Source: Web Platform authors Cool Brick link: <http://www.emergingobjects.com/projects/cool-brick/> last accessed: January 2019.

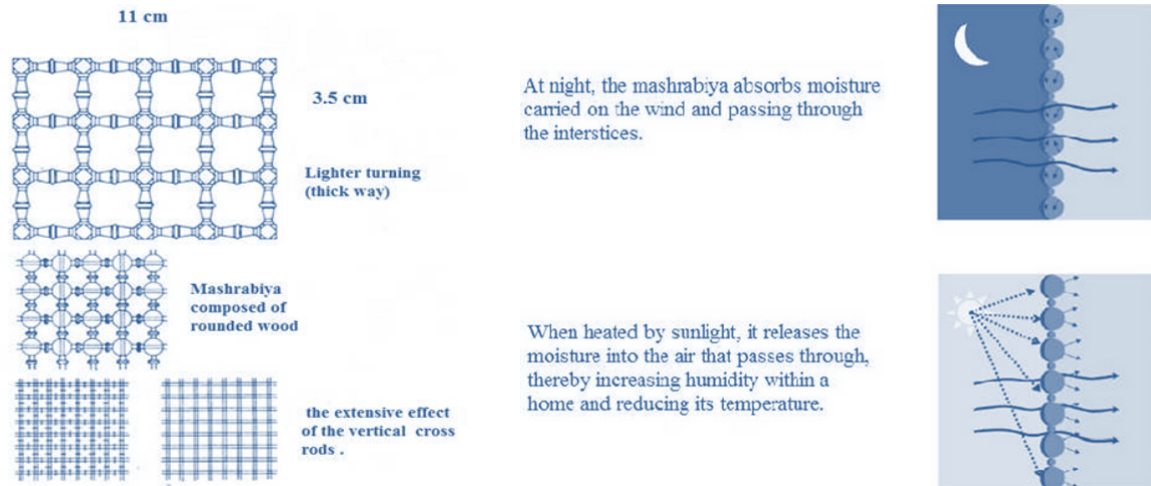


Figure 5: Left: Mashrabiya Traditional Elements (Fathy, 1986). Right: the Mashrabiya Cooling Effect through Evapotranspiration (Fathy, 1986 Illustration BY Abdelgelil, 2014).

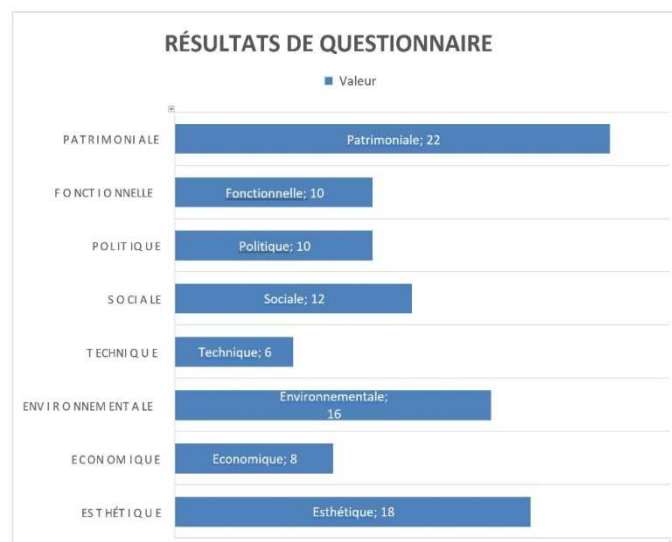


Figure 6: Diagram of the Questionnaire Results. Author.

DISCUSSIONS

The Mashrabiya in its traditional context has a number of parameters and design rules and has specific functions. Particular attention has been given to the Mashrabiya in some contemporary projects. However, contemporary usage in some projects around the Arab region, has ignored its functions, its parameters and its design standards, focusing on aesthetics, reproducing its formal aspect only. Wood, the main material in Mashrabiya has been replaced by steel and perforated Aluminum panels. Double skins systems consist of fixed glass panels that prevent air flow and cause static thermal zones inside spaces, requiring the use of air conditioning units, thereby eliminating the environmental role of Mashrabiya.

In contemporary architectural production, and with no references to the design parameters and functions of the Mashrabiya, some architects ignore the original source of inspiration that is the "Mashrabiya" and mention as inspiration the Arab heritage and Islamic geometric art in general. The social character of Mashrabiya "intimacy preservation" has changed as the purpose of using this architectural element has changed. The actual Mashrabiya became a symbolic representation of its older models. In past, Mashrabiya was pertinently used due to climate, social and culture demands,

nowadays this has changed. Islamic models, once, enriching the traditional Mashrabiya were substituted with abstract patterns on contemporary facades.

Hassan Fathy, an Egyptian architect and theorist whose research focuses on the traditional architecture, tried to show through his research the importance and benefits of studying traditional values and concepts. He mentioned the adaptability of the traditional elements to the contemporary needs while not losing their authenticity.

