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Screen Design and Applications for Sustainable Buildings

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ABSTRACT

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Keywords: Building Screens; Façade Design; Sustainability; Environmental design

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SCREEN DESIGN AND APPLICATIONS FOR SUSTAINABLE BUILDINGS

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Abstract

Traditional vernacular architecture in the United Arab Emirates constituted namely of adobe houses with a limited number of openings in their facades. The thick mud and rubble walls and wooden window screens protected its inhabitants from the harsh desert climate and provided them with privacy and fulfilled their comfort zone needs to an extent. After the rapid increase in reinforced concrete villas with glass and steel fenestration that replaced traditional vernacular dwellings. There is a need to revisit regional architecture and precedent building traditions in order to resolve the increase in carbon footprint per/capita in the UAE. The focus of this paper is on reducing the dependency of mechanical cooling systems through the design of different types of façade screens and shading devices, and to develop awareness to Architecture students to culture through the production of patterns for traditional screens and how they can contribute to climate and privacy requirements in the Middle East region. This paper highlights the importance of hands on education for student architects and how physical modelling helped improve their understanding of Sustainable design.

Keywords: *Building Screens, Façade Design, Sustainability, Environmental design.*

1. Introduction

Traditional vernacular architecture in the United Arab Emirates developed to reflect tribal Bedouin cultural values such as privacy, in addition to climate responsive forms. Sustainability in the pre-petroleum era is manifested by vernacular dwellings that were founded on local/available building materials in each region with adobe courtyard houses with wind towers-*barjeel* as a predominant prototype. The urge for privacy stipulated façade solid to void ratios resulting in mostly solid exterior facades with small highly located fenestration units covered in perforated window screens. Al-Bidyah mosque in Fujairah (Figure 1) with its thick walls creating a thermal mass, stepped domes and stucco windows is a good example of the practicality of the Bedouin community and the importance of human scale reflected in their built heritage. The lack of monumentality in the oldest mosque in the UAE (1480-1680AD) exemplifies how tribal communities used sustainable materials and were conscious of design techniques that responded to hot arid climatic conditions. Al-Bidyah mosque

exemplifies the importance of orientation integration of regional vernacular expression to site context.



Figure 1. Al-Bidyah Mosque Fujairah

Traditional architecture in the UAE highlights the different masonry techniques that availed and how they inherently reflected thermal and visual comfort in addition to their integration to the surrounding urban context. Another form of local building typology was the *Arish* or *Barasti* huts that are palm frond shelters created to allow for ventilation during the hot summer months. These developed a rectangular form with flat roofs, or triangular tent-like structures created by

split-palm trunks and palm fronds that allowed for an infiltration of light and air. (Figure 2) As outlined by Sandra Piesik today in the rapid era of globalization not too many craftsmen remain that have the knowledge to work with traditional materials such as coral stone and palm fronts. [1]



Figure 2. Arish hut and adobe architecture Al-Ain city, Abu Dhabi.

Traditional adobe urban enclaves in the UAE developed climate responsive patterns in the form of the *Fareej* in Abu Dhabi that evolved as result of the interaction between different tribal families to create a neighborhood shaped by adobe courtyard houses and *Arish* huts. Narrow shaded corridors known as *Sikka* opened to local squares known as *baraha* where communal activities took place. The *Fareej* offered a well-recognized arrangement of adobe architecture with perforated screens that evolved to control the harsh solar radiation without compromising the aesthetic quality of the space and the occupants' well-being. Shade was an important factor that was obtained by architectural elements such as desert landscape/palm and supplementary plants in addition to *liwans* which were local loggias that reduced the effect of the direct sunlight on the walls of the buildings.

Today UAE cities have changed dramatically to reflect the monumentality of modernity and the effect of the global economy on the building industry as high-rise concrete and glass towers overshadow traditional building traditions and reshape the city skyline. It is therefore instrumental to educate the new generation of architects to the importance of the carbon footprint caused by modern building stocks, and to develop innovative approaches dedicated to reducing the impact of modernity on its surrounding environment. The Brundtland Report for the World Commission on Environment and Development (1987). [2] highlights that Sustainability is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Therefore reducing the dependency on mechanical systems, and control of climatic conditions through passive strategies is important. [3]

The Abu Dhabi Vision 2030, is planning to implement a series of comprehensive development strategies, the region will transform over the next 20 years, as part of the Economic Vision 2030 which has a Structural Framework Plan, supervised by the Urban Planning Council (UPC). In Abu Dhabi, shading is required throughout the year. As a result, the general rule is to protect all facades from excessive amount of solar radiation. In summer, north and south facades get only limited solar radiation due to the high sun altitude at noon time. In winter, the sun rises in the South East hence, South facades need to get shading by horizontal louvers. East and west facades receive a high portion of solar radiation at low sun angles; hence, flexible shading design is essential to reduce the heat gain. Estidama guidelines seek to mitigate the negative impacts of thermal heat gain through comprehensive systems of shade and ventilation. [4] Such guidelines such as design using shading screens, passive design, and renewable energy sources are essential for future

architects. Therefore it was highlighted to students during the learning process, throughout the course of the semester to think not only about the current needs of people, but also to study the building codes in stipulated by Abu Dhabi UPC such as Estidama and LEED.