For him, the architectural heritage means a set of experiences and "decisions" taken to solve specific problems in a period of history. These decisions unanimously accepted by the community, have been developed and adapted to serve the purposes of the community. Thus, they have become a legacy. He believed also that modernity does not necessarily mean vitality, and that change is not always for the better.

Many authors and philosophers of tradition and modernity share the same point of view. Which means that modernity does not necessarily include a conscious choice and excluding traditional solutions do not always create evolution. Fathy believes that there is confusion in the use of the idea of modernity based on the timeline; what is new is modern and the old (traditional) is obsolete. With the emergence of the trend of sustainable architecture, Fathy established a solid theoretical and practical base for the return of traditional architectural features, particularly Mashrabiya. He found that traditional architecture is closer to the natural environment rather than the international architecture. The traditional, in his eyes, observes and respects the natural environment and spatial circumstances, temporal and social; it also reflects the requirements and needs of the cultural and civilizational reality.

The interpretation of traditional elements comes in architectural design under various generic names "contemporary vernacular," "neo-vernacular" as response to social and environmental challenges. At the end of research, a concern arises regarding the aesthetic imaging of vernacular and traditional values. May these interpretations claimed to be in favor of cultural anchor, lead to architecture acculturation? This field, which is scholarly complex discipline with its own rules (scale, measurement, conception, proportion, composition, perception) Philip Boudon.⁷

In addition to this conclusion, works of architects claimed to be contributions to creating a "local identity" seem to have more in common with the cultural traits of other countries than the characteristics of the place where they were built. Hence, the present example of Mashrabiya, interpreted through architecture projects in Morocco, while its roots are unique to the desert climate characteristics of the middle East. Adaptation to local climate in the Maghreb has done more through the Patio more than Mashrabiya element. These elements of traditional and vernacular architecture are a direct expression of the basic needs of communities, who won their functional maturity through longer process of adaptation. The specificity, originality, authenticity, are they not native visions of the ingenuity and willingness of communities and designers? In the following example, the work of architect Renzo Piano, in New Caledonia, illustrates that inspiration by local craft was relevant to synthesize a convenient and ingenious solution to a local problem.

⁷Philip Boudon (2002) On the architectural space, architecture epistemology test (PP18). Ed brackets.

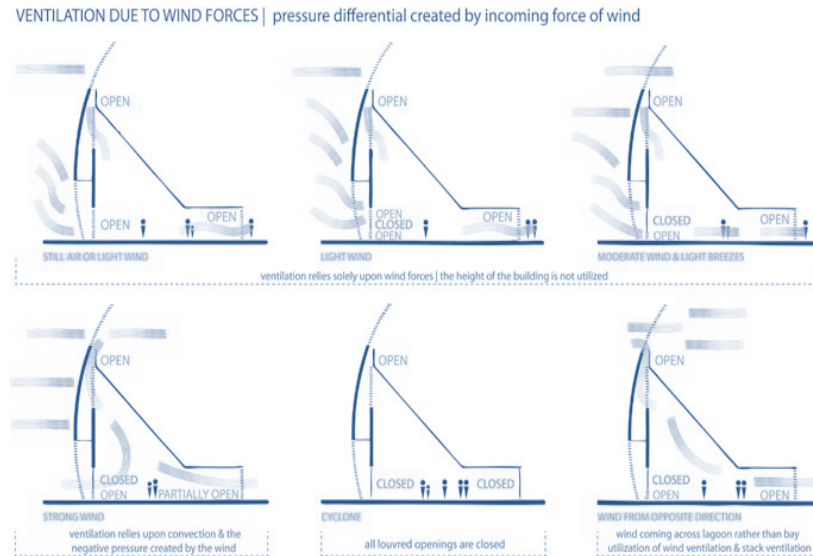


Figure 7: Cultural Center TJIBAOU by RENZO PIANO.

CONCLUSIONS

This research is a modest contribution to broadening the scope of understanding, critical analysis opening up the prospect of other questions about the migration of traditional elements in the context of contemporary architecture and design. Although this study is relevant to the Arab region which shares the same conditions with Morocco, it is also useful for other regions of the world, in their attempt to seek regional, natural and cultural anchor. The interpretation of traditional and vernacular elements in contemporary project context is perceptible in many countries around the world. They are used in many scales from architecture project scale; objects design scale and urban design scale. This debate is relevant to its time, especially with the new parametric tools and genetic architecture that are able to a certain limit to simulate complex processes and more spontaneous forms of art. Reading applied in this research to Mashrabiya, can be used to understand the use of other elements of traditional architecture, crafts, traditional art, within a contemporary context of design and contemporary art.

Abbreviations

- **BIM:** Building Information Modeling.
- **CAM:** Computer-Aided Manufacturing.
- **CAD:** Computer Aided Design,
- **CNC:** Computer Numerical Control. In French.
- **DAO:** Computer Assisted drawing,
- **RCMP:** Glass Reinforced Concrete.
- **3D:** Three-Dimensional

REFERENCES

1. Abdelgelil, N, "A New Mashrabiyya for Contemporary Cairo: Integrating Traditional Latticework from Islamic Cultures and Japanese". *Journal of Asian Architecture and Building engineering* (pp37–44). (2006).
2. Abdelsalam, T. and Rihan, G, "The Impact Of Sustainability Trends On Housing Design Identity Of Arab Cities", *Housing And Building National Research Center, HBRC Journal*, 9, pp.159–172. (2013).
3. Aedas architects,(2012). "The architectural design team of Albahar Tower". Retrieved September 22, 2015 from <http://www.archdaily.com/270592/al-bahar-towers->. Ali Rahim, HinaJamel, 2007, "Beyond the Structural Skin Zaha Hadid Architects: Marsa Dubai Residential Tower", *Elegance* (pp 64). Wiley, 23 March. 2007.
4. Aljawder, H, "Residential windows daylight vs. visual privacy". thesis (PhD.), University of Sydney.(2014)
5. Aljofi, E, "The potentiality of reflected sunlight through Rawshan screens". In: *Proceedings from the International Conference of Passive and Low Energy Cooling for the Built Environment May 2005, Santorini, Greece.* (2005).
6. Almerbati, N. Ford, P., Taki, A., Dean, L, "Beyond Romantic Mashrabiya: the production of a Personalized and Efficient window screen in Middle East Dwellings". In: *9th International Conference on Design Principles and Practices and the Design Principles and Practices knowledge community, March 2015, Chicago: Common Grounds.*(2015).
7. Bryman A, "Social research Method", 4th Edition, Oxford University Press. (2012).
8. Delmoji, S. and Fathy. H, "On the Poetics of Space": Interview with Engineer Hassan Fathy, (1986).
9. EL Hajjami Abdellatif (2010) Interview, Morocco National Order of Architects General Assembly, Tetouan, Morocco.
10. Fathy, H. "Natural Energy and Vernacular Architecture", the United Nations University by the University of Chicago Press. (1986).
11. Fisher, T, "Architecture and the 3rd Industrial Revolution". *Architect*, 103 (1), pp. 100–103.(2014.)
12. Jean Baudrillard, *The system of objects*. Paris: Gallimard. (1968).
13. Julie Beaulieu-Eliane, "ethnodesign: a dialogue between craftsmanship and contemporary design". Quebec: Laval University, (2012).
14. Karen Cilento, 2012, article: "Al Bahr Towers Responsive Façade" / Aedas. Platform-Web: archdaily.
15. Kaine, É., Vachon, JF and J. St-Onge, "Recognize, value and transmit. Workshops Design and material culture in Guarani territory (Brazil): a hybrid between teaching art, craft and design for the development of culturally meaningful vectors of transmission" in É. Dubuc, É. Kaine and P. De Coninck, *the Aboriginal Heritage: transmission, storage and creativity (proceedings - October 2008)*. (2008).
16. Ko, K. and Liotta, J, "Decoding Culture Parametrically: Digital Case Studies Tea House". *International Journal of Architectural Computing*, 4 (9), pp.325-329. (2011).
17. Mohamed, J. "The traditional arts and crafts of gold turnery Mashrabiya" (pp. 12–28). (2015).

18. Mortada, H, "Traditional Islamic principles of built environment". Routledge Curzon, New York. (2011).
19. Mousavi, F, "The Function of Ornament in Kubo, M.(ed) *The Function of Ornament*", Harvard Graduate School of Design.(2008).
20. Moustafa, N. "Divine Inspiration: seven principles of Islamic architecture", IAMM publication. (2008).
21. Philip Boudon,"On the architectural space", *architecture epistemology test (PP18)*. Ed brackets. (2002).
22. Rashid, M. and Ara, DR, "Modernity in Tradition: Reflections on building design and technology in the Asian vernacular". *Frontiers of Architectural Research*, 4 (1), pp. 46–55. (2015).
23. Renzo Piano, *the Cultural Center Tjibaou Tjibaou Cultural Center, a tribute to the Kanak culture, New Caledonia*. (1991).
24. Rhyna, T. Petrick, I., Striukova, M. "3D printing: the next industrial revolution". *Special issue of the International Journal of Manufacturing Technology and Management*. (2013).
25. Samuels, W. "Performance and Permeability: An Investigation of the Mashrabiya for Use dans le Gibson Desert in Australia" (pp 42–57.). *Master Thesis, School of Architecture and Design of Victoria University, Wellington, New Zealand*. (2011).
26. Sidawi, B, "A Conceptual Analytic Model of the Vocabulary of the Islamic Architectural Heritage", *Emirates Journal for Engineering Research*, 17 (1), pp. 47–56.(2012).
27. Starck, P, *Interview with Philippe Starck*. Available from <http://redvisitor.com/people/philippe-starck/>(2014).
28. UNESCO, "Convention on the protection and promotion of the diversity of cultural expressions", available on the web link: http://portal.unesco.org/culture/en/ev.php-URL_ID=29123&URL_DO=DO_TOPIC&URL_SECTION=201.html.
29. Zoran, A, "Hybrid Basketry: Interweaving Digital Practice Within Contemporary Craft". *Leonardo*, 46 (4), pp. 324-331. (2013).