2. Literature Review

In the architecture of traditional Emirati houses traditional Wind towers *barjeel*, and courtyard houses created stack cooling effects that could reduce the dependency on mechanical cooling systems. Examples of vernacular architecture in the Gulf are in contrast to modern villas since traditional architecture had facades a wide use of screening devices such as *Claustra* screens that helped the transition from traditional to modern architecture. Screens in this in-between style that transitions from tradition to modernity the control the direct high-intensity of sunlight allowed a uniform distribution of air flow. [5] Traditional dwellings of the UAE such as the residence of Sheikh Zayed in Al-Ain (Figure 3) demonstrate the essence of sustainable design through the use of screens, shaded colonnaded corridors *liwan* and adobe construction techniques to create private spaces that conformed to particular cultural norms and communal needs such as the flexibility to expand in order to house the extended family throughout time and space. [6] The study of screens based on precedents proved to be a popular technique that helped students understand the importance of sustainable design and passive cooling. After creating models of prototype screens, several tests were conducted to calculate the amount of Sun, light and wind that goes through the screens affecting the heat load and light entering the building. Students understood that sun angles differed during summer when they may be a need to screen against both heat and glare, whilst during winter there will be a need to open up the building. Traditional dwellings such as the Sheikh Zayed residence in Al-Ain are good

design precedents for students since they include *liwans* that circumambulated the building and acted as a loggia that covered the outdoor sitting areas in addition to its climate function of passive cooling and creating of a cool air draft between spaces.

In environmental design choices are often made in relation to the local conditions, so that the facade not only creates the room behind but also constitutes an important element in the control of the room's climate and light levels. Unscreened sunlight can heat a room to an extent where it is not comfortable to stay in it. [7] This means that buildings are often designed with loggias, or porticos which create shaded areas at the building perimeter. Building facades need to be designed to accommodate climatic variation and to create comfort zones using screens that define the spaces adopted from traditional architectural elements such as *liwans*.



Figure 3. Sheikh Zayed House Al Ain

Comparable vernacular typologies are also found in Al-Hiba village in Morocco, which proved useful as an example to teach students about the advantages and disadvantages of Adobe architecture. Especially that the UAE is currently investing in the preservation of adobe vernacular heritage in Morocco. Masdar, the Abu Dhabi renewable energy company, has completed the installation of 9,000 solar home systems Morocco as part of a scheme to advocate renewable energy. It also exemplifies the cross-national

interests in preservation and conservation of environmental architecture from the pre-industrial era. El-Hiba exemplifies an intact urban fabric and living community within traditional courtyard houses. It also represents the dissemination of regional design and building techniques to adapt to climatic context. Similar to the *Fareej* the streets of Al-Hiba village are very narrow to create shade and act as cool air tunnels. Houses densely clustered reflected the *Fareej* concept that had existed in Abu Dhabi with an urban fabric designed with the purpose of screening against the sun creating shaded corridors that provides good protection against heat and strong sunlight. In traditional adobe architecture in the UAE that has undergone restoration lighting has been modified and thereby does not make the building appear as it does in its original context, but instead to offer a very different and selective view. The impact of conservation was also examined since restored buildings usually have facades that are more reflective to daylight. [8]

3. Design Methodology

The approach of physical modelling as an educational means to combine theory with a hands on teaching approach proved very effective. Students were first introduced to the basic definitions of sustainability, they learned through theoretical conduct the different views of sustainability, what it is and how it can be delivered. The negative impact of the building and construction industry on the environment came as a main drive to captivate the students' attention to the cause, since a significant percentage energy resources are consumed by residential architecture. Students were guided throughout the course of the semester to not only think about the current needs of people, but also to put the industry needs and market competition on their minds. That is by trying to create a Thermal Comfort Zone for the habitats. [9] Since contemporary architecture has

evolved to become a mega scaled iconic sculptures admired and appreciated by the users and observers. Yet on the other hand there is a continuous debate and rising importance of renewable energy and CO₂ emissions produced and resources consumed throughout a building's life cycle.

Reducing dependability on mechanical cooling systems was addressed through a hands-on approach to designing screens which proved to be a popular technique that helped the students understand the importance of sustainable design and passive cooling. And allowed them to implement sustainable design concepts they have recently learned and put their newly born sustainable awareness to action. This could be achieved without contradicting with the main design and concept creation phase, as they can actually use it to add individuality and pioneer to their designs and forms

Each group was required to come up with 3 to 4 different innovative Screen designs, that can be constructed and implemented in the United Arab Emirates precisely and the Middle East region generally. The aim of the screen design was to provide privacy for the conservative inhabitants and grant the building with an exclusive unique design, which extinguishes the building façades, and grant the form with particular conceptual approach and cultural trace. They were required to model the screens physically in 30cm x 30cm either by scaling down the full screen design to fit the required dimension or scaled part of the screen that can be used as a repetitive pattern in the original façade area that needs to be covered.

The groups started with sketching and brainstorming concepts and ideas to produce screens that reflect particular design approaches and trends. Variety of concepts were covered, some screens were based for the traditional patterns and embodied designs of the Region as they

were aiming for reproducing traditional patterns, (Figure 4) while another group decided on introducing contemporary and abstract designs that they believed would fit better with the rapid rate of urbanization in Abu Dhabi and the UAE.



Figure 4. Students during the Preliminary sketching stage

Two main criteria were given to students the first being Privacy and the second was the effectiveness in protection from Direct Sunlight. To evaluate the privacy level of the screens a void to solid ratio was quantified, by valuing the ratio of the sum of the areas of the window \screen openings to the gross area of the window\screen with an approximate ratio 1 to 0.7 i.e. the larger area of the screen was actually Void providing more exposure to the interior spaces. The privacy level was increased by proposing to cover the openings in the screen with a translucent material such as fiber glass to allow the sun light in without exposing the interior of the building. For the second criteria the protection from direct Sun light and glare. Students had to study the direct sun reflection level of the screens, by creating a 30 x 30 x 30 cm testing box that is open from one side and had a small opening on the opposite side measure the lighting intensity and effectiveness of the screen.

Students took their inspiration from design abstract shapes that they abstracted and applied irregular in a random distribution. They discussed as a team how geometric shapes could add an edge and character to a modern building and how it affected its volume and form. In another attempt

students opted for an Islamic interlacing star pattern and tried to apply it within a modern context. Students used combinations of repeated squares, circles and polygons, and tried to interlace and overlap to create complex patterns. They came up with repetitive patterns and singular large less clustered motifs. They felt the need of reflecting the culture and tradition of the region through the building façade regardless the building function. The aesthetic feeling that occurs from the shadow casted on the interior developed a cultural identity to the space and students felt that it created a good counter design in an era of globalization.

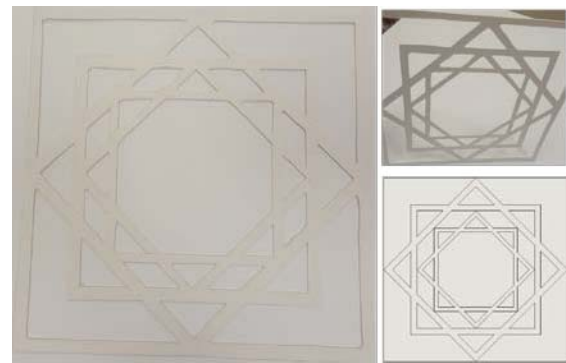


Figure 5. Designing a Screen using a traditional Islamic star pattern

Through screen design students were introduced to a better understanding sun shading devices and louvers and however they function technically through the design of their basic elements. In the context of modern architecture louvers are not known for being a fundamental design elements, they also understood the complexity of combining aesthetic and cultural criteria to a technical device. This incited students to innovate and work as a team to discuss designs that embraced aesthetic as well as technical qualities. Adding the privacy component which is an essential element in the design of Emirati dwellings and community that highly values privacy.

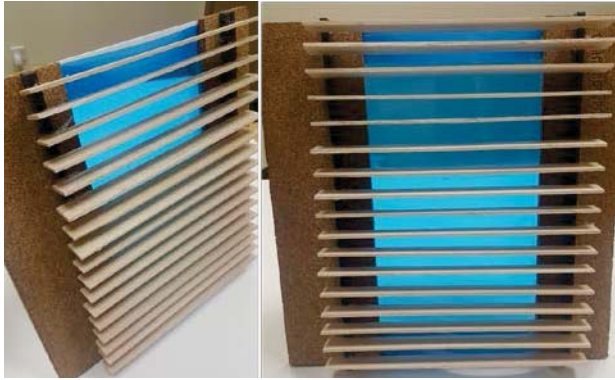


Figure 6. Horizontal louver Screen Design

Another group of students decided to design horizontal louvers since they are essential design components in facades facing south. They also represent the modernist solution to shading interior spaces and exist in different forms and sizes in the Middle East from Colonial times in the 19th century. Student designed horizontal slats to simulate a facade that is facing south and applied the louvers in different angles and with tinted and transparent glass behind it. (Figure 6) The tinted glass provided interesting effects on the indoor daylight and limitation glare.

4. Discussion and Conclusion

In this study, the architectural design of indigenous vernacular architecture was examined in terms of the effects of climate and privacy measures through the study of precedents. The use of contemporary geometries reinterpreting traditional patterns on screens represents an inevitable necessity in the creation of a building's identity in the modern Arab city, to counter global changes in architecture. Although Sustainability has been used broadly in Abu Dhabi the government is taking serious steps through introducing the Estidama initiative which promotes sustainability through a system of ratings for new buildings such as villas and private residences. There is also a notion to revisit the existing heritage and produce new designs that are more culturally sensitive and adhere to communal issues such as privacy. Highlighting the cultural

values of the UAE within the context of sustainability and environmental design proved to be effective since students showed great interest in their production of several screen designs. And their appreciation of explaining complex technical issues through a hands-on approach and learning through implementation.

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